Bacon Creek Watershed Plan

Kentucky Waterways Alliance & Kentucky Division of Water

Funding for this project was provided in part by a grant from the U.S. Environmental Protection Agency through the Kentucky Division of Water, Nonpoint Source Section and the Kentucky Division of Conservation Kentucky Waterways Alliance as authorized by the Clean Water Act Amendments of 1987, Section 319(h) Nonpoint Source Grant #C-9994861-10.

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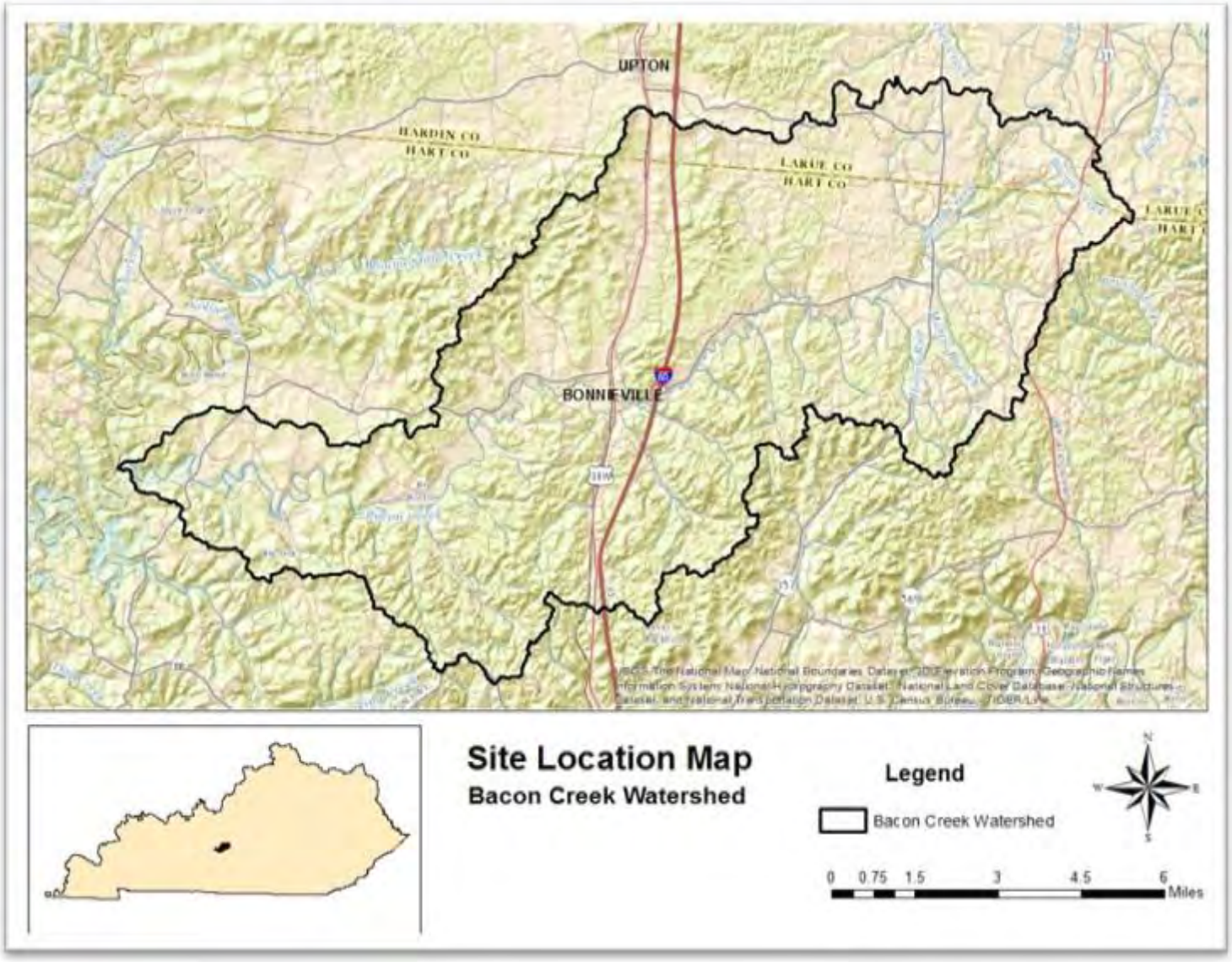

Figure 1.1: Map of the Bacon Creek Watershed (DOW 2015).

The Bacon Creek Watershed is situated in the Upper Green River Basin and lies mostly in Hart County, extending a little into Hardin and Larue Counties (Figure 1.1). The watershed is comprised of seven sub-watersheds: the upper (or headwater) sub-watersheds of Upper Bacon Creek, Middle Bacon Creek, Tampa Branch, Upper Martis Branch, Lower Martis Branch, Honey Branch, and the Lower Bacon Creek (by far the largest), which includes the mouth of Bacon Creek. This plan focuses on the five upper sub-watersheds of Bacon Creek (Figure 1.2).

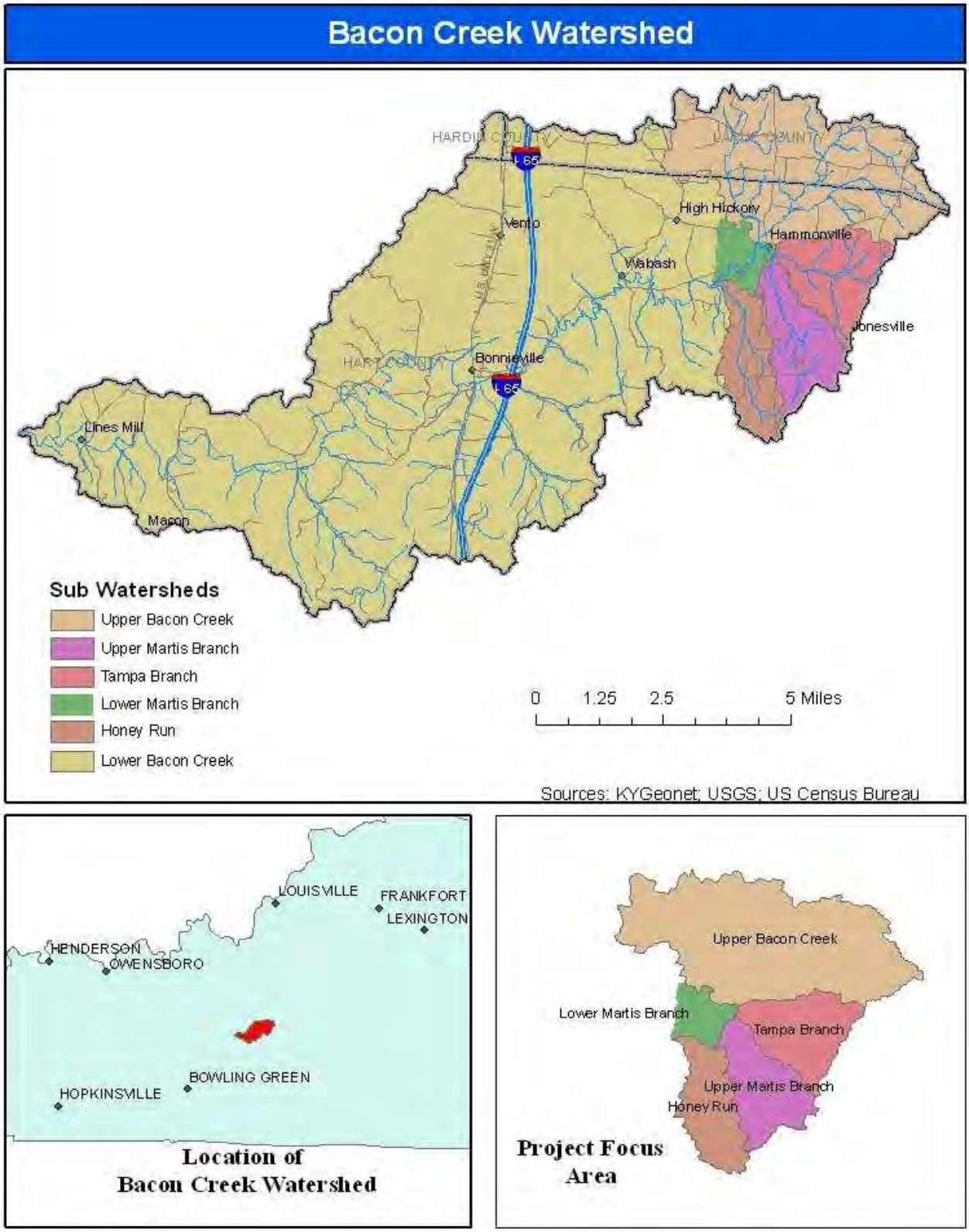

Figure 1.2: Map of the upper sub-watersheds of Bacon Creek.

What is a watershed plan, and why does Bacon Creek need one?

Bacon Creek was chosen for this project because there is an established, dynamic watershed group already in place and because Bacon Creek is a tributary to the Nolin River. The Nolin River is a drinking water source as well as a prime recreation spot, and is listed as full support for Primary Contact Recreation, Secondary Contact Recreation, drinking water and aquatic life. Bacon Creek was first listed by the Kentucky Division of Water (KDOW) as impaired for primary contact due to fecal coliform in the 1988 (*Report to Congress on the Condition of Water Resources in Kentucky).*

Watershed planning is a comprehensive, collaborative way to plan for the protection and improvement of the water quality in a given body of water. Watershed planning involves gathering local stakeholders to share their knowledge, concerns, and ideas in developing the plan. It is a great way to take care of streams with pollution issues and outreach to the local community at the same time. The knowledge gathered from stakeholders, water quality sampling data, background research, and proposed best management practices (BMPs) to combat pollution all go into the plan. This 2013 plan is a revision to the original watershed-based plan written for Bacon Creek with a 2005 grant from KDOW. It includes updated data on sources of pollution and a report of implemented BMPs that the original plan had proposed.

A Brief History

KWA was awarded a grant from KDOW in 1998 to help establish watershed councils around the state. There was a group of concerned citizens in and around Bonnieville with ties to Bacon Creek. And so the Bacon Creek Watershed Council was formed – it was a natural partnership. One of the group's main goals, in cooperation with the Bonnieville City Council and other partners, was to obtain funding and construction of a sewer line to Bonnieville. This would eliminate straight pipes in the area, a big first step to cleaning up Bacon Creek and making it safely fishable and swimmable again. Following a successful effort to get the sewer line funded and moving toward construction, a *Watershed Action Plan* (see Appendix A) was written for the Bacon Creek Watershed in 2005 by Dale Reynolds, former Green River Basin Coordinator for KDOW. Focused on the entire Bacon Creek Watershed, the *Watershed Action Plan* was the steppingstone to the first watershed-based plan. The sewer line became operational in 2007. With that work complete in the lower portion of the watershed, the Bacon Creek Watershed Plan was written as part of a FY05 grant awarded to KWA and the Bacon Creek Watershed Council to address issues in the Upper Bacon Creek Watershed portion. That plan was conditionally approved by KDOW in 2010 with the understanding that the plan would be updated to fit new watershed plan standards and format.

1.2 The Bacon Creek Watershed-based Plan and Implementation Project

The second iteration of the Bacon Creek Watershed-based Plan, this plan, was developed by the Bacon Creek Watershed Council, partners, and stakeholders with the help of a FY10 grant titled *Bacon Creek Watershed Plan and Implementation* awarded to KWA through the KY Division of Conservation. Focused on the headwaters area of the Bacon Creek Watershed (sub-watersheds Upper Bacon Creek, Honey Branch, Tampa Branch, Lower Martis Branch, and Upper Martis Branch), the aim of this revised watershed-based plan project is to implement agricultural and septic system BMPs to reduce the bacteria loading in the upper watershed areas and improve water quality in the entire creek. This watershed plan follows the format of the *Watershed Planning Guidebook for Kentucky Communities,* first edition.

Local Stakeholder Concerns

Because community involvement and local stakeholders are vital to successful watershed planning, this watershed planning project began with a discussion about stakeholder concerns. The following list was created by watershed stakeholders in attendance at a Bacon Creek Watershed Council meeting:

- Swimmable
- Fishable
- Baptismal
- Stable banks
- Drinkable
- Safe and Clean
- Good Habitat

Partners and Stakeholders

The Bacon Creek Watershed Council's core membership has been made up of Bonnieville City Council members, with a broad-based and changing set of stakeholders and partners, listed below. This larger group worked on reaching out to the community as a whole, planning creek cleanups, watershed newsletters, planning roundtable events, farm field days, and speaking engagements. A number of people, agencies and companies have been leaders, stakeholders and partners during different phases in the development of this Watershed Plan. These include but are not limited to the following list:

Bacon Creek Watershed Council	**Residents of Hart and LaRue Counties**
Bonnieville City Council	**Hart County Soil & Water Conservation District**
LaRue County Soil & Water Conservation District	**Caveland Environmental Authority**
Upper Green River Watershed Watch	**Three Forks of Bacon Creek Baptist Church**
Kentucky Onsite Wastewater Association	**Barren River District Health Department**
Hart & LaRue County Judge Executives	**Kentucky Division of Water**
Kentucky Division of Conservation	**Kentucky State Nature Preserves**

Table 1.1 – Project Partner List

Technical Consultants

Western Kentucky University Center for Water Resources acted as technical consultants on this project, collecting, and analyzing data. Additionally, Kentucky Division of Water personnel conducted data analyses and interpretation.

Sponsoring Organization

This project was made possible by a 319 (h) grant from the Kentucky Division of Water and the Kentucky Division of Conservation to the Kentucky Waterways Alliance (KWA). KWA served as the fiscal agent and grant manager for the project. The project entailed this watershed-based plan as well as many other requirements that are outlined in the 2013 project final report.

Funding statement:

Funding for this project was provided in part by a grant from the U.S. Environmental Protection Agency through the Kentucky Division of Water, Nonpoint Source Section and the Kentucky Division of Conservation Kentucky Waterways Alliance as authorized by the Clean Water Act Amendments of 1987, Section 319(h) Nonpoint Source Grant #C-9994861-10.

Chapter 2 – Exploring Your Watershed

2.1 Introduction

Chapter 2 focuses on existing information and local knowledge about the Bacon Creek Watershed. This information is critical to understanding the land and water uses in the watershed and their associated impacts on water quality. This chapter covers water resources, natural features, and human influences. Chapters 3 and 4 discuss water quality data that are being collected specifically for this project.

Bacon Creek starts in southern Larue County and flows west through Hart County and the town of Bonnieville until it reaches the Nolin River (Figure 2.1). It is approximately 31 miles long and drains a 90.36 square mile area. The Bacon Creek Watershed includes the mainstem of Bacon Creek, its tributaries, and the land around them. Bacon Creek is part of the Green River Basin. Other towns in the watershed include Magnolia, High Hickory, Upton, and Hammonville.

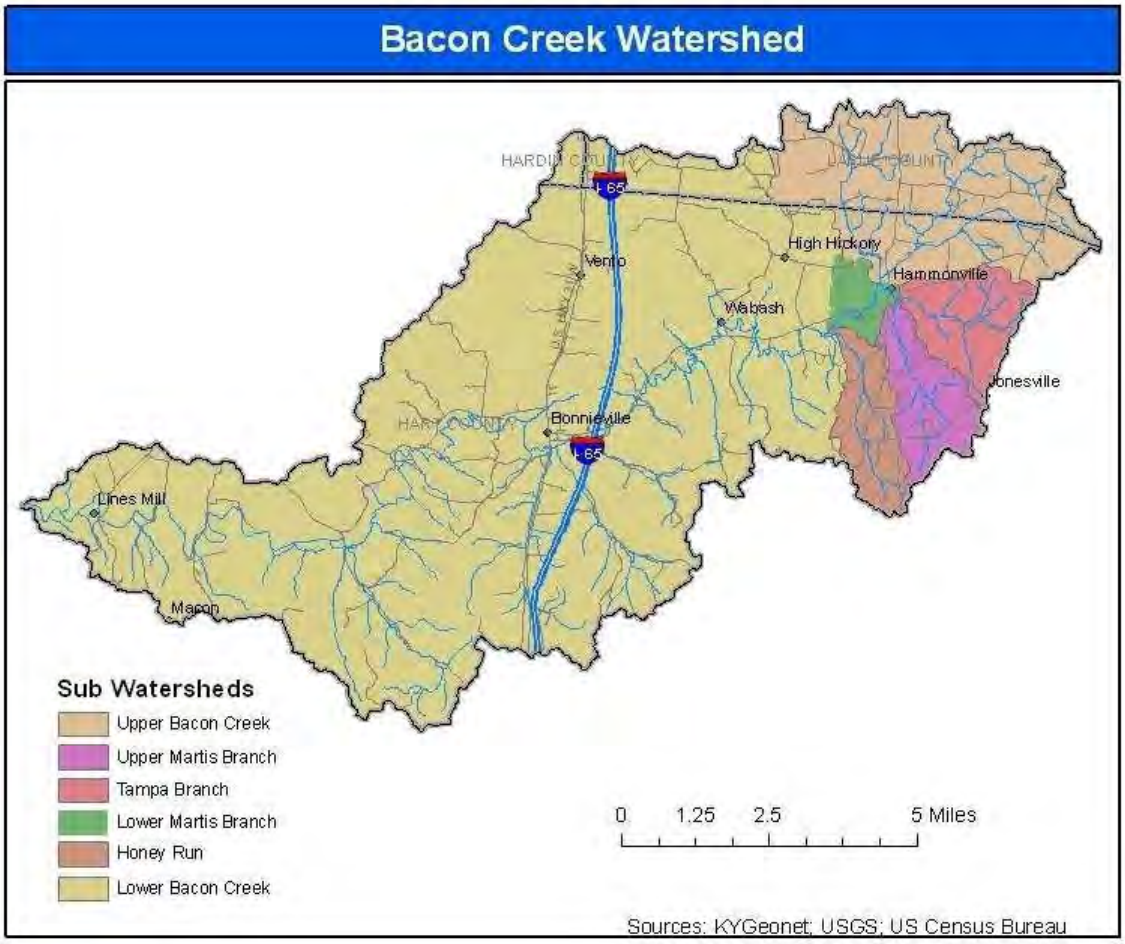

Figure 2.1: Map of the Watershed (KWA 2012).

Figure 2.1 shows the entire Bacon Creek Watershed. The upper watershed area, also called the headwaters, east and north of Bonnieville, is the focus of this watershed plan. Most maps and other information in this plan focus on this upper watershed area, named Upper Bacon Creek Watershed. It is 13,833 acres and includes six smaller sub-watersheds:

- Middle Bacon Creek (HUC 05110001150050),
- Upper Bacon Creek (HUC 05110001150010),
- Tampa Branch (HUC 05110001150030),
- Upper Martis Branch (HUC 05110001150020
- Lower Martis Branch (HUC 05110001150040)
- Honey Run (HUC 05110001150060)

For the purposes of this plan, Lower Martis and Middle Bacon Creek have been combined and are referred to as "Lower Martis" on maps. Thus, there are five sub-watersheds referenced on maps and in text throughout this watershed plan. There is an Upper Bacon Creek Sub-watershed (the peach shaded area in Figure 2.1), which should not be confused with the Upper Bacon Creek Watershed (the five sub-watersheds together). The entire area in Figure 2.1 is the Bacon Creek Watershed.

2.2 Water Resources

Hydrology

The hydrology of Bacon Creek includes where the creek flows (including above ground and underground flow), how much water is in the creek, and the quality of that water (see Figure 2.2). Stream flow measures the amount of water traveling through a stream in cubic feet per second (cfs). The US Geological Survey (USGS) has gaging stations that record these data year-round on many streams throughout the country. There is one gage station in the lower reaches of Bacon Creek near Priceville, Kentucky. It was not active in the past decade: Station #03310400 operated from 1959 until September 1994 collecting stage and sediment data; however, it was recently reactivated with combined funding from USGS and the KDOW.

Flow data is useful as it indicates how much water is in a waterway and how fast that water is moving at a certain time and place. Mean annual flow is the average volume of water in a year to flow past a specific point. Typically, a downstream location will have a greater flow than an upstream location in the same body of water. This is because tributaries and precipitation add volume to the stream as it travels downstream toward the mouth.

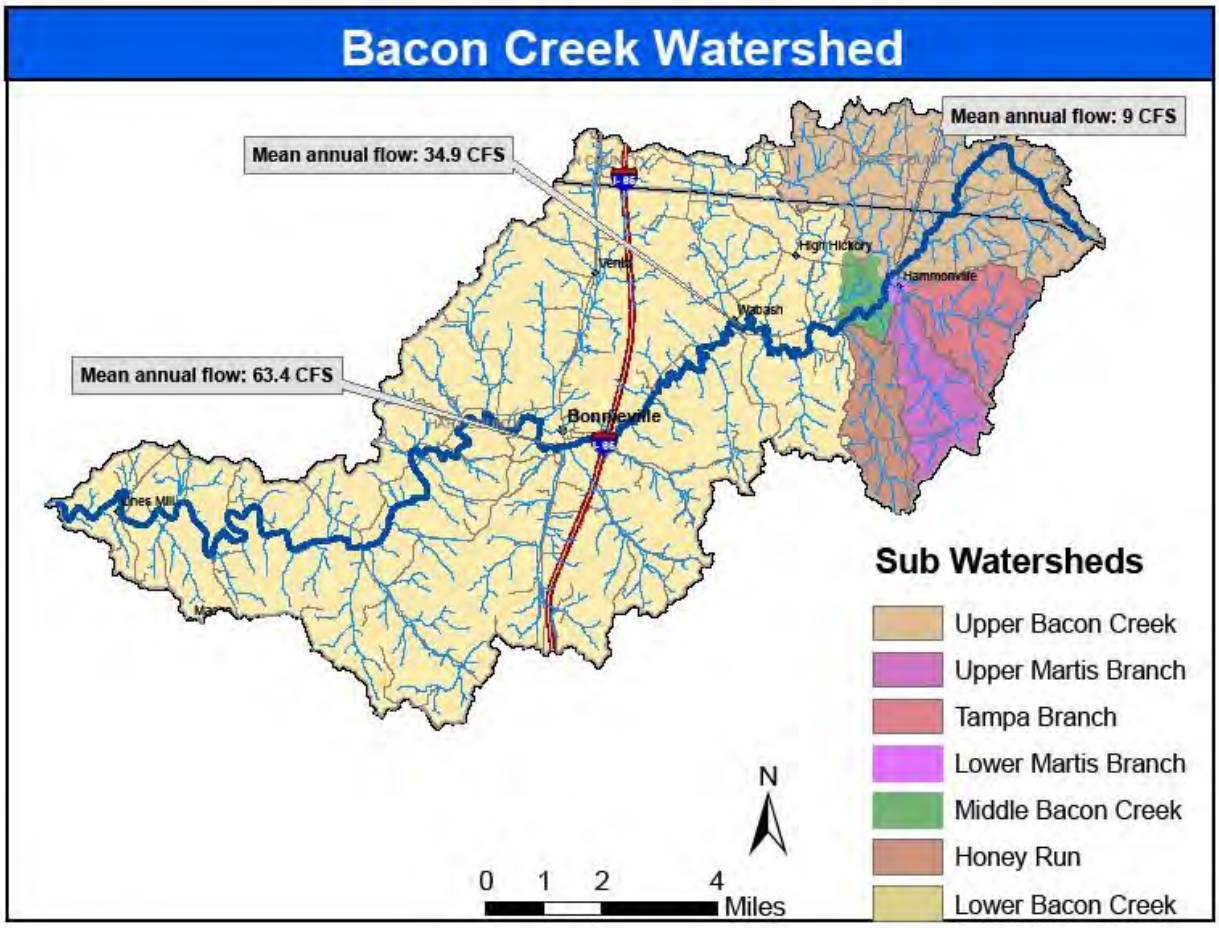

Figure 2.2: Mean Annual Flow Estimates on Bacon Creek (KY Hydrology Viewer data 2012).

Climate and Precipitation

The climate and precipitation of an area can have significant influence on a stream's characteristics. Bacon Creek is fed by springs, but much of its flow comes from rainfall and melting snow. The general climate for Hart and Larue Counties is temperate and humid. Annual precipitation averages between 46-51 inches (Midwest Regional Climate Center 2012). Table 2.1 illustrates the temperature and precipitation data for 2011 for Hart County.

2011	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	total
Max Temp F°	40.7	49.4	57.2	70.2	73.9	84.9	89.8	87.7	75.7	67.5	59.8	50.3	
Min Temp F°	25	29.4	39.7	49.2	55.1	64.8	70	65.3	56.7	44.3	40.6	33.1	
Ave Temp F°	32.9	39.4	48.5	59.7	64.5	74.8	79.9	76.5	66.2	55.9	50.2	41.7	
Total Precip in.	**2.14**	**7.43**	**4.09**	**13.46**	**2.7**	**2.7**	**2.12**	**3**	**5.92**	**2.21**	**9.54**	**4.10**	**59.41**

Table 2.1: 2011 Climate Data for Hart County, Munfordville Weather Station (KY Mesonet 2012).

Tables 2.2 and 2.3 display climate data for 2012 and long term data for Hart County for the years 1972 to 2000. Both of these sources of climate data (KY Mesonet and the Midwest Regional Climate Center) use a weather station in Munfordville, KY.

2012	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	total
Max Temp F°	62.9	74.3	82.3	83.4	91.0	105.8	103.6	93.3	90.3	78.7	71.4	72.2	
Min Temp F°	13.9	16.0	27.4	28.4	43.4	47.1	64.5	52.7	37.0	33.2	19.4	33.9	
Ave Temp F°	39.8	43.0	58.7	59.2	70.0	74.3	80.0	74.1	67.2	55.5	44.3	55.0	
Total Precip in.	**4.14**	**3.88**	**3.47**	**1.94**	**4.48**	**0.4**	**5.26**	**2.74**	**5.86**	**1.96**	**1.62**	**0.41**	

Table 2.2: 2012 Climate Data for Hart County, Munfordville Weather Station (KY Mesonet 2012).

Element	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
Precip. (in)	4.30	3.97	5.15	4.08	5.38	4.62	4.63	3.60	3.83	3.19	4.28	4.88	51.91

Table 2.3: Historical Precipitation Data (combined monthly averages for years 1972-2000) from Hart County station in Munfordville (Midwest Regional Climate Center 2012).

Groundwater-Surface Water Interaction

Nearly all surface water features (streams, lakes, reservoirs, wetlands, and estuaries) interact with groundwater. These interactions are important to consider because a stream can get water from, or lose water to, the groundwater system. This exchange of water can have an impact on the water quality and quantity of waterways. Withdrawal of water from streams can deplete groundwater or conversely, pumping of groundwater can deplete water in streams, lakes, or wetlands. Similarly, pollution of surface water can cause degradation of groundwater quality, and pollution of groundwater can degrade surface water. Effective watershed planning requires an understanding of the links between groundwater and surface water as it applies to any given setting (USGS 2012). Groundwater systems do not necessarily share the same watershed boundaries of surface waterways.

One important feature of the Bacon Creek Watershed is that it has karst topography. "Karst" is a term used to describe features of limestone deposits that have become eroded by surface and/or groundwater. Features of karst topography include caves, sinkholes, springs, and underground streams. There are numerous documented sinkholes and springs scattered throughout the watershed, some springs discharge directly into Bacon Creek (see Figure 2.3).

Typically, predominant water flow patterns for a watershed are determined by the lay of the land (or surface topography). Karst features, however, introduce some variations that ignore topography. So while the surface topography may show that some areas of the watershed are connected and some are not, karst features can form a different interconnected system altogether.

The practical side of karst features in the Bacon Creek Watershed is that some connections of waterways are unknown. While a surface water or topographic map will show what sources and land uses are inside the watershed and thus have the potential to impact the water quality of Bacon Creek, karst features and their underground network will not appear on such a map.

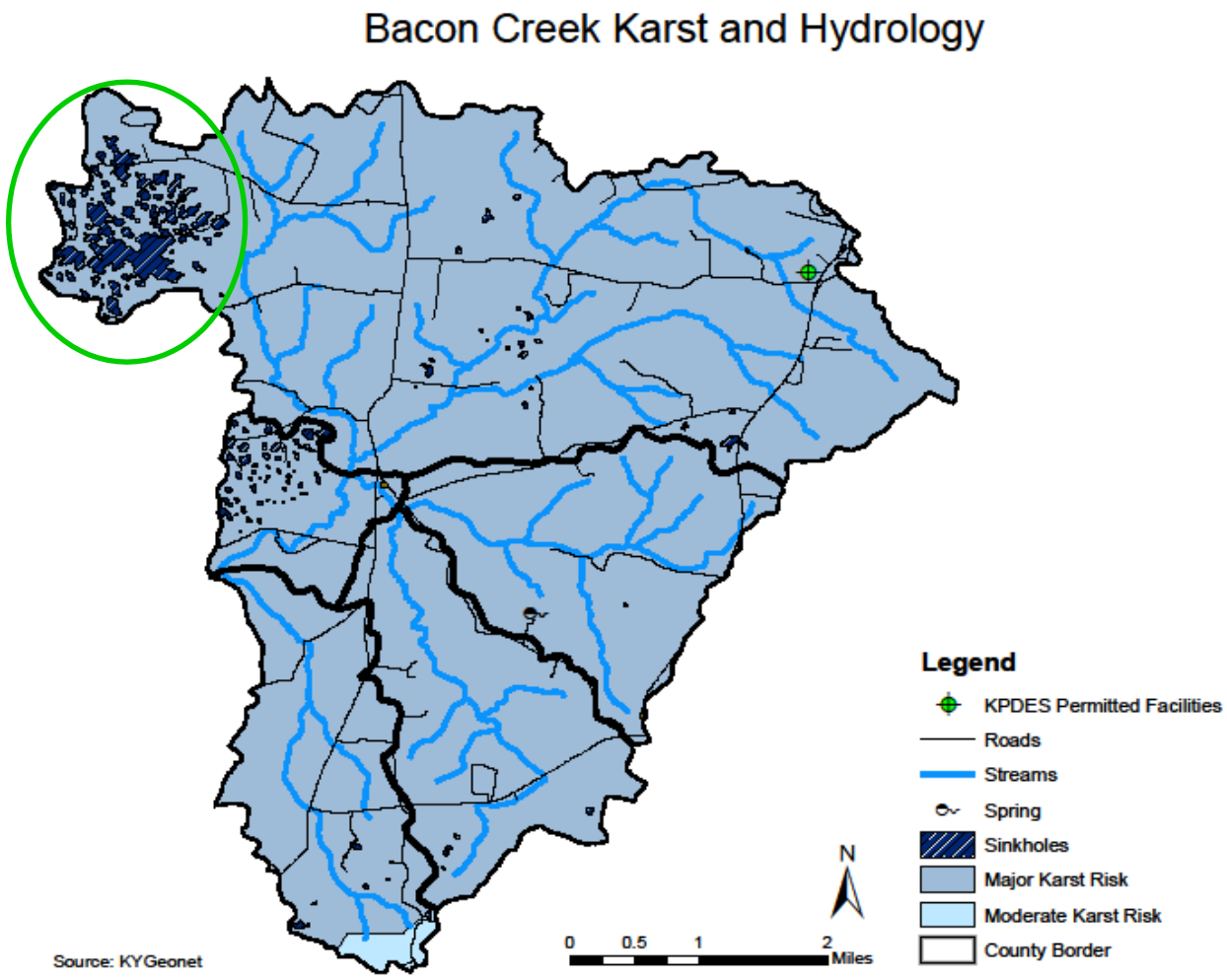

Figure 2.3: Upper Bacon Creek Watershed Surface Hydrology and Karst Features (KWA 2012).

In fact, the northwest portion of the Upper Bacon Creek Watershed is in a different karst basin than the rest of the project study area. Note the green circle on Figure 2.3 that surrounds sinkholes and major karst risk. While it is part of the surface topography, its karst features are connected to a different basin.

Over a dozen dye-traced karst flows have been mapped within and across the watershed boundaries (Figure 2.4). One can see from Figure 2.4 that the karst and groundwater basins do not follow surface water boundaries.

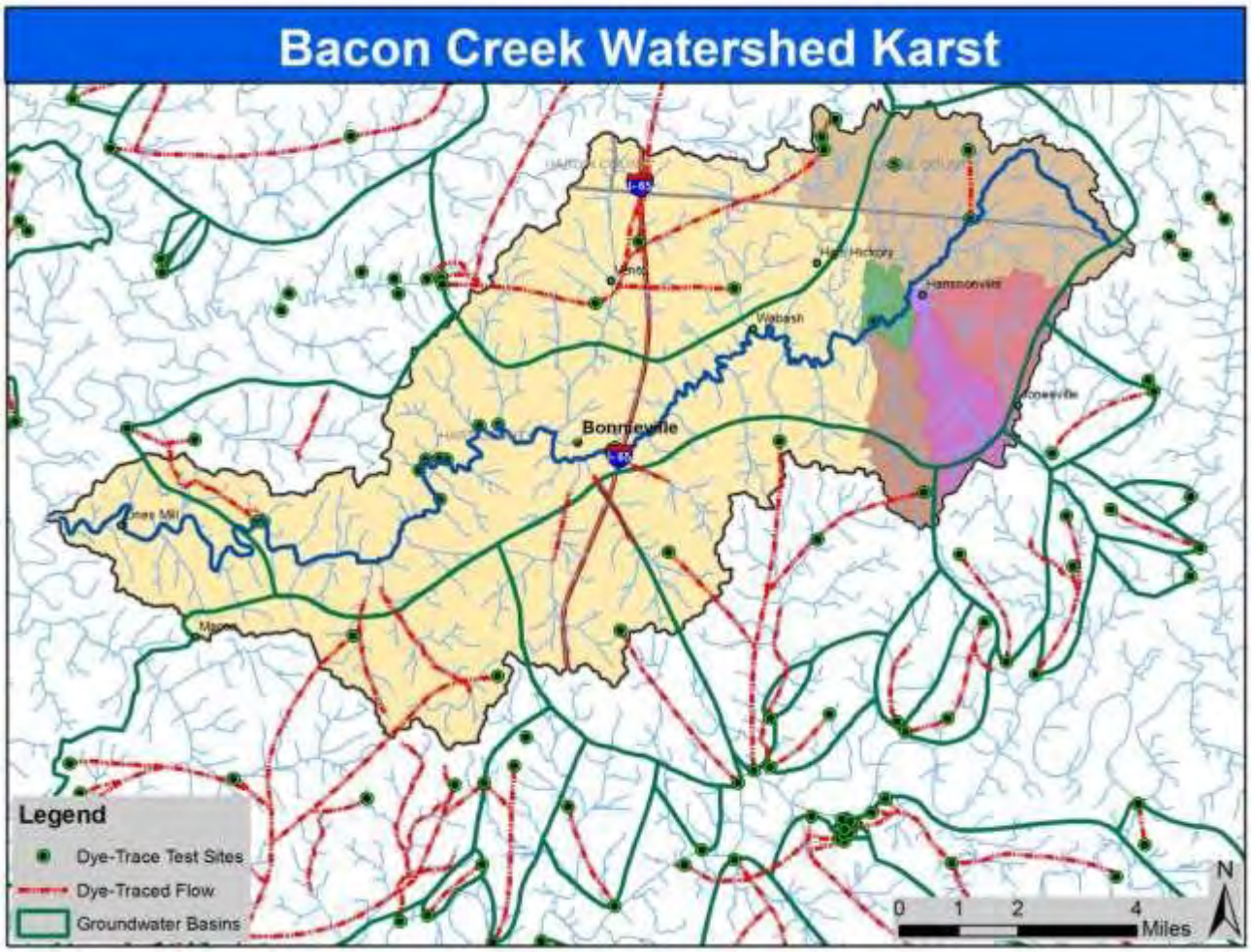

Figure 2.4: Central Kentucky Karst Basins (KY Geonet 2013).

Flooding

Flooding is a natural phenomenon. When portions of floodplains are preserved in a natural, vegetated state, they provide many benefits including aesthetic value, reduction in number and severity of floods, help handling stormwater runoff, and minimizing nonpoint source water pollution. By allowing floodwater to slow down, the sediments settle out, thereby benefitting water quality. The natural vegetation filters out impurities and uses dissolved nutrients.

While there are not a lot of impervious surfaces in the Bacon Creek Watershed, roads and parking lots most likely do contribute some pollutants to the creek. Figure 2.5 illustrates the floodplains of the watershed area.

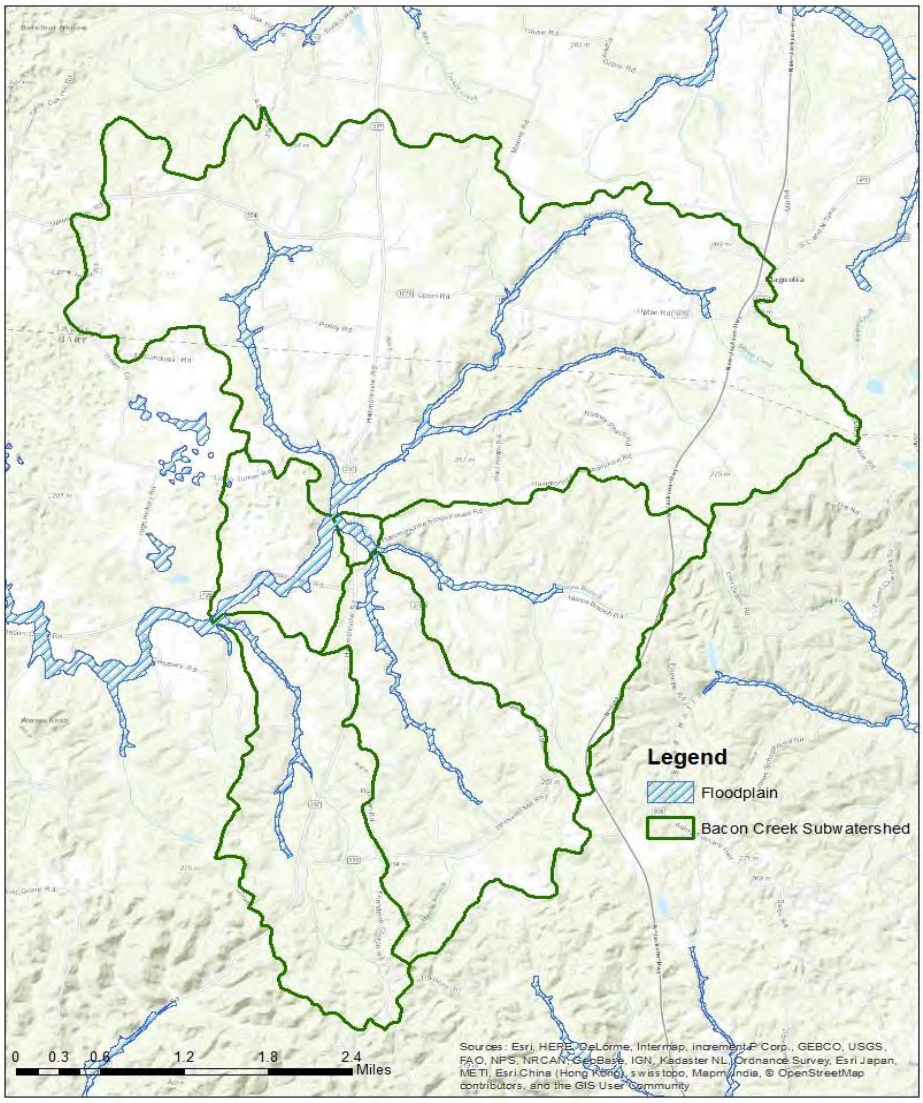

Figure 2.5: Floodplain Map of Bacon Creek (DOW 2015).

Regulatory Status of Waterways

The Kentucky Division of Water (KDOW) is required by Congress to evaluate a sampling of creeks and rivers to find out if they are safe for a variety of uses by humans, such as swimming, wading, fishing, drinking, and eating fish from them. Water bodies are also evaluated to find out if they are healthy enough to support other uses, such as a home for the plants and animals that live there. The uses are called "designated uses." Every two years KDOW is required to send a report, called the "Integrated Report to Congress on the Condition of Water Resources
in Kentucky" to Congress and the Environmental Protection Agency about the streams sampled. In addition, they must report on which of those streams sampled have problems, or are "impaired" for designated use(s).

Bacon Creek is listed by KDOW as impaired in its *2010 Integrated Report to Congress on the Condition of Water Resources in Kentucky.* Impaired streams are those that do not meet their designated uses. An impaired classification is based on water quality data. Designated uses for Kentucky waterways include:

- Primary Contact (swimming)
- Secondary Contact (wading, boating, etc)
- Domestic Water Supply/Drinking Water
- Warm Water Aquatic Habitat
- Cold Water Aquatic Habitat
- Outstanding State Resource Water

Bacon Creek is impaired for Warm Water Habitat and Primary Contact Recreation (see Table 2.4). Fecal coliform bacteria is a known pollutant along the entire 31.2 mile length of the creek. Sediment is also a known pollutant for the segment of Bacon Creek from river miles point 17.2 to 26.3 (extending from Exum Lane, upstream from Wabash, to just over a quarter mile below the corporate limits of Bonnieville). Sedimentation refers to soil buildup on the stream bottom, and siltation indicates a high degree of soil suspended in the creek surface water. A lot of sediment and silt in the creek makes it hard for aquatic organisms to thrive.

Stream Name	Assessment Date	County	River Miles	Pollutant
Bacon Creek to Nolin River	3/1/2003 to 10/25/2007	Hart	0.2 to 17.2	Fecal Coliform
Bacon Creek to Nolin River	2/26/2003	Hart	17.2 to 27.1	Fecal Coliform and Sedimentation/Siltation
Bacon Creek to Nolin River	3/1/2003	Hart	27.1 to 32.6	Fecal Coliform
Bacon Creek Headwaters	10/29/2007	LaRue	32.6 to 33.5	Fecal Coliform and Sedimentation/Siltation

Table 2.4: Impaired Stream Segments of Bacon Creek (Integrated Report to Congress 2010).

Total Maximum Daily Load

KDOW is required to complete a study of each of the impaired streams listed in the *Integrated Report to Congress on the Condition of Water Resources in Kentucky*. This study looks at the pollutants in the part of the stream that is listed as impaired and identifies the sources and amounts of those pollutants that are entering the stream. Based on this information, KDOW calculates the amount by which the pollutant must be reduced for the stream to meet its designated uses. This study is called a Total Maximum Daily Load (TMDL). The total maximum daily load is also the amount of pollution a stream can receive before violating pollution standard limits. So a TMDL is both the name of a report and amount of pollution.

A TMDL study of Bacon Creek was completed in 2010 using data collected in 2007. It established the current instream pollutant loads and pollutant load reductions required to meet the stream's designated uses (these pollutant load factors are discussed in detail in Chapter 4). In addition to collecting data and calculating pollutant loads, KDOW created the "Bacon Creek Watershed Health Report" (see Appendix B) in which the creek was given a letter grade of "C-." The report listed negatives as turbidity and total habitat. The positive characteristic listed was dissolved oxygen. A public meeting was conducted in Bonnieville by the TMDL staff of KDOW on May 12, 2011 where the Watershed Health Report was distributed and a presentation was made by the TMDL section of KDOW. It should be noted that data collected by KDOW for the TMDL was gathered before the installation of the sewer lines in Bonnieville 2007.

The Watershed Health Report, including the assigned letter grade, is a tool used by KDOW to explain the findings of their TMDL study. This watershed plan will focus on the TMDL pollution limits, along with data being collected by Western Kentucky University (see Chapter 3 for more information), to calculate the amount by which the current pollutant loads in the creek must be reduced to meet Bacon Creek's designated uses. There will not be a new Watershed Health Report or revised letter grade issued.

Watershed Plan and Water Quality Data

<u>Bacon Creek Watershed Plan and TMDL Data</u>

The Bacon Creek Watershed Council began working on an initial watershed plan in 2005. Part of the project was to implement Best Management Practices, or BMPs, on farms in the upper part of the watershed. As of November 2008, no landowners had volunteered to implement appropriate BMPs to control nonpoint pollution sources. Therefore, it was decided that one round of bacteria source testing would be conducted to help determine the exact source of bacteria in the sub-watersheds. These bacterial source tracking data were collected in 2010. The data identified the Upper Bacon Creek Sub-watershed as a source of animal bacteria and Honey Run Sub-watershed as a source of human bacteria. It is because of these data that this current iteration of the watershed plan has focused agricultural BMPs on the Upper Bacon Creek Sub-watershed and septic BMPs on the Honey Run Sub-watershed. TMDL data was not available when the first watershed plan was written in 2005-2008, but is now available. TMDL data and the bacterial source tracking data can be found in Appendix B.

Geomorphology

The physical characteristics of stream channels strongly influence aquatic and riparian habitat, bank erosion, and sediment loads. Siltation, habitat modification, and flow alteration are the causes of nearly half of identified stream impairments in Kentucky (KDOW 2008). Thus, there is a direct connection between the physical characteristics of a stream and its water quality.

Bacon Creek has known sediment issues, and so the geomorphology of the creek is an important component to understanding its water quality.

The geomorphology, in the case of the Bacon Creek Watershed, is that there are so many karst features that a 'regional curve' (a standard tool that geomorphologists use to describe a stream) has not been developed (Hansen 2012). The karst features mean that Bacon Creek loses and gains water at various places, and so its flow cannot be predicted in the typical way. In general, increased drainage in a watershed affects channel dimension change dramatically, but with a karst stream, that equation is not the same (Parola et al. 2010).

2.3 Natural Features

Geology, Topography, and Soils

The geology of the watershed is located within the Western Pennyroyal physiographic province of the Mississippian Plateau. Topographically, the watershed is made of rolling hills and lies on the Mississippian Plateau. Relief varies from 535 feet at the confluence with Nolin River to 916 feet in elevation above sea level in the headwaters. Karst features, such as large sinkholes, are present where the overlying sandstone has collapsed into a sub-surface cavity in the underlying limestone (USGS; KDOW field observations; Reynolds, 2011).

Soils within the watershed tend to be thin (3-4 feet deep) and sandy or silty. The predominant soil types have moderate to high tendency to erode. Soils are a thin layer of alluvium deposits, underlain by Mississippian age bedrock from the Lower Member of the Girkin Formation, which, in turn, overlies the St. Genevieve limestone formation (see Figure 2.6). The bedrock layers of the Girkin Formation consist of argillaceous sandstone and shale. Several miles of fault lines underlie this watershed. The alluvium forms terraces and flood plains along Bacon Creek. Soil variability ranges from loamy, fertile, permeable soil to clayey, poor quality, low permeability soil (see Figure 2.7). In areas with slopes that vary between 0-10 percent, riparian buffers tend to be thin to non-existent (Reynolds, 2011).

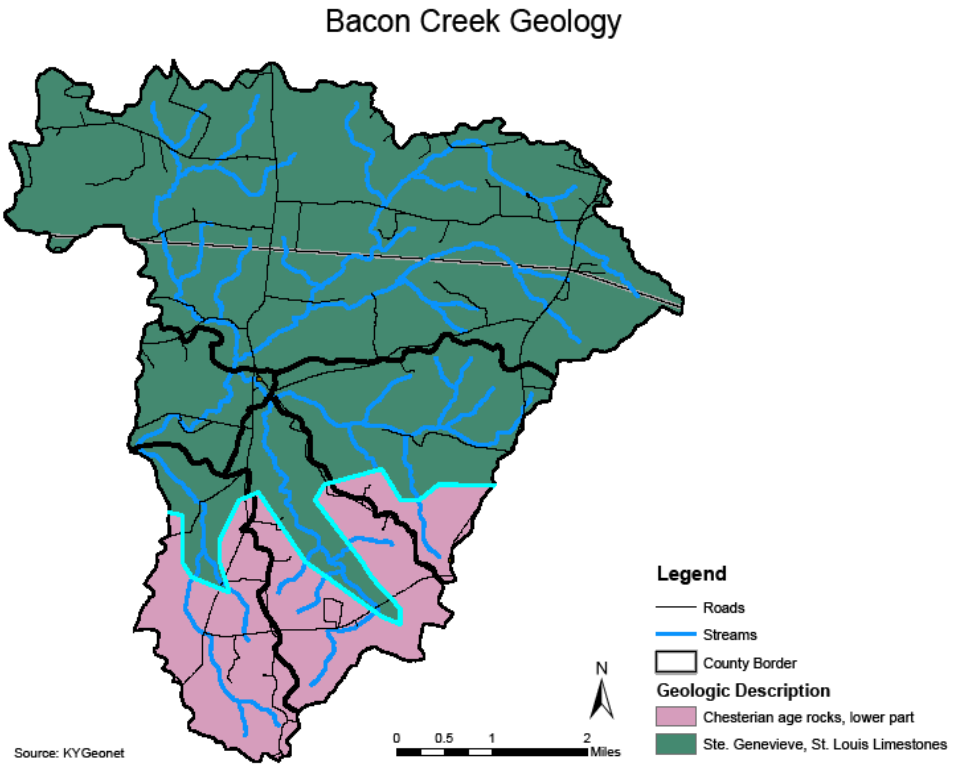

Figure 2.6: Bacon Creek Geology (KWA 2012).

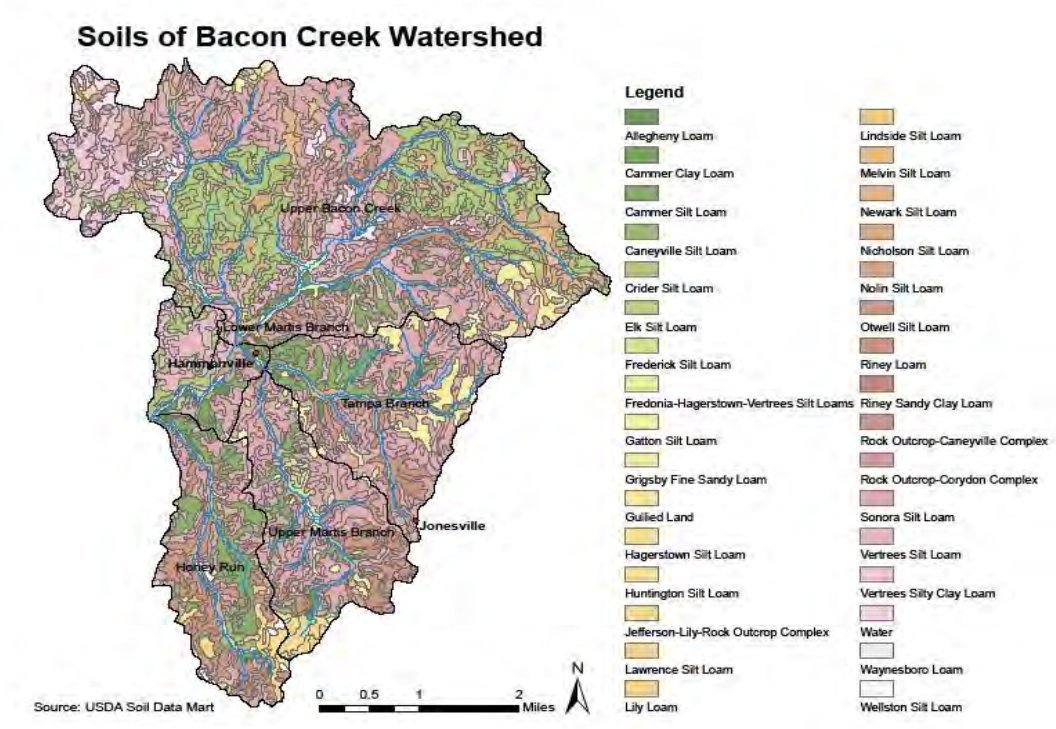

Figure 2.7: Bacon Creek Upper Watershed Soils Map (KWA 2012).

Ecoregion

Ecoregions are those areas that represent general similarity in ecological systems and in the type, quality, and quantity of environmental resources. They are typically broad-scale subdivisions based on terrain, rock type, and geologic structure and history. The Ecoregions of Kentucky have been described with a map (Figure 2.8) and descriptions of the ecoregions (with a paper copy of the map, the descriptions of ecoregions appear on the back).

The Bacon Creek Watershed is located in the Interior Plateau Region, predominantly in the "71a Crawford-Mammoth Cave Uplands" and the "71b Mitchell Plain." Physiographical information, discussed below, references the physical characteristics of specified areas. The Ecoregions of Kentucky descriptions include other information about each region not covered here such as climate, geology, soils, and land cover.

The physiography (or physical geography) of 71a Crawford-Mammoth Cave Uplands area is described thusly on the Ecoregions of Kentucky Map:

> Unglaciated. Hilly uplands containing cliffs and wide karst valleys. Dry valleys, hanging valleys, sinkholes, caverns, and subterranean drainage occur but surface drainage can still be significant. Upland streams are rocky, cool, clear, and often fed by groundwater. Many springs discharge into rivers that are deeply incised into bedrock.

The physiography of 71b Mitchell Plain area is described thusly on the Ecoregions of Kentucky Map:

> Unglaciated. Rolling karst plain containing depressions, ponds, sinking creeks, and dry valleys; scattered ridges, knobs, and hills occur. Many depressions are seasonally ponded. Streams have moderate to low gradients. Stream density is low and incision is typically limited except along major rivers. Springs are common in incised areas.

(Woods, A.J., Omernik, J.M., Martin, W.H., Pond, G.J., Andrews, W.M., Call, S.M, Comstock, J.A., and Taylor, D.D., 2002, Ecoregions of Kentucky (color poster with map, descriptive text, summary tables, photographs): Reston, VA., U.S. Geological Survey (map scale 1:1,000,000).

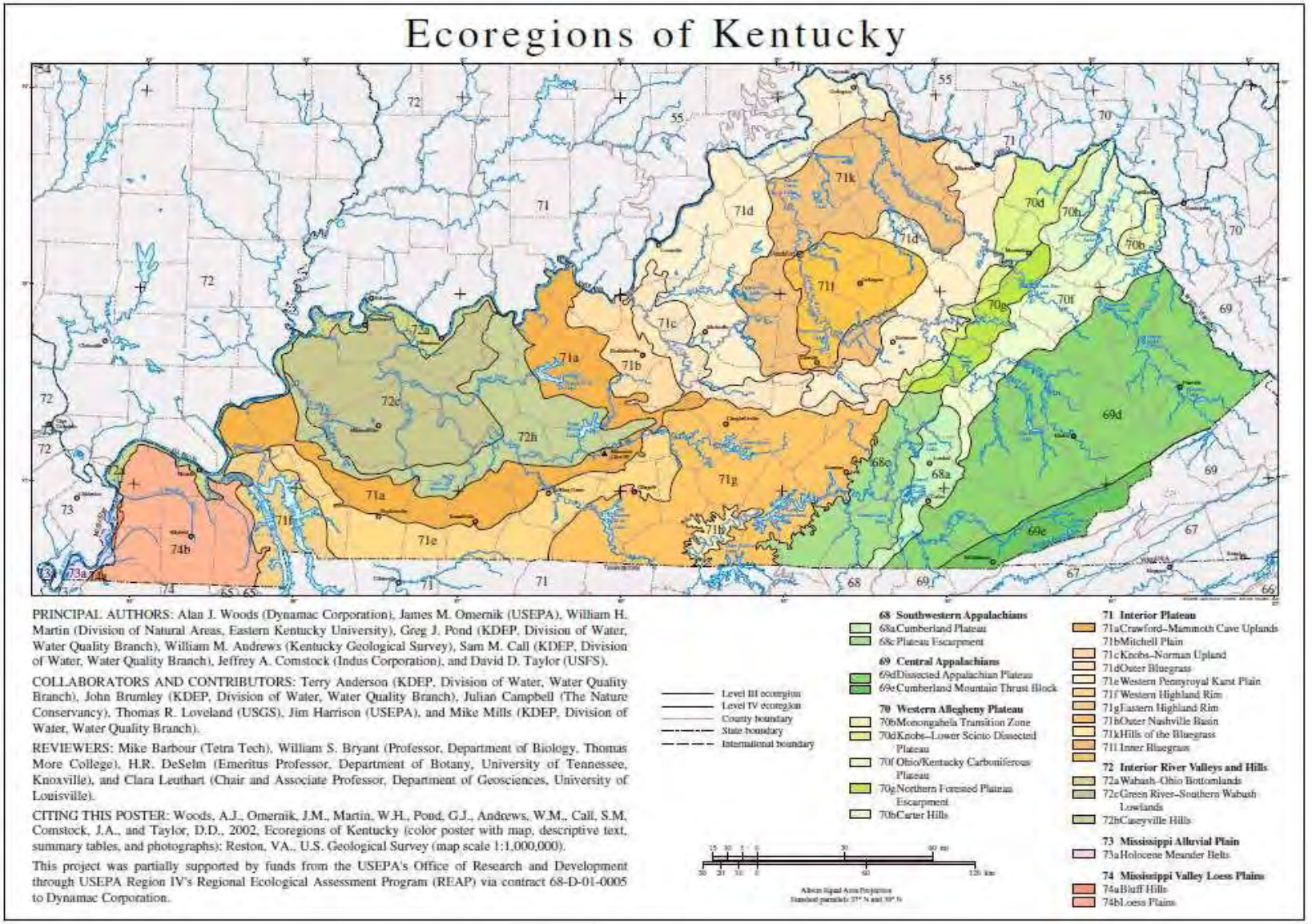

Figure 2.8: Ecoregions of Kentucky (Woods, A.J., Omernik, J.M., Martin, W.H., Pond, G.J., Andrews, W.M., Call, S.M, Comstock, J.A., and Taylor, D.D., 2002, Ecoregions of Kentucky (color poster with map, descriptive text, summary tables, photographs): Reston, VA., U.S. Geological Survey (map scale 1:1,000,000).

Streamside Vegetation

Streamside vegetation is also known as riparian vegetation or a riparian buffer. Having trees, grasses, and shrubs along a streambank is beneficial to the health of the stream in many ways. In one important way, streamside vegetation serves as a buffer or sort of protective area for the stream. The vegetation slows down water running over land as it enters the creek and acts as a physical barrier, trapping the soil or pollutants that might otherwise wash into the stream.

Another important way a riparian area can help a waterway is by providing shade. This makes the water temperature lower and generally better habitat for aquatic organisms. The roots of the plants also help stabilize the stream banks and reduce erosion and sedimentation. The riparian buffer in much of the Bacon Creek Watershed is degraded. The streambank slopes for much of the watershed are steep, greater than 10% (field reconnaissance, Reynolds, 2011). Figure 2.9 illustrates that while there are trees present in some areas, trees and other vegetation have been removed throughout much of the riparian area of the watershed. As mentioned above, in areas with slopes that vary between 0-10 percent, riparian buffers tend to be thin to non-existent (Reynolds, 2011).

There is a total of 8,991.23 acres of land cover type that meets and/or touches the streams and rivers in this watershed. A total of 3,154.7 acres are streamside forest or vegetation. That means only 39% of the watershed has streamside forest or vegetation. Figure 2.9 shows where the streamside forest/vegetation is located.

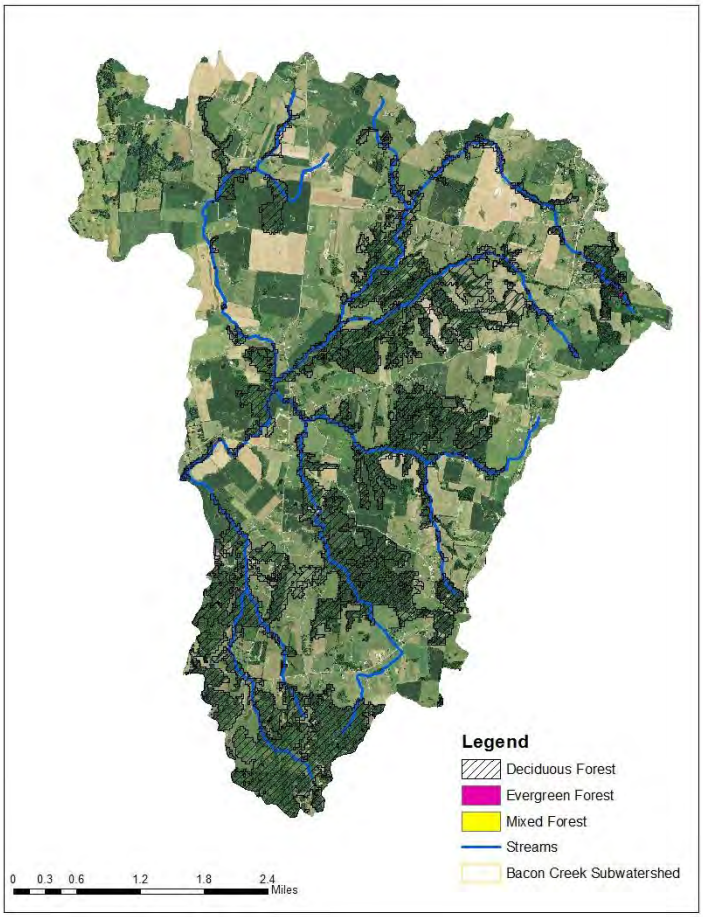

Figure 2.9: Riparian Zones of the Bacon Creek Watershed (DOW, 2015)

Type	Acres	Percentage
Deciduous Forest	3,151.59	99.90%
Evergreen Forest	2.89	0.09%
Mixed Forest	0.22	0.01%

Table 2.5 – Acres and Percentages for riparian zones in Bacon Creek

Rare and Exotic/Invasive Plants & Wildlife

The Bacon Creek Watershed is home to the usual cadre of invasive plant species found in central Kentucky. Commonly found are bush honeysuckle, vine honeysuckle, Russian olive, Johnson grass, and winter creeper in open areas. There are 30 endangered species in Hart County (KSNPC 2015). All endangered species for Hart County are listed in the table below. Of the listed endangered species, 17 species are directly tied to water and water quality. We do know deer densities per square mile in each of the counties within the watershed; Hart County = 26 deer per square mile, and LaRue County = 21 deer per square mile. The Kentucky Department of Fish and Wildlife Resources (KDFWR) consider 25 deer per square mile to be the optimum/preferred density. Both Hart and LaRue counties are in Deer Hunting Zone 2 because it is at or near KDFWR's target/preferred level of deer population density.

Taxonomic Group	Scientific Name	Common Name
Vascular Plant	*Gentiana puberulenta*	Prairie Gentian
Vascular Plant	*Glyceria acutiflora*	Sharp-scaled Manna-grass
Vascular Plant	*Rhynchospora macrostachya*	Tall Beaked-Rush
Vascular Plant	*Silene regia*	Royal Catchfly
Vascular Plant	*Trifolium reflexum*	Buffalo Clover
Freshwater Mussels	*Cumberlandia monodonta*	Spectaclecase
Freshwater Mussels	*Cyprogenia stegaria*	Fanshell
Freshwater Mussels	*Epioblasma obliquata obliquata*	Catspaw
Freshwater Mussels	*Epioblasma torulosa rangiana*	Northern Riffleshell
Freshwater Mussels	*Epioblasma triquetra*	Snuffbox
Freshwater Mussels	*Lampsilis abrupta*	Pink Mucket
Freshwater Mussels	*Lampsilis ovata*	Pocketbook
Freshwater Mussels	*Obovaria retusa*	Ring Pink
Freshwater Mussels	*Plethobasus cyphyus*	Sheepnose
Freshwater Mussels	*Pleurobema clava*	Clubshell
Freshwater Mussels	*Pleurobema plenum*	Rough Pigtoe
Freshwater Mussels	*Pleurobema rubrum*	Pyramid Pigtoe
Crustaceans	*Palaemonias ganteri*	Mammoth Cave Shrimp
Fishes	*Ammocrypta clara*	Western Sand Darter
Fishes	*Hybopsis amnis*	Pallid Shiner
Fishes	*Percina macrocephala*	Longhead Darter
Amphibians	*Cryptobranchus alleganiensis alleganiensis*	Eastern Hellbender
Mammals	*Myotis austroriparius*	Southeastern Myotis
Mammals	*Myotis sodalis*	Indiana Bat

Table 2.6: List of Exotic Species listed for Hart County (KSNP 2015)

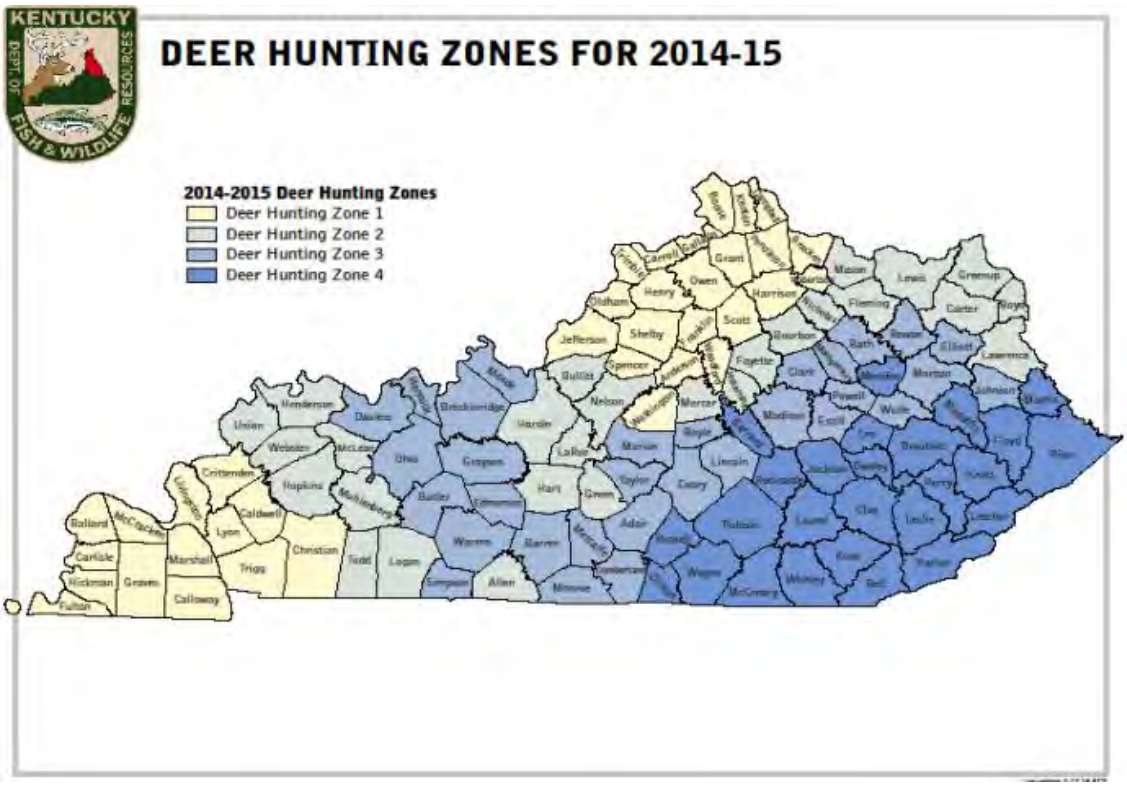

Figure 2.10 Deer Hunting Zones for 2014-2015

2.4 Human Influences and Impacts

Water Use

Drinking Water Sources

The public water supply for the project area is the Green River Valley Water District, which withdraws water from the Green River. Bacon Creek is a tributary to the Nolin River, which discharges into the Green River downstream of the water district intake. According to the KDOW database, around 100 wells in the watershed are used for human consumption.

Point Sources and Permitted Discharges

The Kentucky Pollution Discharge Elimination System (KPDES) is the system set up in Kentucky to issue and monitor such permits. Each permit issued has specified limits for how much of certain pollutants it may discharge. There is only one permitted discharge in Bacon Creek Watershed, but it has been inactive since 2012. The Spring Park Mobile Home Community held a discharge permit but has ceased its discharge and moved to a contained onsite system in 2011. This facility still appears on some datasets as an active permit (KY0089761), but in fact, it has expired and is not operational. The facility was located in the Upper Bacon Creek Subwatershed.

Facility Name	KPDES Permit Number	Type of Facility	# of Permit Limit Exceedances in Last 3 Years
Spring Park MH Community	KY0089761	Minor Sanitary	0

Table 2.7: KPDES permitted facilities in the Upper Bacon Creek Watershed.

Nonpoint sources

Nonpoint source pollution is that pollution that does not have a specific point of origin. It originates from dispersed sources. Nonpoint sources of pollution are the focus of this watershed planning project. Often, nonpoint source pollution is carried over land by rainwater moving across land. For example, oil dripped from a car onto a parking lot can be washed into a waterway during a rainstorm. Or a stock pond full of dirt and manure can overflow in a rainstorm and run into a waterway.

Potential nonpoint sources in the Bacon Creek watershed include runoff from agricultural, residential, and commercial activities:

- Livestock and Pastures Sources (contributing animal manure and/or sediment)
- Animal feeding operations (contributing animal manure and/or sediment)
- Fertilizer, herbicide, and pesticide applied to field crops
- Failing septic systems or straight pipes
- Stormwater runoff from parking lots and roads

Sewer and Septic

The estimated population within the watershed is 667 people (2010 census). The human built structures in the watershed are not serviced with sewer, so On-site Sewage Treatment and Disposal Systems (OSTDSs) are utilized throughout. When properly sited, designed, constructed, maintained, and operated, septic systems are an effective means of disposing and treating domestic waste. The effluent from a well-functioning OSTDS is comparable to secondarily treated wastewater from a sewage treatment plant. When not functioning properly, they can be a source of *E. coli* to both groundwater and surface water. It is estimated that every failing septic system can discharge more than 76,650 gallons of untreated wastewater into groundwater and surface waters each year (Lee, B. et al).

The soils in the watershed are not suitable and are very limited to septic tank absorption suitability. Plus, there are no future plans to install sewer lines in this area. The nearest sewer lines are located in Bonnieville (see Figure 2.11) In addition to the bacteriological impairment due to in part to failing and improperly maintained septic systems, the presence of straight pipes in the watershed is a suspected source of the pathogen impairment. A straight pipe is a sewer line from a house or building that discharge raw sewage directly into a receiving stream or river.

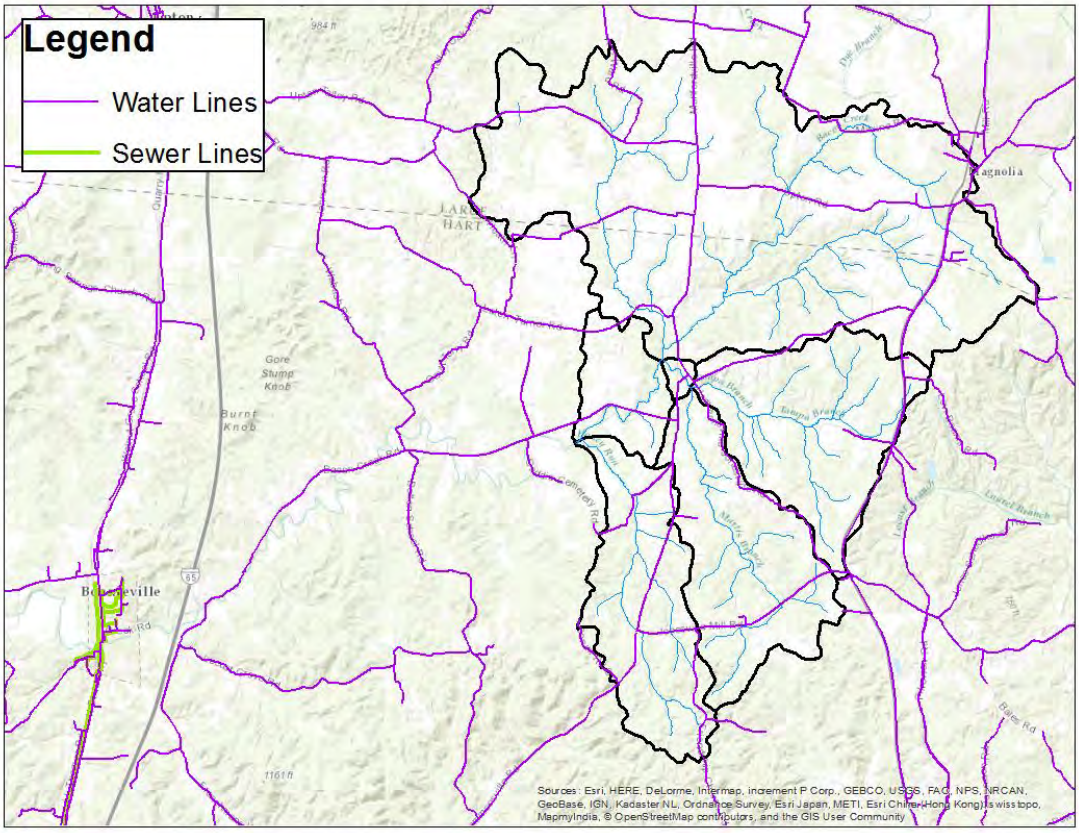

Figure 2.11 – Water and Sewer Line Availability within Bacon Creek Watershed

Until 1992 there was a septic Farmstead Exemption in place, which stated that if a property was on greater than or equal to ten acres they did not have to apply for a septic system permit. Prior to 1986 the permitting and installation of on-site sewage treatment systems was the responsibility of the Division of Plumbing. After 1986 these job functions moved to the local health department. Due to this transition, all of these older records are not available to health department staff. Unless there was a new house built in the watershed it is extremely difficult to find any information about the type of system installed, the date and any subsequent maintenance activities.

	Median Income (By Household)	Population below Poverty Level	Percent High School Graduate or Higher	Percent B.A. Degree or Higher
Hart County (Census Tract 9701)	$34,774	22.0%	73%	10%
LaRue County (Census Tract 9603)	$38,578	18.1%	83%	10%

Table 2.8 Bacon Creek Watershed Project – Socio-Economic Statistics

The census tract data for the watershed gives us an idea of the income level of the area. Based on the median income by household, we can infer that the cost of removing a straight pipe or repairing a failing system would be cost prohibitive in many circumstances.

Land Use

The land cover of the Upper Bacon Creek Watershed consists of a mixture of pasture, cultivated crops, forest, grassland and developed areas (Figure 2.14). Pasture and cultivated lands occupy the majority of land in the Upper Bacon Creek Sub-watersheds. Forestland within this area contains a mixture of oak, hickory, and soft wood varieties. The bulk of industry is agricultural and forestry-related. While there are no confined animal feeding operations registered, there are a number of animal feeding operations, mostly dairy farms (Hart County Chamber of Commerce; Reynolds, 2010; KDOW).

The Bacon Creek Watershed is a total of 13,839.37 acres. Of that area, 5,466.12 acres are Cultivated Crops and Pasture/Hay area that touches a stream or river, which is 39% of the watershed. Since bacteria is one of the issues this watershed faces, this 39% should be the target area for the agricultural best management practices.

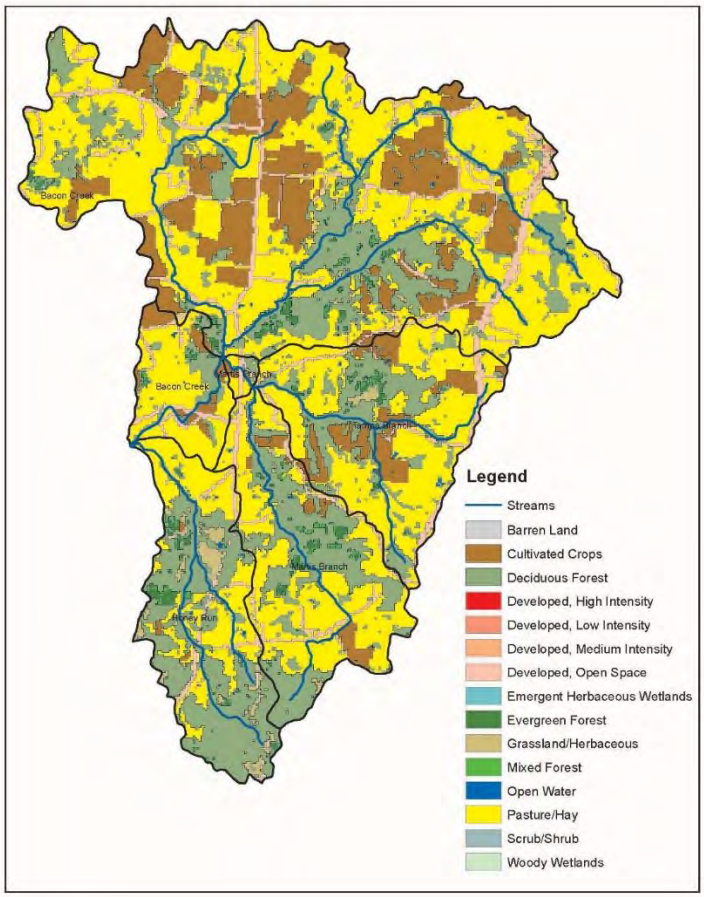

Figure 2.14: Bacon Creek Land Cover map (DOW 2015).

Land Use	Acreage	Percentage
Developed, open space	855.65	6.18%
Developed, low intensity	17.54	0.13%
Developed, medium intensity	8.43	0.06%
Developed, high intensity	1.10	0.01%
Barren Land	3.34	0.02%
Forest-mixed	92.71	0.67%
Scrub/shrub	37.83	0.27%
Grassland/herbaceous	157.85	1.14%
Pasture/hay	6536.73	47.23%
Cultivated crops	2019.00	14.59%
Woody Wetlands	0.44	0.003%
Evergreen Forest	171.35	1.24%
Emergent herbaceous wetlands	5.56	0.04%

Table 2.9: Land use acreages in Upper Bacon Creek Watershed (DOW 2015)

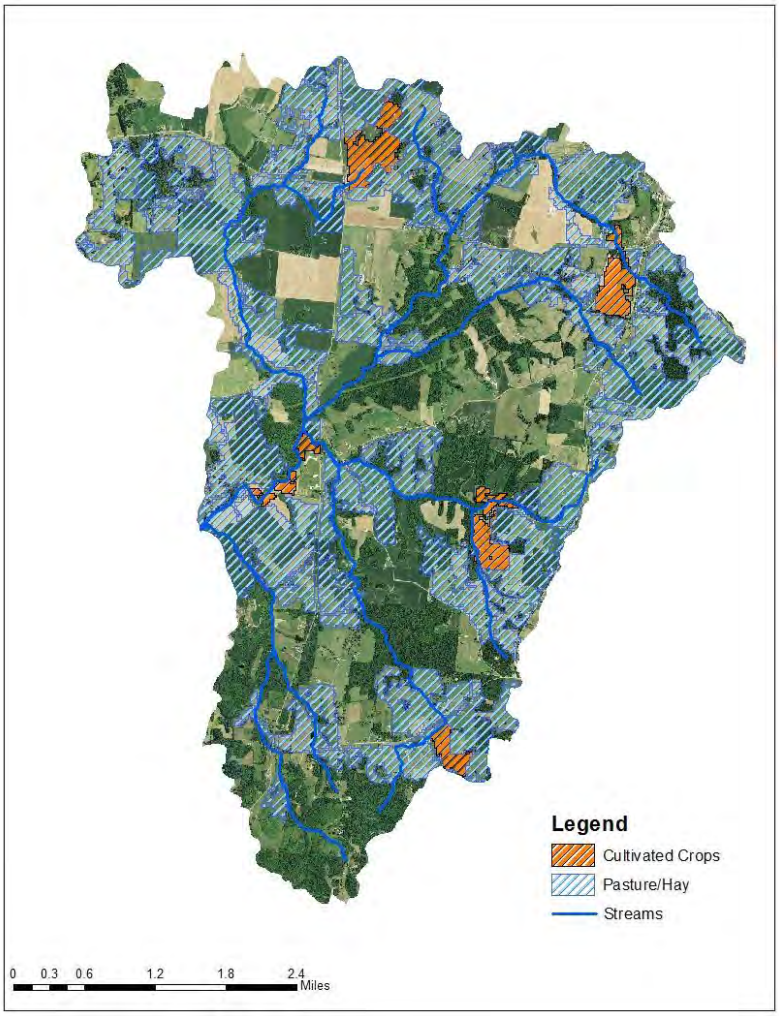

Figure 2.15: Bacon Creek Watershed Land Cover Potentially Impacting Streams Map

Land Use	Acres
Cultivated Crops	372.17
Pasture/Hay	5,093.95

Table 2.10 – Acres of Cultivated Crops and Pasture/Hay

Hazardous Materials

According to KDOW, there are no known hazardous materials being stored or produced in the Bacon Creek Watershed (Edelen personal communication October 2012).

2.5 **Watershed management activities**

The extension of Caveland Environmental Authority sewer service to Bonnieville in 2007 connected over 100 homes with straight pipes and failing or marginally effective septic systems. The service area is located within city limits, and a city ordinance requires that all homes within a certain distance from the sewer lines must connect. Bonnieville city limits are well below the upper watershed area, and, therefore, had no impact on sources of fecal matter in those areas.

Summaries of local plans, ordinances, and other documents that have a bearing on the fecal coliform pollution in this watershed include:

Agricultural Water Quality Plan – Agricultural operators plan to address environmental issues associated with agriculture and silviculture by using Best Management Practices for crops, livestock, pesticides, fertilizer, farmstead, silviculture, and streams and other waters. Part of this project's agricultural BMP was to strongly encourage area farmers and producers to update a plan.

Groundwater Protection Plan (GPP) – Sites that use or store significant quantities of potentially hazardous chemicals are required to prepare a document that establishes a series of practices designed to prevent groundwater pollution.

Hart County 2000 Comprehensive Plan Update – Hart County Planning Commission, prepared by the Barren River Area Development District. This document, dated August 2000, provides broad-based background information about Hart County and makes recommendations about future planning issues.

NRCS Watershed Plan – Project plans and programs dealing with conservation and usage of water resources, flood/erosion prevention and control, plus floodwater and sediment damages are maintained by NRCS.

Area Solid Waste Management Plan – Develops goals and objectives for improving solid waste management. A representative of the Hart County Solid Waste Board is on the Watershed Council.

Chapter 3: Learning More

The work presented in Chapter 2 is an inventory of available information about the project area and its sub-watersheds. Now additional data and in-depth analysis are needed to identify current pollutant sources and guide implementation projects to places where they will have the most benefit. This chapter outlines the various sources of data that are analyzed in Chapter 4. It also provides a historical perspective on data collection in the watershed.

Waterbody & Segment	Total Size	County	Use	Impair-ment	Suspected Source
Bacon Creek 0.2 to 17.2	17 miles	Hart	PCR	E. coli	Agriculture, On-Site Treatments (Septic Systems and Similar Decentralized Systems)
Bacon Creek 17.2 to 27.1	9.9 miles	Hart	PCR	E. coli	Agriculture, On-Site Treatments (Septic Systems and Similar Decentralized Systems)
Bacon Creek 27.1 to 32.6	5.5 miles	Hart	PCR	E. coli	Agriculture, On-Site Treatments (Septic Systems and Similar Decentralized Systems)
Bacon Creek 32.6 to 34.9	2.3 miles	Larue	PCR	E. coli	Agriculture, On-Site Treatments (Septic Systems and Similar Decentralized Systems)
Honey Run 0.0 to 3.65	3.65 miles	Hart	PCR	E. coli	Agriculture, On-Site Treatments (Septic Systems and Similar Decentralized Systems)
Tampa Branch 0.0 to 2.15	2.15 miles	Hart	PCR	E. coli	Agriculture, On-Site Treatments (Septic Systems and Similar Decentralized Systems)
UT to Bacon Creek at RM 17.8, 0.0 to 3.7	3.7 miles	Hart	PCR	E. coli	Agriculture, On-Site Treatments (Septic Systems and Similar Decentralized Systems)
UT to Bacon Creek at RM 28.9, 0.0 to 2.45	2.45 miles	Hart	PCR	E. coli	Agriculture, On-Site Treatments (Septic Systems and Similar Decentralized Systems)

Table 3.1 - 303(d) Listed Streams in the Bacon Creek Watershed

3.1 Water Quality Sampling

Water quality sampling is conducted as part of a watershed planning project. Even if there are existing data, collecting new data allows for an up-to-date look at the condition of the water. Furthermore, conducting project-specific sampling can provide information about target areas or measure the effectiveness of implemented best management practices (BMPs). Table 3.2 illustrates the parameters typically sampled for watershed planning projects, including this project.

The state of Kentucky has legal standards for some water quality parameters (see Table 3.3). Standards are either numeric or narrative. There are other parameters for which there are no Kentucky standards such as phosphorus, nitrogen, and conductivity. For this watershed planning project, the Division of Water created a set of “benchmarks.” These benchmarks are water quality values this project can use to provide perspective on those parameters. The benchmarks are not legal standards.

Group	Parameter	Monthly	5X/30days May or June	1X/year May or June	Every Time	Standard Operating Pro.
Bacteria	*E. coli* (*Escherichia coli*)	x	x			DOWSOP03017
	NO3/ NO2 (Nitrate/Nitrite)	x				DOWSOP03015
	NH3-N (Ammonia – Nitrogen)	x				DOWSOP03015
	TKN (Total Kjeldahl Nitrogen)	x				DOWSOP03015
	TP (Total Phosphorous)	x				DOWSOP03015
	OP (Orthophosphate)	x				DOWSOP03015
	BOD5* (Biochemical Oxygen Demand)	x				DOWSOP03015
Sediment	TSS (Total Suspended Solids)	x				DOWSOP03015
Flow	Stream Discharge				x	DOWSOP03019
Field Data	Turbidity (actual or estimated)				x	DOWSOP03014/ DOWSOP0315
	pH				x	DOWSOP03014
	DO (Dissolved Oxygen)				x	DOWSOP03014
	Conductivity				x	DOWSOP03014
	% Saturation (Percentage of DO)				x	DOWSOP03014
	Temperature				x	DOWSOP03014
Habitat	Habitat Assessment			x		EPA 841-B-99-002
Biology	Biological Assessment			x		WWSOP04000

*BOD5: the amount of dissolved oxygen consumed in five days by biological processes breaking down organic matter.
Table 3.2: Watershed Plan Monitoring

Parameter	Water Quality Standards
Dissolved Oxygen	≥ 5.0 mg/l Daily Average; ≥ 4.0 mg/l Instantaneous
pH	6.0 – 9.0 Standard Units
Temperature	≤ 89° F(31.7° C) Instantaneous; 84° F (28.9° C) 30-Day Summer Average (July-September)
Total Dissolved Solids	No adverse effects on indigenous aquatic community
Total Suspended Solids	No adverse effects on indigenous aquatic community
Settleable Solids	No adverse effects on indigenous aquatic community
Ammonia (Un-ionized)	< 0.05 mg/l after mixing
Fecal Coliform (Primary Contact Recreation)	≤ 200 CFU / 100 ml geometric mean based on a min. of 5 samples over 30 days, 5/1 – 10/31. ≥ 20% of samples shall not exceed 400 CFUs over 30 days.
Escherichia coli (Primary Contact Recreation)	≤ 130 CFU / 100 ml geometric mean based on a min. of 5 samples over 30 days, 5/1 – 10/31. ≥ 20% of samples shall not exceed 240 CFU / 100 ml over 30 days.
Fecal Coliform (Secondary Contact Recreation)	1000 CFU / 100 ml geometric mean based on a min. of 5 samples over 30 days, year-round. ≥ 20% of samples shall not exceed 2000 CFU / 100 ml over 30 days.

Table 3.3: Kentucky State Water Quality Standards (401 KAR 10:031).

The benchmarks were created specifically for this project and take the watershed's environment into account. Table 3.4 displays the nutrient and non-nutrient benchmarks. For a full explanation of the benchmarks, see Appendix C. It is important to note that benchmarks for data screening and prioritization do not necessarily represent targets for water quality.

Parameter	Benchmark Value Nutrient:
Total Phosphorus	0.05 mg/L
Total Kjeldahl Nitrogen	0.50 mg/L
Nitrate-Nitrite	1.10 mg/L
Total Nitrogen	1.60 mg/L
Non-Nutrient:	
Ammonia-N	0.05 mg/L
Sulfate	21.0 mg/L
Specific Conductance	443 (µS/cm)
Alkalinity	199 (mg/L as $CaCO_3$)
Total Suspended Solids*	7.0 mg/L
Turbidity*	6 NTU

Provided by the Kentucky Division of Water (2012).

Table 3.4: Nutrient and non-nutrient benchmarks for Upper Bacon Creek.

3.2 Existing Data

The existing data for the Bacon Creek Watershed are extensive. These data have been collected by three separate entities over a period of several years: the Kentucky Division of Water (KDOW), Upper Green Watershed Watch (UGRWW), and Western Kentucky University's Center for Water Resource Studies (WKU). Within KDOW, several different programs have collected data. Data collection stretches back to 1984, but data have not been collected regularly (at least monthly) on a continuous basis by any entity for more than one year. WKU has collected data once a month for one year. UGRWW has collected data at some sites for many years, three times per year, beginning in 2000. Much of these data were collected in the lower sections of the watershed, closer to Nolin Lake.

Because there has been a lot of activity by different entities in the watershed through the years, it is helpful to refer to a timeline. Table 3.5 summarizes activity in the watershed, including data collection and community activities, beginning with early KDOW habitat monitoring and ending with this current watershed planning project. Not all of these activities are related to this project or to each other. Watershed Watch data and TMDL data can be found in Appendix B. Figure 3.1 illustrates river mile (RM) points on the mainstream of Bacon Creek and some of its tributaries. The timeline refers to river miles for some KDOW data collection sites.

The first *Bacon Creek Watershed-Based Plan* collected bacterial source tracking (BST) data to isolate sources of bacteria (see Appendix B). Those data indicate that BMPs for reducing agricultural sources of bacteria would be most effective in the Upper Bacon Creek Sub-watershed, and BMPs for reducing residential sources of bacteria would be most effective in the Honey Run Sub-watershed.

1. KDOW conducts Basin Management program monitoring in lower watershed (RM 7.2) in 1984. Other habitat and biology data are collected in the watershed 1992-2001.

2. Bacon Creek Watershed Council is formed with the help of KWA 319 grant and Bonnieville City Council in 2000.

3. UGRWW collects data from sites in the Bacon Creek Watershed beginning in 2000 for 2 sites (G25 and G26). UGRWW subsequently recruits additional volunteers and adds several more sites in the watershed. There are now 8 sites that have been sampled consistently since 2005.

4. WKU conducts study on Fecal Coliform and *E. coli* in 2001-2002 on 7 sites in watershed.

5. Bacon Creek at RM 0.2 to 17.2 is assessed by KDOW Aquatic Biology program 2003 to 2007.

6. UGRWW conducts study at 9 sites in watershed for *E. coli* and Fecal Coliform in 2004.

7. Watershed Action Plan is completed in 2005 by Dale Reynolds of KDOW. It is a precursor for first watershed-based plan.

8. KWA and Bacon Creek Watershed Council accept a 319 grant in 2005 to write a watershed- based plan including limited data collection and BMP implementation. Sampling was done at 6 sites for fecal coliform and *E. coli* three times in 2004, prior to start of the project.

9. AMEC Consulting conducts Watershed Assessment as part of KWA 319 grant including sediment modeling using the AVGWLF Model. This report is used to write the first iteration of the *Bacon Creek Watershed-Based Plan*. It is completed in 2007.

10. Sewer lines are installed in Bonnieville in 2007 with Bacon Creek Watershed Council.

11. TMDL study begins in 2007 with data collection at 13 sites. Several sites yield no data due to low flow. It ends in 2010 with the Bacon Creek Health Report with data from 9 sites.

12. Watershed plan BMP implementation is cancelled due to lack of participation. Bacteria source tracking data collection is conducted instead to isolate sources of bacteria in watershed.

13. *Bacon Creek Watershed-Based Plan* is completed in 2010 including bacteria source tracking data and AMEC Consulting watershed assessment.

14. KWA and Bacon Creek Watershed Council win a 2010 319 grant to update the watershed plan, conduct water sampling, and implement BMPs. KWA contracts WKU to collect data at 8 sites in upper watershed for one year from June 2011-May 2012. Delays in QAPP approval push back data collection to May 2012 – April 2013.

Table 3.5: Bacon Creek Data and Watershed Study Activity Timeline

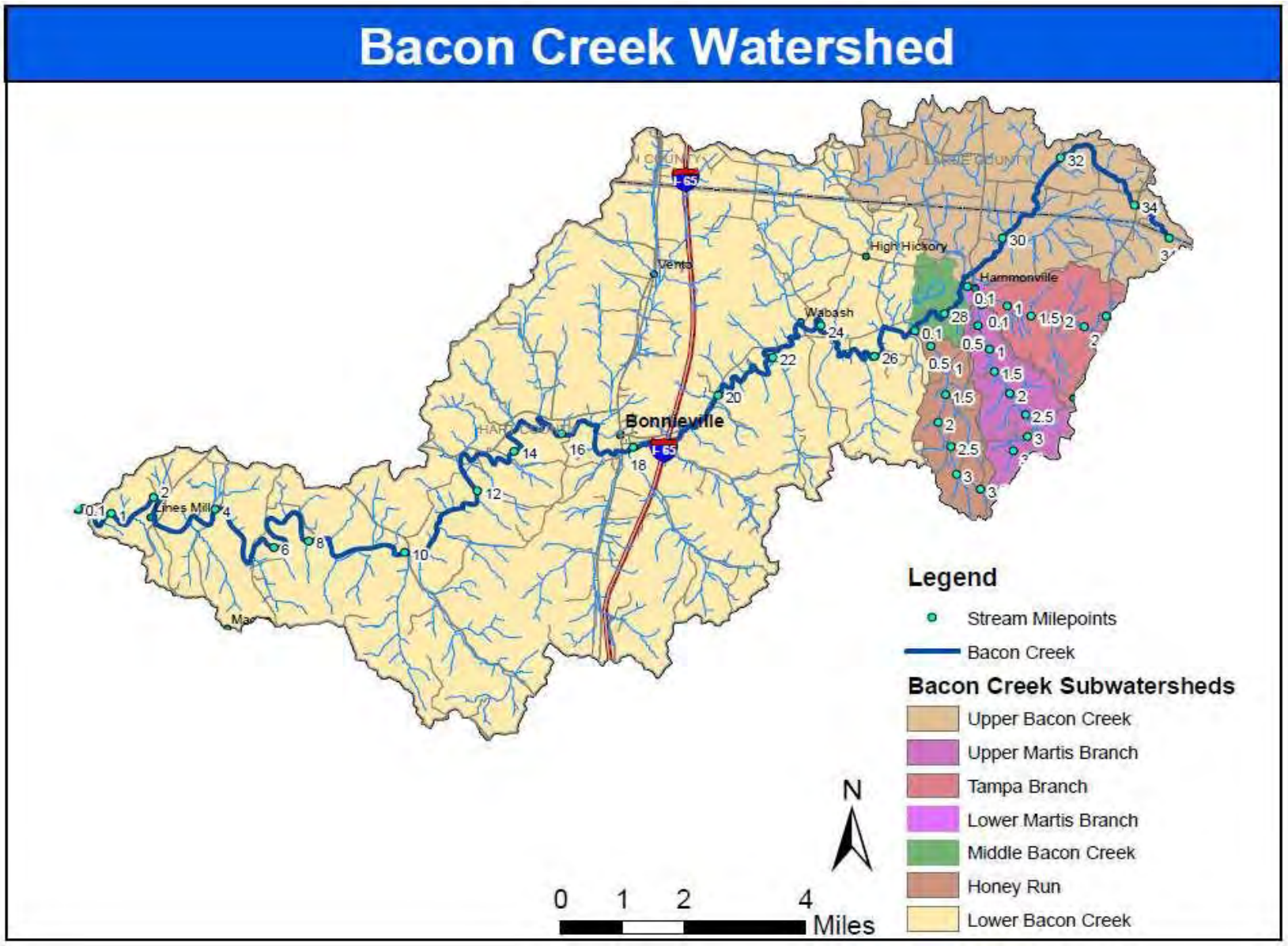

Figure 3.1: Bacon Creek Watershed River Miles (KWA 2013 from KYGeonet data).

3.3 New Data

Kentucky Waterways Alliance and the Bacon Creek Watershed Council were awarded a 319 grant in 2010 to update the Bacon Creek Watershed Plan. The updated watershed plan was written using the *Watershed Planning Guidebook for Kentucky Communities* (First Edition). The grant specifies that data collection be conducted for one year in the Upper Bacon Creek Watershed. Data for 319 grants are collected under the guidelines of a Quality Assurance Project Plan (QAPP) approved by KDOW (see Appendix C). The QAPP lays out, in detail, how each parameter should be sampled.

Because there are existing data and a watershed-based plan for the Bacon Creek Watershed, it was possible for this watershed project to begin with Phase 2 Monitoring and Phase 2 Analysis. This is why the plan and data collection are focused on a relatively small area of the overall Bacon Creek Watershed.

Data was collected once a month at eight sites in the watershed from May 2012 to April 2013. Sites were also sampled 5 times in 30 days in May and June for bacteria. There were also two wet weather and two dry weather sampling events. Pesticide sampling for atrazine was conducted in April. KWA contracted with Western Kentucky University's Center for Water Resource Studies to collect the data.

Sampling sites

Sites were selected based on several factors including historical site location (some sites have been used in the past by other studies), access to the creek, and location of tributaries. Sites were located where the most information about the water in stream could be obtained, usually near the point where a tributary meets the larger stream. The data collected at each site provides information about what is happening on the land above the site (the sub-watershed). Because collecting and analyzing water quality data can be expensive, watershed planning projects generally try to limit the number of sites while still obtaining the necessary data to draw conclusions about water quality and sources of pollution.

Each site has unique properties that impact water quality and how to best address water quality issues. Field technicians made note of any pollutants, riparian zone status, biological activity, and unusual odors near the sample sites. Upper Martis Branch was sampled in 2016 by the Division of Water in order to list the tributary and have baseline data for the watershed project.

Upper Bacon Creek

Four sampling sites are located in the Upper Bacon Creek subwatershed: 1Ba, 1Bb, 1A, and 1.

Site 1Ba is located most upstream Bacon Creek, on the middle fork of Upper Bacon Creek, near a roadway and downstream of agricultural land. Field technicians have reported livestock drinking from the stream at this site. Tire tracks, litter, and other signs of human activity were observed by field technicians.

Figure 3.2 – Site 1Ba Downstream

Figure 3.3 – Site 1Ba Upstream

Site 1Bb is on private property along a tributary that feeds into Bacon Creek. It is on the east fork of Upper Bacon Creek. A large algae bloom was noted by field technicians at this site in December 2012. In April 2013, juvenile crayfish, dragonfly larvae molt, and fly larva were all observed in the water.

Figure 3.4 – Site 1Bb Downstream

Figure 3.5 – Site 1Bb Upstream

Site 1A also feeds into Bacon Creek, but is between private property and a roadway where sparse riparian zones protect the creek from nearby human activity. It is on the north fork of Upper Bacon Creek. Tire tracks, litter, and other signs of human activity have also been observed by field technicians at this site.

Figure 3.6 – Site 1A Downstream

Figure 3.7 – Site 1A Upstream

Site 1 is at the mouth of the Upper Bacon Creek sub-watershed. It is located directly on Bacon Creek behind a large agricultural field on private property where human activity has been noticed in and around the creek. It has a significant year round flow. Field technicians noted on the January 29, 2013 site visit that the site had flooded recently, and the riparian zone had been partially bulldozed and cleared.

Figure 3.8 – Site 1 Downstream

Figure 3.9 – Site 1 Upstream

Tampa Branch

Site 2 is located at the mouth of the Tampa Branch sub-watershed, and appears to have the least riparian zone protecting the creek, as it is located near a roadway where field technicians found large amounts of litter. Field technicians noted that on October 12, 2012, significant clearing had been done 50ft upstream on both banks with no erosion control. They also noted in November 2012, vegetation from bank was removed, there were fewer trees, and bare dirt on both sides.

Figure 3.10 – Site 2 Downstream

Figure 3.11 – Site 2 Upstream

Martis Branch

Site 3 on the Lower Martis Branch sub-watershed is along a roadway where oil has been observed leaking into the creek.

Figure 3.12 – Site 3 Downstream

Figure 3.13 – Site 3 Upstream

Honey Run

Site 5 is at the mouth of the Honey Run sub-watershed. Site 5 was noted as having a strong riparian zone, diverse biological activity, and few odors. Sites 5 and 6 are in close proximity, but are located in separate sub-watersheds.

Figure 3.14 – Site 5 Downstream

Figure 3.15 – Site 5 Upstream

Middle Bacon Creek

Site 6 is at the mouth of the Middle Bacon Creek sub-watershed, on the main stem of Bacon Creek, furthest downstream of all eight sampling sites. Thus, it receives flow from all of the upstream sub-watersheds and has the highest flow of all the sites. Site 6 was also noted as having a strong riparian zone, diverse biological activity, and few odors.

Figure 3.16 – Site 6 Downstream

Figure 3.17 – Site 6 Upstream

Upper Martis Branch

In 2016 the Kentucky Division of Water sampled Upper Martis before it merges with Tampa Branch. After reviewing the data previously collected for this watershed, KDOW determined more samples needed to be taken for the Upper Martis sub-watershed in order to establish baseline data, list that section of stream and determine loading for that sub-watershed. The site selected for Upper Martis Branch was located off of Hammonsville-Jonesville Rd and was accessed by walking along Tampa Branch until it met Martis Branch. The Sample was taken just upstream on Martis Branch. This sampling site was located on a farm where cattle had access to the stream and a riparian zone was not present. On more than one sampling days, a strong manure smell was present. This site is labeled as point 7 on Figure 3.18.

Figure 3.18 – Sampling Location for Upper Martis Branch Sub-watershed, sampled in 2016

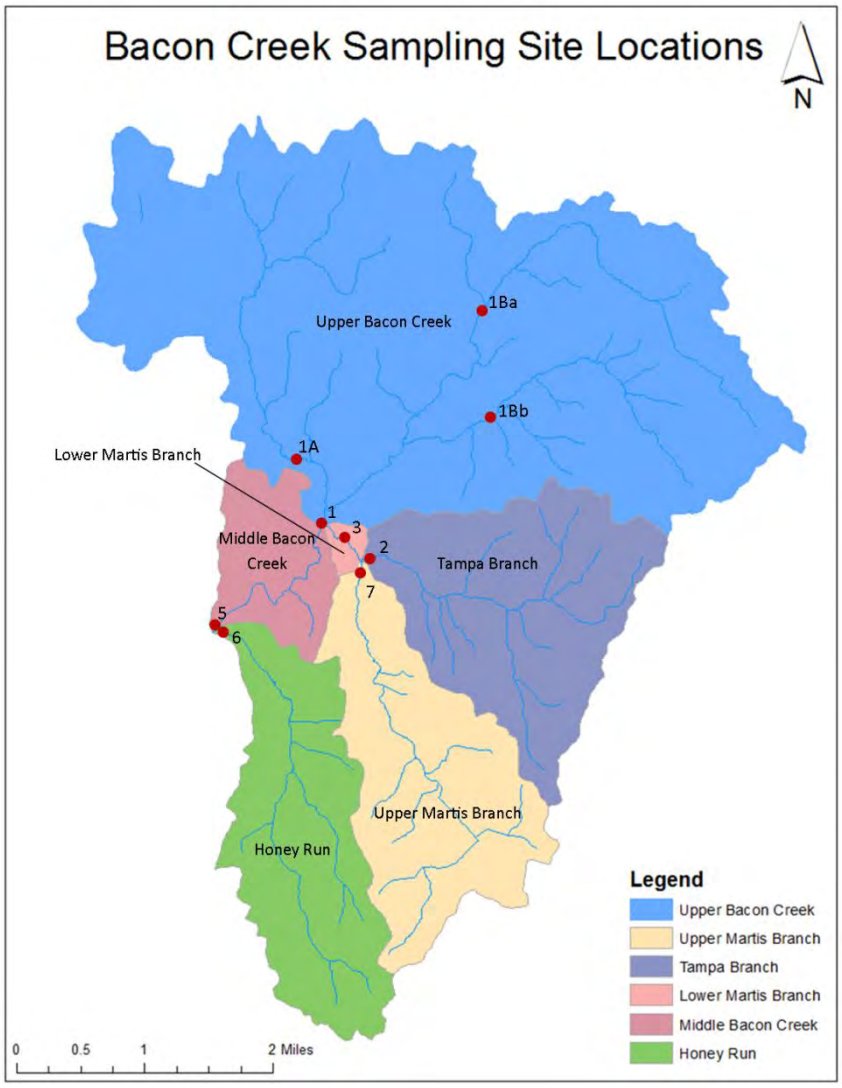

Figure 3.19 – Updated Sampling Site Locations for Bacon Creek Watershed (KDOW 2017)

Site	Latitude	Longitude	Stream Branch
1Ba	37.440311	-85.778785	Upper Bacon Creek Middle Fork
1A	37.423331	-85.805755	Upper Bacon North Fork
1Bb	37.427321	-85.780092	Upper Bacon East Fork
2	37.412072	-85.794489	Tampa Branch
1	37.416429	-85.801272	Upper Bacon Creek
3	37.414843	-85.795811	Lower Martis Branch
6	37.403881	-85.817169	Bacon Creek
5	37.403974	-85.816936	Honey Run
7	37.411853	-85.795922	Upper Martis Branch

Table 3.6 – Latitude & Longitudes for Sampling Sites

Chapter 4- Analyzing Results

Identifying Sources and Targeting Efforts

For twelve months, field scientists visited eight sampling locations regularly to monitor stream flow and discharge, as well as test water quality. This chapter summarizes the analysis by comparing benchmarks from Chapter 3 to pollutant loads of the Bacon Creek watershed. Laboratory results revealed large amounts of *E. coli*, a form of bacteria that indicates contamination from human or animal waste, throughout the study area. Scientists were able to use data and field notes to prioritize areas of the watershed for repair and protection. Through the practice of BMPs and community involvement, poor water quality may be improved while healthy regions may be protected.

4.1 Problems & Goals

In the KDOW watershed health reports from 2011, several factors were given a letter-grade for the watershed leading to an overall score of "C-". Turbidity and habitat were graded a "D+" or below. *E. coli*, specific conductivity, riparian zone, available cover, and aquatic invertebrates were listed as "C's". Sample sites further downstream, generally received better scores than sites upstream in the watershed.

The Bacon Creek TMDL report of 2011 stated, "Assessment results indicated that several additional stream segments within the watershed are impaired… due to pathogen indicators *E. coli* or fecal coliform." This report also listed possible nonpoint sources from human waste disposal (septic systems, sewer lines, etc.) to agricultural runoff; it also considers environmental factors, such as periods of dry weather followed by a rain event.

Field scientists were instructed to take notes and make observations about the watershed and surrounding areas during their sampling events. In these field notes, all sample sites indicated some debris either upstream or downstream of the sample site. Riparian zones are essential for preventing watershed pollution, however very few of the sample sites have effective riparian zones. Some of these riparian zones were limited to small bridge guardrails (see Figure 4.1), while those with more effective protection had thick vegetation surrounding the stream.

Figure 4.1 Riparian Zone

Often times field scientists would find man-made pollutants, such as tires, in or around the stream with no effective riparian zone. Few sites demonstrated an effective riparian zone, with several trees and thick vegetation protecting the stream, however human activity easily penetrates riparian zones (see Figure 4.2).

Figure 4.2 Creek Condition

Sites where there are signs of automobile traffic often produced evidence of oil & grease in the watershed (see Figure 4.3). Even small concentrations of oil in the watershed can have devastating effects on wildlife and biological activity.

Fish, larvae, and other aquatic wildlife may suffer from severe respiratory or reproductive problems leading to a loss in biological activity in the watershed.

In most cases, even with riparian zones, there will be some trace of nearby waste being flushed into the watershed. However, pollutant sources can be managed by human activity and proper waste disposal. Pollution in the waterways can have serious biological and chemical effects by depleting the water of dissolved oxygen as the waste decomposes.

Figure 4.3 Creek Conditions

Figure 4.4: Human activity in the watershed

The goal of the water sampling and analysis project in the Bacon Creek Watershed is to use the data to determine which areas could most benefit from restoration or protection efforts. This is based on a variety of factors, including the concentration of contaminants, volume of flow in the stream channels, and likelihood of improvement based on local conditions such as stakeholder involvement and landowner participation in BMPs.

4.2 Watershed Analysis

Eight sample sites were selected in the Upper Bacon Creek watershed for monthly sampling (see Figure 3.19). Sites 5 and 6 are in close proximity, but are in separate streams, where site 5 flows into site 6. Site 1Ba is located most upstream on Bacon Creek near a roadway and downstream of agricultural land, where field scientists reported livestock drinking from the stream (a source of animal waste). Site 1Bb is on private property along a tributary that feeds into Bacon Creek. Site 1A also feeds into Bacon Creek, but is between private property and a roadway where sparse riparian zones protect the creek from nearby human activity. Site 1 is along Bacon Creek behind a large agricultural field on private property where human activity has been noticed in and around the creek. Site 2 appears to have the least riparian zone protecting the creek, as it is located near a roadway where field scientists found large amounts of litter. Similarly, site 3 is along a roadway where oil appears to be leaking into the creek. Each site has unique properties that contribute to pollutant loads, and must be addressed accordingly.

The first step to repairing the Bacon Creek watershed is to identify non-point sources of contaminants. Examples of non-point sources can be found in Chapter 3. Field scientists tested sample sites for water quality by testing water chemistry and *E coli* bacteria. *E. coli*

E.coli and Fecal Coliform contaminants in Bacon Creek are traced to human and animal waste, such as straight pipes, failing septic systems, and livestock in or near the streams. These contaminants have exceeded the *E. coli* water quality standard of 240 MPN/100mL at every sampling site. In some cases the *E. coli* MPN/100ml exceeded 24,000 (100 times the standard). These extraordinarily high levels of pathogens would likely cause intestinal illness to anyone swimming in or drinking from the creek.

No sites met the Kentucky State Water Quality Standard for *E. coli* (See table 4.1). This indicates concentrations of human or animal waste entering the watershed, either through direct contact or runoff. In some cases, field scientists noted livestock drinking from the creek upstream from sample sites. Near some of the sampling sites, field scientists reported the scent of animal waste; often the

sites reported as having a "manure smell" demonstrated higher levels of *E. coli*. The highest values of *E. coli* were found during the April 19, 2013 sampling event, which was considered a wet-weather event. This indicates that *E. coli* levels in the streams are heavily influenced by precipitation runoff from the watershed area.

Site #	Site Name	May-12	Jun-12	Jun-12	Jul-12	Aug-12	Sep-12	Oct-12	Nov-12	Dec-12	Jan-13	Feb-13	Mar-13	Apr-13	May-13	Average
1Ba	Upper Bacon Creek Middle Fork	5172	2755	19863	3076	1223	1314	496	594	717	6131	1014	1081	1541	4611	3542.00
1A	Upper Bacon North Fork	1076	160	134	161	359	2247	173	73	146	399	10	313	109	605	426.07
1Bb	Upper Bacon East Fork	3076	203	135	1374	158	228	75	30	122	86	31	130	63	450	440.07
2	Tampa Branch	1467	97	226	1291	31	218	110	155	145	75	52	75	41	288	305.07
1	Upper Bacon Creek	2143	379	313	464	933	882	384	52	52	275	30	488	237	471	507.36
3	Lower Martis Branch	1664	399	146	663	145	203	110	393	173	98	97	1050	933	1076	510.71
6	Bacon Creek	1723	216	199	131	410	420	110	20	75	216	20	576	189	355	332.86
5	Honey Run	2987	457	189	780	487	389	183	20	41	195	<1	25	97	203	465.62

Table 4.1 *E. coli*/100mL for each sampling event. Average values are well above the water quality standard of 240 MPN/100mL. *Red denotes exceedences.

Figure 4.5 shows the *E. coli* levels over a 12-month sampling period for each site. There is a huge spike in April. Following a seven-day dry period, precipitation prior to the sample collection on April 19th, 2013, combined with increased agricultural activity explains why some sites experienced *E. coli* levels beyond laboratory detection limits during this sampling event.

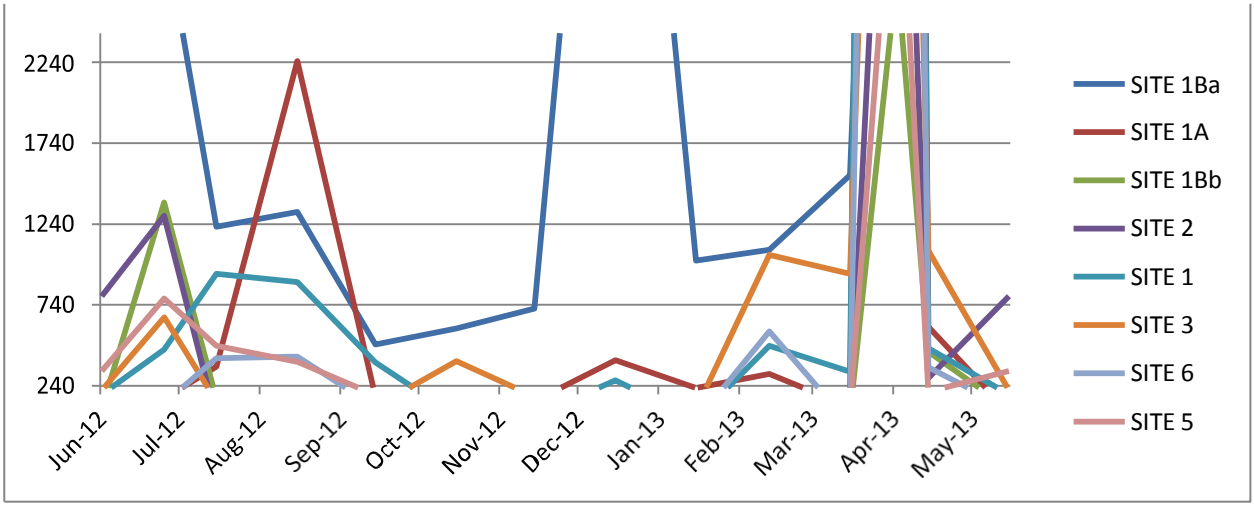

Figure 4.5 *E. coli* levels for each site from June 2012 to May 2013 (MPN/100mL).

Although *E. coli* is a strong indicator of pollution, and is a major factor in Bacon Creek impairment status, Total Suspended Solids (TSS), Total Phosphorus (TP), Nitrate and Nitrite Nitrogen (N-N), and Total Nitrogen (TN) all play important roles in the prioritization for each sub-watershed. Combining and comparing all pollutant parameters with watershed inventory data (stream size, surrounding land-use, biological activity) allows for the inclusion of feasibility factors in the prioritization phase of the analysis.

The starting value on the y axis of each graph is set at the benchmark value associated for each nutrient / pollutant (see Chapter 3 for benchmark values and water quality standards). Almost

every site was above the benchmark values for spring and summer, with several sites falling below the benchmark values during winter months for all pollutants. Rain events following a 7 day dry period also produced spikes in the values (October 2012, January 2013, and April 2013). On average, site 5 was the only site to fall below benchmark values for TSS, TN, and TP.

TSS levels followed a similar pattern to the *E. coli* levels from June of 2012 to May of 2013. Levels declined following the late summer months and stayed relatively low throughout the winter. Levels of TSS also spiked during the April 19th collection date (see Figure 4.6). Sites with much higher levels of TSS after a rain event indicate that they are susceptible to sediment and other contaminants entering the stream through stormwater runoff due to streambank erosion and lack of effective riparian buffers.

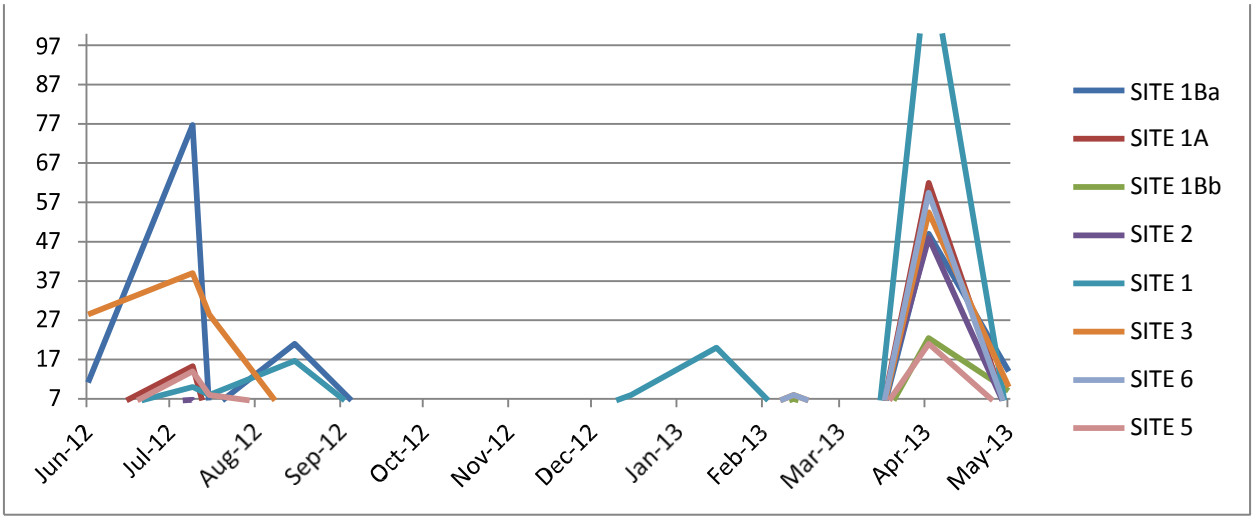

Figure 4.6 TSS levels above the benchmark of 7.0 mg/L for each site from June 2012 to May 2013.

Phosphorus and nitrogen are nutrients essential to plant and animal life, however excess of either of these nutrients in a watershed can have devastating effects. Too much nitrogen can deplete the watershed of dissolved oxygen and cause algae scum on the surface of the water, which can kill aquatic wildlife. Similarly, human consumption of excess levels of nitrogen can lead to depletion of oxygen in the bloodstream. Too much phosphorus can speed up eutrophication in the streams, which causes excessive plant growth due to excess nutrients. Both of these nutrients can be found in manure and many fertilizers, which enter the watershed through runoff. Similar to *E. coli* and TSS, the TP and TN values follow a seasonal pattern (see Figures 4.7 and 4.8). Levels climb in the spring months and decline in the early fall months.

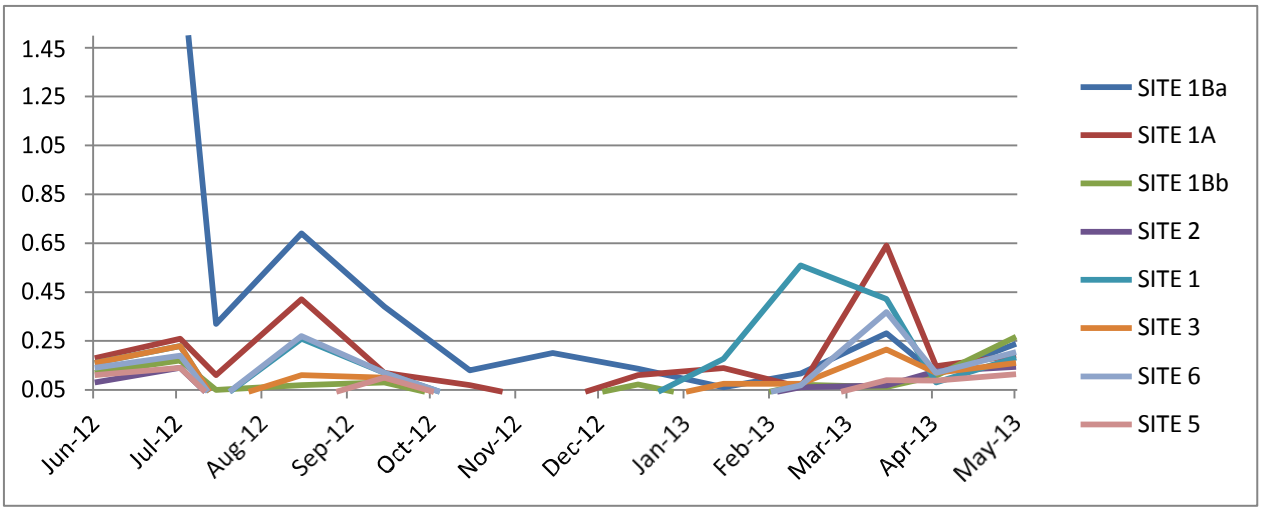

Figure 4.7 TP levels above the benchmark of .05 mg/L for each site from June 2012 to May 2013.

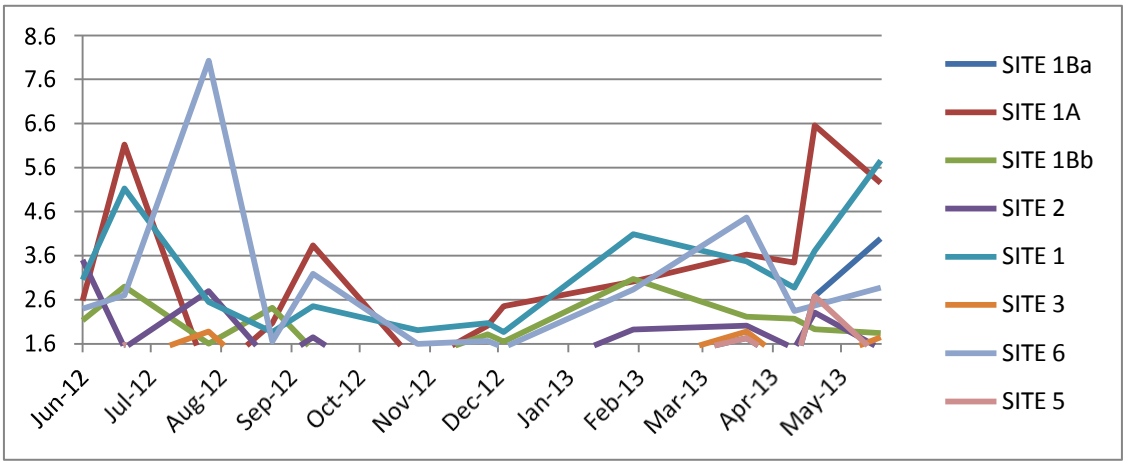

Figure 4.8 TN levels above the benchmark of 1.6 mg/L for each site from June 2012 to May 2013

In general, sites 2, 3 and 5 do not appear to have a nitrogen problem, while sites 1A, 1Bb, 2 and 6 don't seem to be prone to high sediment levels.

Measuring the stream profile and flow data allows the above concentrations of each pollutant to be converted to load data. Flow for each site followed a similar annual pattern to the pollutant concentration patterns (see Figure 4.9).

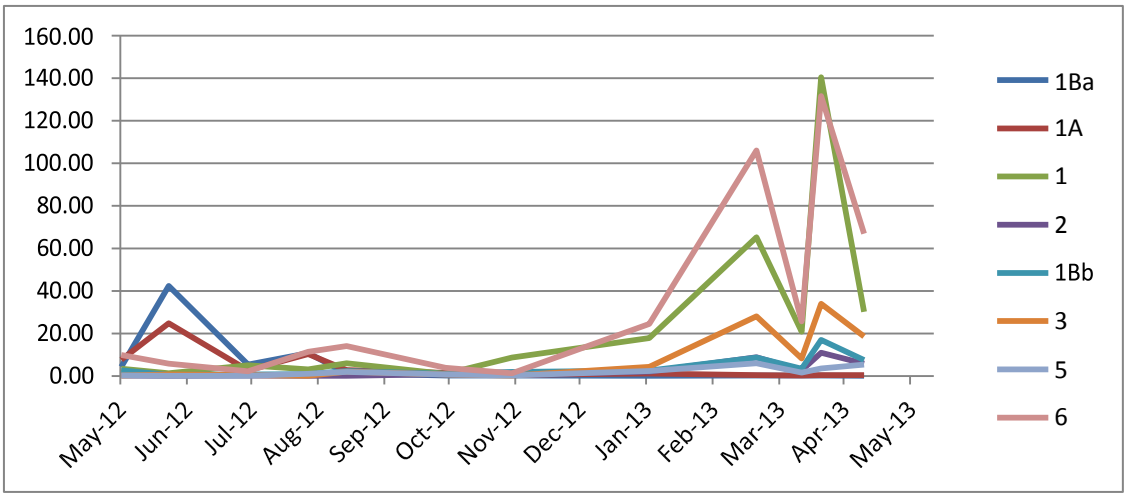

Figure 4.9 Monthly flow data (ft^3/sec) for each site from May 2012 to May 2013

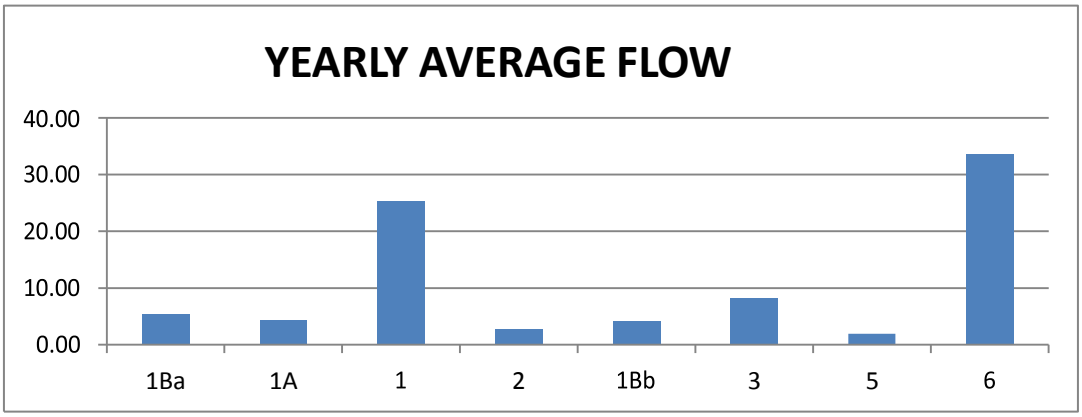

Figure 4.10 Mean annual flow for each site (ft^3/s)

Flow appears to be significantly higher at sites 1 and 6 year-round (see Figure 4.10). This means that a larger volume of water is flowing at these sites on average. These variables help determine the actual pollutant load for the watershed, as the creeks do not maintain the same volume throughout the watershed. The pollutant load is calculated by multiplying the discharge volume of the stream at the sampling point by the concentration of the pollutant at that point, then multiplying by a conversion factor for daily and annual loads (see example in Table 4.2). The actual pollutant loads for each contaminant found at site 1Ba are listed on the left half of the table, while benchmark loads are listed on the right half of the table. The annual reduction needed for each major pollutant is the far right column.

Contaminant	Average daily load (lbs / day)	Annual load (lbs / year)	Average Daily Target Load (lbs / day)	Annual Target Load (lbs / year)	Annual Load Reduction Needed (lbs/yr)
E. coli	814 Billion	297 Trillion	30 Billion	11 Trillion	**286 Trillion**
TSS	948	346,146	193	70,598	**275,548**
N-N	38	13,917	30	11,094	**2,823**
TN	82	30,020	44	16,137	**13,884**
TP	7	2,712	1	504	**2,208**

Table 4.2 Benchmark and Pollutant Loads for site 1Ba.

Figure 4.11 shows the pollutant load divided by the target load for each pollutant at each site. Site 1A, for example, has five times the TSS annual load than the benchmark annual load for TSS at this site. This is also heavily influenced by precipitation. In fact, with wet sampling events removed from the dataset, site 1A is below the annual target load for TSS. From the graph it is clear that *E. coli* is the biggest pollutant contributor, and therefore BMPs will be implemented based on the load reduction needed for *E. coli*. Sites 5 and 1Bb appear to have the lowest pollutant loads, however the numbers still climb well above the benchmark annual load.

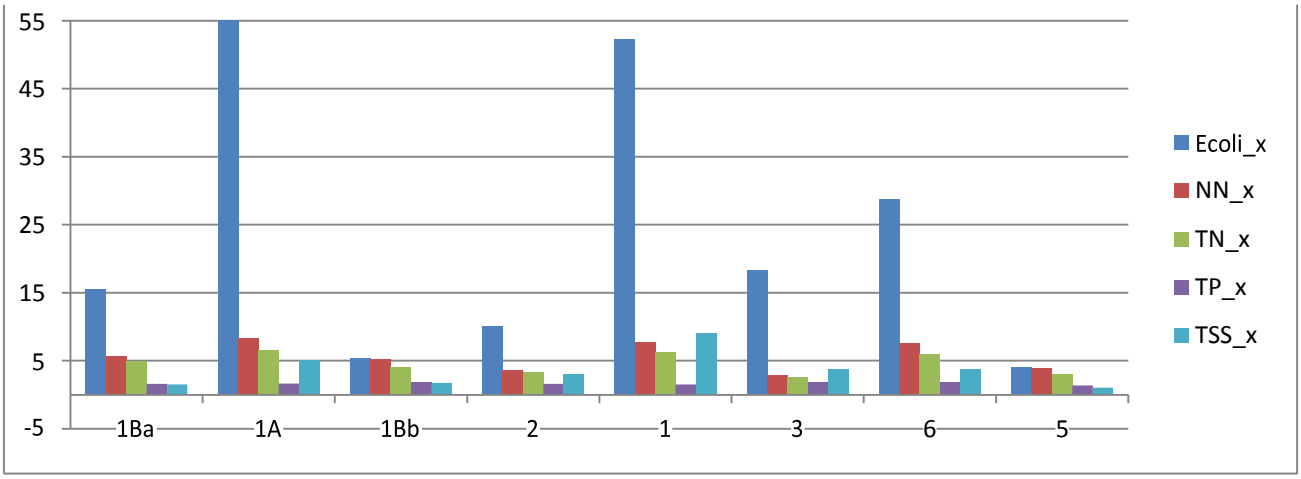

Figure 4.11 Graph of each pollutant load compared to each benchmark load for all eight sampling sites. Zero is the target load value on this graph; however, no sites' pollutant loads were below the target load.

4.3 Watershed Impairment

The pollutant loads for all sites are shown in table 4.3 (below). The actual daily load for each site is in the purple section and the benchmark daily load is in the blue section. By comparing the actual load (purple) to the target load (blue) it becomes evident that some areas of the watershed are significantly more polluted than others. All site pollutant loads were above the target load, particularly *E. coli*. Some sites were contaminated with over fifty times the target load for *E. coli*. Other contaminants in question include Total Nitrogen (TN), Nitrates + Nitrites (NN), Total Phosphorus (TP), and Total Suspended Solids (TSS).

Site	Total Phosphorus	Benchmark Total Phosphorus	*E. coli*	Benchmark *E. coli*	Total Nitrogen	Benchmark Total Nitrogen	Total Suspended Solids	Benchmark Total Suspended Solids
1Ba	7.4	1.4	814	30 Billion	82	44	948	193
1A	9.0	1.0	1.2	22 Billion	104	33	717	143
1Bb	2.0	0.9	105	20 Billion	37	29	208	127
2	1.2	0.6	132	13 Billion	25	20	243	85
1	34.5	6.2	7	135 Billion	429	198	7,791	867
3	6.5	1.8	716	39 Billion	50	57	952	251
6	19.3	7.7	4.8	168 Billion	480	247	4,032	1,082
5	0.6	0.4	35	8 Billion	13	12	55	55

Table 4.3 Daily pollutant load (lbs/day) for each contaminant at each site on the left, with benchmark pollutant loads to the right.

E.coli is a significant indicator of human or animal waste entering the watershed, and is a major impairment for Bacon Creek. However, other indicators help identify nonpoint sources such as high levels of TP, which can indicate contamination from fertilizers, human or animal waste. Soil erosion is a major contributor of phosphorus to streams. Generally, colder months and dry periods demonstrated lower TP levels, while warmer months and wet sampling events demonstrate high TP levels (see table 4.4).

	Jun-12	Jul-12	Aug-12	Sep-12	Oct-12	Nov-12	Dec-12	Jan-13	Feb-13	Mar-13	Apr-13	Apr-13	May-13	AVERAGE	Benchmar	Met?
SITE 1Ba	1.73	1.85	0.32	0.69	0.39	0.13	0.20	0.14	0.06	0.12	0.28	0.11	0.24	0.16	0.05	NO
SITE 1A	0.18	0.26	0.11	0.42	0.12	0.07	0.00	0.11	0.14	0.06	0.64	0.15	0.19	0.18	0.05	NO
SITE 1Bb	0.12	0.17	0.05	0.07	0.08	0.00	0.00	0.07	0.00	0.07	0.06	0.11	0.27	0.08	0.05	NO
SITE 2	0.08	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.07	0.13	0.14	0.06	0.05	NO
SITE 1	0.16	0.23	0.00	0.26	0.12	0.00	0.00	0.00	0.18	0.56	0.42	0.08	0.18	0.20	0.05	NO
SITE 3	0.16	0.23	0.00	0.11	0.10	0.00	0.00	0.00	0.08	0.08	0.22	0.12	0.16	0.09	0.05	NO
SITE 6	0.14	0.19	0.00	0.27	0.12	0.00	0.00	0.00	0.00	0.07	0.37	0.12	0.21	0.11	0.05	NO
SITE 5	0.11	0.14	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.09	0.09	0.11	0.04	0.05	YES

Table 4.4 Phosphorus results in mg/L by month and site. April 19, 2013 and Oct 26, 2012 were both wet sampling events, and produced the highest numbers.

Figure 4.12 Litter at Site 1Ba.

Field scientists noted any pollutants, riparian zones, biological activity, and unusual odors near the sample sites. Sites 5 and 6 were noted as having strong riparian zones, diverse biological activity, and few odors. Upstream from these sites, however, tire tracks, litter, and other signs of human activity were discovered. The heavy flow of Bacon Creek upstream from site 6 carries pollutants to the sample sites. Laboratory test results show high concentrations of *E. coli* and TSS for site 6, especially during the summer months. The annual pollutant loads are nearly thirty times the benchmark value for *E. coli*, and triple the benchmark value for TSS at site 6.

Figure 4.13 Human Activity at Site 6

Sites 1 and 1A have the heaviest annual pollutant loads for *E. coli* and TSS, however both sites were noted as having vegetation riparian zones, but show signs of human activity near or in the streams (see Figure 4.13). Some biological activity was noted at these sites, such as darter fish or small aquatic invertebrates.

Conclusive Analysis

E. coli samples were collected throughout the period between May 2012 and May 2013. The average for each site exceeded the Kentucky Division of Water's Water Quality Standard for E. coli (240CFU/100mL). Temperature of the water, conductivity, and pH are the only water quality standards met for all sites, year-round. While TSS does not have a numeric standard, high levels are likely to have adverse effects on aquatic wildlife.

Fall/Winter*	1Ba	1	1Bb	2	1A	3	6	5
Dissolved Oxygen								
pH								
Temp								
Ammonia-N								
E.Coli	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL
Phosphorus	FAIL	FAIL	FAIL	FAIL	FAIL	NI**	FAIL	FAIL
Nitrogen	FAIL	FAIL	FAIL	NI**	NI**		NI**	
Conductuance								
Total Suspended Solids	NI**	FAIL						NI**

*** Includes Sept 2012 to Mar 2013.**

**** NI - Needs Improvement. Failed to meet the benchmark 20-35% of the time**

Spring/Summer***	1Ba	1	1Bb	2	1A	3	6	5
Dissolved Oxygen	FAIL							
pH								
Temp								
Ammonia-N	FAIL					FAIL		
E.Coli	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL
Phosphorus	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL
Nitrogen	FAIL	FAIL	FAIL	FAIL	FAIL	NI**	FAIL	
Conductuance								
Total Suspended Solids	FAIL	FAIL			NI**	FAIL		FAIL

***** Includes May - Aug 2012 and Mar - May 2013**

Table 4.5 Sites that failed the benchmarks at least twice for Fall/Winter and Spring/Summer sampling events.

Generally, spring and summer months have higher pollutant loads than fall and winter months. Due to excess nitrogen and phosphorus in the water, dissolved oxygen levels are depleted during the summer months in much of the watershed. Site 1Ba failed to meet the standard for dissolved oxygen in the summer months of 2012. This can have a devastating impact on biological activity in the area.

For prioritization of the sub-watersheds in Bacon Creek, the pollution loads, benchmark parameters, and available feasibility factors were considered to evaluate the impairment for each sub-watershed. Data collected from each sample site, along with field notes and available GIS data indicate severe impairment in the Upper Bacon Creek and Middle Bacon Creek sub-watersheds. These sub-watersheds need to be considered a top priority in watershed repair.

The Middle Bacon Creek sub-watershed is an example of severely impaired water quality that could strongly benefit from increased protection. Because Middle Bacon Creek is downstream of Upper Bacon Creek, the quality of the water will greatly depend on the repairs upstream. Increased protection in Upper Martis Branch, Honey Run, Lower Martis Branch, and Tampa Branch sub-watersheds will have a positive impact on sub-watersheds that face severe impairment. Although these sub-watersheds are impaired, the pollutant loads are moderate compared to those listed as “severely impaired”.

Honey Run displays the least amount of contamination when reviewing datasets, however high amounts of debris and litter were noted upstream of site 5; cleanup and increased protection will prevent Honey Run from becoming further impaired. Geographic information systems (GIS) can represent areas of severe impairment by following heavy pollutant loads upstream (see Figure 4.16).

4.4 Data Analysis for Upper Martis Branch

In the summer of 2016 the Kentucky Division of Water sampled Martis Branch. In previous sampling, Martis Branch was only collected after it joined with Tampa Branch. So sampling site 7 was added to the sampling site locations.

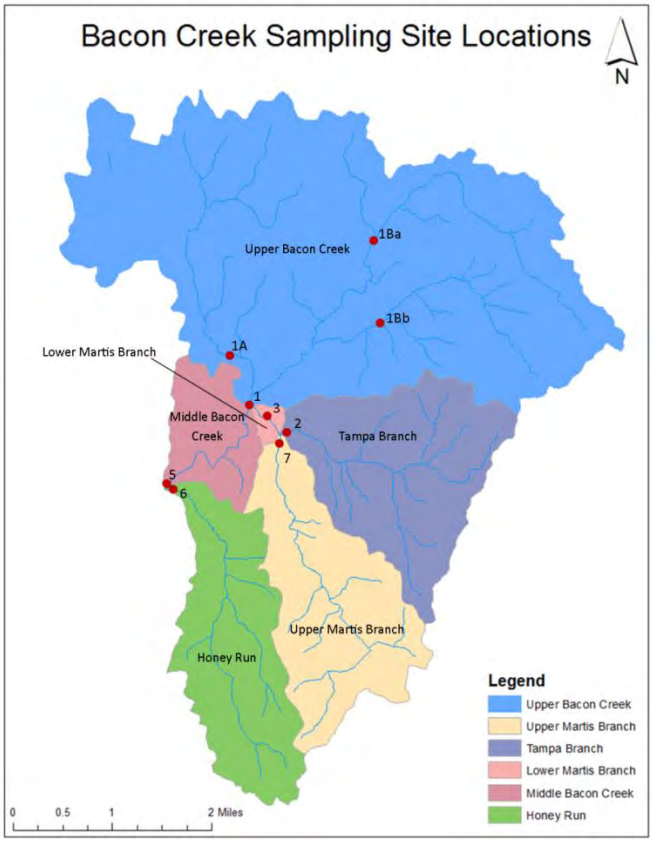

Figure 4.14 Bacon Creek Sample Locations

In order to get a better view of water quality in Upper Martis Branch, five (5) samples in 30 days were collected to gain more information about this subwatershed, see Table 4.6.

Location Name	Date Sampled	Result
Martis Branch	05/05/2016	1,203.30
Martis Branch	05/11/2016	1,732.90
Martis Branch	05/24/2016	1,553.10
Martis Branch	05/25/2016	980.4
Martis Branch	06/01/2016	>2,419.60

Table 4.6 – Sampling data from 2016

According to the Consolidated Assessment and Listing Methodology: Surface Water Quality Assessment in Kentucky, the Integrated Report, a partially supported designation is given when the geometric mean of five samples collected over a 30-day period during the six-month recreation period exceed the criterion of 130 CFU/100mL. The geomean for samples collected in Martis Branch is 1503.48, which lists this stream as Partial Support for Primary Contact Recreation. Having this set of data also establishes a baseline for future monitoring and the potential for success.

Chapter 5 – Summary of BMPs

In watershed planning, a best management practice, or BMP, is traditionally defined as something built on the ground with documentable results in reducing nonpoint source pollution. The selection and location of BMPs is a critical component to the success of the watershed plan. BMP implementation that is targeted to specific pollution issues is vital to successful watershed planning. In order to implement the BMPs effectively, Hart County Health Department and LaRue County Conservation District were consulted.

For Bacon Creek Watershed these characteristics exist:

- The watershed relies on on-site wastewater systems. The soils in the Bacon Creek Watershed are not ideal for installation of properly functioning septic systems.
- Land use in the watershed is primarily pasture, hay & cultivated crops, making up 62% of the entire priority subwatershed. Of the priority subwatershed, 39% of the land use is pasture, hay & cultivated crops that connect directly to Bacon Creek and its tributaries.
- The watershed does not support primary contact recreation (PCR) due to *E. coli* loading from runoff related sources, both agricultural and on-site sewage treatment. Portions of the watershed partially support for warm water habitat due to sedimentation and siltation loading from runoff related to agricultural and lack of streamside vegetation.

Figure 5.1: Best Management Practices: Planting native trees, shrubs, and grasses; riparian stream buffers; and silt fences (counter clockwise from the top).

5.1 Summary of Work Completed

The Bacon Creek Watershed has had various organizations work on improving the water quality. By using EPA's 319(h) Grants through the Division of Water, those organizations and partners have been able to implement the following BMPs:

Type of BMP	*Number installed*	*Type*	*Implementation Date*	*Sub-Watershed*
Heavy Use Area	1	Agriculture BMP	2012	Upper Bacon Creek
Waste Water Pumpout	7	On-Site Water Treatment BMP	2012	Upper Bacon Creek
Heavy Use Area	1	Agriculture BMP	2012	Upper Bacon Creek
Watering Facility	1	Agriculture BMP	2012	Upper Bacon Creek
Onsite Waste Water System (New)	4	On-Site Water Treatment BMP	2013	Lower Bacon Creek
Onsite Waste Water System (New)	2	On-Site Water Treatment BMP	2013	Upper Bacon Creek
Onsite Waste Water System (New)	2	On-Site Water Treatment BMP	2013	Lower Bacon Creek
Stream Crossing	20ft.	Agriculture BMP	2013	Lower Bacon Creek
Fencing	3,584ft.	Agriculture BMP	2013	Lower Bacon Creek
Fencing	2,659ft.	Agriculture BMP	2013	Upper Bacon Creek
Watering Facility	1	Agriculture BMP	2013	Upper Bacon Creek
Pasture & Hayland Management	3	Agriculture BMP	2014	Upper Bacon Creek
Conservation Crop Rotation	3	Agriculture BMP	2014	Upper Bacon Creek
Heavy Use Area	1	Agriculture BMP	2015	Upper Bacon Creek
Watering Facility	1	Agriculture BMP	2015	Upper Bacon Creek
Stream Exclusion Fencing	4,063ft.	Agriculture BMP	2016	Upper Bacon Creek
Onsite Waste Water System (New)	2	On-Site Water Treatment BMP	2016	Upper Bacon Creek
Forage and Biomass Planting	8 AC	Agriculture BMP	2016	Upper Bacon Creek
Stream Crossing	2480 ft^2	Agriculture BMP	2016	Upper Bacon Creek
Waste Water Pumpout	1	On-Site Water Treatment BMP	2016	Upper Bacon Creek
Fencing	4,930ft	Agriculture BMP	2016	Upper Bacon Creek

Table 5.1: BMP Installation from 2012 - 2016

5.2 Summary of BMPs

Before beginning work, it is important to strategize about the best practices to use in the watershed to create the most change. The following BMPs are targeted for *E.coli* reduction.

	Structural BMPs	Non-Structural BMPs
Agriculture	• Livestock exclusion fencing • Alternative water sources • Cross fencing • Pasture Renovation • Winter Feeding Area • Feeding and Heavy Use Area Management • Nutrient Management • Karst Sinkhole Treatment • Riparian Buffers • Stream Crossings • Gully Erosion Treatment	• Workshops/training for developing nutrient management plans/Ag Water Quality Plans • Conservation Easements • Farm Field Day held in conjunction with LaRue Co Conservation District • Technical Assistance for BMP Implementation
On-site Sewage Treatment	• Pump-outs and maintenance • Replace or repair system if required	• Educational materials on proper maintenance • Workshops for proper septic maintenance

Table 5.2 - Agriculture and On-site Sewage Treatment Best Management Practices for Bacon Creek

5.3 Agricultural BMPs

The agricultural BMPs selected are targeted to address the reduction of bacterial levels in the watershed in an effort to meet water quality standards for primary contact recreation. The BMPs identified that would have the greatest impact on achieving the water quality standards include exclusion fencing of riparian areas, cross fencing for rotational grazing, pipeline for alternative watering facility, watering facility, heavy use and feeding areas, pasture renovations and winter feeding areas. All of these BMPs are a high priority.

The nonstructural BMPs are an important components to improve water quality in Bacon Creek. In the past few years, the LaRue County Conservation District, in conjunction with Kentucky Waterways Alliance, have hosted a number of Farm Field Days with local Middle and High School students. The LaRue County Conservation District and Hardin County Natural Resources Conservation Service have provided technical assistance for BMP implementation for landowners in the project area. All of these nonstructural BMPS are important and should be used in conjunction with the structural BMPS.

5.4 On-site Sewage Treatment BMPs

The on-site sewage treatment BMPs are targeted to address the reduction of *E. coli* levels in the watershed in an effort to achieve safe primary contact recreation use and warm water aquatic habitat. These BMPs include proposed inspection of on-site sewage treatment systems to identify potential problems, maintenance of system if necessary and replacement or installation as required. All BMPs listed in the Table above are a high priority.

The nonstructural on-site sewage treatment BMPs are also important for the success of this project. By educating the public about the importance of maintaining their on-site sewage treatment system it will equip those homeowners with the information and tools to make decisions about operating and maintaining their system. The Barren River Health Department District was consulted about these issues and work with the community on this education piece.

5.5 BMP Descriptions

Agricultural:

Agricultural Water Quality Plans: An Agricultural Water Quality Plan is pro-active way for farmers and producers to plan for the long term health of their resources, including surface waters. It is a legal requirement for farms with 10 acres or more.

Fencing/Alternative Watering Systems: These BMPs help to keep domestic livestock out of Bacon Creek and sensitive areas, thereby reducing erosion and pathogen issues and damage to stream bank vegetation. There are several existing programs helping farmers with these issues.

Heavy Use Area Protection: The stabilization of areas frequently and intensively used by people, animals, or vehicles by establishing vegetative cover, surfacing with suitable materials, and/or installing needed structures.

Nutrient Management Plans: A written record of how much fertilizer is applied, what time of year onto what kind of soil has been shown to significantly reduce the application of nutrients to agricultural lands. It also saves product money upfront.

Pasture Management: There are several BMPS that address pasture and vegetation conditions to prevent erosion and pollution transport: conservation cover, critical area planting, crop rotation, inner fencing, filter strips, pasture renovation, prescribed grazing, etc. Landowners and conservation professionals can best determine which BMPs where would be most suitable.

Riparian Buffers: Suitable for agricultural, residential, and commercial areas of the watershed. Development of a streamside management zone, 25 – 200 feet wide, consisting of plant species adapted to the soils and topography and designed for single or multi-purpose objectives such as water quality enhancement, wildlife habitat, stream shading, or bank stabilization.

Karst Sinkhole Treatment: Livestock should be excluded from sinkholes and other karst features by fencing off the sinkhole's drainage area. Sinkholes should be fenced at least 25 feet out from the top rim of the depression, since it is may be impractical to fence off the entire drainage area. (*Sinkhole Management for Agricultural Producers*, Wightman, Higgins)

Stream Crossings: This best management practice is intended for use with exclusion fencing that restricts cattle access to the stream. Implementation of a stream crossing with exclusion fencing will improve water quality, reducing nutrient, sediment, pathogen and organic matter loads to stream. (*Stream Crossing for Cattle*, Higgins, Agouridis & Wightman)

Winter Feeding Stations: Facilities specially designed to allow for the feeding of livestock in combination with the safe storage of manure. Through the use of heavy use perimeters in combination with concrete floors in the feeding and manure storage areas, erosion is significantly reduced.

Gully Erosion Treatment: removal of soil along drainage lines by surface water runoff. Each time the gully washes out, the soil is lost to the nearest stream or creek. These gullies not only carry a large amount of sediment into the stream, but they create a direct line to the stream for manure. By fixing, revegetating and fencing out these areas, erosion is significantly reduced.

BMP	NRCS Practice Code	Design and Construction Costs	Required Maintenance Period
Fence (Cross Fence)	382	$2.67/Linear Ft.	20 Years
Livestock Pipeline	516	$5.07/Ft.	20 Years
Watering Facility (tanks)	614	$2,654.67 each	10 Years
Feeding and Heavy Use Area Management	561	$2.07/SqFt.	10 Years
Forage and Biomass Planting (Pasture Renovation)	512	$196.66/Acre	5 Years
Winter Feeding Area	998	$10,000	10 Years
Stream Crossing	578	$3,72/SqFt	20 Years
Nutrient Management	KYNMP		

Table 5.3: Agricultural BMPs, Cost & Maintenance Period

*Cost estimates taken from State Cost Share Estimated Payment Schedule, 2014

**Required maintenance period for best management practices taken from 2014 KY State Cost Share Manual

The BMPs outlined in the above table were recommended by the Agriculture Coordinator who has worked in the are for the past 4 years. However, if the ability to install these identified BMPs is not feasible on a location, then we will consider other alternatives to reach the PCR water quality standard.

Wastewater:

Septic System Education: Education is key to properly maintaining onsite wastewater systems. Septic systems and other onsite waste water systems are affective at treating residential wastewater, if installed and maintained properly. The KY Onsite Wastewater Association recommends pumping out septic tanks every three to five years, depending on the number of people living in the home (KOWA, 1999). Community septic system education could take the form of mailers, workshops, and/or financial incentive programs for unsewered areas.

Septic System Inspection Pump out: A properly installed septic systems may function well for decades if

regularly inspected and pumped out. A financial cost-share program for watershed residents may help homeowners wary or unaware of septic maintenance issues. This program requires working with Health Department and service providers.

Septic System Repair or Replacement: A financial cost-share program may encourage homeowners who know they have a broken or failing septic system to address problems. This program will require consultation with Health Department officials and local service providers.

Education:

Community watershed education: Nonpoint source pollution does not come from a single source, but from the collective actions of a community. Education about watershed issues, in general, and Bacon Creek issues, specifically, may go a long way to preventing future pollution issues. Educational messages may be incorporated into other BMPs, take the form of creek cleanups, festivals, workshops, or outreach materials for dissemination.

Technical Assistance for BMPs Implementation: Bacon Creek has an Agricultural Watershed Coordinator that can assist landowners and farmers with BMP implementation and Agricultural Water Quality Plan applications. This knowledge is a huge asset to help with education within the watershed

Chapter 6: Best Management Practice Prioritization

6.1 Agriculture Prioritization:

In order to determine the subwatershed to prioritize for BMP implementation, the following assumptions were made:

- All cattle are found within areas designated as Pasture/Hay in the NLCD layer, see Figure 2.14.
- Each head of cattle produces 1.28×10^{12} CFU *E. coli*, per animal, per year (Metcalf and Eddy, 1991).
- Beef cattle spend about 50% of their time in the stream, so the yearly deposition directly in to a stream is 6.4×10^{11} CFU *E. coli*, per animal, per year.
- All beef cattle, dairy cattle and calves are counted as equal contributors
- Cattle density is based on number of cattle per acre of pasture as determined using the 2011 NLDC GIS Layer
- Where a subwatershed has two sampling points, load reductions needed were averaged to generate a single load reduction for the area.

	HART COUNTY	LARUE COUNTY
TOTAL ACRES, COUNTY	267,398.4	168,691.2
TOTAL ACRES PASTURE, COUNTY	85,548.81	54,542.31
TOTAL CATTLE, COUNTY	36,000	19,000
CATTLE PER ACRE OF PASTURE	0.42	0.35

Table 6.1 Calculations for number of cattle per acre of Pasture/Hay

HUC NAME	HART COUNTY	LARUE COUNTY
UPPER BACON	1,631.54	2,510.25
MIDDLE BACON	607.28	0
TAMPA BRANCH	2,123.86	0
LOWER MARTIS	387.31	0
UPPER MARTIS	1,980.44	0
HONEY RUN	1,445.82	0

Table 6.2 Acres of Pasture/Hay in each subwatershed

HUC NAME	HART COUNTY	LARUE COUNTY	TOTAL CATTLE IN SUBWATERSHED
UPPER BACON	685.25	878.59	1,564
MIDDLE BACON	255.06	0	255
TAMPA BRANCH	892.02	0	892
LOWER MARTIS	162.67	0	168
UPPER MARTIS	831.78	0	832
HONEY RUN	607.24	0	607

Table 6.3 Cattle per acre of Pasture/Hay in Hart & LaRue Counties

HUC NAME	TOTAL CATTLE IN SUBWATERSHED	LOAD REDUCTION NEEDED (CFU/YEAR)	HEAD OF CATTLE TO EXCLUDE FROM STREAM
UPPER BACON	1563.84	3.66E+13	**57**
MIDDLE BACON	255.06	4.95E+13	**77**
TAMPA BRANCH	892.02	8.53E+13	**133**
LOWER MARTIS	167.67	1.93E+13	30
UPPER MARTIS	831.78	5.16E+13	**81**
HONEY RUN	607.24	1.18E+13	18

Table 6.4 Cattle to be excluded from the stream

Based on the information provide above, the priority sub-watershed for the Bacon Creek Watershed are Tampa Branch, Upper Martis Branch, Middle Bacon Creek and Upper Bacon Creek. BMPs should be implemented heavily in the in these sub-watersheds, with the most emphasis on Tampa Branch. BMPs should be focused in areas near the headwaters and properties that near or have direct connection to the stream.

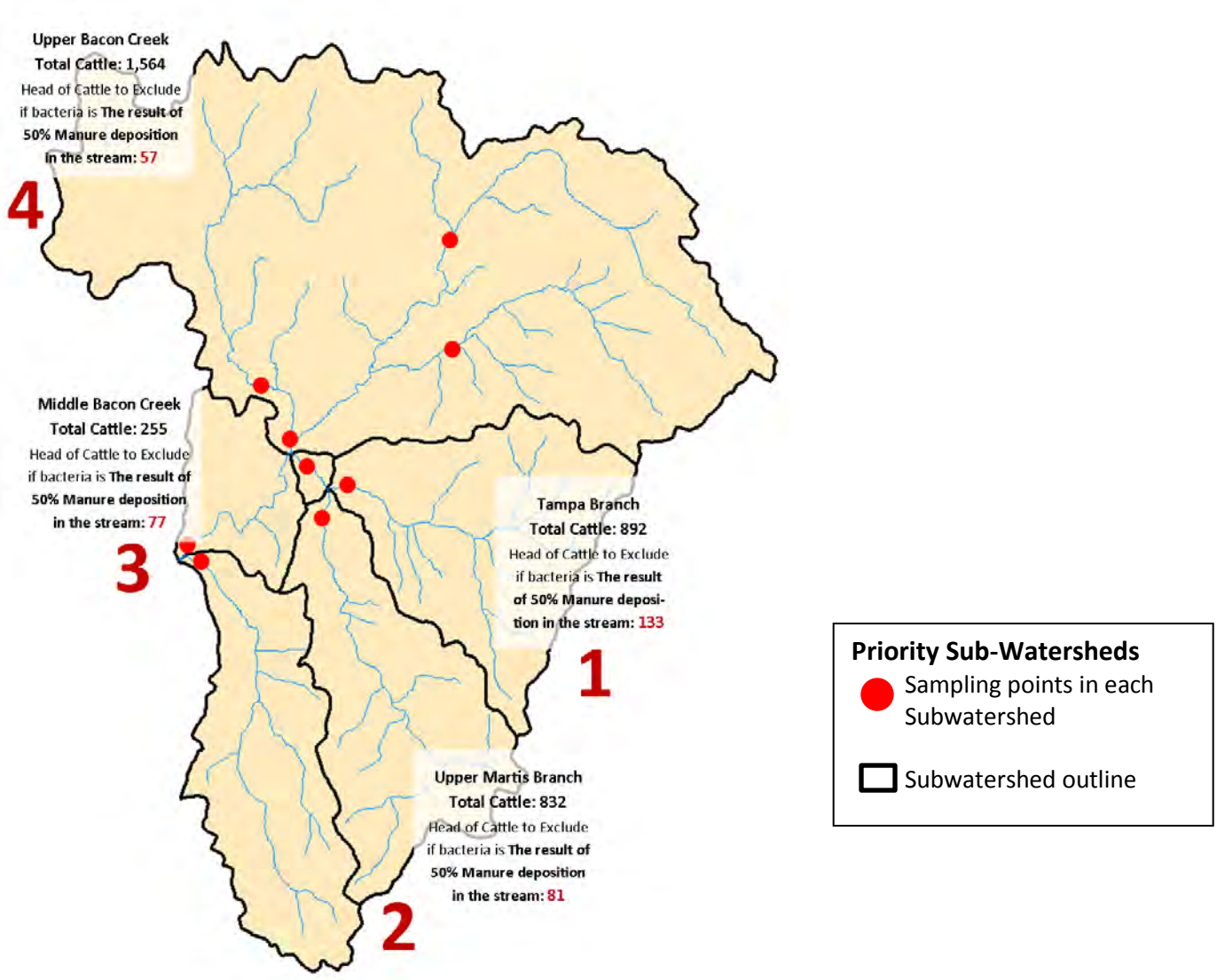

Figure 6.1: Priority Sub-Watershed for Agriculture BMPs

6.2 On-site Waste Water System Prioritization:

In order to determine the subwatershed to prioritize for BMP implementation, the following assumptions were made:

- An estimate of the population with septic in the riparian corridor was made for the Bacon Creek Watershed Plan area
- The entire population lives within 100 m of a road.
- The population is evenly dispersed along the roads.
- The stream corridor was set at 60 m.
- All households were assumed to have septic systems.
- The 2010 census was used to determine population density.

ESTIMATE OF RIPARIAN ZONE POPULATION IN BACON CREEK

SUBWATERSHED NAME	Watershed Population in Riparian Corridor
UPPER BACON CREEK	227.9
MIDDLE BACON CREEK	4.3
TAMPA BRANCH	14.1
LOWER MARTIS BRANCH	0.7
UPPER MARTIS BRANCH	4.8
HONEY RUN	6.6

Table 6.5 Estimate of Riparian Zone Population in Creek

SUBWATERSHED NAME	WATERSHED POPULATION IN RIPARIAN CORRIDOR	NUMBER HOUSEHOLDS ON SEPTIC
UPPER BACON CREEK	227.9	91
MIDDLE BACON CREEK	4.3	2
TAMPA BRANCH	14.1	6
LOWER MARTIS BRANCH	0.7	0
UPPER MARTIS BRANCH	4.8	2
HONEY RUN	6.6	3

Table 6.6 Watershed Population and Household Septic

SUBWATERSHED NAME	WATERSHED POPULATION IN RIPARIAN CORRIDOR	#HOUSEHOLDS ON SEPTIC	# SYSTEMS NEEDING REPLACEMENT (34% FAILURE RATE)
UPPER BACON CREEK	227.9	91	**31**
MIDDLE BACON CREEK	4.3	2	1
TAMPA BRANCH	14.1	6	**2**
LOWER MARTIS BRANCH	0.7	0	0
UPPER MARTIS BRANCH	4.8	2	1
HONEY RUN	6.6	3	1

Table 6.7 Number of Septic Systems needing replacement

Based on the information provide above, the priority sub-watershed for the Bacon Creek Watershed are Upper Bacon Creek, Tamp Branch and Honey Run Watersheds. On-site waste water treatment systems should be replaced in these sub-watersheds, with the most emphasis on Upper Bacon Creek. On-site waste water treatment systems should be focused in areas near the headwaters and properties that near or have direct connection to the stream.

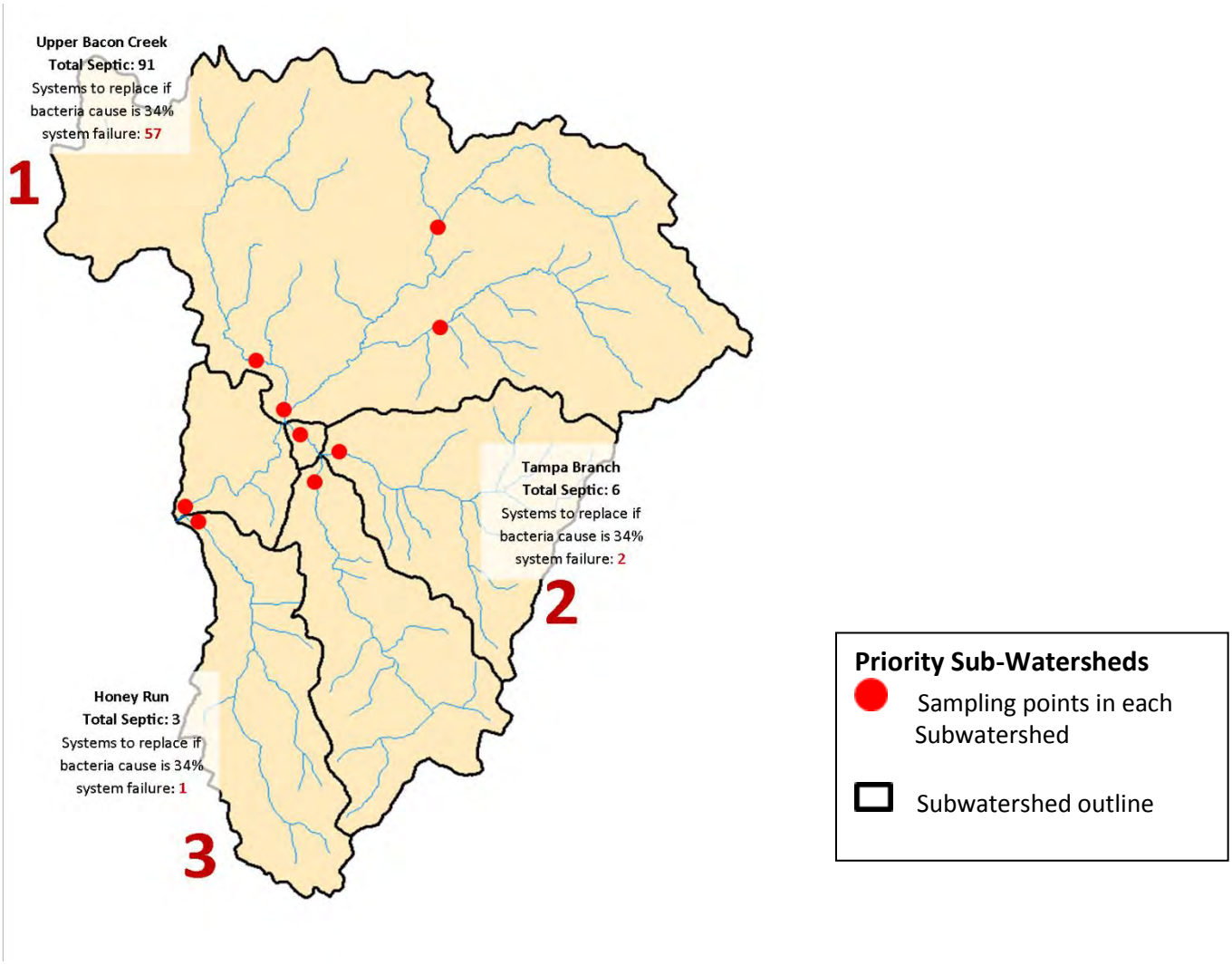

Figure 6.2: Priority Subwatershed for Septic Repair/Replacements

6.3 Conclusion

The BMPs selected for the Bacon Creek Watershed are not all appropriate or feasible for just the priority watersheds. In Chapter 6, feasibility factors like economics, stakeholder cooperation, regulatory matters, political will, and other watershed management activities are considered to create a list of BMPs that will work for Bacon Creek. For those BMPs that are found to be feasible, an action plan will be created to facilitate implementation down the road. It is important to keep in mind that watershed planning is iterative and that this watershed plan can be revised as new information or additional resources become available.

Chapter 7: Implementation Schedule and Milestones

7.1 Cost Predictions

The US EPA provides funding through Section 319(h) of the Clean Water Act to the Kentucky Division of Water, Nonpoint Source Pollution (NPS) Control Program. These funds will be match at the state level with Division of Conservation State Cost Share and through voluntary in-kind donations. The Kentucky Division of Water will direct contract with the LaRue County Conservation District and Barren River District Health Department to implement this plan. These cost estimates are for the priority subwatersheds, but are subject to change based on need and participation availability.

Subwatershed	Number of Estimated Failing Septic Systems	Recommended BMP: Septic Repairs or Replacements*	Total Cost
Upper Bacon Creek	57	$4,000	$228,000
Tamp Branch	2	$4,000	$8,000
Honey Run	1	$4,000	$4,000
Total Cost			$240,000

Table 7.1: Estimated Cost of Onsite Sewage Disposal Systems BMPs in Priority Subwatersheds

*Estimates are based on the average cost for this area. Prices for repairs range from $175 to $5,000. Ranges for replacements range from $500 to $14,000. Therefore, the estimate of $4,000 should accommodate both the lower and higher ranges for the implementation. (Estimates curtsey of homeadvisor.com)

Best Management Practice	Quantity	Cost Per BMP*	Total Cost
4-Hole Waterer	2	$2,376 each	$4,752.00
Heavy Use Area Associated with tanks	25'x25'=625sqft x 2 tanks	$2.07/sqft	$2,587.50
Water pipeline	2,000lnft	$3.87/ft	$7,740.00
Creek Fence	3,000lnft	$2.67/ft	$ 8,010.00
Cross Fence	3,000lnft	$1.80/ft	$5,400.00
Pasture Renovation	50 ac	$189/ac	$9,450.00
Winter Feeding Area	1	$10,000 each	$10,000.00
Total for an individual farm			$47,939.50
Total cost for Bacon Creek Watershed			$379,148.00

Table 7.2: Estimated Cost of Agricultural BMPs per farm in Bacon Creek Watershed.

*Estimates are based on invoices previously submitted for the Bacon Creek Watershed implementation project.

Objective	BMP	Action Items
#1: Reduce bacteria loads from failing residential septic systems	Education on residential septic system function and maintenance including a workshop with certified installers, real estate agents, and community members.	1. Gather and adapt relevant materials for use in education and outreach. 2. Reach out to installers, real estate agents, and community groups for workshop.
	Address failing and improperly maintained septic systems and straight pipes.	1. Notify landowners within the watershed of an education workshop regarding onsite sewage disposal systems 2. Landowners will have the ability to sign-up for free maintenance inspections 3. Upon inspection, if the system is identified as in need of repair or replacement, the homeowner will complete the application for assistance. These applications will be ranked and systems will be repaired or replaced based on ranking. 4. Conduct field days with conservation district and NRCS.
#2: Reduce bacteria loads from livestock	1. Restrict grazing in the riparian area 2. Create alternative water sources for cattle 3. Create feeding areas and renovate pastures 4. Find and eliminate gully erosion	1. The LaRue County Conservation District will reach out to landowners in the priority subwatersheds and work with them to install selected BMPs on their property. The BMPs identified include NRCS Code: 382,516, 614, 561, 512, 998, 578, 590.
	Work with farmers in the watershed to update or write Agricultural Water Quality Plans and Nutrient Management Plans.	4. Outreach: speak to local farming groups, direct mail, and post information in public places about the plan benefits and requirements. 5. Work directly with landowners to complete their AWQP and NMP.
#3: Community Outreach and Education	Farm Field Days	1. The LaRue County Conservation District will coordinator with LaRue and Hart County Schools to organize a Farm Field Day for community to show off completed work.
	Local Partnerships	2. The Health Department and Conservation District will work together to communicate their programs to the community through local churches, schools and other area partners.

Table 7.3: Objectives, BMPs and Action Items

7.2 Public Information and Participation

Division of Water will work with partners in the watershed to provide landowners with pertinent information on water quality issues, appropriate BMPs and funding sources. The outreach will include landowner mailings, workshops, and site visits. Other mechanisms to deliver the information to the people who need it may develop through the course of the project. Division of Water staff will work with the Barren River District Health Department to conduct workshops for landowners in the watershed about proper on-site sewage system maintenance. The workshops will provide more detailed information about the water quality issues in the watershed and the appropriate BMPs. During the workshop and through contact made by landowners to health department staff, landowners will have the opportunity to have their on-site system pumped and inspected free of charge.

The septic system maintenance and repair will be performed by a certified septic pumping company contracted by the local health department. If the septic system repair company determines that there is a problem or if the homeowner knows there is an issue with their system, they can apply for the repair program by applying to the local health department. The application will include information on the location of the home, distance to stream, current wastewater situation and household income. Applications will be prioritized based on these factors; homes within the targeted subwatershed and with the closest proximity to the stream will be given the highest priority.

If the application is selected for assistance, the homeowner will be required to sign a commitment to pay for the required permit fees and site evaluation costs and to maintain the system with proper care and regular pump outs. If an in-sufficient number of homeowners within the targeted subwatershed are not identified, then we will move to the next prioritized subwatershed.

The Division of Water will partner with the LaRue County Conservation District and NRCS to produce landowner mailings. These mailings will give agricultural producers within the watershed a timeframe in which to contact the office. This voluntary contact will begin the process where producers can apply for funding to reduce their farm's impact on water quality. The producers will be asked to complete an application and the applications will be ranked according to greatest potential to positively impact water quality.

Responsible Parties	Estimated Cost	Funding Source	Technical Assistance	Short-Term Milestone (0-5 Years)	Mid-Term Milestone (5-10 Years)	Long-Term Milestone (10-25
LaRue County Conservation District	$379,148.00 in best management practices installation	319(h) /State Cost Share	Need to work with Conservation District/NRCS to determine the most effective BMPs for the area and the impairment.	Installation	Maintenance as required by agreement	Repair/rehabilitation as required by agreement
Barren River District Health Department	$240,000.00 maintenance, repair, replacement of onsite sewage treatment systems	319(h) /State Cost Share	Proper septic care information	Evaluate systems, maintenance or installation	Ongoing maintenance	Ongoing maintenance
KDOW/Health Department	$20,000.00 administrative cost of producing mail outs, facilitating workshops, etc.	319(h) /State Cost Share	Mercer Co. Health Department developing materials, Septic System Installers	Development of workshop materials	Send out maintenance reminders	Send out maintenance reminders
LaRue County Conservation District	$80,000.00 administrative costs and hiring contractual watershed coordinator	319(h) /State Cost Share	Landowners consulting with DOC on development of Ag Water Quality Plan, ranking applications, preparing mail outs	Development of Ag Water Quality Plans		Send out reminders to update plans if needed

Table 7.4: Milestone Worksheet

7.3 Evaluation of Implementation Progress

Effectiveness monitoring will be conducted to determine if the BMPs being implemented are working towards achieving the Primary Contact Recreation water quality standard. Since it has been determined that the Agriculture BMP implementation will begin in the Tampa Branch, Upper Martis Branch and Middle Bacon Creek subwatersheds, sampling will be conducted at same monitoring locations in those subwatersheds. For the on-site waste water BMPs, Upper Bacon and Tamp Branch will be sampled. A five and thirty *E. coli* sampling event will be conducted at those locations during the primary contact recreation (PCR) season of one year following the installation of BMPs, and continue into the PCR season of the following year. The monitoring plan will help evaluate the effectiveness of the WBP, by evaluating if the BMPs being implemented are addressing the bacteria pollutant loading. The data produced as a result of these sampling events will determine the future course of action. If after these two sampling events the subwatersheds are meeting the PCR water quality standard or showing

improvements we can infer that the correct BMPs have been selected and installed to effectively address the bacteria loading. If however, we conclude that the installed BMPs are not allowing these subwatersheds to meet the designated goals then we will reassess and develop further BMP implementation if needed.

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Appendix A

Watershed Action Plan by Dale Reynolds

Watershed Action Plan by Dale Reynolds (2005)

Table of Contents

INTRODUCTION

The purpose of this document is to present background information about the geology, hydrology, land uses, and water quality of the Bacon Creek watershed. Based on these conditions, this document reflects the goals and objectives for solutions to the existing watershed problems.

A. Background

Approximately 14 miles of the Bacon Creek main stem is listed as not supporting primary contact recreation (swimming), due to the presence of excessive fecal coliform bacteria (See Figure 1). The Kentucky Division of Water has documented this condition for at least the past seventeen years. It is unknown if the sources are domestic (there are over 100 straight pipes in the watershed), agricultural (the area is primarily farmland), or some percentage of both. The Division of Water has only collected samples from one or two locations on the main stem; however, over the past six years, Upper Green River Watershed Watch volunteers have collected samples in both the main stem and near the confluence of headwater tributaries. The sample results indicate that there are, indeed, multiple sources. This watershed action plan will look at all of these historic analytical results, plus a couple of special sampling studies conducted by Western Kentucky University (WKU) and a watershed watch volunteer. It is hoped that a careful review of this data will at least indicate where additional sampling would be best located, and hopefully, indicate some of the sources.

B. Geography

The watershed predominantly lies in Hart County, but also extends into Hardin and Larue Counties. It is located within the Western Pennyroyal physiographic province of the Mississippian Plateau. The Western Pennyroyal is underlain by Mississippian-age through Ordovician-age limestone, calcareous shale, sandstone, siltstone, and shale. Alfisols are a common type of soil in this area. Almost the entire watershed lies within the Turnhole Bend karst basin (see Figure 2). There are several miles of fault lines that underlie this watershed. Forestland within this area contains a mixture of oak, hickory, and soft wood varieties. Bonnieville is the only city in the watershed.

C. Waterways

This watershed drains 90.466 square miles. The waterways in the watershed include the Bacon Creek main stem, and its tributaries: Tampa Branch, Martis Branch, and Honey Run. This drainage area also contains about 20 miles of karst streams.

D. Land Cover/Land Use

The bulk of industry is agricultural while there are no confined animal feeding operations (CAFO) registered, there are a number of animal feeding operations (AFOS's), which are mostly dairy farms. There are numerous documented springs scattered throughout the watershed. There is 1 US Geological Survey (USGS) gaging station on Bacon Creek near Priceville, Kentucky. The Kentucky Pollution Discharge Elimination System has 5 permitted dischargers in this drainage area. Spring Park Mobile Home Community has the only package treatment facility in this watershed. Additionally, there are two rock quarries in this basin; one is located in Hart County (KY. Aggregates) and the other is located in Hardin County (Hanson Aggregates

Midwest, Inc.). There are also 2 landfills located within this watershed and they are located in Hart County.

Agency Data Assessment

The first basin-wide assessment for the Green/Tradewater Rivers Basin was conducted in FY2002 and concluded that in the following areas/categories accepted standards were not being attained:

Observed Impact- Human Health

Primary Contact Recreation

Tissue Consumption

Observed Impact- Ecological Health

Aquatic Life

The 2002 303 (d) Report concerning this watershed:

Bacon Creek in Hart and Larue Counties, from River Mile 0.0 to 31.2: (Segment Length is 31.2 miles) was listed on the 1998 303 (d) Report:

- oImpaired Use: Swimming (Nonsupport)
- oPollutant of Concern: Pathogens
- oSuspected Sources: Agriculture, Land Disposal (Onsite Wastewater Treatment Systems-Septic Tanks).

The 2002 303 (d) Report (1st Priority Listing) says that some data collection has been done throughout the watershed (by Western Kentucky University) to define the areas of the watershed contributing the most to the impairment.

E. Bacon Creek Taskforce

A previous 319(h) grant funded the formation of local watershed councils in each of the seven major (HUC 6) Kentucky Watersheds. These councils were aimed at fostering local involvement in efforts to educate the residents of the watershed about how land uses impact water quality/quantity. In addition, the councils were charged with involving the residents in activities that drew them to the water, gave them a sense of responsibility, and undertook tasks to make improvements in the watershed.

The Bacon Creek Council consisted mainly of the Bonnieville city council members. The council worked on getting a sewer system installed, to eliminate over 100 straight pipes; conducted several creek cleanups; and initiated an annual Bacon Creek Heritage Day. The 4th annual heritage day festival will be held in 2005 and has grown every year. In addition, there are two successful creek cleanups each year. The council is currently seeking funding under the 319(h) program to prepare a Watershed Based Plan.

The Bacon Creek Council formed the core of the later formed Bacon Creek Taskforce. The Taskforce will continue the efforts of the council and focus on bringing in more residents and providing more outreach efforts to effect changes in the watershed. During the preparation of this WAP, taskforce members will reconnoiter the watershed for fecal coliform pollution sources and assist the owners of those properties with accessing expertise for determining appropriate BMPs, implementation assistance, and cost-sharing where possible.

II. WATERSHED DESCRIPTION

A. Description of the Watershed

1. Project Setting

In the Bacon Creek Watershed, soils are a thin layer of alluvium deposits, which are underlain by Mississippian age bedrock from the Lower Member of the Girkin Formation, which, in turn, overlies the St. Genevieve limestone formation. The bedrock layers of the Girkin Formation consist of argillaceous sandstone and shale. Topographically, the watershed lies on the Mississippian Plateau, with relief varying from 535 feet at the confluence with Nolin River, to 1150 feet in elevation above sea level above the headwaters. The focus area of this study is limited to the upper portion of the watershed, from the west side of Route 31W to the headwaters of the HUC11 watershed. The focus area contains five HUC14 sub-watersheds (Upper Bacon Creek, Tampa Branch, Martis Branch, Honey Run, Middle Bacon Creek) and the main stem of Bacon Creek above the City of Bonnieville (See Figures 3- 6).

The climate for Hart and Larue Counties is temperate and humid. Annual precipitation averages around 46 inches. Soils within the watershed tend to be thin (3-4 feet deep) and vary from prime farmland to marginal pastureland, having a tending to be sandy and/or silty in nature. The predominant soil types have moderate to high tendency to erode. Riparian buffers tend to be thin to non-existent and slopes vary from 0-10 percent.

The focus area of the watershed extends from the community of Hammonville in the east to the City of Bonnieville and covers over 50 square miles of the overall Bacon Creek Watershed. Hammonville is a small, unincorporated community of less than 100 people, and Bonnieville is a small city of just over 350 people. There are no sewers in the entire Bacon Creek (HUC11) Watershed, with the exception of the Spring Park Mobile Home Community, which has a package plant that serves 12 homes. This plant discharges into the headwaters of Bacon Creek. This Watershed Action Plan focuses on the upper portion of the HUC11 watershed to make sure that the project area was of manageable size. Follow-up efforts can address the remaining 40 plus square miles of the lower portion of Bacon Creek. The goal is to target a manageable area and demonstrate successes, which can be used throughout the remainder of the watershed.

3. Hydrogeology

The alluvium forms terraces and flood plains along Bacon Creek. Soil variability ranges from loamy, fertile, permeable soil to clayey, poor quality, low permeability soil. The rolling topography of the watershed is underlain by the lower members of the Girkin Formation. Karst features such as numerous large sinks are present; where the overlying sandstone has collapsed into a sub-surface cavity in the underlying limestone. While the predominant flow patterns for the watershed are determined by surface topography, karst features introduce some variations that ignore topographic gradients. Over a dozen dye-traced karst flows have been mapped within and across the watershed boundaries (See Figure 5). All of the sinkhole features were considered palustrine wetland features in the National Wetland Inventory. Fortunately, there is no evidence of stream channel alteration, man-made diversions, dams, or significant withdrawals from this water body.

4. Biodiversity and Habitat

Despite near total removal of the riparian buffer, this stream has a fairly diverse aquatic assemblage. However, the focus of this project is to reduce fecal coliform contributions and there are no significant adverse effects on aquatic life from the levels of fecal coliform typically found in this stream (under 10,000 colony forming units).

5. Watershed Uses

The public water supply for this watershed is the Green River Valley Water District, which withdraws water from the Green River. Bacon Creek is a tributary to the Nolin River, which discharges into the Green River several miles below the intake for the water district. There are domestic groundwater wells in the Bacon Creek watershed but they are not generally used for human consumption.

As stated before, the only sewer in the entire Bacon Creek (HUC11) Watershed is the Spring Park Mobile Home Community, which has a package plant that serves 12 homes. This plant is considered a "minor source" by the Kentucky Discharge Elimination System (KPDES) and is permitted to discharge up to 5,000 gallons of effluent into the headwaters of Bacon Creek (permit # KY0089761). Accordingly, the average flow from this plant should be under 2.5 gpm; however, surge volumes could be higher. Plant discharge is generally the majority of the stream volume at the point of discharge (since the stream flow averages less than 0.5 gpm), and during dry periods the plant discharge is the only flow in the receiving stream channel.

There are three other KPDES facilities in the watershed, but none of them discharge to the surface. Newtech Enterprises, Inc. (metal stamping facility) is the only industry in the watershed and it is permitted as a no-discharge facility (KY0100463). Hanson Aggregates Midwest, Inc. mines and is also permitted as a no-discharge facility (KYG840100). The Magnolia Elementary School has a no-discharge permit for their septic system (KY0023558).

As of 2001, agriculture represented approximately 35% of the watershed acreage, which consisted of five times as much pastureland as cropland. There are only 7 permitted animal feeding operations in the watershed. They are all are dairy operations and constitute a total of 335 animal units.

There are between 425 and 500 homes located in the watershed, all of which have either septic systems or straight pipes for domestic waste disposal. The number of cisterns and domestic wells are unknown. There are no public recreation areas in this watershed. No planning and zoning regulations apply within the watershed. A large segment of Bacon Creek is cited on the Clean Water Act section 303(d) list as being impaired by pathogens.

6. Resources

Agency/Organization	Type of Assistance
Lincoln Trail Area Development District For Hart County Barren River ADD, P.O Box 90005, Bowling Green, KY 42102; Phone: (270) 781-2381 For Hardin County Lincoln Trail ADD, P.O. Box 604, Elizabethtown, KY 42702; Phone: (270) 769-2393	Business, industry, economy, natural resources, tourism, government, GIS mapping and planning, legal issues, recreation planning, financial management and planning, and County Water Supply Plans
KY Department of Fish & Wildlife Resources Bonny D. Laflin Southwestern Fishery Biologist Bowling Green, KY (207) 746-7127	Habitat improvement
Kentucky Division of Conservation 805 Main St, PO Box 186, Munfordville, KY 42765 Steven Olt, **Green Co. Cons. Dist**., (270) 932-4244	Cooperative soil survey mapping, Watershed Conservancy Districts
Kentucky Division of Water **(502) 564-3410** **Facilities Construction Branch** Bill Chlebowy **Groundwater Branch -** Beverly Oliver **KPDES Branch -** Jory Becker **Nonpoint Source Section -**Corrine Wells **Water Quality Branch -** Tom VanArsdal **Water Resources Branch -** Bill Caldwell **Drinking Water Branch -** Donna Marlin	-201 Facility Plans for wastewater, wastewater treatment availability -Groundwater Protection Plans (GPPs) -KPDES permits, discharges, wastewater treatment -BMPs -Regulatory use designation of waterways -County Water Supply Plans / drinking water supply -Drinking water facility information
U. S. Environmental Protection Agency	Maps, databases, publications
Kentucky Legislative Research Commission	Economic and demographic Data (Kentucky statewide summary information (updated 7/31/96), profiles of Kentucky counties, Census Profiles, Census of Agriculture Summaries, Bureau of economic analysis REIS data, civilian labor force estimates for Kentucky and counties, and commonly used boundaries in Kentucky)
USDA, Kentucky Agricultural Statistics Service	Agricultural statistics (usually by county or census tract)
US Census Bureau	Private wells, demographics
United States Geological Survey (USGS)	Maps, hydrologic information

B. Water Quality of Your Watershed

1. Monitoring Data & Assessments

Because Bacon Creek is a 303(d) listed stream, the Division of Water has sampled this stream

regularly, yielding a historic database that supports the determination of impairment. In addition, there is historic data collected by Upper Green Watershed Watch volunteers, plus studies done by Western Kentucky University and the Bacon Creek Taskforce.

2. TMDL Report

No TMDL has been produced for this watershed and none is scheduled at this time.

3. Resources

The following resources will be used in determining the water quality and identifying the sources of problems in this watershed.

Agency/Organization	Type of Assistance
Kentucky Division of Water **KPDES Branch** **Water Quality Branch**	-Assistance with monitoring & assessment data - Assistance with monitoring and assessment data, databases
Kentucky Watershed Watch	Volunteer sampling/monitoring coordinated through Watershed Watch Steering Committees
United States Geological Survey	Assistance with flow estimation (rating curves)
Local Conservation Districts	Provide technical assistance and outreach
River Basin Team	Information and assistance
Western Kentucky University	Assist with sampling, interpreting monitoring results, determining priorities for action, etc.

C. Planning

Current Planning Processes

Summaries of local plans, ordinances, etc that have a bearing on fecal loading in this watershed are provided below.

- *201 Wastewater Facility Plan* - This watershed is part of the 201 Wastewater Plan for Caveland Environmental Authority. The plan reserves this area for future expansion, which will begin with the extension of the sewer trunk line from the rest area on I-65 up to the City of Bonnieville. The trunk line will be a force-main that will connect to a collection system within the Bonnieville city limits. All city residents will be required to connect to sewer, but, not residents outside the city. Sewer construction is expected to begin in 2005 and completed in 2006. Continued expansion to Upton, which lies to the north along US Route 31, will likely follow.
- *Agricultural Water Quality Plan* – Agricultural operators plan to address environmental issues associated with agriculture and silviculture by using Best Management Practices for crops, livestock, pesticides, fertilizer, farmstead, silviculture, and streams and other waters. For more information see KRS Chapter 224.71. **Resources:** Division of Conservation or local NRCS office will be contacted on a case-by-case basis for details about individual farm plans.
- *Groundwater Protection Plan (GPP)* – Sites that use or store significant quantities of potentially hazardous chemicals are required to prepare a document that establishes a series of practices designed to prevent groundwater pollution. For

more information see 401 KAR 5:037. **Resources:** Division of Water's Groundwater Branch will be contacted for information about any facility that is suspected of being a potential source of fecal coliform.

- *Local Planning and Zoning, Land Use Plans* – Neither Hart nor Larue Counties, nor any of the communities within this watershed have planning and /or zoning standards.
- *NRCS Watershed Plan* - Project plans and programs dealing with conservation and usage of water resources, flood/erosion prevention and control, plus floodwater and sediment damages are maintained by NRCS. **Resources:** Natural Resources Conservation Service plans and programs will be examined.
- *Area Solid Waste Management Plan* - Develops goals and objectives for improving solid waste management. For more information see 401 KAR 49:011. **Resources:** Local Solid Waste Coordinator or County Judge Executives' office will be contacted for potentially pertinent information.

III. IDENTIFYING GOALS AND OBJECTIVES

A. Targeting Your Project

The Bacon Creek Council was formed in July of 2001 under a Kentucky Waterways Alliance 319(h) grant project to raise community awareness about water issues and to develop community pride for the local watershed. As that grant wound down, the council became the Bacon Creek Taskforce. Building on this group's interest in improving conditions within their watershed, the taskforce began to look at a more systematic approach to the pathogens pollution problem. The core of the taskforce is the city council of Bonnieville, which includes the mayor and several council members.

This WAP is being prepared in preparation for the commencement of a 319(h) grant to develop a Watershed Based Plan (WBP). The WAP will compile all available data and discuss its implications, inventory the watershed for potential pathogen sources, and determine where to focus the available resources. The WBP will define Best Management Practices (BMPs) to be applied to various types of pollution sources,

Given the limited resources of this grant, the focus of the Watershed Based Plan will be on the headwaters of the watershed and downstream as far as time and money allows. Starting in the headwaters provides a better opportunity to have a measurable impact on the stream segment we are trying to improve. In addition, by improving our chances of success, we also gain credibility with the citizens of the watershed, which, in turn, yields greater acceptance of the BMPs we are trying to employ.

B. Description of Goals and Objectives

Bacon Creek has been on the 303(d) list of impaired streams, due to pathogens, since 1996. The predominant land use within this 90.5 square mile watershed is agriculture, and there are over 100 straight-pipes in the community of Bonnieville, plus septic systems in a marginally compatible geologic setting. As part of the Kentucky Watershed Management Framework process, the Green and Tradewater River Basins Team (RBT) have chosen Bacon Creek HUC11

Watershed as a Targeted (Priority) Watershed. The team has established a Task Force of local residents and will assist them in their efforts to mitigate stream impairments.
The goal of this project is to assist the Bacon Creek Task Force as they work to develop and implement a watershed based-plan to restore healthy recreational uses of this stream.

The objectives are to:

1) Educate the residents about the geology of this area and how land use impacts water quality, i.e. via non-point source (NPS) pollution.
2) Teach the residents about appropriate Best Management Practices (BMPs), including riparian buffers and livestock fencing.
3) Introduce the residents to the available cost share programs and technical assistance.
4) Prepare and begin implementation of a Watershed Based Plan

C. Resources

Partners in the grant include the Kentucky Waterways Alliance, the Division of Water, the Division of Conservation, Western Kentucky University (WKU) Center for Water Resource Studies, and the Upper Green Watershed Watch. Efforts will also be made to take advantage of the training and advertising available under the Comprehensive Commonwealth Water Education Project as a means of giving a broader level of importance and appropriateness for proactive involvement by citizens.

IV. SOLUTIONS / PLAN IMPLEMENTATION

The goal is to develop a Watershed-Based Plan that addresses the nine criteria the USEPA has identified (in Environmental Protection Agency. Supplemental Guidelines for the Award of Section 319 Nonpoint Source Grants to States and Territories in FY2003. This document is also available at the EPA website: http://www.epa.gov/owow/nps/Section319/319guide03.html

- **Objective 1A:** Empower and involve the Bacon Creek Task Force in assisting with the development of Watershed-Based Plan.
- **Objective 1B:** Determine which sub-watersheds are significant contributors of fecal coliform.
- **Activity 1B1:** Each of the seven sub-watersheds (HUC14s) will be sampled and the flow rate measured, to determine which sub-watersheds deliver the highest pathogen contribution.
- **Objective 1C:** Using concentrations and flow measurements proportional loading will be computed per sub-watershed (HUC14) and for the overall (HUC11) watershed.
- **Activity 1C1:** The Project Manager will examine the data, and in consultation with Task Force members about known land uses per watershed, determine which tributaries are responsible for the greatest fecal coliform loading.

Goal #2: Increase public awareness of the connections between development and/or land uses on water quality and quantity.

- **Objective 2A:** Inform public of Task Force findings, in terms of contamination levels and known/suspected sources.
- **Activity 2A1:** Hold four public meetings per year to discuss sampling data, the implications of the data, instructional presentation by an agency representative, and to

recruit volunteer landowners to implement "typical" BMPs that can be monitored and modified as needed. Suspected sub-watershed residents will be targeted for personal invitations.

Goal #3: Begin Implementation of WBP.

- **Objective 3A:** Through public meetings, and targeted visits by Task Force members to the owners of properties that are suspected of being a source of fecal coliform pollution, this project will recruit landowners for expanded use of "typical" BMPs.
- **Activity 3A1:** Involve technical representatives from the appropriate agencies to advise on the most appropriate BMP and investigate the eligibility for cost sharing.
- **Activity 3A2:** Near the end of the project, monitoring will be conducted to determine the success of the project.

Goal #4: Conduct in-stream monitoring of pathogens.

- **Objective 4A:** The Task Force will prepare documentation based on sampling results and implementation of BMPs.
- **Activity 4A1:** The Task Force will gather data on the Bacon Creek main stem to determine if the stream is receiving reduced pathogen loading.

A. Conservation / Best Management Practices (BMPs)

The following resources will be involved in choosing/modifying and implementing BMPs to apply in the Bacon Creek sub-watersheds.

Agency/Organization	Type of Assistance
Agriculture Water Quality Authority, *contacted through the Kentucky Division of Conservation*	Agriculture & Silviculture Best Management Practices
USDA Natural Resource Conservation Service and USDA Farm Services Agency	Agriculture BMPs, conservation planning
Kentucky Division of Forestry	Silvicultural BMPs, tree planters
Local Conservation Districts	Agriculture, silviculture, and construction BMP; specialized equipment, BMP implementation; cost share for BMP's
Kentucky Division of Conservation	Agriculture, silviculture and construction BMPs; specialized equipment, BMP implementation
UK Cooperative Extension Service	Publications on agricultural and silvicultural BMPs

B. Land Preservation

Land preservation is not appropriate in this watershed, since development is not an issue.

C. Training / Education / Technical Assistance

This project will build on the successes of the existing Task Force, on-going statewide education efforts of the Commonwealth Comprehensive Water Education Project (funded by KY DOW-NPS for FFY02), and other existing programs operating in Kentucky. Trainers and literature produced by other projects and programs will be utilized to reduce duplication of efforts.

The core group of the Task Force has established an annual Bacon Creek Heritage Day, which combines outdoor activities and indoor exhibits that both educate and entertain. As attractions to encourage attendance there are booths that sell food and novelty items, but there are also stream-side events, such as water sampling training (how and why) taught by a Kentucky Division of Water employee and a Watershed Watch instructor/ coordinator. Additionally, a stream cleanup is conducted. The indoor exhibits display findings from prior sampling events. Kentucky Waterways Alliance (KWA) exhibits this and other projects as well as some historic photos of Bacon Creek and some civil war relics. During the first year of this project, the 4th Annual Bacon Creek Heritage Day will be held in the fall. Project information will be conveyed to the attendees; additional Taskforce members will be sought, and Taskforce members will log landowners interested in evaluating their NPS contributions for follow-up site visits. Site information and pictures will be evaluated for potential remedies or mitigation efforts, so that the landowner can take steps to reduce their NPS contributions.

As this project kicks off, the Taskforce, under the leadership of KWA Project Manager, will begin by transferring the findings of the Watershed Action Plan into the Watershed Based Plan to learn what is needed to complete a WBP that includes all nine elements specified under EPA guidance. A timeline will be established to allow submission of the first draft to DOW - Nonpoint Source Section in early 2006. Revisions to the WBP will be completed and implementation will begin in early 2007.

The Task Force will meet every month, during the first ten months of 2005. These meetings will be scheduled at the preceding meeting and at least one week prior to the meeting date; a public notice will be given to the local paper and radio station. Following each Task Force meeting there will be a press release or article submitted to the local newspaper that summarizes the activities of the Task Force. During all subsequent years, Task Force meetings may be reduced to every other month, but following the same announcement and progress-reporting format. In addition, there will be frequent progress reports made in the KWA newsletter, which has an average circulation of 1,000 people.

As previously described, there will be four public meetings per year, which will be aimed at instructing the residents of the Bacon Creek watershed about local conditions, the nature of NPS pollution, best management practices, sources of technical assistance, and available cost-sharing programs. In addition to reporting on the activities of the Task Force towards improving the water quality of Bacon Creek, guest speakers will be invited to provide informational presentations at each public meeting.

During 2005 this project will collect samples and measure sub-watershed (HUC14) discharges so that loading contributions can be determined. This will allow the Task Force to focus its field investigation efforts in the sub-watersheds that contain the most significant sources. KWA will prepare a Request for Proposals to coordinate and gather technical data for the WBP. Once all the major sources of fecal coliform pollution are located, the landowners contributing to the water quality problems will be determined and personally invited to the public meetings.
If there is any willingness to look into what can be done to reduce NPS contributions, the Task Force will work with the landowner. Efforts will be made to research the problem, seek

appropriate technical assistance, and obtain approval for agency programs that offer cost sharing. For those contribution sources that cannot be addressed easily, the detected impacts will noted for inclusion in the development of the WBP.

The overall process of seeking sources, developing a plan, implementation, and subsequent success monitoring will demonstrate to residents that as stakeholders they can take action that will result in positive water quality changes and this understanding should evoke changes in local attitudes about activities that cause NPS pollution. The change in attitudes, combined with the neighborhood relationship of stakeholders, as they develop and implement the management plan will result in the reduction of NPS pollutants in the stream, in particular pathogens, which should also reduce the runoff contributions of nutrients, pesticides, and herbicides. The end result of a successful WBP is that this stream should be de-listed for pathogens by 2012.

The Project Manager, with assistance from the Basin Coordinator, will insure that all pertinent local, state, and federal agencies will be urged to actively participate in this project to ensure that all relevant programs are utilized to aid the stakeholders. Some of the agencies and programs envisioned to be useful are the KY- Assist Program, which cost-shares with homeowners for on-site domestic sewerage treatment; USDA-NRCS conservation and cost-share practices; Kentucky Health Department and KDOW On-Site Waste Disposal Coordinator for guidance on acceptable alternative septic systems; University of Western Kentucky - Center for Water Resource Studies for reduced cost environmental sample analyses; and the regional sewer authority for any opportunities to expand sanitary sewer service.

Four public meetings per year will be aimed at instructing the residents of the Bacon Creek watershed about local conditions, the nature of NPS pollution, best management practices, sources of technical assistance, and available cost-sharing programs. In addition to reporting on the activities of the Taskforce towards improving the water quality of Bacon Creek, guest speakers will be invited to provide informational presentations at each public meeting.
The completed WBP will be distributed to the Task Force, advertised in the KWA newsletter and available on the KWA web site. The availability of the completed WBP will be announced at the Green/Tradewater River Basin Team Meeting as well as at the next Watershed Framework Steering Committee meeting. A final news article will be written and distributed to area media

D. Monitoring / Assessment

A monitoring database already exists for the Bacon Creek watershed. This project will utilize the existing data and on-going volunteer data to gage success of out efforts to implement BMPs in the headwaters of this watershed.

1. Analysis of Existing Data

Existing data does not definitively point to any one facility or location as a clear source of pathogen contribution. However, it does indicate that significant inputs occur in the headwaters, which are diluted and then reinforced around Bonnieville, and again west of the city. All results are in terms of the number of fecal colonies per 100 milliliters of sample. All sampling sites are shown on Figure 6.

DOW Data

DOW reference reach site 03025001 is located on the Martis Branch sub-Watershed

Watershed Watch Data for Martis Branch

ID #	July 2000	July 2001	Sep 2001	May 2002	Jul 2002	Sep 2002	Oct 2002	May 2003	July 2003	May 2004	July 2004	Sept 2004
Precip												
G179										**3,455**		**2,560**
G172										**1775**		56
G25	22	800	536	**1,120**	744	**1,280**	568	600	**1,440**	**1,440**	400	296
G126					256	176	408	960	**1,480**	**2,070**	**1,000**	616
G70		168	144	**1,200**	680	**2,320**	288	640	680	**27,375**	350	392
G66		448	640	**>12000**	880	544	96	**1,240**	**1,000**	**13,775**	600	640
G173										**5,810**	<100	88

WKU Study

DATE (mmddyyyy)	**SAMPLE ID**		**FC colonies Per 100mg**		**TF** CFU Per 100mL	***E. coli*** (CFU/100 mL)
10/29/2001	BC-2		8	>	1,000	60
10/29/2001	BC-3		32	>	1,000	170
10/29/2001	BC-4		8	>	1,000	20
10/29/2001	BC-5		8	>	1,000	15
10/29/2001	BC-6		8	>	1,000	60
10/29/2001	BC-8		40	>	1,000	45
10/29/2001	BC-9		64	>	1,000	68
12/13/2001	BC-2		6,000			
12/13/2001	BC-3		5,500			
12/13/2001	BC-4		1,300			
12/13/2001	BC-5		1,600			
12/13/2001	BC-6		1,800			
12/13/2001	BC-8		1,700			
12/13/2001	BC-9		1,100			
2/18/2002	BC-2	<	8	>	1,000	155
2/18/2002	BC-3	<	8	>	1,000	15
2/18/2002	BC-4		30	>	1,000	45
2/18/2002	BC-5		10		1,000	40
2/18/2002	BC-6		30	>	1,000	45
2/18/2002	BC-8	<	8	>	1,000	70
2/18/2002	BC-9	<	8	>	1,000	115
5/21/2002	BC-2					
5/21/2002	BC-3					
5/21/2002	BC-4					
5/21/2002	BC-6					
5/21/2002	BC-8					
5/21/2002	BC-9					
5/21/2002						

Watershed Watch Special Study

Laboratory Results

	Sept. 21, 2004		Sept. 29, 2004		Oct. 7, 2004		Oct. 13, 2004		Oct. 21, 2004	
Last Rain	48hrs+		48hrs+		48hrs+		<24hrs.		?	
Site ID	**Fecal Col.**	**E-Coli**	**Fecal Col.**	**E-Coli**	**Fecal Col.**	**E-Coli**	**Fecal Col.**	**E-Coli**	**Fecal Col.**	**E-Coli**
A	6000		4091	4140	2000	2430	3545	2950	2182	2310
B	880		73	200						
C	270						818	610		
D	1320		5545	4640	909	2280	2727	970	909	980
E									84	<100
F					182	410	3727	3090	909	840
F(alt)					273	100				
G										
H			91	300						
100	<4	<100								
101			<4	<100						
102					<4	<100				
103							<4	<100		
104									<4	<100

NOTE: Samples 100 – 104 were field blanks

FIELD MEASUREMENTS									
Date	**Site ID**	**T-air**	**T-water**	**Sample**	**Time for D**	**Distance**	**Velocity**	**Area**	**Discharge**
		C^0	C^0	Time	sec	feet	ft/sec	cu.ft.	cu.ft./sec
22-Sep	A	N.M.	17	9:56	220	20	0.0909091	2.88	0.2613636
22-Sep	D	N.M.	15	10:52	218	20	0.0917431	10.69	0.9805046
22-Sep	B	N.M.						0.00	0
22-Sep	C	N.M.						0.00	0
29-Sep	A	14	16	9.42	35.49	20	0.563539	3.30	1.8610876
29-Sep	B	16	14	10.51	41.62	20	0.4805382	4.26	2.0446901
29-Sep	D	14	15	10.15	8.48	10	1.1792453	2.83	3.3402123
7-Oct	H	14	15.5	11.38	204.89	10	0.0488067	9.84	0.4800137
7-Oct	A	N.M.						0.00	
7-Oct	D	N.M.						0.00	
7-Oct	F	N.M.						0.00	
7-Oct	F-alt	N.M.						0.00	
13-Oct	A	14	15		119.73	10	0.0835213	3.22	0.2685208
13-Oct	C	N.M.	14		22.97	10	0.4353505	9.69	4.2185459
13-Oct	D	N.M.	14	10.32	31	10	0.3225806	4.54	1.4653226
13-Oct	E	N.M.	15	9:20				0.00	
13-Oct	F	N.M.						2.96	
21-Oct	A	N.M.	15	10.05	307	10	0.0325733	3.35	0.1091205
21-Oct	D	N.M.	16	10.25	27.7	10	0.3610108	4.03	1.4539711
21-Oct	F	N.M.	14	9.31				0.00	

2. Planned Monitoring

There will be six permanent locations sampled once a month (on the second Tuesday of each month) during the period of May to October of two years (2005 and 2008). The sampling points will be located at the mouths of sub-watersheds (HUC14s) in the headwaters of Bacon Creek. Each sampling event will measure water and air temperature, stream cross-section, and flow rate in the field. Water samples from each event will be collected and analyzed by WKU's Center for Water Resource Studies for fecal coliform. For more details refer to the Bacon Creek Watershed Based Plan Sampling QAPP.

3. Resources

These resources will be utilized to obtain pertinent data to for monitoring and assessment.

Agency/Organization	Type of Assistance
Kentucky Division of Water, Water Quality Branch	Collect and assess physiochemical & biological data, review water quality impacts, on-site evaluations
Kentucky Watershed Watch	Volunteer sampling and monitoring coordinated through River Basin Local Steering Committee
Kentucky Division of Water, Water Watch	Volunteer water quality monitoring, community education, leadership development and community organization
KY Farm Bureau, Agriculture Watershed Awareness Program	Volunteer water quality monitoring, community education, leadership development, community organization, landowner involvement and education
Mammoth Cave National Park Service	monitoring, technical assistance, and data analysis
Local health departments	Can do some monitoring, provide technical assistance, and data analysis
United States Geological Survey	Real time water data, drought information, mapping, stream flow data
Western Kentucky University	Information, technical assistance, labs, research

E. Permitting / Compliance & Enforcement

1. Statutes

The most recently published Kentucky statutes are available on the Internet and are located at http://www.lrc.state.ky.us/statrev/frontpg.htm

2. Regulations

The Legislative Research Commission also maintains Kentucky regulations in effect as of the 15th of the previous month on its website, at http://www.lrc.state.ky.us/kar/frntpage.htm
Federal regulations are available at: www.access.gpo.gov/su_docs/aces/aces140.html

3. Permitting

a) Role of Permitting in Watershed Management

Residents, businesses, and industries may have local, state, and / or federal permits for activities such as floodplain activities, wastewater treatment plants, water withdrawals, construction sites and water discharges. Permits can help you locate potential partners as well as potential pollutants. Permit limits and conditions may assist in watershed management. Local watershed task force members may want to participate in public hearings and meetings.

b) KPDES Watershed Permitting

Kentucky has been in the process of watershed permitting since 1997. KPDES permits have been issued/reissued and cycled into one of 5 respective basin management units. Starting in July 2001, KPDES permits were issued on a watershed basis, referred to as watershed permitting. As permits expire they will be re-scheduled as necessary to expire during the next year that the basin management unity within which they are located is due for watershed permitting.

The 5 respective basin management units and the scheduled watershed permitting (done on a state fiscal year basis) are as follows:

1. Kentucky River - July 1, 2001 to June 30, 2002
2. Salt & Licking Rivers - July 1, 2002 to June 30, 2003
3. Upper & Lower Cumberland and Tennessee Rivers - July 1, 2003 to June 30, 2004
4. Green & Tradewater Rivers - July 1, 2004 to June 30, 2005
5. Big Sandy, Little Sandy, & Tygarts Rivers - July 1, 2005 to June 30, 2006

Permits are processed in a "domino-like" fashion as one goes through a basin management unit. In this manner, permits for small watersheds within the larger basin management unit are processed within the same time period (e.g. week, month, etc). The process continues all the way through the basin by proceeding to each successive sub-basin. This allows the agency to have more coordinated and locally focused attention on technical reviews of KPDES permits.

In addition to the above, public involvement is enhanced as a result of watershed permitting. Groups of permits that are under reconsideration are concurrently announced by public notice, in order that public participation can be conducted and coordinated on a local level. In some situations, public hearings may be conducted for multiple permitted entities rather than one permit at a time.

The Division of Water maintains a listing of KPDES permits to be processed, and when each is set for review within each respective basin management unit for a given state fiscal year. Any questions regarding the Division's watershed permitting process are directed to KPDES Branch at 502-564-3410.

4. Compliance & Enforcement

The Bacon Creek watershed task force will work closely with the Division of Water (DOW) Regional Office in matters of compliance and enforcement. Any problems or violations identified by the watershed task force will be passed on to the local DOW Regional Office.

5. Resources

The following resources may assist in permitting and enforcement.

Agency/Organization	Type of Assistance
City and County Government	Create local ordinances, if appropriate
Kentucky Division of Water	Information regarding the agency's statutes, regulations, and permitting
KY Division of Water Regional Offices	Handles complaints, inspections, compliance

F. Funding

1. Grants, Cost-Share Programs, Loans

This watershed action plan was written in preparation for initiating a Clean Water Act section 319 grant to write a Watershed Based Plan with partial implementation. As part of the process of constructing the WBP any detected water quality impairment or threat will be investigated and the sources of the problem will be documented so the problem can be addressed. After thoroughly documenting all relevant activities and problem areas in the headwaters of this watershed, it will be possible to compose a viable plan to systematically address the sources of the discovered problems. There is insufficient funding in the grant to address more than a few sites, but the BMPs developed/modified and employed in the headwaters can be readily applied elsewhere throughout the watershed.

2. Resources

This plan is being used as a starting point for the creation of a WBP for the watershed, which will, in turn, be used to secure additional funds and assistance to address the problems discovered and documented in the WBP.

Appendix B

- The KDOW TMDL “Bacon Creek Watershed Health Report”
- Upper Green River Watershed Watch data (2012 only)
- TMDL data
- Bacterial source tracking data from 2010

Bacon Creek Watershed Health Report by KDOW TMDL Section:

Kentucky Division of Water
200 Fair Oaks Lane, 4th Floor
Frankfort, KY 40601
Phone: 502-564-3410
Website: http://water.ky.gov/waterquality/Pages/TMDLHealthReports.aspx

Bacon Creek Watershed Health Report

Department for Environmental Protection - Division of Water

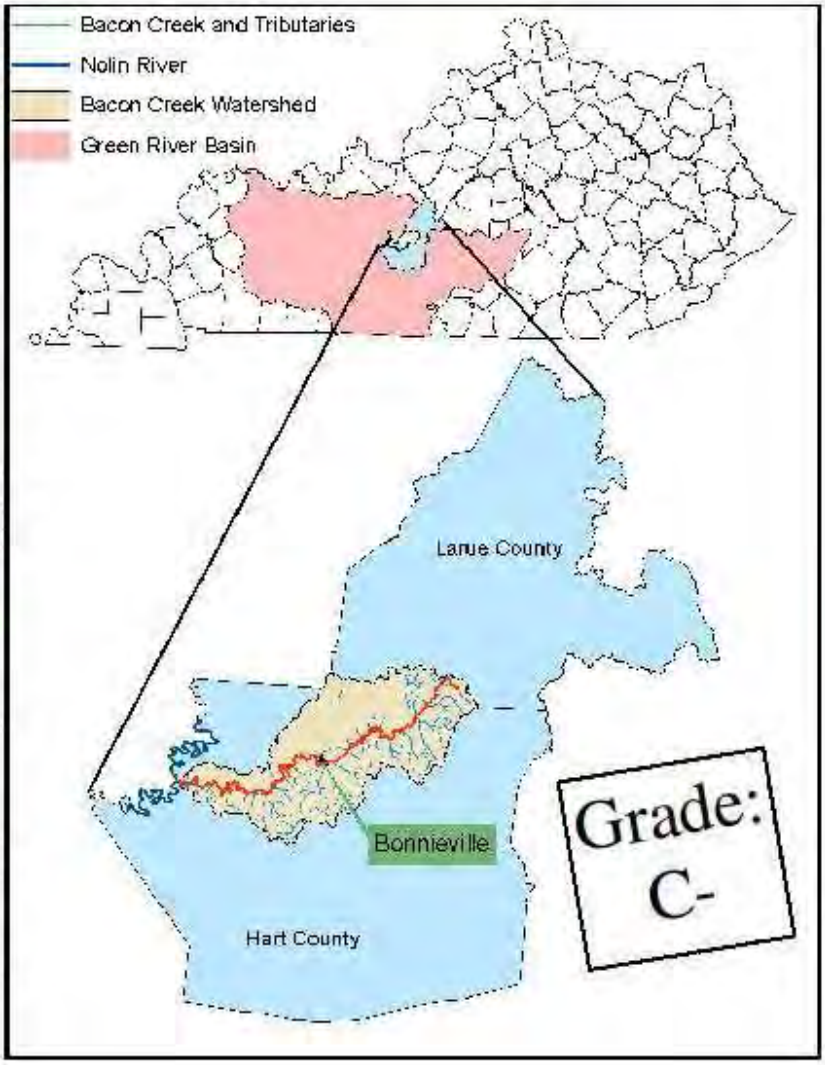
The Kentucky Division of Water (DOW) is the state agency responsible for carrying out the requirements of the Clean Water Act to reach the goal of making all waters in Kentucky safe for swimming and fishing (called **uses**).

DOW has developed this health report to inform the residents of Larue and Hart counties of efforts to examine the health of Bacon Creek and the area of land that drains into Bacon Creek, which is called a **watershed**.

Upon initial evaluation, it was determined that Bacon Creek (shown in **red** on the map) does not support the swimming use required by the Clean Water Act due to high levels of *E. coli*.

The U.S. Environmental Protection Agency (EPA) requires that states conduct watershed studies on all such waters to calculate the maximum amount of pollution a creek can receive and still support a healthy watershed. This amount is known as a **Total Maximum Daily Load**, or TMDL.

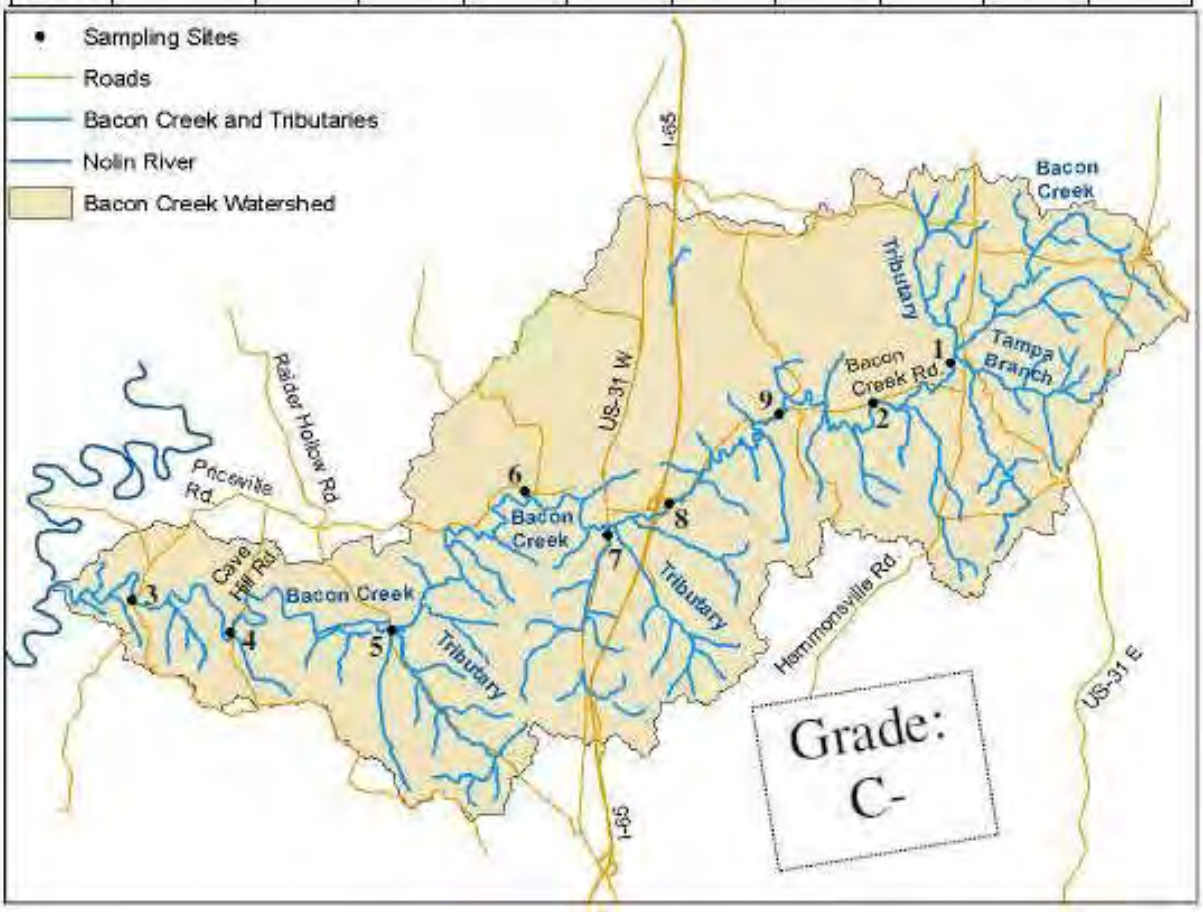
Following a year-long study by DOW biologists to gather scientific data, the division has given a "report card grade" of a C- to the watershed. This health report explains the signs of health that went into assigning that grade and provides information on how the grade can be improved.



Appendix B Figure 1: First page of KDOW TMDL Health Report for Bacon Creek.

Grades by Sampling Site & Sign

Site #	Creek Name	O_2								Site Grade
1	Bacon Creek					B	F	C	C	C
2	Bacon Creek						F	D	D	D-
3	Bacon Creek	C	C	C-	C		B	A	B	B-
4	Bacon Creek	C	C	D	B		C	B	B	C+
5	Bacon Creek	B-	C	D+	C		F	F	D	D
6	Bacon Creek	B	C	D	D		F	B	B	C
7	Tributary to Bacon Creek	B	D+	C-	F		F	D	B	D+
8	Bacon Creek	B	C	C-	C		F	D	C	C-
9	Bacon Creek	B-	C+	D	D		F	C	C	C-
Sign Grade		B-	C	D+	C-	B	D-	C	C	



Appendix B Figure 2: KDOW TMDL Health Report for Bacon Creek page 3.

Summary: Room for Improvement

POSITIVES

Dissolved oxygen (DO) levels were suitable for fish and bugs at most sites. Some lower DO grades may have resulted from high levels of turbidity, which shades aquatic plants and increases bacterial communities that consume oxygen.

NEGATIVES

Turbidity was often high, indicating that Bacon Creek's waterways tend to be "cloudy" from suspended sediment or organic matter. High turbidity can negatively affect how aquatic organisms breath and feed, which can reduce their populations.

Total habitat was reduced throughout the Bacon Creek Watershed. Total habitat is the base of the building blocks for a healthy watershed, and when it is lacking, aspects of water quality and biological health begin to degrade.

GRAY AREA

E. coli concentrations exceeded the level considered safe for swimming 50% of the time, on average. These levels may cause gastrointestinal illness if the water is swallowed or an infection if contact is made with an open sore or wound.

Specific conductivity most often scored a C, indicating elevated levels of total dissolved solids. These levels can negatively affect bug communities, thereby reducing the amount of food available for fish.

The riparian zone width varied greatly throughout the Bacon Creek Watershed. When the riparian zone is wide (grade A), streams are well shaded, banks are more stable and runoff is filtered before entering the stream. As the riparian zone width decreases, these benefits are reduced.

Available cover is greatly reduced throughout the watershed. Not only is available cover an important place for fish and bugs to live, feed, hide from predators and mate, it also provides habitat for beneficial bacteria, an important food source for aquatic bugs.

Aquatic macroinvertebrates (bugs) were only collected at site 1 where they received a B. It is difficult to make a conclusion based on one collection, therefore the bug community status in the Bacon Creek Watershed is undetermined.

What can you do?

- **Trees are the best way to protect and restore water quality and biological health.**
  - Leave in place or establish vegetation alongside streams to provide natural filters that stabilize stream banks, minimize erosion, regulate water flow, provide shade, retain sediment and absorb excess nutrients.
  - Plant trees and do not mow within 18 yards of the stream bank.
- **To keep water safe for swimming,** keep animals out of the streams, which will limit the amount of animal waste entering the waterways, reduce stream bank erosion and protect habitat.
- **To improve habitat,** allow fallen trees, logs, leaves, gravel, cobble and boulders to remain in the stream to create habitat for fish and bugs to feed, find refuge and reproduce.
- **To reduce turbidity,** maintain streamside vegetation, plant cover crops, install settling ponds and properly guard waterways during construction activities.
  - **By reducing turbidity** toxins and metals, which bind to sediment, will also be reduced.
- Keep grass clippings, petroleum products, trash, and litter out of storm drains; this material enters the stream directly without treatment.
- Service your vehicle regularly to prevent oil and antifreeze leaks and reduce noxious emissions.
- Become a certified citizen **volunteer** water quality monitor or establish a program in your local community or watershed.
- **Talk to your local legislators** about improving the health of your watershed. Stress the importance of land management as land is developed.

Where to go for more information

- **Making changes at home and work:** Bluegrass PRIDE at www.bgpride.org/gallery1.htm
- **Volunteering:** Watershed Watch in Kentucky at water.ky.gov/wsw/Pages/default.aspx or contact Jo Ann Palmer at 800-928-0045 or JoAnn.Palmer@ky.gov
- **Purchasing or planting native trees and plants**
  - Division of Forestry: forestry.ky.gov/Pages/default.aspx
  - Kentucky Native Plant Society: www.knps.org/plant_resources.html

Grants and Programs

- KY's Nonpoint Source (Runoff) Pollution program: water.ky.gov/nsp/Pages/default.aspx
- KY's Natural Resource Conservation Service: www.ky.nrcs.usda.gov/
- KY's 319 Grant program: water.ky.gov/Funding/Pages/NonpointSource.aspx or contact James Roe at 502-564-3410 or James.Roe@ky.gov
- Hinkston Creek Watershed Protection Project: http://www.hinkstoncreek.org/index.html

Appendix B Figure 3: KDOW TMDL Health Report for Bacon Creek page 4.

Bacon Creek TMDL Data

Station ID		Collection Date	Time	Temp	SpCond	pH	DO	%Sat	Turb	RP	Flow	*E. coli*	TSS
DOW030 25005	Bacon Creek 0.2 mi above confluence w/ Nolin River	17-May-07	1200	No field sheet on file								64	N/A
	off Briggs-Webb Rd.	22-May-07	1000	16.98	388.1	7.48	7.46	76.7			Backwater	23	N/A
	Lat. = 37.36043	13-Jun-07		Not sampled - Backwater									N/A
	Long. = -86.06351	26-Jun-07		Not sampled - Dry									N/A
	River Mile = 0.2	11-Jul-07		Not sampled - Backwater									N/A
	Catchment Area = 88.6	20-Jul-07		No field sheet on file									N/A
		09-Aug-07		No field sheet on file									N/A
		23-Aug-07		Field sheet not completed									N/A
		06-Sep-07		Not sampled - Dry									N/A
		26-Sep-07		Not sampled - Dry									N/A
		23-Oct-07		Not sampled - Backwater									N/A
		30-Oct-07		Not sampled - Backwater									N/A
Station ID		Collection Date	Time	Temp	SpCond	pH	DO	%Sat	Turb	RP	Flow	*E. coli*	TSS
DOW030 25006	Bacon Creek below KY728 bridge; near intersection of KY2786	17-May-07	1215	No field sheet on file								101	N/A
	Lat. = 37.35691	22-May-07	1035	16.15	395.8	7.66	8.97	90.6		43.53	6.500	101	N/A
	Long. = -86.04155	13-Jun-07	920	19.30	398.6	7.60	7.51	81.1		42.78	2.758	156	N/A
	River Mile = 2.25	26-Jun-07	900	21.85	389.0	7.80	5.68	65.8		43.12	1.823	1095	N/A
	Catchment Area = 87.5	11-Jul-07	905	23.35	348.3	7.73	5.91	69.4		42.12	2.569	888	N/A
		20-Jul-07	920	23.47	343.3	7.72	5.57	65.5		42.15	1.996	650	N/A
		09-Aug-07	845	25.45	366.0	7.62	4.34	51.8	7.31	41.60	0.529	359	N/A
		23-Aug-07	1000	25.12	377.3	7.43	4.35	53.4		42.85	0.748	85	N/A
		06-Sep-07	950	22.60	351.6	7.32	4.59	52.9			1.241	121	N/A
		26-Sep-07	915	22.27	319.2	7.22	4.64	54.2		42.86	0.507	211	N/A
		23-Oct-07	1005	16.77	255.6	6.86	10.49	107.7		41.13	9.573	>24196	N/A
		30-Oct-07	930	9.26	416.0	8.12	10.46	90.4	19.00	41.95	17.640	336	N/A
Station ID		Collection Date	Time	Temp	SpCond	pH	DO	%Sat	Turb	RP	Flow	*E. coli*	TSS
DOW030 25007	Bacon Creek below Cave Hill Rd Bridge	17-May-07		No field sheet on file									N/A

	Lat. = 37.34916	22-May-07	1120	16.07	393.4	7.66	9.51	95.8		14.83	10.619	131	N/A
	Long. = -86.01263	13-Jun-07	1000	19.29	397.4	7.64	7.72	83.4		15.73	3.144	88	N/A
	River Mile = 5.1	26-Jun-07	950	22.14	392.0	7.87	7.02	79.6	43.00	15.92	2.211	197	N/A
	Catchment Area = 83.51	11-Jul-07	950	23.32	340.5	7.68	5.70	67.0		15.09	2.115	602	N/A
		20-Jul-07	955	23.32	344.7	7.71	5.80	68.0		15.10	1.899	683	N/A
		09-Aug-07	920	25.03	381.0	7.68	3.25	39.1	7.13	14.61	0.590	187	N/A
		23-Aug-07	1040	25.07	387.1	7.47	3.88	45.5		15.66	0.658	86	N/A
		06-Sep-07	1025	23.11	364.6	7.56	6.65	77.0		15.77	0.044	156	N/A
		26-Sep-07	955	21.63	371.9	7.43	5.42	62.1		15.71	0.734	201	N/A
DUP		26-Sep-07	955									199	N/A
		23-Oct-07	1045	16.51	274.5	7.08	10.07	105.7		14.70	57.902	5794	N/A
		30-Oct-08	1015	9.47	413.0	8.08	10.29	89.3	18.40	15.17	18.363	389	N/A
Station ID		Collection Date	Time	Temp	SpCond	pH	DO	%Sat	Turb	RP	Flow	*E. coli*	TSS
DOW030 25008	UT Bacon Creek off KY1140	17-May-07	1300	No field sheet on file								147	N/A
	Lat. = 37.34823	22-May-07	1208	17.33	304.2	7.19	1.08	11.2			0.048	161	N/A
	Long. = -85.96616	13-Jun-07		Not sampled - Dry									N/A
	River Mile = 9.75	26-Jun-07		Not sampled - Dry									N/A
	UT River Mile = 0.1	11-Jul-07		Not sampled - No flow									N/A
	Catchment Area = 2.0	20-Jul-07		No field sheet on file									N/A
		09-Aug-07		No field sheet on file									N/A
		23-Aug-07		Field sheet not completed									N/A
		06-Sep-07		Not sampled - Dry									N/A
		26-Sep-07		Not sampled - Dry									N/A
		23-Oct-07		Not sampled - Backwater									N/A
		30-Oct-07		Not sampled - Dry									N/A
Station ID		Collection Date	Time	Temp	SpCond	pH	DO	%Sat	Turb	RP	Flow	*E. coli*	TSS
DOW030 25009	Bacon Creek below KY1140 bridge	17-May-07	1248	No field sheet on file								86	N/A
	Lat. = 37.34968	22-May-07	1217	16.22	397.4	7.54	9.28	93.8		15.98	24.528	84	N/A
	Long. = -85.96532	13-Jun-07	1040	No data - Hydrolab malfunction						16.93	15.194	236	N/A
	River Mile = 9.8	26-Jun-07	1030	20.89	394.0	7.86	7.41	84.2	73.00	17.22	13.549	211	N/A
	Catchment Area = 75.16	11-Jul-07	1030	22.40	361.6	7.68	6.58	75.9		16.15	13.498	305	N/A
		20-Jul-07	1030	22.31	363.8	7.68	6.56	75.1		16.38	11.647	309	N/A

		09-Aug-07	1000	24.65	381.0	7.75	5.64	67.3	5.45	15.73	7.543	213	N/A
		23-Aug-07	1115	24.03	388.1	7.52	6.40	75.7		16.76	2.002	279	N/A
DUP		23-Aug-07	1115									265	N/A
		06-Sep-07	1100	22.14	302.3	7.58	7.03	80.3		16.94	5.557	175	N/A
		26-Sep-07	1035	21.27	374.0	7.53	6.87	78.3		17.05	5.574	201	N/A
		23-Oct-07	1200	16.29	254.7	6.97	9.77	101.7		15.63	25.890	17329	N/A
		30-Oct-07	1055	10.27	419.0	7.94	10.06	88.5	21.60	16.42	22.314	546	N/A
Station ID		Collection Date	Time	Temp	SpCond	pH	DO	%Sat	Turb	RP	Flow	*E. coli*	TSS
DOW030 25010	UT Bacon Creek off KY1140	17-May-07		No field sheet on file									N/A
	Lat. = 37.35010	22-May-07		Not sampled - Dry									N/A
	Long. = -85.96562	13-Jun-07		Not sampled - No Flow									N/A
	River Mile = 9.8	26-Jun-07		Not sampled - Dry									N/A
	UT River Mile = 0.1	11-Jul-07		Not sampled - No Flow									N/A
	Catchment Area = 0.06	20-Jul-07		No field sheet on file									N/A
		09-Aug-07		No field sheet on file									N/A
		23-Aug-07		Field sheet not completed									N/A
		06-Sep-07		Not sampled - Dry									N/A
		26-Sep-07		Not sampled - Dry									N/A
		23-Oct-07	1205	17.74	204.9	6.53	7.55	79.8			2.605	24196	N/A
		30-Oct-07	1125	13.06	374.0	7.42	7.35	68.9	26.70	16.42	0.007	431	N/A
Station ID		Collection Date	Time	Temp	SpCond	pH	DO	%Sat	Turb	RP	Flow	*E. coli*	TSS
DOW030 25011	UT Bacon Creek above KY1140 bridge	17-May-07		No field sheet on file									N/A
	Lat. = 37.34947	22-May-07		Not sampled - Dry									N/A
	Long. = -85.96328	13-Jun-07		Not sampled - Dry									N/A
	River Mile = 10.0	26-Jun-07		Not sampled - Dry									N/A
	UT River Mile = 0.1	11-Jul-07		Not sampled - No Flow									N/A
	Catchment Area = 4.42	20-Jul-07		No field sheet on file									N/A
		09-Aug-07		No field sheet on file									N/A
		23-Aug-07		Field sheet not completed									N/A
		06-Sep-07		Not sampled - Dry									N/A
		26-Sep-07		Not sampled - Dry									N/A
		23-Oct-07		Not sampled - Backwater									N/A

		30-Oct-07		Not sampled - Dry									N/A
Station ID		Collection Date	Time	Temp	SpCond	pH	DO	%Sat	Turb	RP	Flow	*E. coli*	TSS
DOW030 25012	Bacon Creek off KY728; 0.2 mi east of KY1391 intersection	17-May-07	1310	No field sheet on file								150	N/A
	Lat. = 37.38318	22-May-07	1248	17.41	395.0	7.70	9.93	103.0			20.288	186	N/A
	Long. = -85.92691	13-Jun-07	1110	No data - Hydrolab malfunction							10.134	222	N/A
	River Mile = 15.2	26-Jun-07	1115	21.34	389.0	7.87	7.79	89.6	56.70		8.816	523	N/A
	UT River Mile = 0.1	11-Jul-07	1110	23.16	378.1	7.78	7.03	82.1			13.258	313	N/A
	Catchment Area = 60.05	20-Jul-07	1110	22.17	348.7	7.68	6.62	75.9			8.004	860	N/A
DUP		20-Jul-07	1110								8.226	624	N/A
		09-Aug-07	1045	25.67	386.0	7.83	6.22	72.9	7.55		5.082	241	N/A
		23-Aug-07	1150	25.67	321.8	7.65	4.91	73.4			4.941	63	N/A
		06-Sep-07	1130	23.02	376.2	7.64	7.33	85.1			4.359	295	N/A
		26-Sep-07	1110	21.73	376.6	7.57	6.95	79.8			4.506	767	N/A
		23-Oct-07	1320	16.56	237.2	6.91	9.36	102.4				9804	N/A
		30-Oct-07	1150	10.96	417.0	7.88	9.83	88.5	24.70		17.453	399	N/A
Station ID		Collection Date	Time	Temp	SpCond	pH	DO	%Sat	Turb	RP	Flow	*E. coli*	TSS
DOW030 25013	UT Bacon Creek 0.25 mi below US31W bridge; off KY728	17-May-07		No field sheet on file									N/A
	Lat. = 37.38265	22-May-07		No field sheet on file									N/A
	Long. = -85.90758	13-Jun-07		Field sheet not completed									N/A
	River Mile = 16.5	26-Jun-07		Not sampled - Dry									N/A
	UT River Mile = 0.15	11-Jul-07		Not sampled - No Flow									N/A
	Catchment Area = 9.28	20-Jul-07		No field sheet on file									N/A
		09-Aug-07		No field sheet on file									N/A
		23-Aug-07		Field sheet not completed									N/A
		06-Sep-07		Not sampled - Dry									N/A
		26-Sep-07		Not sampled - Dry									N/A
		23-Oct-07		Not sampled - No collectable H2O									N/A
		30-Oct-07		Not sampled - Dry									N/A
Station ID		Collection Date	Time	Temp	SpCond	pH	DO	%Sat	Turb	RP	Flow	*E. coli*	TSS
DOW030 25014	UT Bacon Creek off US31	17-May-07	1320	No field sheet on file								96	
	Lat. = 37.37265	22-May-07		No field sheet on file									

	Long. = -85.90265	12-Jun-07	1145	20.47	474.1	7.62	8.39	92.2	5.38		0.142	774	5.00
	River Mile = 17.5	26-Jun-07	1150	22.66	470.0	7.88	7.01	80.8	25.10		0.257	870	
	UT River Mile = 0.2	11-Jul-07	1145	22.54	468.1	7.81	7.13	82.3	6.80		0.250	1956	6.00
DUP	Catchment Area = 5.79	11-Jul-07	1145						6.91			2481	8.00
		20-Jul-07	1210	22.14	442.6	7.76	7.01	80.2			0.141	2359	
		09-Aug-07	1115	25.50	488.0	7.67	3.95	48.1	2.09		0.036	573	4.00
		23-Aug-07		Not sampled - No Flow (Pooled)									
		06-Sep-07		Not sampled - Dry									
		26-Sep-07		Not sampled - Dry									
		23-Oct-07	1345	17.21	200.3	6.90	9.03	95.2	23.40		1.236	4611	31.0 (T,X)
		30-Oct-07	1230	12.37	501.0	7.90	9.47	88.0	43.90		0.113	784	
DUP		30-Oct-07	1230								0.177	1222	
Station ID		Collection Date	Time	Temp	SpCond	pH	DO	%Sat	Turb	RP	Flow	*E. coli*	TSS
DOW030 25015	UT Bacon Creek off KY2754; 0.3 mi N of Chestnut Grove Rd	17-May-07		No field sheet on file									
	Lat. = 37.36310	22-May-07		No field sheet on file									
	Long. = -85.89092	13-Jun-07		No field sheet on file									
	River Mile = 17.6	26-Jun-07		Not sampled - Dry									
	UT River Mile = 1.05	11-Jul-07		Not sampled - No Flow									
	Catchment Area = 3.65	20-Jul-07		No field sheet on file									
		09-Aug-07		No field sheet on file									
		23-Aug-07		Field sheet not completed									
		06-Sep-07		Not sampled - Dry									
		26-Sep-07		Not sampled - Dry									
		23-Oct-07		Not sampled - No collectable H2O									
		30-Oct-07		Not sampled - Dry									
Station ID		Collection Date	Time	Temp	SpCond	pH	DO	%Sat	Turb	RP	Flow	*E. coli*	TSS
DOW030 25016	Bacon Creek below KY2754 bridge; before KY728 intersection	17-May-07		No field sheet on file									
	Lat. = 37.38037	22-May-07	1330	17.37	382.4	7.54	9.88	102.3	5.27	25.73	17.417	96	4.50
	Long. = -85.88449	13-Jun-07	1200	20.52	462.7	7.70	8.57	92.9	10.80	27.22	9.221	130	10.00
DUP	River Mile = 18.75	13-Jun-07	1200									No dup	10.00
	Catchment Area = 37.54	26-Jun-07	1210	21.90	377.0	7.81	6.97	78.5	117.00	29.27	8.895	358	

		11-Jul-07	1210	23.28	364.2	7.75	7.30	85.6	9.58	27.40	7.636	350	12.00
		20-Jul-07	1235	22.94	361.9	7.67	7.07	82.2		26.45	7.780	301	
		09-Aug-07	1145	25.36	376.0	7.74	6.51	79.5	4..81	28.73	2.536	74	6.00
		23-Aug-07	1225	24.70	375.6	7.50	6.44	76.0		27.05	4.145	63	
		06-Sep-07	1230	21.90	368.2	7.51	7.30	83.0	5.94	26.83	3.651	41	5.00
		26-Sep-07	1145	21.43	370.8	7.46	6.77	77.2		27.03	4.218	175	
		23-Oct-07	1415	16.91	225.6	7.11	9.10	95.6	125.00	25.15	19.220	24196	17.0 (T,X)
		30-Oct-07	1310	11.11	400.0	7.89	9.43	85.1	21.70	26.47	14.049	369	
Station ID		Collection Date	Time	Temp	SpCond	pH	DO	%Sat	Turb	RP	Flow	*E. coli*	TSS
DOW030 25017	Bacon Creek below KY728 bridge	17-May-07	1335	No field sheet on file								249	
	Lat. = 37.40182	22-May-07	1410	17.70	374.2	7.66	9.56	99.5		11.83	13.571	120	3.00
DUP	Long. = -85.85226	22-May-07	1410									138	3.50
	River Mile = 22.5	13-Jun-07	1245	19.29	384.3	7.47	10.01	108.8	8.55	24.97	7.598	160	4.50
	Catchment Area = 32.29	26-Jun-07	1245	21.77	372.0	7.83	7.06	79.4	310.00	25.12	5.774	321	
		11-Jul-07	1245	22.86	307.3	7.69	6.76	78.7	18.80	22.25	6.282	556	22.50
		20-Jul-07	1310	22.57	354.7	7.66	6.96	80.4			6.685	408	
		09-Aug-07	1220	25.40	367.0	7.87	6.06	73.0	4.54	23.53	3.323	331	5.00
		23-Aug-07	1300	24.86	366.1	7.59	6.47	77.0		27.82	3.693	171	
		06-Sep-07	1315	22.68	329.6	7.58	6.33	73.0	8.07	24.85	5.144	122	4.50
DUP		06-Sep-07	1315									134	6.00
		26-Sep-07	1210	21.87	360.7	7.56	6.18	70.6		25.25	3.843	657	
		23-Oct-07	1445	17.18	190.0	7.02	9.24	97.8	237.00	22.75	6.431	>24196	14.0 (T,X)
DUP		23-Oct-07	1445						200.00			>24196	12.0 (T,X)
		30-Oct-07	1345	11.43	397.0	7.87	9.46	85.8	45.20	23.51	5.965	521	

Estimated Flow
T, X = Exceeded Holding Time, Analyst Error
Discharge calculated from stage/discharge graph

Upper Green River Watershed Watch Data from 2012

Table 2.5: Upper Green River Watershed Watch 2012 results, spring sampling events (UGRWW 2013).

Site	Location	Date	Flow	Rain	Turbidity	D.O.	pH	Temp	Conductivity	Atrazine, ppb
506	North Fork Bridge in Hammonville Hart Co	5/6/2012	3	1.5	1	6.6	7.5	19	NA	0.13
544	Half mile upstream from 1140 bridge Raider Hollow bridge near Mud Branch Rd. Hart Co	5/6/2012	3	1.5	3	6.0	7.4	21	NA	0.96
548	50 meters downstream from bridge at 31W in Bonnieville at railroad trestle Hart Co	5/6/2012	3	>1.5	1.5	6.2	7.8	21.5	NA	0.4
602	Off Gaddie Cemetery Rd, off 728 Hart County	5/6/2012	3	1.5	1	5.8	7.4	20	NA	2.04
648	Route 357 at Jonesville-School Rd Hart Co	5/6/2012	3	1.5	3	5.8	6.9	21	NA	0.84
649	End of Briggs-Webb Rd. 200 meters upstream of where Bacon Creek meets Nolin River Hart Co	5/6/2012	2	>1.5	3	6.8	7.8	23	350	<0.1
655	Rt 1079 about 1 mile from Rt 357. Hart Co	5/6/2012	2	>1.5	1.5	3.8	7.5	25.5	NA	0.73
681	Gaddie Cemetery Rd, Hart Co	5/6/2012	3	1.5	1	8.4	7.4	19	NA	<0.1

Table 2.6: Upper Green River Watershed Watch 2012 results, summer sampling events (UGRWW 2013).

Site	Location	Date	Rain	Flow	Turbidity	D.O.	pH	Temp	Conductivity	*E. coli*
506	North Fork bridge, Hammonville, Hart Co	7/14/2012	>1.5	3	1	11.20	7.40	20.0	330	882
544	Half mile upstream from 1140 bridge Raider Hollow bridge near Mud Branch Rd, Hart Co	7/14/2012	1.5	3	3	9.80	7.40	24.0	340	816

548	50m downstream from bridge at 31W in Bonnieville, at RR trestle, Hart Co	7/14/2012	1.0	2	1	6.80	7.60	22.0	340	241
602	off Gaddie Cemetery Rd., off 728, Hart Co	7/14/2012	>1.5	3	2	8.60	7.40	22.0	330	481
648	Rt357 at Jonesville-School Rd S Fork of Bacon Cr., Hart Co.	7/14/2012	>1.5	2	1	7.60	7.30	23.0	290	1,178
649	End of Briggs-Webb Rd 200m upstream of where Bacon Cr meets Nolin Rv, Hart Co	7/14/2012	1.0	2	2	6.60	7.80	27.0	300	10
655	Rt1079, one mile from Rt357, Hart Co	7/14/2012	1.0	2	2	2.60	7.50	24.0	290	7,701
681	At Gaddie Cemetery Road, Hart Co.	7/14/2012	>1.5	2	0	9.80	7.30	19.0	350	1,274

Table 2.7: Upper Green River Watershed Watch 2012 results, fall sampling events (UGRWW 2013).

Site	Location	Date	Flow	Rain	Turbidity	D.O.	pH	Cond.	Temp^{0}C
506	North Fork bridg, Hammonville, Hart Co	9/15/2012	3	0.0	0	9.60	7.40		18.0
544	1/2mi upstrm from 1140 bridge Raider Hollow bridge near Mud Branch Rd, Hart Co	9/15/2012	3	0.0	2	7.40	7.40		19.0
548	50m downstream from bridge at 31W in Bonnieville, at rr trestle, Hart Co	9/14/2012	2	0.0	1	5.00	7.80	380	19.5
602	Bacon Creek Off Gaddie Cemetery Rd, off 728, Hart Co.	9/15/2012	3	0.0	0	10.00	7.40		18.0
648	Rt357 at Jonesville-School Rd S Fork of Bacon Cr., Hart Co.	9/15/2012	3	0.0	0	7.80	7.30		19.0
649	end of Briggs-Webb Rd 200m upstream of where Bacon Cr meets Nolin Rv, Hart Co	9/14/2012	2	0.0	2	9.00	8.70	240	24.0
655	Rt1079, 1mi from Rt357., Hart Co	9/14/2012	2	0.0	1	4.20	7.60	330	22.0
681	At Gaddie Cemetary Road, Hart Co.	9/15/2012	3	0.0	0	11.50	7.20		17.0

Site	Location	Date	Turbidity2	Fluoride	Chloride	Nitrite	Bromide	Nitrate	Phosphate	Sulfate

506	North Fork bridg, Hammonville, Hart Co	9/15/2012	2.40	0.10	7.93	BMDL	BMDL	9.29	BMDL	2.94
544	1/2mi upstrm from 1140 bridge Raider Hollow bridge near Mud Branch Rd, Hart Co	9/15/2012	10.60	0.07	8.44	BMDL	BMDL	4.73	BMDL	3.36
548	50m downstream from bridge at 31W in Bonnieville, at rr trestle, Hart Co	9/14/2012	4.96	0.06	5.88	BMDL	BMDL	6.17	BMDL	3.38
602	Bacon Creek Off Gaddie Cemetery Rd, off 728, Hart Co.	9/15/2012	2.65	0.10	8.05	BMDL	BMDL	8.40	BMDL	2.85
648	Rt357 at Jonesville-School Rd S Fork of Bacon Cr., Hart Co.	9/15/2012	5.56	0.10	4.76	BMDL	BMDL	2.80	BMDL	2.48
649	end of Briggs-Webb Rd 200m upstream of where Bacon Cr meets Nolin Rv, Hart Co	9/14/2012	8.15	0.22	13.30	BMDL	BMDL	0.18	BMDL	9.16
655	Rt1079, 1mi from Rt357, Hart Co	9/14/2012	5.10	0.11	6.46	0.35	BMDL	7.84	0.12	2.28
681	At Gaddie Cemetery Road, Hart	9/15/2012	2.06	0.05	3.57	BMDL	BMDL	3.00	BMDL	1.48

Notes on the data reported below from the UGRWW data manager:

1. All laboratory analyses were performed by WKU's WATERS laboratory
2. Atrazine values were obtained using immunoassay kits
3. Lab turbidity values were obtained using a turbidimeter
4. BMDL= Below Minimum Detection Limit for the analytical method used
5. MPN = Most Probable Number (of bacterial colonies)
6. NTU = Nephelometric Turbidity Units

Bacterial source tracking data (2010)

Data collected and analyzed by Western Kentucky University, Center for Water Resources with input from the KDOW Green River Basin Coordinator.

Data Explanation:
The ALL *Bacteroides* (AllBac) is a marker for all bacteriodes, regardless of source. The HUMAN *Bacteroides* (HuBac) is the subset which have human markers. Testing for this project was used to quantify AllBac and to quantify the subset of HuBac compared to the same standard.
All reactions ran in triplicate with the following controls:

- Spikes of all Bacon Creek Samples
- Concentration standards and positive control (HuBac plasmid)
- Negative controls (DI water, BoBac plasmid, *E. coli* DNA)
- Fecal spiked DI water dilution series (with known fecal content in ppm)

AllBac is proportional to the concentration of fecal matter in the water because it detects *Bacteroides* of any origin. HuBac is proportional to the contribution of human fecal contamination to the total because it detects *Bacteroides* of human origin.

- ***1Ba, 3R, and 6 consistently had the highest level of contamination from any source (AllBac).***

Ratio of *Bacteroides* that are of human origin (HuBac) divided by *Bacteroides* of any origin (AllBac) identifies the sites most impacted by human contamination.

- ***1Bb and 5 had the highest proportion of human contamination whether wet or dry.***
- ***Most samples, especially 1A and 2, showed an increase in human contamination after a rain, with a tenfold dilution of overall fecal concentration in all samples.***

Numbers reported in results may be equated to approximate concentration of mixed fecal material spiked in DI water.

- ***A reported value of 200,000 copies/5mL is approximately equivalent to 1000 ppm fecal material in the water.***

Using the HuBac/AllBac ratio eliminates any differences among different labs and among standard sets.

	Bacon Creek 2010 Sampling Results											
	4/7/2010 (Dry)			4/8/2010 (Wet)			4/15/2010 (Dry)			6/28/2010 (Wet)		
Site ID	E-Coli	HuBac	AllBac	E-Coli	HuBac	AllBac	E-Coli	HuBac	AllBac	E-Coli	HuBac	AllBac
1Ba	**15531**	4100	182000	**5172**	110	20100	**5475**	<100	188000	**3076**	<899	110991
1A	**905**	<100	19800	**3076**	925	8590	**1664**	<100	25500	**1274**	<899	22704
1Bb	203	577	8060	**355**	145	2190	120	<100	31800	**241**	4228	8282
2	86	<100	9890	**262**	196	2320	30	<100	7100	**359**	7370	7370
3R	**1396**	<100	124000	**2755**	459	19200	**2909**	<100	109000	No Sample	N.S.	N.S.
1	161	589	68200	**1250**	278	14100	146	471	51800	**1169**	23331	50199
5B	158	<100	4090	**2755**	<100	4680	73	<100	9800	**3255**	5164	8536
5A	**420**	<100	10300	**3255**	<100	11200	**327**	<100	13100	**3076**	2139	17658
5	197	1000	8080	**738**	739	7880	96	<100	6100	**583**	53253	56578
6	**256**	1220	91400	**650**	281	12200	135	<100	104000	**350**	6174	84511
F_Blank	<1			<1			<1			<10		

KEY: **256** Values of 240 or greater are bold font and represent an exceedance for grabsample

15531 Values of 2000 or greater are bold red font and represent a threat to raw drinking water supplies

	E-Coli values vs Hubac and Allbac percentages											
	4/7/2010 (Dry)			4/8/2010 (Wet)			4/15/2010 (Dry)			6/28/2010 (Wet)		
Site ID	E-Coli	HuBac	Other	E-Coli	HuBac	Other	E-Coli	HuBac	Other	E-Coli	HuBac	Other
1Ba	**15531**	2.3%	97.7%	**5172**	0.5%	99.5%	5475	N.A.	N.A.	3076	N.A.	N.A.
1A	**905**	N.A.	N.A.	**3076**	10.8%	89.2%	1664	N.A.	N.A.	1274	N.A.	N.A.
1Bb	203	7.2%	92.8%	**355**	6.6%	93.4%	120	N.A.	N.A.	241	51.1%	48.9%
2	86	N.A.	N.A.	**262**	8.4%	91.6%	30	N.A.	N.A.	359	100.0%	0.0%
3R	**1396**	N.A.	N.A.	**2755**	2.4%	97.6%	2909	N.A.	N.A.	No Sample	N.S.	N.S.
1	161	0.9%	99.1%	**1250**	2.0%	98.0%	146	0.9%	99.1%	1169	46.5%	53.5%
5B	158	N.A.	N.A.	**2755**	N.A.	N.A.	73	N.A.	N.A.	3255	60.5%	39.5%
5A	**420**	N.A.	N.A.	**3255**	N.A.	N.A.	327	N.A.	N.A.	3076	12.1%	87.9%
5	197	12.4%	87.6%	**738**	9.4%	90.6%	96	N.A.	N.A.	583	94.1%	5.9%
6	**256**	1.3%	98.7%	**650**	2.3%	97.7%	135	N.A.	N.A.	350	7.3%	92.7%

Greater than 10% human contributions highlighted in yellow

Appendix C

- KDOW Nutrient and Non-Nutrient Benchmark Recommendations
- Quality Assurance Project Plan approved by KDOW

KDOW Benchmark Recommendations for Nutrients

Bacon Creek Watershed Plan
Benchmark Recommendations for Nutrient Parameters
Kentucky Division of Water - 8/1/12

Nutrient benchmark recommendations given here represent the best information available to the Kentucky Division of Water (KDOW) at this time. The goal is to provide estimates of typical in-stream concentrations below which it is unlikely that nutrients would be a cause of aquatic life impairments. As such, benchmarks are useful in identifying sub-basins with potential nutrient issues when setting priorities for further monitoring or for developing strategies for load reductions. In making these recommendations we considered regional and watershed-specific nutrient expectations, regional-scale patterns in biological effects, and relevant published literature. These benchmarks may be different than targets to be used ultimately as management endpoints; watershed-specific characteristics, practical considerations, and insight gained from early phase monitoring might suggest alternate values for that purpose. The Watershed Group may wish to discuss with KDOW alternative benchmarks and/or targets based on more detailed local information or consultation with experts familiar with the watershed. Also, these benchmarks should be reviewed as more information becomes available on conditions in the Bacon Creek watershed, including any specific nutrient-related issues that may be observed in the course of monitoring.

A summary of candidate benchmarks follows the final set of recommendations to provide supplemental information in interpreting nutrient data.

Benchmark Screening Numbers

Total P mg/L	0.05
TKN mg/L	0.50
Nitrate+Nitrite-N mg/L	1.1
Total N mg/L	1.6

Candidate benchmarks description and summary

Ecoregional Reference Reach candidate benchmarks:
The Reference Reach network of streams represents the least-impacted conditions for aquatic life in wadeable streams in the respective ecoregions. Upper Bacon Creek and associated sub-watersheds span multiple ecoregions: 71b (Mitchell Plain), 71a (Crawford-Mammoth Cave Upland), and 72h (Caseyville Hills). The local features of the watershed also have characteristics in common with the nearby ecoregion 71e (Western Pennyroyal Karst Plain). There are no Reference Reaches in ecoregion 71b. Reference Reach data from the remaining 3 ecoregions are summarized below. There is a wide range of nutrient conditions present in Reference Reach streams in these regions, especially in terms of nitrogen.

	Eco-region	Number Samples	MIN	MED	75^{th} percentile	90^{th} percentile	MAX
TP(mg/L)	71a	67	<0.010	0.027	0.044	0.073	0.128
	72h	13	<0.010	<0.010	0.010-0.020	0.010-0.020	0.025
	71e	12	<0.01	0.0238	0.051	0.076	0.092

	Eco-region	Number Samples	MIN	MED	75th percentile	90th percentile	MAX
NN-N(mg/L)	71a	75	0.027	0.295	1.085	2.194	5.850
	72h	13	<0.010	0.066	0.084	0.179	0.240
	71e	13	2.190	4.790	5.320	5.950	6.290
TKN(mg/L)	71a	75	<0.200	0.0200-0.500	0.0200-0.500	0.517	0.900
	72h	13	<0.200	<0.200	<0.200	0.0200-0.500	0.713
	71e	13	<0.200	<0.200	<0.200	0.0200-0.500	0.0200-0.500
TN(mg/L)	71a	75	0.041-0.241	0.492-0.743	1.285-1.585	2.410-2.670	6.050-6.350
	72h	13	<0.210	0.066-0.266	0.130-0.330	0.408-0.708	0.904
	71e	13	2.190-2.390	4.800-5.060	5.320-5.520	5.950-6.150	6.290-6.490

Watershed reference candidate benchmarks:
If there are segments within the watershed or within closely comparable watersheds where uses are fully supported, then nutrient data from those streams can be summarized and used a as "watershed reference". These need not be Reference Reaches designated by KDOW, but should have been assessed as being fully supporting of the most sensitive use, in this case aquatic life, and closely comparable. KDOW does not have intensive nutrient data on any streams within the upper Bacon Creek watershed or a comparable nearby watershed that can be used as watershed reference. A single sample was collected at a site on Bacon Creek (DOW03025003) 0.5 miles downstream of the fully supporting segment (8/6/01): TP 0.029 mg/L, NN-N 1.9 mg/L, TKN <0.5 mg/L. A site on Cane Run (DOW03025004), a nearby Reference Reach also had one water sample, with TP 0.034 mg/L, NN-N 0.401 mg/L, TKN <0.5 mg/L.

Effects-based (empirical) candidate benchmarks:
The sub-watersheds fall mainly in the Pennyroyal Bioregion. The benchmarks from a KDOW draft bioregional nutrient thresholds report are TP 0.05 mg/L, TN 1.4 mg/L. However, it is noted that many streams in the Pennyroyal bioregion, especially in ecoregion 71e maintain high biological integrity despite much higher levels of TN. This point is important to consider with this watershed because of its proximity and similarity to watersheds within ecoregion 71e.

Literature-based candidate benchmarks
Literature guidelines for the boundary between oligotrophic and mesotrophic conditions are TP 0.025 mg/L and TN 0.700 mg/L. The boundary between mesotrophic and eutrophic conditions are given as TP 0.075 mg/L and 1.5 mg/L. Reference Reaches and watershed reference data summarized above place 71a Reference streams in the oligotrophic category and 71a Reference streams in the mesotrophic category.

Summary
Because of the position of the upper Bacon Creek watershed at the intersection of several ecoregions, it

is difficult to estimate the expected levels of nutrients. The final screening benchmark recommendations are based primarily on ecoregion 71a Reference Reach data and estimates of biological response thresholds for the Pennyroyal bioregion. These levels also are consistent with a mesotrophic condition. The Nitrate+Nitrite-N and Total Nitrogen benchmarks in particular should be reviewed as more data becomes available.

KDOW Benchmark Recommendations for Non-Nutrients

Bacon Creek Watershed Plan
Benchmark Recommendations for Non-Nutrient Parameters
Kentucky Division of Water - 8/1/12

Please consult water quality standards for parameters that have a numeric standard (e.g., pH, dissolved oxygen, unionized ammonia). For parameters with no numeric standard, consult the benchmark screening numbers described below. The numbers are intended as estimates of typical in-stream values in the region for streams with relatively low levels of impacts. Values above these benchmarks are not necessarily cause for concern, but a pattern of higher numbers may help to identify potential stressors or unusual conditions in the watershed.

It is important to note that benchmarks for data screening and prioritization presented here do not necessarily represent targets for water quality. If targets for reduction are to be developed for any of these parameters then those will need to be developed with consideration of the extent and magnitude of problems as well as achievability. Consult the TA for further assistance.

In addition to the final recommendations, a full ecoregion summary follows to help in interpretation of monitoring results.

Benchmark Screening Numbers

Ammonia-N (mg/L)	0.05
Sulfate (mg/L)	21
Specific Conductance (µS/cm)	443
Alkalinity (mg/L as $CaCO_3$)	199
TSS (mg/L)	7*
Turbidity (NTU)	6*

**Important qualification: For TSS and Turbidity use the benchmark screening numbers only to compare base level April-October flow conditions and not high flow events or winter samples. The reference stream data came exclusively from biology sampling visits which are conducted only during stable flow conditions during these months. New monitoring data collected for the watershed plan or a review of relevant literature will be useful in development more widely useful benchmarks and reduction targets.

Ecoregional Reference summary

In general, for non-nutrient parameters that do not have numeric standards, the 75th percentile of ecoregion reference samples provides a conservative estimate of typical values for reference conditions. Upper Bacon Creek and the associated sub-watersheds span multiple ecoregions: 71b (Mitchell Plain), 71a (Crawford-Mammoth Cave Upland), and 72h (Caseyville Hills). In addition, the local features of the watershed also have many characteristics in common with the nearby ecoregion 71e (Western Pennyroyal Karst Plain). There are no Reference Reaches in ecoregion 71b. The table below summarizes Reference Reach sample data from the remaining ecoregions. Since a large portion of the watershed lies in ecoregion 71a and this ecoregion had the greatest number of samples, the values from that ecoregion were weighted higher in deriving benchmarks for most parameters. For alkalinity and specific conductance, ranges in ecoregion 71e were considered to be better estimates because of the similarities in geology and hydrology with that region and associated influence on those parameters.

	Eco-region	Number samples	MIN	MED	**75th Percentile**	90th Percentile	MAX
Ammonia-N (mg/L)	71a	75	<0.025	0.025-0.050	0.025-0.050	0.065	0.179
	72h	13	<0.025	<0.025	0.025-0.050	0.025-0.050	0.067
	71e	13	<0.025	0.025-0.050	0.025-0.050	0.025-0.050	0.025-0.050
Unionized Ammonia (mg/L)	71a	44	<0.001	<0.001	0.001	0.002	0.004
	72h	7	<0.001	0.001	0.001	0.001	0.001
	71e	3	<0.001	<0.001	*	*	<0.001
Sulfate (mg/L)	71a	48	5.0	14.3	21.1	27.4	65.7
	72h	4	9.3	21.7	*	*	131.0
	71e	12	5.0	8.0	9.0	10.5	10.7
Specific Conductance (µS/cm)	71a	71	113	268	316	401	593
	72h	8	101	231	*	*	551
	71e	16	266	433	443	460	469
Alkalinity (mg/L as $CaCO_3$)	71a	41	34.6	113.0	132.0	162.0	206.0
	72h	7	28.0	60.0	*	*	124.0
	71e	10	138.0	191.0	199.3	205.7	212.0
TSS (mg/L)	71a	47	<1.5	4.0	6.8	13.0	20.0
	72h	4	<1.5	2.3	3.0	3.0	3.0
	71e	12	<1.5	3.5	4.5	7.8	9.0
Turbidity (NTU)	71a	35	1.7	4.0	6.1	9.3	73.0
	72h	4	0.6	1.6	*	*	7.4
	71e	8	0.5	2.0	*	*	4.5

* 75th and 90th percentiles are not given for ecoregions with less than 10 samples for a parameter

Quality Assurance Project Plan (QAPP) approved by KDOW

Provided on disc to save paper.

Appendix D: NRCS Resource Management System Planning Tool Information for BMP selection

http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/technical/econ/data/?cid =nrcs143_009740

Effects Quantification

Substantial Improvement	5
Mod to Substantial Improvement	4
Moderate Improvement	3
Slight to Substantial Improvement	3
Slight to Mod Improvement	2
Slight Improvement	1
Not Applicable	0
Neutral	0
Slight Worsening	-1
Slight to Mod Worsening	-2
Moderate Worsening	-3
Slight to Substantial Worsening	-3
Mod to Substantial Worsening	-4
Substantial Worsening	-5

RMS Options Worksheet

Practices / Concerns	Water Quality – Harmful Levels of Pesticides in Surface Water	Water Quality – Harmful Levels of Pathogens in Surface Water	Water Quality – Excessive Suspended Sediment and Turbidity in Surface Water	Water Quality – Excessive Nutrients and Organics in Surface Water
Wetland Restoration (Ac.) 657	1	1	3	1
Wetland Enhancement (Ac.) 659	1	1	3	1
Wetland Creation (Ac.) 658	1	1	3	1
Watering Facility (No.) 614			4	4
Water & Sediment Control Basin (No.) 638	3	1	3	3
Wastewater Treatment Strip (Ac.) 635		4	2	4
Waste Utilization (Ac.) 633	2	3	2	3
Waste Treatment Lagoon (No.) 359		4		4
Waste Treatment (No.) 629		3		4
Waste Storage Facility (No.) 313		3		4
Vegetative Barrier (Ft.) 601	2		3	2
Underground Outlet (Ft.) 620	3	3	1	3
Surface Roughening (Ac.) 609			3	3
Stream Crossing (578)		-3	3	-1
Solid/Liquid Waste Separation Facility (632)		2		3
Sediment Basin (No.) 350	3	1	3	3
Row Arrangement (Ac.) 557	-1	-1	-1	3
Riparian Herbaceous Cover (Ac.) 390	3	3	4	4

Residue Management, Seasonal	2	1	3	3
Residue Management, No-Till/Strip Till/Direct Seed (Ac.) 329	3	1	3	3
Residue and Tillage Management, Mulch Till (Ac.) 345	2	1	3	3
Prescribed Grazing (Ac.) 528	2	1	3	3
Precision Land Forming (Ac.) 462			3	
Pipeline (Ft.) 516		3	3	
Pest Management (Ac.) 595	3			
Nutrient Management (Ac.) 590				5
Manure Transfer (No.) 634		3		3
Lined Waterway or Outlet (Ft.) 468			3	
Land Reclamation, Toxic Discharge Control	3	3		3
Irrigation Water Management (Ac.) 449	3	3	3	3
Irrigation Water Conveyance, Pipeline	3	2	4	3
Irrigation Water Conveyance, Ditch and Canal Lining (Ft.) 428	2	2	3	2
Irrigation System, Tailwater Recovery 447	3	3	3	3
Irrigation Storage Reservoir	3	3	3	3
Irrigation Regulating Reservoir (No.) 552	3	3	3	3
Heavy Use Area Protection (Ac.) 561		3	3	3
Grazing Land Mechanical Treatment 548	2	3	2	2
Grassed Waterway (Ac.) 412	2		4	2
Grade Stabilization Structure (No.) 410			3	
Forage Harvest Management (Ac.) 511	2	1	3	3
Filter Strip (Ac.) 393	3	2	4	4
Feed Management (No.) 592				3
Drainage Water Management (Ac.) 554	3	3	3	3
Diversion (Ft.) 362	3	1	3	3
Dam, Diversion (No.) 348	3	-2	3	3
Dam (No.) 402	3	-2	3	3
Critical Area Planting (Ac.) 342	3	3	1	3
Contour Orchard and Other Fruit Area	2	1	3	3
Contour Farming (Ac.) 330	2	1	3	3
Contour Buffer Strips (Ac.) 332	3	1	3	3
Constructed Wetland (Ac.) 656	3	3	2	3
Conservation Cover (Ac.) 327	3	1	3	3
Closure of Waste Impoundments		3	3	3
Channel Stabilization (Ft.) 584			4	
Anionic Polyacrylamide (PAM) Erosion Control (Ac.) 450			4	
Animal Trails and Walkways (Ac.) 575		3	3	3
Animal Mortality Facility (No.) 316		3		3
Anaerobic Digester, Controlled Temperature (No.) 366		3		3
Anaerobic Digester, Ambient Temperature		3		3
Amendments for the Treatment of Agricultural Waste (No.) 591		2		3
Alley Cropping (Ac.) 311	3	2	2	2
Agrichemical Handling Facility (No.) 702	5			5

**worksheet "cropland" and "pastureland" selected for land use category*