Darby Creek Watershed Plan

May 2016

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Kentucky Waterways Alliance

Photo of Darby Creek by Debbie Bergman

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Figures and Tables:

Chapter 1 Introduction

The Darby Creek Watershed Plan outlines point and nonpoint pollution sources in the watershed, discusses pollution coming from various sources, and makes recommendations for Best Management Practices (BMPs) to improve and protect water quality in Darby Creek.

1.1 The Watershed

The Darby Creek Watershed is a 6,017 acre area located in Oldham County, Kentucky (Figure 1.1). Darby Creek is a tributary of Harrods Creek and is located in the Salt River Basin.

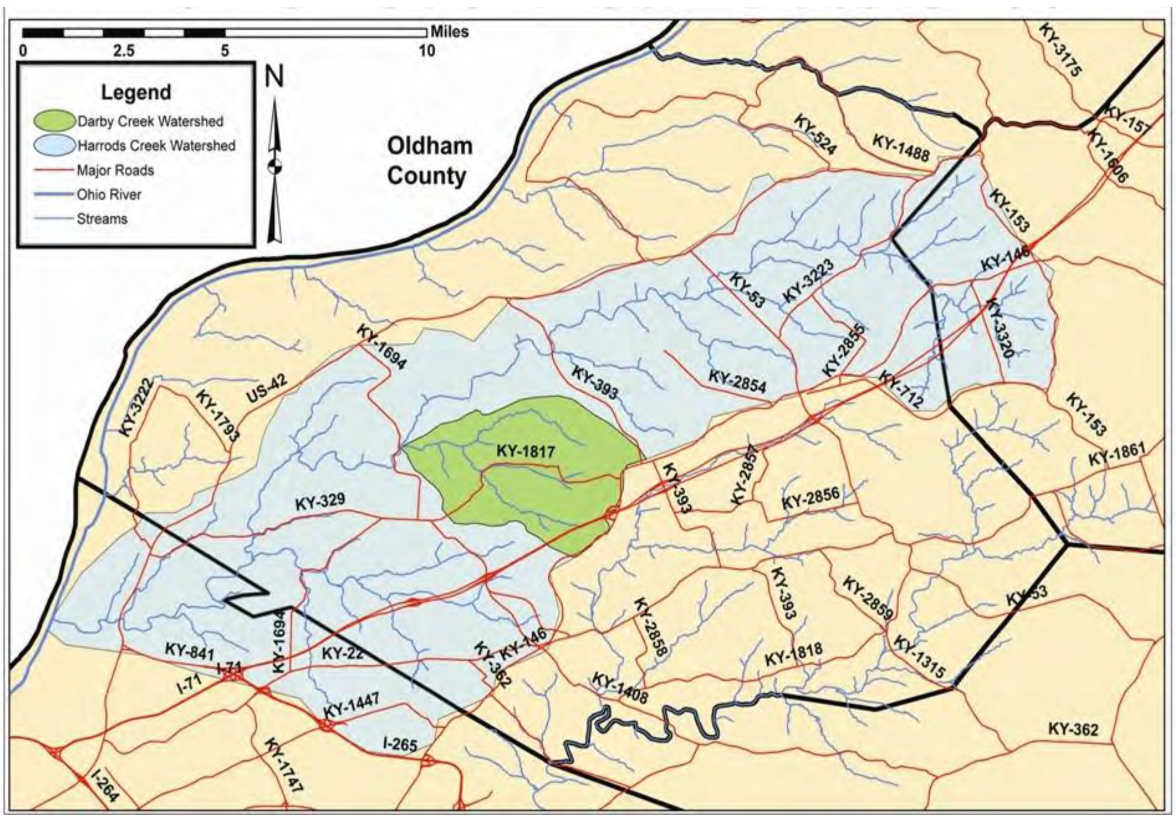

Figure 1.1: Location of the Darby Creek Watershed (Oldham County Office of Planning and Zoning).

1.2 Goals

The Darby Creek Watershed Planning Team worked with the community to create a plan that raises awareness of watershed issues, promotes healthy streams, and protects the watershed for the future.

Specific goals for the Darby Creek Watershed Plan include:

Goal #1: Protect high quality areas of the creek and decrease water pollution in impaired areas.

Goal #2: Increase wildlife, fish, and aquatic life in the watershed and stream.

Goal #3: Work with local governments to enforce current regulations and to create codes and ordinances that work to protect and restore the streams and the watershed.

Goal #4: Educate the public about watershed issues.

These goals have been refined and added to as the planning process progressed and more data on water quality were collected.

1.3 Partners and Stakeholders

The watershed planning effort was funded in part by a grant from the U.S. Environmental Protection Agency under 319(h) of the Clean Water Act through the Kentucky Division of Water to the Kentucky Waterways Alliance.

The Darby Creek Watershed Planning Team was formed in the fall of 2007. The planning team is made up of partners and stakeholders who will work with the plan's sponsor, the Kentucky Waterways Alliance, to draft the Darby Creek Watershed Plan. Beth Stuber, the Oldham County Engineer, serves as the group's facilitator.

The Darby Creek Watershed Planning Team held its first Roundtable in February 2008 to draw more stakeholders into the watershed planning process, increase the public visibility, educate the public on issues facing the Darby Creek Watershed, and to gain stakeholders' input for the planning process. A Roundtable Report is attached as Appendix A.

Professor Tony Arnold's Land Use and Planning Law Class at the University of Louisville, Louis D. Brandeis School of Law completed a project that reviewed Oldham County's codes and ordinances as related to water quality in spring 2008. The report from this project, which is an academic project and not meant to serve as legal advice or representation, can be found on the Kentucky Waterways Alliance's website:
http://www.kwalliance.org/Portals/3/pdf/darby_creek_codes_and_ordinances.pdf

Partners on the Darby Creek Planning Team include:

- Brownsboro Conservation Council
- Kentucky Division of Water
- Natural Resources Conservation Service and Oldham County Soil and Water Conservation District, Kurt Mason
- Oldham Ahead, Doug Wampler
- Oldham County Fiscal Court, Magistrate Rick Rash
- Oldham County Government, Beth Stuber
- Oldham County Planning and Zoning, Emily Liu
- Oldham County Health Department, Todd Lafollette
- Oldham County Sewer District, Vince Bowlin
- Oldham County Cooperative Extension Service, Traci Missun

The Darby Creek Watershed Planning Team is also made up of many dedicated residents of the Darby and Harrods Creek watersheds. Several members of the planning team have also been active in the creation of the Brownsboro Master Plan, an effort led by Oldham County Planning and Zoning. Several members have also been very active in the Licking River Watershed Watch program.

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Chapter 2 Watershed Information

This chapter will serve to describe existing data to further delineate Darby Creek's attributes and water quality.

2.1 Water Resources

The Darby Creek Watershed is a 9.4 square mile (6,017 acre) area located in Oldham County, Kentucky (Figure 2.1). The communities of Brownsboro, Buckner, and Demplytown are located within its boundaries. Darby Creek is a tributary of Harrods Creek and is located in the Salt River Basin. While much of the watershed remains forested, there is continuing residential and commercial development focused around Buckner. Highway I-71 cuts across the southeastern section of the watershed. A larger aerial photograph marked with watershed boundaries, significant tributaries, and area water bodies can be found in Figure 2.2.

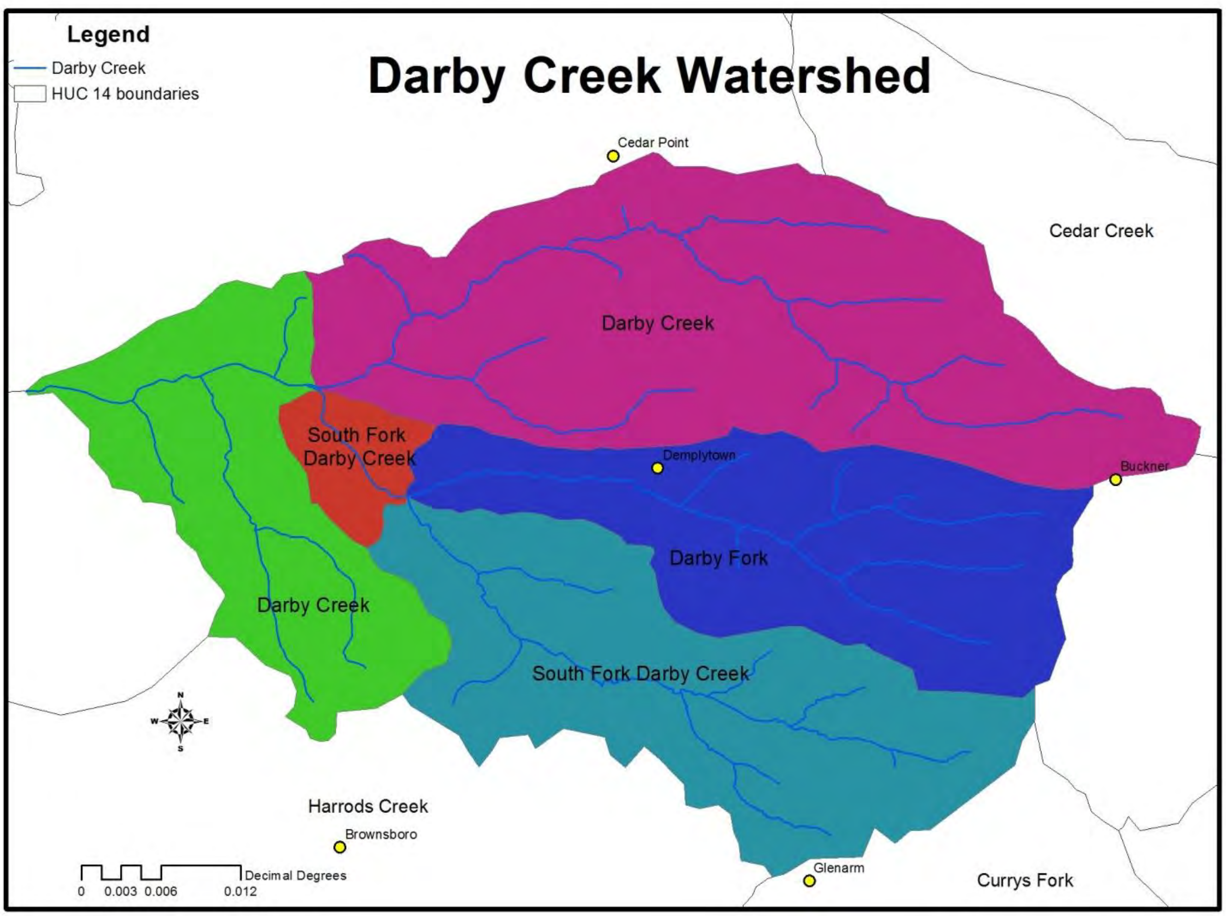

Figure 2.1: Darby Creek Watershed.

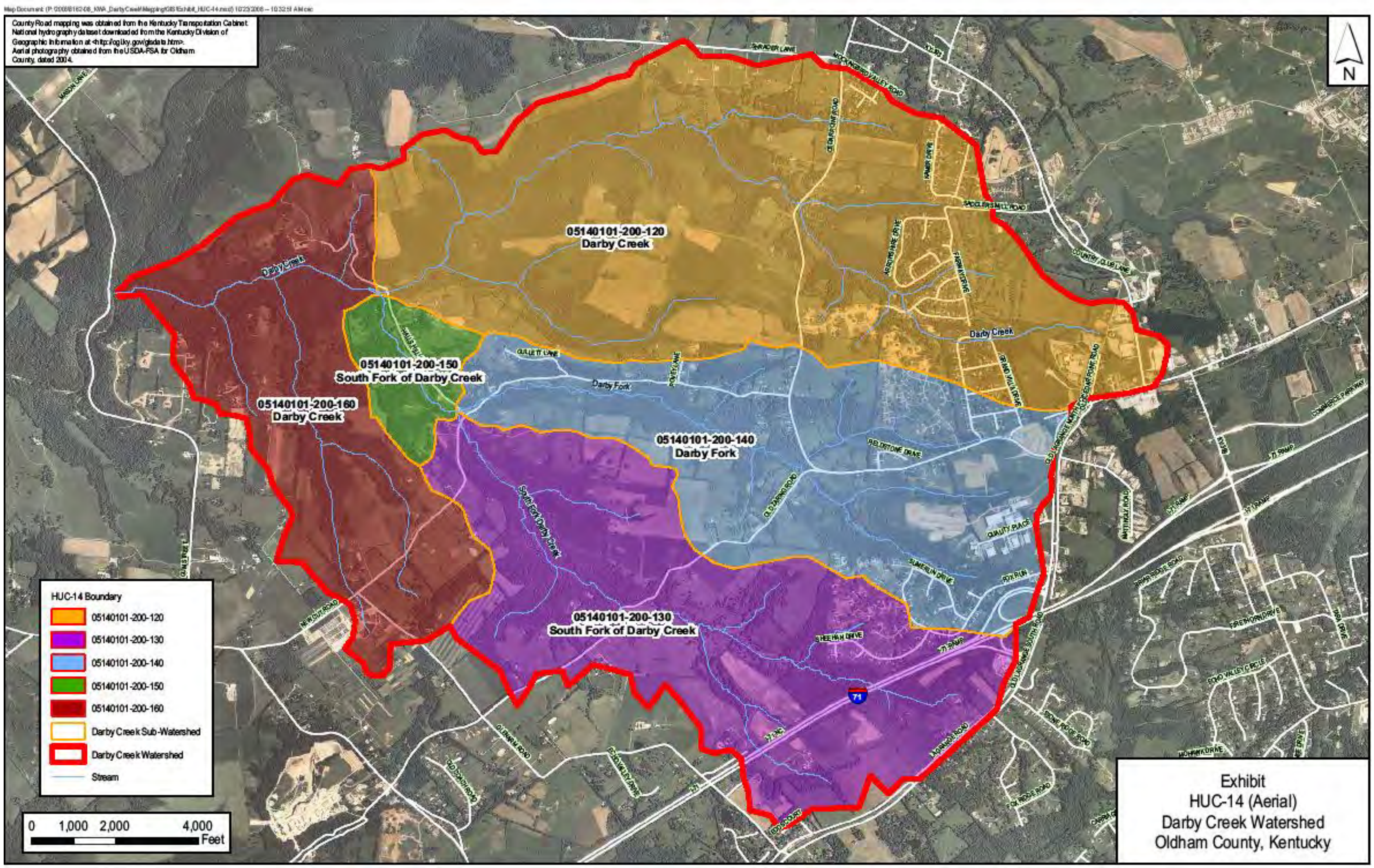

Figure 2.2: Darby Creek Watershed within the Harrods Creek Watershed, Oldham County, Kentucky (Third Rock Consulting, 2008).

The US Geologic Service developed a standardized Hydrologic Unit Coding System to organize watershed boundaries by size. The more digits in the HUC number, the smaller the watershed. As depicted in the previous figures, the Darby Creek Watershed is made up of five small sub-watersheds; each described by a 14 digit Hydrologic Unit Code (referred to as a HUC-14). This code includes a two digit number at the end of the sequence that uniquely identifies each sub-watershed (20, 30, 40, 50, 60) along with other identical precluding numbers that essentially act as an address; providing information about the region, sub-region, basin and sub-basin. Other watersheds comparable in size will also have a 14-digit number while larger watersheds have smaller HUC numbers, showing that they cover a larger area. Darby Creek is a HUC-14 while the larger Harrods Creek watershed is a HUC-12. Throughout the watershed plan, the Darby HUC-14s will be referred to with their names and/or last three digits where names overlap. Table 2.1 further details the HUC-14s along with the size of each sub-watershed of concern.

Table 2.1: Sub-watershed Information.

Watershed Name	HUC-14	Acres	Square Miles
Darby Creek	05140101200120	2,434.98	3.805
South Fork Darby Creek	05140101200130	1,585.38	2.477
Darby Fork	05140101200140	1,386.04	2.166
South Fork Darby Creek	05140101200150	193.1	0.302
Darby Creek	05140101200160	1,070.52	1.673

2.1.1 Hydrology

Stream/drainage network

According to a USDA NRCS Study referred to in the Oldham County Sewer District Facilities Plan, Darby Creek is a high gradient stream serving as one of five major tributaries of Harrods Creek. The study identifies Harrods Creek and its major tributaries below Highway 393 as valley forming with narrow floodplains and steep cliffs surrounding them. These cliffs open to gently rolling broad higher lands (Oldham County Sewer District [OCSD], 2007).

The headwaters of Darby Creek, Darby Fork, and South Fork Darby Creek are located in the eastern section of the watershed, which is the most developed area. Darby Fork drains into South Fork Darby Creek, which then drains into Darby Creek. Darby Creek drains into Harrods Creek, which then flows into the Ohio River. There are a number of artificial ponds in the Darby Creek Watershed, the largest being Lake Lotawata.

Stream Flow

Stream flow measures the cubic feet per second (cfs) of water traveling through a stream at any given point in time. The flow rate increases as velocity and volume increase. Rates can be affected by season, weather, and water withdrawals/discharges. Stream flow directly determines what types of plants and organisms are able to flourish in the area. Flow rate also has direct impacts on erosion, sediment/pollutant transport, turbidity and dissolved oxygen levels.

Stream flow (also called discharge) measures the amount of water traveling through a stream in cubic feet per second (cfs). The USGS has gaging stations that record these data year-round on many streams throughout the country. There are no USGS gaging stations in the project study area. Current stream conditions can be viewed for nearby areas on a USGS website (http://waterdata.usgs.gov/ky/nwis/nwis).

Various stream flow levels are estimated for all streams in Kentucky based on historical data from nearby gaging stations and can be viewed at the Kentucky Watershed Viewer (http://gis.gapsky.org/watershed/).

The modeled mean annual flow from the KY Watershed Viewer immediately above Darby's confluence with Harrods Creek is 12.3 cfs. Data points were chosen at various river divergences throughout the watershed to provide an idea of modeled average flow, low flow, and high flow conditions (Kentucky Watershed Viewer, 2015). The results can be viewed in Table 2.2, with Figure 2.3 depicting the calculated divergence flow.

In hydrology terms, "7Q10" is the lowest average flow that occurs for 7 days every 10 years, and "Q2" and "Q100" represent the 2 and 100 year recurrence flood events, respectively. A 2 year recurrence interval describes an event that has a 50% probability of happening in any given year. A 100 year recurrence interval describes an event that has a 1% probability of happening in any given year (USGS, 2014). Although the 2 year flood is a far more common event, 100 year floods are used by FEMA to identify Special Flood Hazard Areas (SFHA) which affects building permits, flood insurance and environmental regulations (FEMA, 2014).

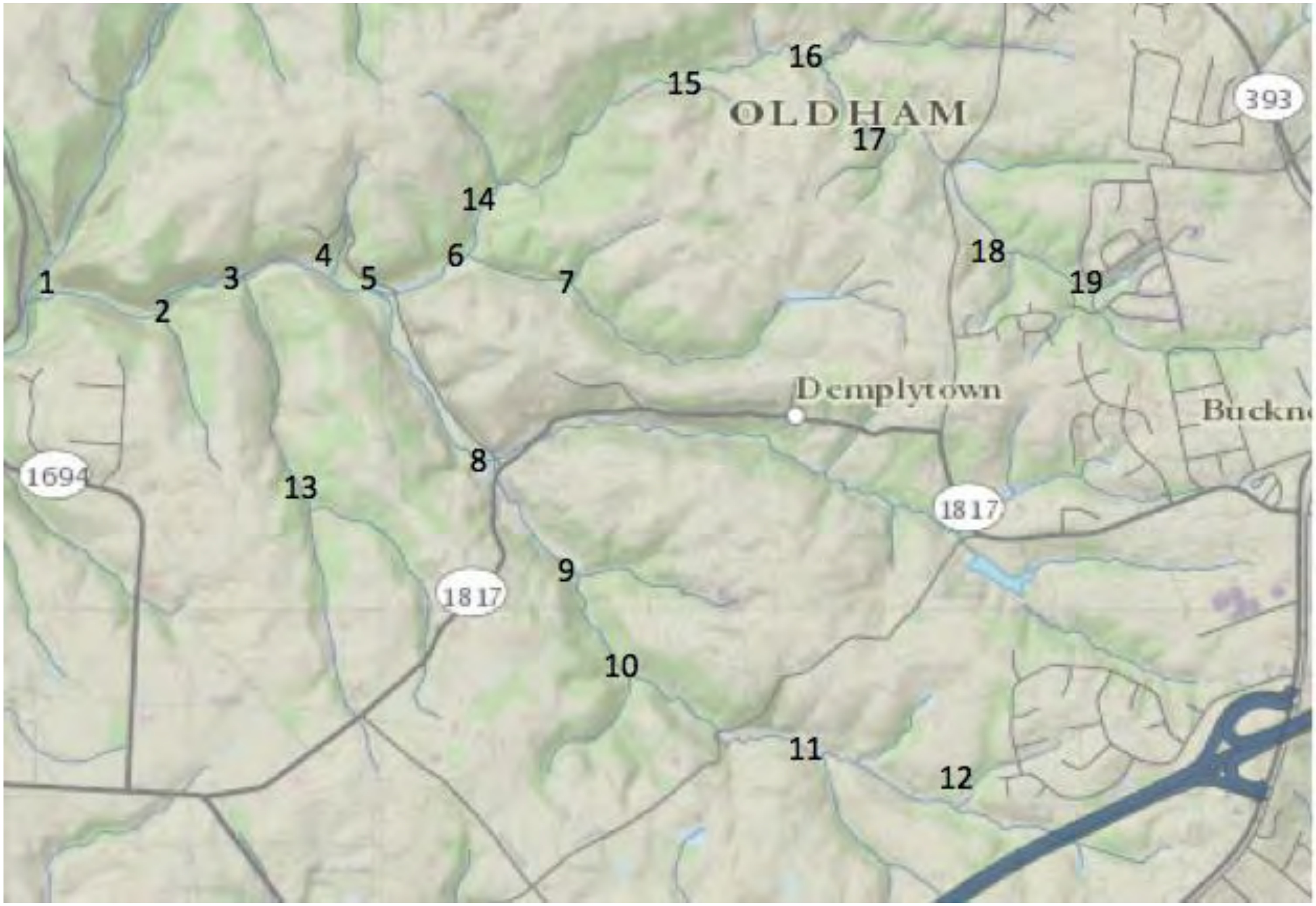

Figure 2.3: Sites where projected flow was calculated (Kentucky Watershed Viewer, 2015).

Table 2.2: Modeled mean annual flow, 2 year flood, and 100 year flood for various locations throughout Darby Creek from the KY Watershed Viewer (Kentucky Watershed Viewer, 2015).

Location	Length (Km)	Square Miles	Q2 (cfs)	Q100 (cfs)	Mean annual flow (cfs)
1: Darby Creek (mouth)	0.762	10.44	1512.66	4561.59	12.3
2: Darby Creek	0.558	10.12	1481.29	4473.69	11.9
3: Darby Creek	0.534	9	1368.86	4157.48	10.6
4: Darby Creek	0.226	8.78	1346.25	4090.75	10.4
5: Darby Creek	0.525	3.76	760.77	2409.47	4.5
6: Darby Creek	0.59	0.76	259.38	887.03	0.9
7: Darby Creek	1.512	0.42	174.02	612.29	0.5
8: South Fork	1.201	4.93	912.94	2854.02	5.9
9: South Fork	0.371	2.4	562.39	1819.95	2.8
10: South Fork	0.457	1.95	489.04	1598.45	2.4
11: South Fork	1.424	1.35	381.83	1270.24	1.6
12: South Fork	0.64	0.69	243.05	835.04	0.8
13: Darby Fork	1.728	2.04	504.12	1644.17	2.4
14: Darby Creek upper	0.48	2.85	631.34	2026.31	3.4
15: Darby Creek upper	1.167	2.42	595.05	1917.91	3.2
16: Darby Creek upper	0.426	2.01	499.12	1629.02	2.5
17: Darby Creek upper	0.614	1.58	424.47	1401.49	1.9
18: Darby Creek upper	0.623	1.03	318.27	1072.63	1.3
19: Darby Creek upper	1.242	0.5	198.31	691.29	0.6

*Note: The 7Q10 was zero for each site and is not depicted above.

Climate and Precipitation

Kentucky's climate is characterized by hot and humid summers while winters are mild and cool. Figure 2.3 shows the average monthly minimum, maximum, and average temperatures from 1981-2010 for a Louisville area weather station (located in a county near the watershed of concern). The monthly average temperature ranges from 26.8° F (January) to 88.7° F (July). Annual precipitation averages 44.91 inches (monthly averages are depicted in Figure 2.4). Average monthly rainfall is highest in May with 5.27 inches and is lowest in September with 3.05 inches (SERCC, 2015).

Data specific to Oldham County is available from 2011 through 2014 through Kentucky Mesonet and is depicted in Table 2.3. This information is sourced directly from LaGrange in Oldham County and generally provides the most accurate portrayal of the area of concern. It may be worthwhile to note that two abnormally large precipitation events occurred in April (one in 2011 and one in 2014) which drives the average higher than it would otherwise be. With these events discounted, in general, Oldham County also experiences the largest rainfall amounts in May as well (Kentucky Mesonet, 2015).

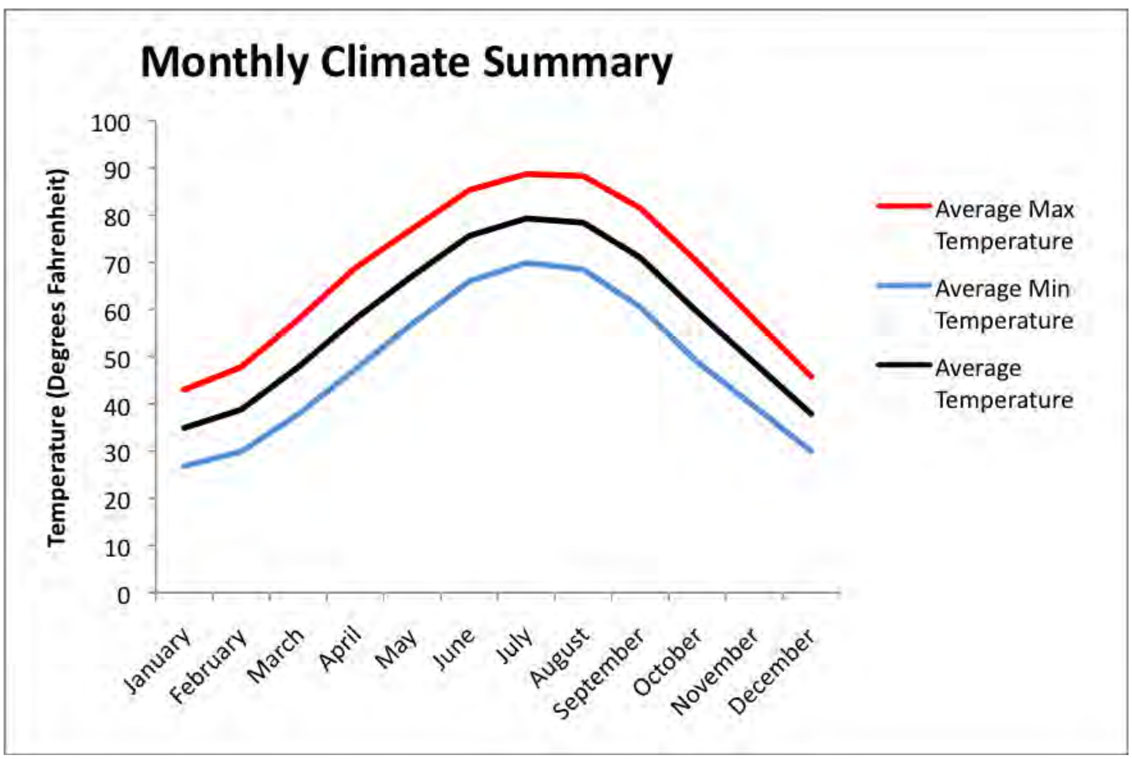

Figure 2.4: Monthly Climate Averages from 1981-2010 for Louisville area weather stations (SERCC, 2015).

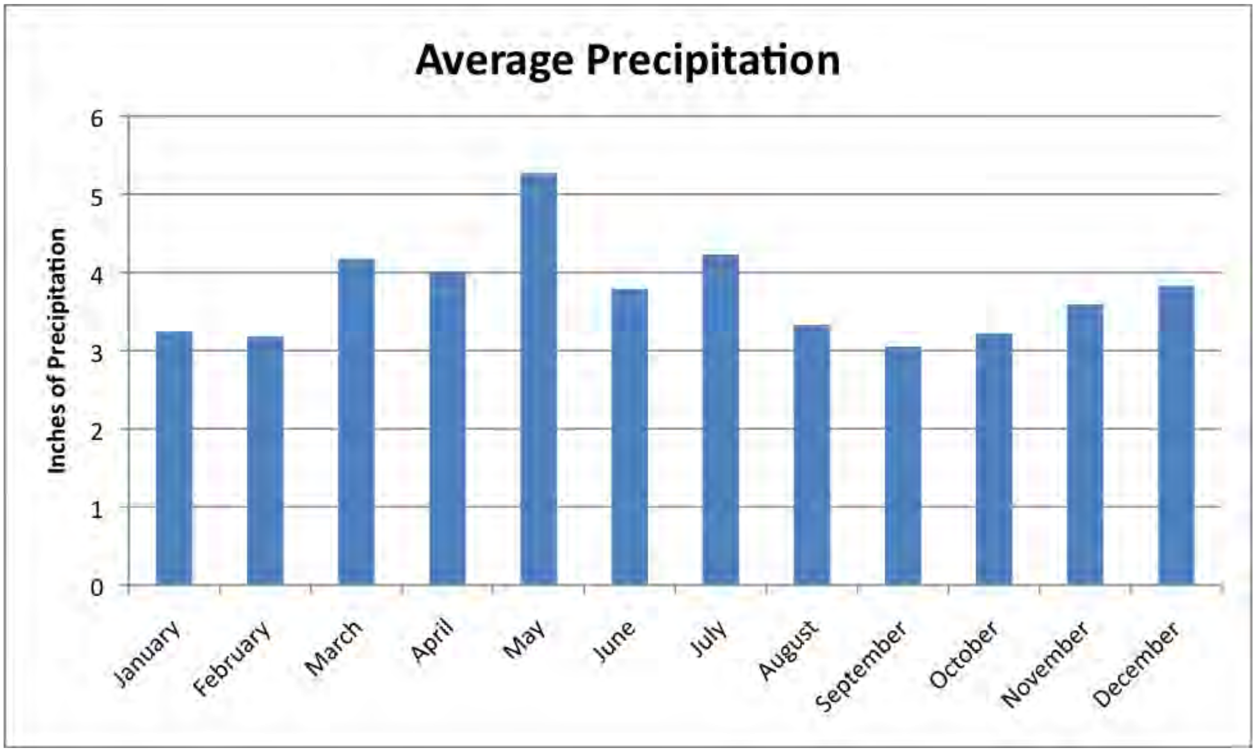

Figure 2.5: Average precipitation from 1981 to 2010 obtained from Louisville area weather stations (SERCC, 2015).

Table 2.3: Average precipitation and Temperature for Oldham County from 2011-2014 (Kentucky Mesonet, 2015).

Month	***Average Precipitation (in)***	***Average Temperature (F)***
January	3.32	31.7
February	2.89	35.95
March	3.97	45.58
April	8	56.65
May	5.48	66
June	3.23	73.13
July	3.06	76.53
August	2.59	75.08
September	4.4	67.2
October	4.51	55.98
November	3.04	43.93
December	5.53	39.45

2.1.2 Groundwater-Surface Interaction

Oldham County has moderate changes in elevation, ranging from 430 feet at the Ohio River to 900 feet in other sections. Rocky outcroppings are dispersed throughout the county. Karst areas are defined by topography that has numerous sinkholes, sinking streams, caves, and springs. The underlying rock in these areas is usually limestone (occasionally calcareous shale), which fractures as water runs over and through it for hundreds of thousands of years. Sinkholes and caves are created from the gradual degradation of rock by acids in rain and groundwater (Currens, 2002). Third Rock Consulting has delineated general karst areas in Figure 2.6, although karst topography has not been mapped in detail in the Darby Creek Watershed. According to this map, the area is full of moderate and major karst, indicating that there is the capacity for a great deal of surface-groundwater interaction. This interaction means that surface pollutants (like oil dripping in a driveway) can easily end up in groundwater.

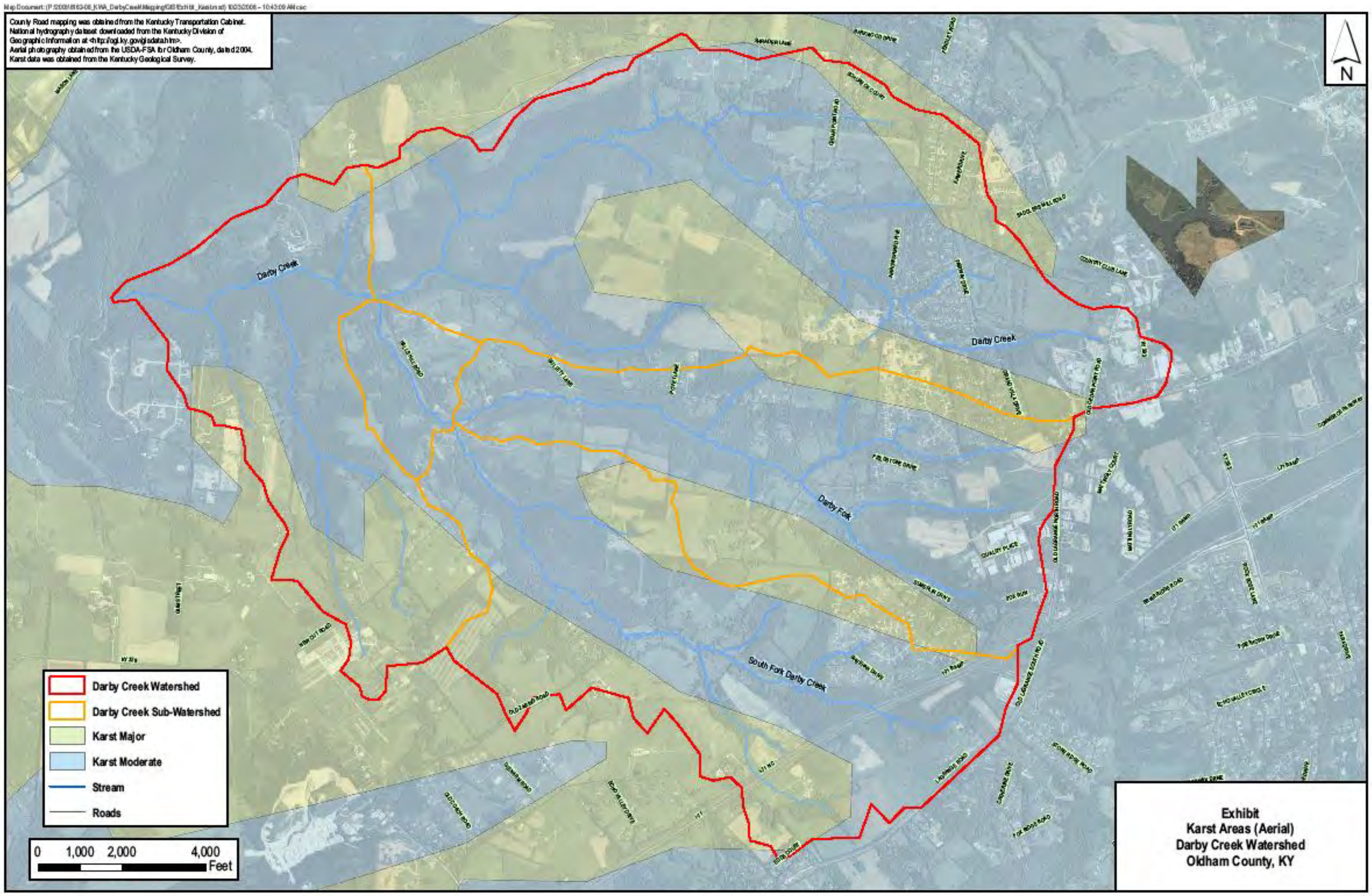

Figure 2.6: Map showing major and moderate karst areas in the Darby Creek Watershed (Third Rock Consulting, 2008).

2.1.3 Flooding

Flooding is a natural phenomenon. The area immediately surrounding a waterway is prone to flooding and is defined as the "floodplain." When portions of floodplains are preserved in a natural and vegetated state, they provide many benefits including aesthetic value, reduction in number/severity of floods, help in handling storm water runoff, and the ability to minimize non-point source water pollution. By allowing floodwater to slow down, the sediments settle out and water quality is better maintained. The natural vegetation filters out impurities and uses excess nutrients (such as Nitrogen) that would otherwise be detrimental to the stream.

Also affecting that rate and frequency of flooding is the amount of impervious surface (a surface that does not permit passage or infiltration) in a community. If a woodlot is converted into a shopping center, for example, all the rain that would have infiltrated into the soil or been taken up by the vegetation will now run off the roof and parking lot into area streams. This swells the waterway downstream even more and carries pollutants from the land into the water. With more development and impervious surfaces, there is more and more run-off and flooding. This is something that is happening in communities across the U.S. Storm water runoff is considered a nonpoint source of pollution. Since Oldham County is continually expected to experience increasing development, mitigating this effect will be critical in maintaining water quality.

There have only been a few flooding and surface water drainage issues in the Darby Creek Watershed in recent history. Heather Hills Subdivision was developed over 20 years ago on a site with a drainage swale through the middle of what is now the subdivision. Homes were built within the former drainage swale area and surface water still seeks that path. While there have been several reports of damage to property by surface water runoff, there is only one report of flooding. There have also been reports of poor drainage in the Kamer Place Subdivision, but they appear to be related to poor design and grading. Figure 2.7 shows the floodplain in the Darby Creek Watershed.

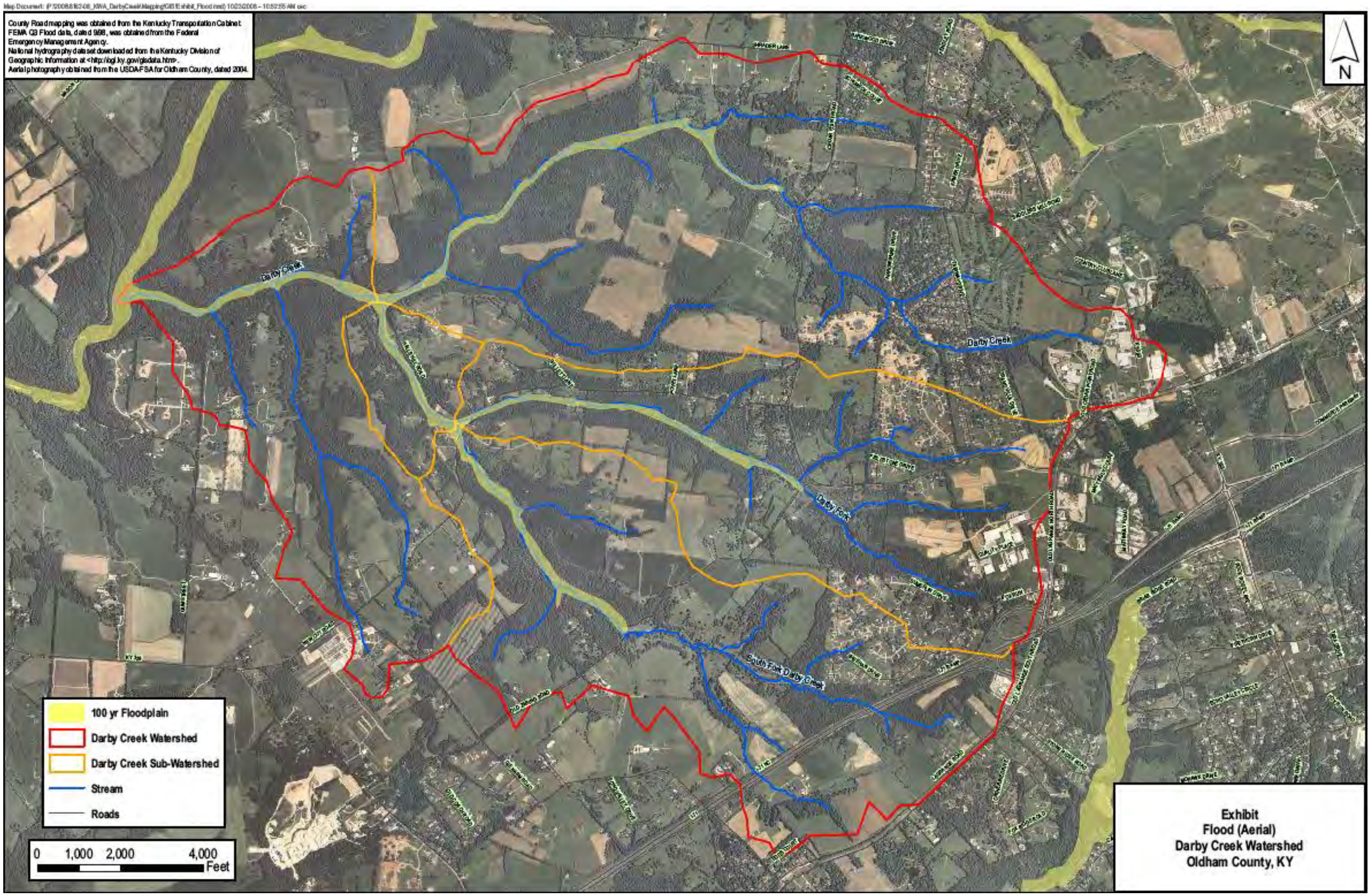

Figure 2.7: Floodplain in Darby Creek Watershed (Third Rock Consulting, 2008).

2.1.4 Water Supply

In Kentucky, the water withdrawal program, administered by the Kentucky Division of Water (KDOW), regulates all withdrawals of water greater than 10,000 gallons per day from any surface, spring, or groundwater source with the exception of water required for domestic purposes, agricultural withdrawals including irrigation, steam-powered electrical generated plants regulated by the Kentucky Public Service Commission, or injection underground as part of operation for the production of oil and gas.

Currently, according to the Water Quantity Section of KDOW, there are no permits for water withdrawals in any of the five HUC-14s that make up the Darby Creek Watershed. There may, however, be water withdrawals that do not have to be regulated, such as water used for irrigation or agricultural purposes.

2.1.5 Watershed Management Activities

Source Water Protection Plans, Wellhead Protection Program, Groundwater Protection Plans
Source Water Protection Plans are required under the Safe Drinking Water Act to assess the quantity of water used in a public water system and to formulate protection plans for the source waters used by these systems.

According to KDOW Drinking Water section's online "Drinking Water Watch" database, both LaGrange Utilities and Oldham County Water District draw their drinking water from groundwater sources (which are not located in the Darby Creek Watershed). As there are no drinking water utilities in Oldham County that obtain drinking water from surface water sources, there are no Source Water Protection Plans for the Darby Creek Watershed.

Wellhead Protection Plans are used to assist communities that rely on groundwater as their public water source. According to the Wellhead Protection Program of KDOW, there are no Wellhead Protection plans in the Darby Creek Watershed. Oldham County's main drinking water supply comes from groundwater along the Ohio River, but these wells are not located within the Darby Creek Watershed.

Groundwater Protection Plans (GPPs) are required for anyone engaged in activities that have the potential to pollute groundwater. These activities include anything that could leach into the ground, including septic systems and pesticide storage. The law requires that these facilities have a GPP, but does not monitor this requirement. GPPs are required to be recertified every three years and must be updated if activities are changed. KDOW retains the plans indefinitely. According to the Groundwater Branch of KDOW, there were two GPPs on file for facilities in the Darby Creek Watershed. It is not known if there are other facilities in the watershed that need GPPs. Because the GPP regulations are self-guided, it can be difficult to know if all facilities are in compliance. The Darby Creek Watershed Team recommendations include public education and outreach on groundwater protection issues.

No watershed plans have been developed for Darby Creek in the past. There are, however, other watershed plans being created in the county. These plans have the potential to affect all of Oldham County, and planning will be coordinated with these projects if possible.

Wastewater Authorities

The Oldham County Environmental Authority (OCEA) (formerly known as the Oldham County Sewer District) was first established in 1996 and is currently the wastewater authority for the watershed. Prior to this, onsite septic tanks were constructed for residential/commercial buildings along with small packaging plants. The OCEA defined a goal to reduce the number of packaging plants in the county and reduce the number of on-site disposal systems by transitioning to regional facilities that consistently follow regulatory standards. In 2000, they borrowed $4 million to update existing packaging plants and construct the Buckner WWTP. This plant became operational in 2001, eliminating the need for two packaging plants. In 2005, the OCEA obtained funding to construct the Ohio River Regional Wastewater Treatment Plant, which served to further eliminate existing packaging plants. The OCEA more recently invested $1 million in the Kentucky State Reformatory (KSR) WWTP, allowing the Buckner and Buckner Industrial Tract WWTPs to be decommissioned in 2013. New sewer lines were built from these plants to KSR, allowing for all wastewater to be re-routed. Currently, KSR is the largest WWTP in the service area, servicing the city of Buckner, which is expected to experience a large population increase. Based on 2010 Census data, the OCEA estimated that this plant serves largest population in the area, covering 15,580 people and 5,880 households. The Darby Creek Watershed falls within the area covered by the KSR plant (OCEA, 2013).

According to the June 2007 OCSD Draft Facilities Plan, there were 24 private, municipal, or public permitted wastewater treatment plants in Oldham county, serving a relatively small portion of the population. Most wastewater is still received by onsite residential treatment systems, which the OCEA acknowledges result in stream/groundwater pollution due to malfunctions. It is pointed out that the soil type/depth in the area is generally not optimal for on-site disposal systems. OCEA points to these on site disposal systems as a likely cause of stream water quality impairment in surrounding creeks (such as Floyds Fork and Harrods Creek). In general, the Facilities Plan defined these plants as nearing the end of their useful life and/or operating at full capacity. Since 2007, the number of permitted WWTP has been in flux as plants are being decommissioned and rerouted.

Since both the Buckner and Buckner Industrial plants were decommissioned in 2013, there is currently only one WWTP that discharges into Darby Creek. The Mockingbird Valley plant is an older publically owned domestic sewage package treatment plant, consisting of commutation, screening, activated sludge, aerobic digestion, chlorination and de-chlorination. Sludge is transported to the Kentucky State Reformatory. Treated water is discharged into an unnamed tributary at mile point 0.8 which discharges into Darby Creek at mile point 3.12. This plant most recently applied for a new permit in 2012, which became effective on August 1st, 2013. It may be worth noting that the Mockingbird Valley plant was found on average to treat 10,000 GPD in dry weather with 16,000 GPD of infiltration and 87,000 GPD of inflow. Figure 2.8 shows where this treatment plant is located. OCEA currently manages this treatment plant and seeks to decrease its use in the future, eventually leading to its elimination (OCEA, 2013).

Table 2.4: Existing Wastewater Treatment Plants in Darby Creek Watershed (OCEA Regional Facility Plan, 2013).

WWTP	***KPDES Permit No.***	***Receiving Stream***	***Design Capacity (GPD)***	***Average Daily Flow (GPD)***
Mockingbird Valley	KY0076813	Darby Creek	40,000	12,000*

*Average Daily Flow was based on 2005 operating data and estimates

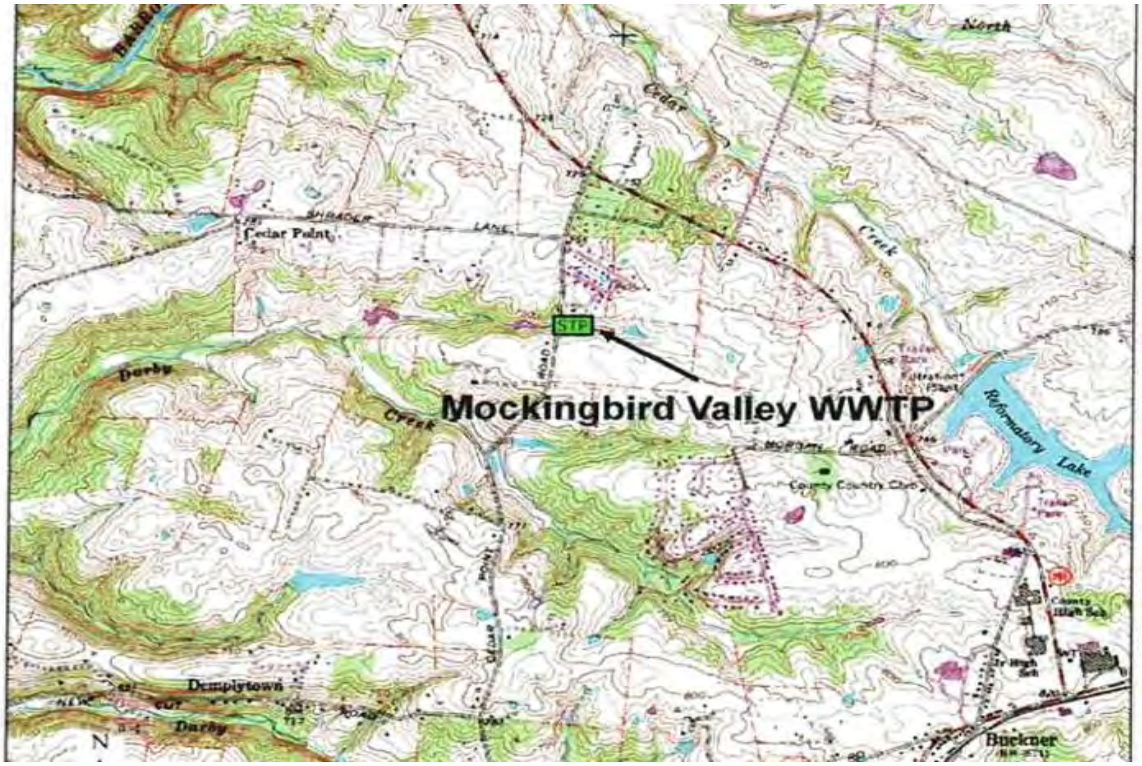

Figure 2.8: Location of Mockingbird Valley WWTP.

According to the Facilities Plan, Oldham County has been one of Kentucky's fastest growing counties and is expected to continue growing. Figure 2.9 depicts documented population growth in the County from 1960 to 2010. Between 2000 and 2010, Oldham County saw a 30.62% increase in population. The US Census lists Oldham County with a population of 60,316 in 2010 and estimates 3.4% growth by 2013. With predicted continued increase in population, OCSD feels it important to move away from septic systems and outdated package plants and make the development of regional wastewater collection and treatment systems a priority. A Facilities Plan with the goals of "eliminating existing package plants, eliminating the use, to the maximum extent possible, of on-sited disposal systems and providing wastewater services for the anticipated growth and development within the County" was created (OCSD, 2013).

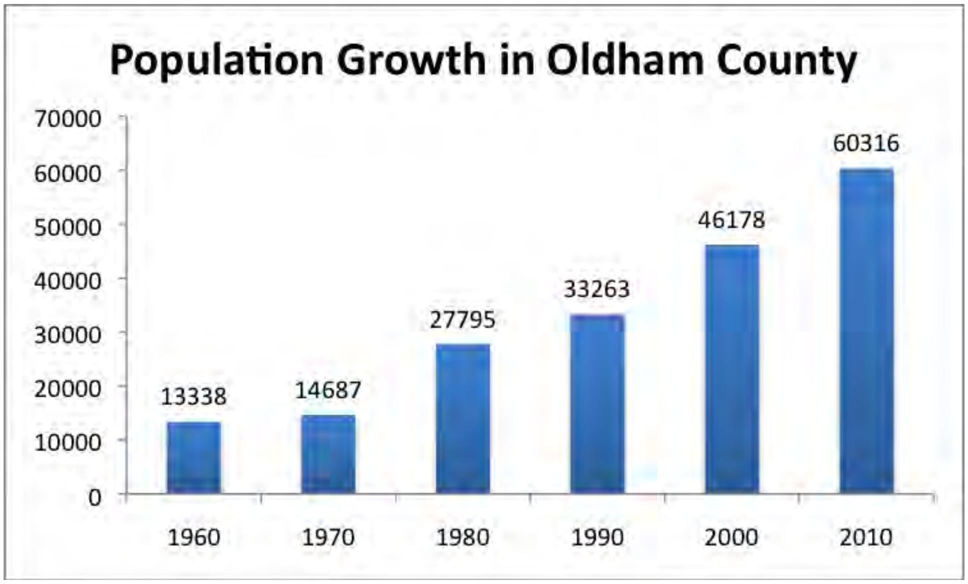

Figure 2.9: Population Growth in Oldham County as documented by the US Census.

The completion of a regional system has been divided into a 4 phase approach, costing approximately $17 million. Specific treatment plants in the County have been identified by the Department for Environmental Protection as consistently not meeting their permit requirements (Willow Creek, Orchard Grass and Ash Avenue) and have been issued Notices of Violations and as no longer permitted to receive any new connections. This plan makes a high priority to eliminate these non-compliant plants. Of note, none of these plants are within the Darby Creek Watershed (OCEA, 2013).

The county was divided into four service areas for the planning effort. The Darby Creek Watershed falls mainly into the Kentucky State Reformatory Service Area. The OCEA developed a twenty year plan to consolidate all the small treatments plants into larger facilities. This plan also considers providing sewer lines to existing neighborhoods served by septic tanks and areas where new development is likely to occur. The intent of the plan is to remove as much wastewater flow as possible from Oldham County streams. Figure 2.10 shows which pump stations were exceeding threshold as of the last OCEA report. It is worth recalling that both Buckner and Buckner Industrial tract have been taken offline since this image was created (OCEA, 2013).

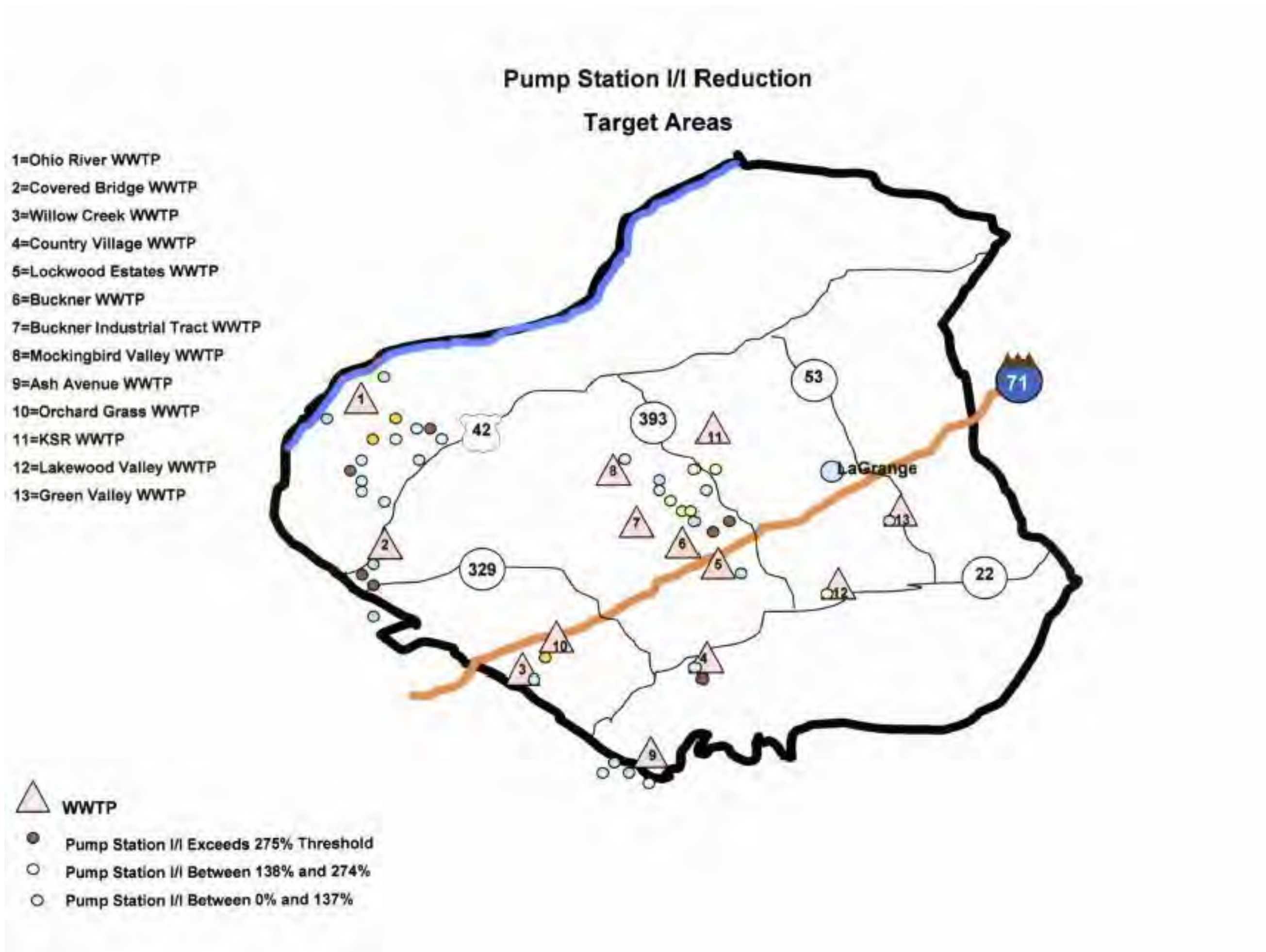

Figure 2.10: Map of WWTP in Oldham County and Threshold exceeding at pump stations (OCEA, 2013).

The plant at Kentucky State Reformatory is used by the facilities located on the reformatory property and is now receiving wastewater that has been re-routed from the decommissioned Buckner and Bucker Industrial plants. The Mockingbird Valley plant located near the headwaters of Darby Creek is also scheduled to be re-routed to the same location, although the plans for this have not yet been solidified. The long term plan is to pump the discharge from the plant to the Ohio River. OCEA wants to remove as much discharge from Harrods Creek, Curry's Fork, and Floyd's Fork as possible.

In July 2009, Veolia Water took over the operation of the OCEA. The map below shows the sewered areas of the watershed as of 2009. This still needs to be updated to reflect recent changes.

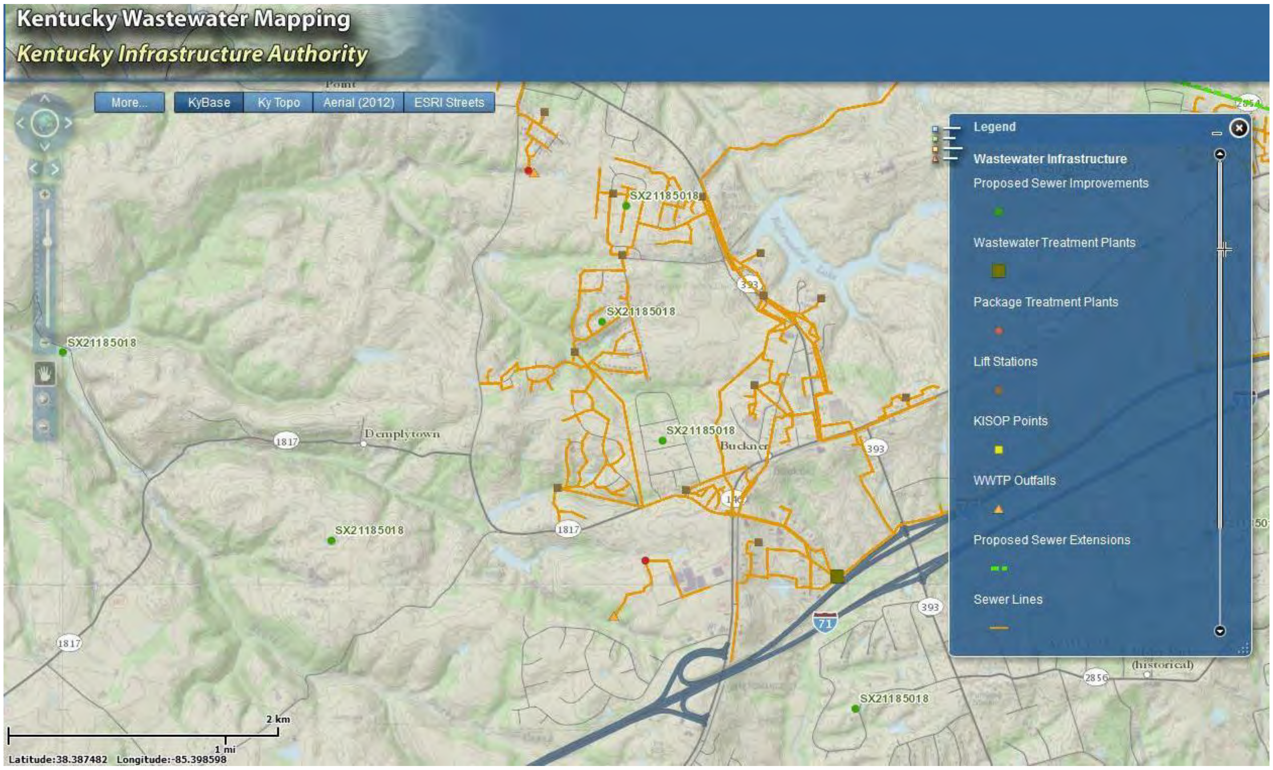

Figure 2.11: Map of sewered areas of the Darby Creek Watershed (obtained from Kentucky Infrastructure authority wastewater mapping).

Agricultural Water Quality Plans

The Kentucky Agriculture Water Quality Act was passed in 1994, with the main goal of protecting surface and groundwater resources from pollution as a result of agriculture and silviculture activities. As a result of this law, any farm operation on a tract of land situated on ten or more contiguous acres that engage in agriculture or silviculture activities is to develop and implement a water quality plan based on guidance from the Kentucky Agriculture Water Quality Plan. The Kentucky Agriculture Water Quality Plan consists of best management practices from six areas: 1) Silviculture, 2) Pesticide & Fertilizer, 3) Farmsteads, 4) Crops, 5) Livestock and 6) Streams and Other Water. Landowners must prepare and implement these plans based on their individual farm operations and keep a record of planning and implementation decisions. The Agriculture Water Quality Plan generally gives an overview of each landowner's decisions regarding how they plan to address potential water quality impacts generated by their operation. These plans are maintained on file with the individual farm operator or owner. A landowner certification can be filed with the Oldham County Soil and Water Conservation District if the owner/operator desires to do so. Because of the self-certification requirement established in the Act, there is no way of knowing the actual number of farms with completed water quality plans on their agricultural enterprise. The Oldham

County Conservation District has copies of landowner certifications on more than 1500 acres in the watershed.

Special Land Use Planning

<u>Oldham County Comprehensive Plan</u>

The Oldham County Zoning Ordinance and Subdivision Regulations are derived from the Oldham County Comprehensive Plan, which was developed in 2002. An updated version was officially accepted by Oldham County in January 2014. The "Environment Element" section of the plan sets goals and objectives for the protection of environmental resources, such as streams, riparian buffers, and natural topography.

Objective E-2-6 (page 19) pledges to:

1. Continue to improve the existing landscape guidelines to guide the preservation of on-site woodlands
2. Provide appropriate buffers from adjacent uses,
3. Increase the urban and suburban tree canopy,
4. Provide a vegetative buffer to riparian corridors,
5. Mitigate the effect of flood and stormwater run-off
6. Improve the visual appearance of structures, stormwater and parking facilities.

Additionally, on page 69, in discussion of the MS4 program, the plan says:
The Oldham County Environmental Authority will assess the development of a "gray to green" program to reduce impervious surface area which reduces stormwater runoff and increases the amount of land available for habitat restoration, urban farming and trees. This will include initiatives to minimize or reduce the amount of impervious pavement in construction projects and promote the responsible and creative reuse and recycling of concrete and asphalt. The Authority will research a pilot project to restore one mile of riparian vegetation along a local waterway, the results of which will be shared in a best practices guide book. Developed runoff can contain a number of pollutants such as suspended solids, trash and oils. Filtration can be an effective means at removal of such pollutants. The Oldham County Environmental Authority will investigate opportunities to collaborate with Oldham County Planning and Development to develop and promote a green infrastructure program that includes filtration designs such as rain gardens, sand filtration beds, grass buffer strips, to list a few. The program would encourage the use of green infrastructure in both redevelopment and new development areas. For example, establishing best practices and cost-neutral options to build green infrastructure elements will help all developers better handle stormwater runoff. In addition, the County and the Authority will use green infrastructure elements in all future projects when feasible and based on the project resources.

Brownsboro Master Plan

The Brownsboro Master Plan recommends policies and best management practices above and beyond those outlined in the Oldham County Comprehensive Plan and ordinances and regulations. Plans have been outlined to best maintain the rural characteristics of this area while allowing for needed growth. As mentioned above, Oldham County is expecting large increases in population. Specifically, the Brownsboro area (delineated in Figure 2.12) experienced a 55.4 % increase between 1990-2000. As of 2009, it was estimated that an average of 87 residential units were being built per year. Most of the Darby Creek Watershed is included in the Master Plan area (Brownsboro Mater Plan, 2009). This document was approved in April 2009. The final plan mentions the creation of buffer areas as well as prevention of pollution, storm water and erosion. In general, these are in reference to Harrods Creek.

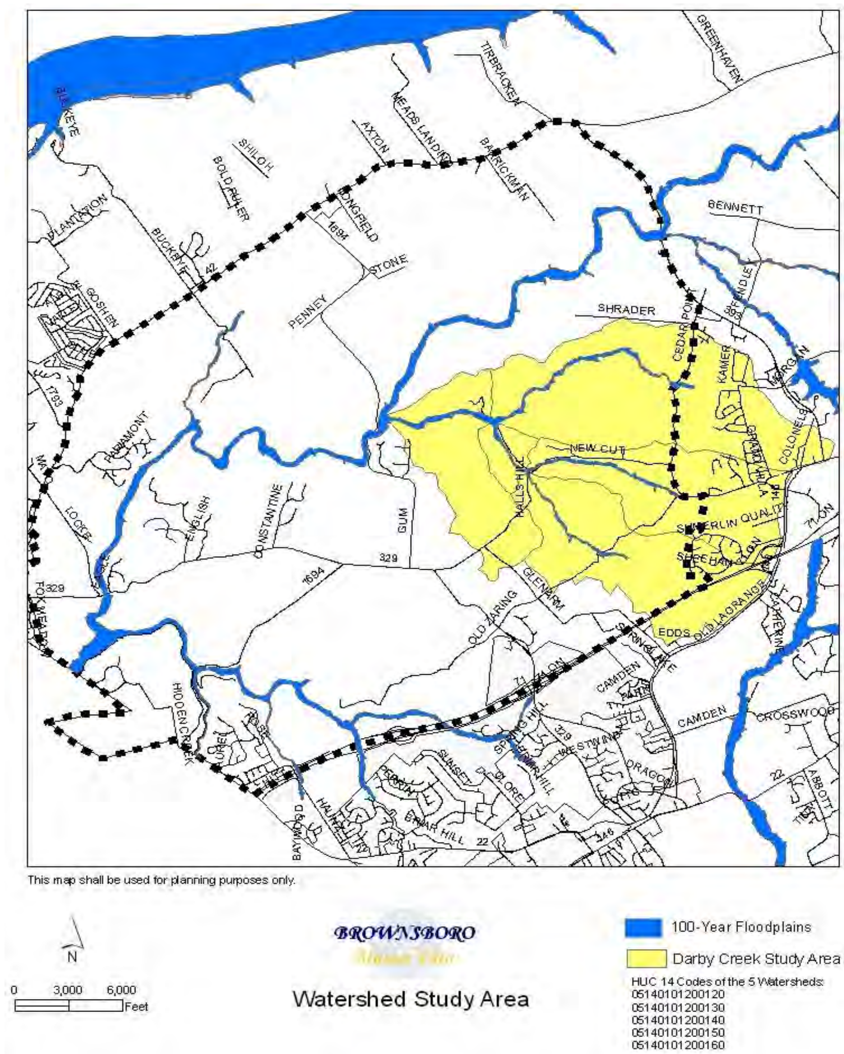

Figure 2.12: Map showing Darby Creek Watershed within the Brownsboro Master Plan, outlined in dots (Oldham County Planning and Zoning, 2008).

Codes and Ordinances

The Oldham County Codes and Ordinances can be found through the county's website. Professor Tony Arnold's Land Use and Planning Law Class at the University of Louisville, Louis D. Brandeis School of Law completed a project that reviewed Oldham County's codes and ordinances as related to water quality in spring 2008. The report from this project, which is an academic project and not meant to serve as legal advice or representation, can be found on the Kentucky Waterways Alliance's website.

Zoning

The University of Louisville codes and ordinances review, mentioned above, contains information on zoning in the Darby Creek Watershed. As shown in Figure 2.13, there are three main zoning codes that determine the Darby Creek Watershed. R-2 Residential District makes up 43 percent of the watershed, CO-1 Conservation/Residential District accounts for 27 percent, and AG-1 Agricultural/Residential District makes up 24 percent of the watershed. These zoning districts guide development in the watershed (see Figure 2.13). Any zoning changes since 2008 have not yet been reflected in this report, but should be similar.

Table 2.5: Zoning districts in the Darby Creek Watershed (Oldham County Planning and Zoning 2008).

Zone	*Acres*	*Percent*
AG-1	1,629.54	24.42
C-1	2.14	.03
C-3	27.42	.41
C-4	26.51	.4
CO-1	1807.59	27.09
I-2	179.88	2.7
R-1	104.38	1.56
R-2	2,843.78	42.62
R-2A	50.73	.76

Of these three zoning districts, R-2 is the most conducive for development and most of the new subdivisions in the watershed are located in this zoning district. The Oldham County Comprehensive Zoning Ordinance describes the purpose of the R-2 Residential District:

> "The purpose of the R-2 Residential District is to allow, preserve, and protect the character of low density, detached single family areas and neighborhoods at densities of up to 3.63 dwelling units per acre" (p. 14).

The CO-1 Conservation/Residential District's purpose as described by the Oldham County Comprehensive Zoning Ordinance is as follows:

> "The Conservation/Residential District is intended to promote and protect significant natural features, wooded areas, water courses, existing and potential lake sites, other recreational and conservation resources, wildlife, habitat, present and future water supplies, and to minimize erosion of soil and the siltation and pollution of streams and lakes" (p. 14).

The CO-1 zone is located primarily along stream corridors in the watershed, and provides protection for the streams in the Darby Creek Watershed.
Finally, the third most prominent zoning district in the watershed, AG-1 Agricultural/Residential District's purpose is described in the Oldham County Comprehensive Zoning Ordinance:

> "The AG-1 Agricultural/Residential District is intended to: (1) support and encourage agriculture for the purpose of recognizing the cultural heritage of the community and the agricultural contribution to the economic base; and (2) minimize the urban-type development in rural areas until urban-type services and utilities can be efficiently provided" (p. 14-15).

This zoning district also limits the types of development possible in the watershed, largely in the northwest section (Barkley et al, 2008). More information about Oldham County's zoning regulations can be found at the county's website.

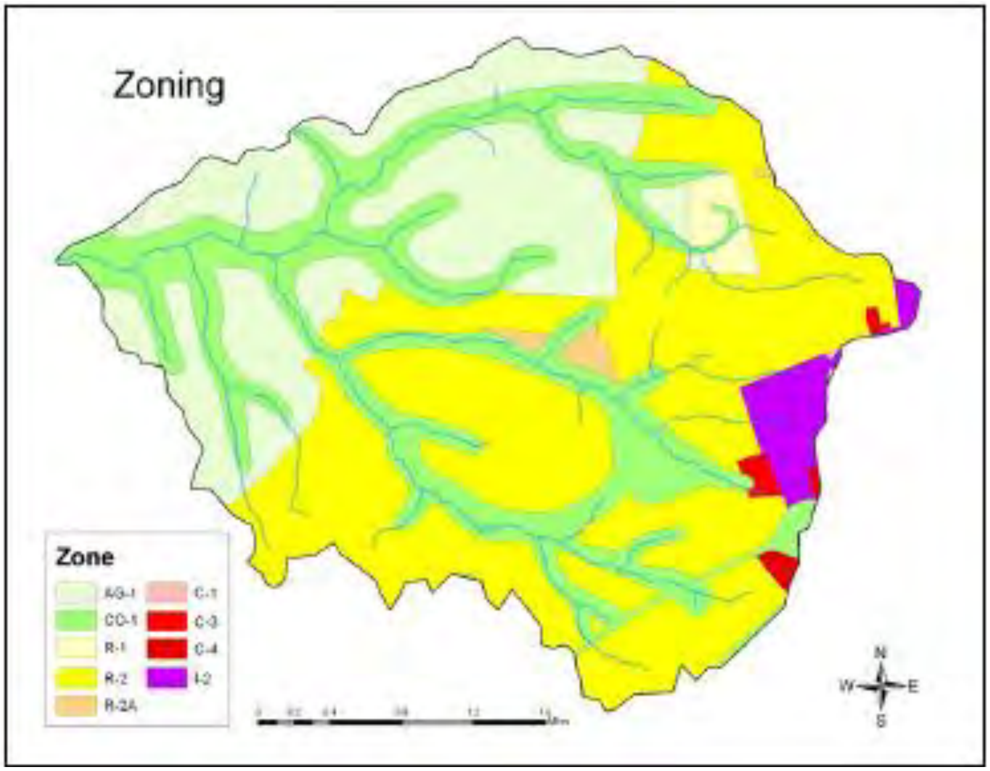

Figure 2.13: Map showing the zoning districts in the Darby Creek Watershed (Oldham County Planning and Zoning, 2008).

2.1.6 Regulatory Status of Waterways

Kentucky assigns designated uses to each of its waterways, such as recreation, aquatic habitat, and drinking water. For each use, certain chemical, biological, or descriptive ("narrative") criteria apply to protect the stream so that its uses can safely continue. The criteria are used to determine whether a stream is listed as "impaired," and therefore needs a watershed-based plan or Total Maximum Daily Load (TMDL).

Designated Uses

According to KDOW, all un-assessed waters in Kentucky are labeled as "High Quality" waters. High quality waters have the following designated uses: primary contact recreation (PCR), secondary contact recreation (SCR), warm water aquatic habitat (WAH), and domestic water supply (WS). Darby Creek's designated uses are warm water aquatic habitat, primary and secondary contact recreation, and drinking water supply.

Impairment Status

Darby Creek was not assessed in the 2012 Integrated Report to Congress, and therefore is not listed as an impaired waterbody. However, Darby Creek is a tributary of Harrods Creek which has been declared as only partially supporting Primary Contact Recreation (PCR) due to high levels of bacteria, specifically *E. coli*. As a tributary of Harrods, Darby Creek is very likely to be a contributing source of bacteria to Harrods, and may in fact be determined to be impaired once bacteria levels are actually assessed.

Special Use Waters

Kentucky identifies certain Special Use Waters, which receive greater protection. These waters include Outstanding State Resource Waters, Reference Reach Waters, Kentucky Wild Rivers, and Outstanding National Resource Waters. Special Use designations are made because of some exceptional quality of the water that needs further protection. There are no Special Use Waters in the Darby Creek Watershed.

Total Maximum Daily Load Report

The Clean Water Act requires Kentucky to prioritize streams listed as impaired for studies that will determine the amount of pollution they can assimilate while still meeting water quality standards. The outcome of such studies is a Total Maximum Daily Load (TMDL) Report. The TMDL reports sets forth strategies to meet water quality standards such as higher permit limits for point source dischargers or management practices for specific sources of nonpoint source pollution. While Darby Creek does not have a TMDL, it is a tributary of Harrods Creek, which has an established TMDL for organic enrichment from river mile 0.0-3.2. Any upstream area could be contributing to the conditions causing that organic enrichment, so assessment of Darby Creek could be critical in controlling a source that has impaired Harrods Creek.

2.1.7 Water Quality Data

Data collection was conducted by Third Rock Consulting in 2008 for this watershed planning process. Their data indicated potential impairments but called for further monitoring to identify which sections were affected and not meeting the PCR designated use. Table 2.6 outlines the current designated use for the sections of Darby Creek assessed by Third Rock Consulting. Data were also collected in June and July of 2014 by the KDOW at seven different sampling locations. Chapter 3 goes into depth regarding data collected specifically for this project.

Table 2.6: Water Quality Summary Data (see Figure 2.2 for location of HUC-14 sub-watersheds).

Stream Segment	*Designated Uses*	*Regulatory Status*	*Summary of Water Quality Monitoring*
Darby Creek (160)	PCR, SCR, WAH, DW	Not assessed	Third Rock Consulting
South Fork Darby Creek (150)	PCR, SCR, WAH, DW	Not assessed	Third Rock Consulting and U of L
Darby Fork (140)	PCR, SCR, WAH, DW	Not assessed	Third Rock Consulting
South Fork Darby Fork (130)	PCR, SCR, WAH, DW	Not assessed	Third Rock Consulting
Darby Creek (120)	PCR, SCR, WAH, DW	Not assessed	Third Rock Consulting

*The last 3 digits of the HUC-14 are used to specify the watershed

The Kentucky water quality standard, meaning the level required to support aquatic life, for an instantaneous sample of dissolved oxygen (DO) is a minimum of 4.0 mg/L. As DO levels drop below 5.0 mg/L, aquatic life is put under stress. Six grab samples for DO were collected at Darby Creek and Halls Hill Road by the University of Louisville in September and October of 2006. Levels ranged from 7.2 to 12 mg/L, meeting the acceptable standard for DO.

The Salt River Watershed Watch program performed *E. coli* sampling at this same site four times from July 2003 to November 2006. They obtained additional data from a site at Old Zaring Road 1.2 miles North of Highway 329 and a site at Marina Landing on the same days in July 2013 and July 2014. *E. coli* is a species of fecal coliform bacteria specific to humans and warm-blooded animals.

The presence of high *E. coli* levels may pose a health risk to those in contact with the water and can serve as a good indicator of bacterial loading. In order to be safe for primary contact recreation or swimming, *E. coli* levels for an instantaneous grab sample should be below 240 colonies/100mL. Only one of the four samples taken from 2003-2006 exceeded this limit. This sample, which measured 1120 colonies/100 mL, was taken after a wet weather event.

Three of the four samples taken in July 2013 and July 2014 also exceeded the acceptable level of *E. coli*. These were taken during documented dry conditions with no rainfall within 48 hours of observation (see Table 2.7 for summary of results).

Table 2.7: ***E. coli*** **present in samples taken by the Salt River Watershed Watch.**

Sample Date	***Sample Conditions***	***E. coli present (colonies/100mL)***
July 2003-November 2006	Dry	100
July 2003-November 2006	Dry	20
July 2003-November 2006	Dry	21
July 2003-November 2006	Wet	1120
July 2013 (Old Zaring Road)	Dry	1024
July 2013 (Marina)	Dry	262
July 2014 (Old Zaring Road)	Dry	378
July 2014 (Marina)	Dry	40

The Salt River Watershed Watch also collected data from 2012-2014. There is discussion in Chapter 3 on some components of these data; some are discussed here to provide an overview of other possible problems in the watershed. The EPA's conductivity criterion for streams in this area is 500 micromhos/cm. EPA defines streams in their natural state as having a conductivity of 100-200 micromhos/cm. Values greater than 300 micromhos/cm begin to affect plant and animal life, while values above 500 micromhos/cm can have severe effects with most life being killed at 1,000 micromhos/cm. The Salt River Watershed Watch measured conductivity on four occasions. Each time, conductivity was higher than the defined natural state of 100-200 micromhos/cm. On one occasion, prior to which there was documented 0.1 inches of rain, the measurement exceeded the EPA defined limit, indicating that biota and animal life may have been affected. These results, along with pH and DO measurements, can be viewed in Table 2.8. In all cases, pH and DO levels weren't concerning, although improvements could be made.

Table 2.8: Salt River Watershed Watch Data from 2013-2014.

Sample Date/Location	***Conditions***	***Conductivity (micromhos/cm)***	***DO (ppm)***	***pH***
July 2013 Old Zaring Rd.	Dry	480	N/A	7.8
July 2013 Marina	Dry	300	6.4	7.7
July 2014 Old Zaring Rd.	Dry	410	8.2	7.5
July 2014 Marina	Dry	N/A	6.6	7.5
September 2014 Old Zaring Rd.	0.1 inches of rainfall	740	8.8	7.8

In September 2014, samples were also sent to the U of L Environmental labs for further analysis. Their findings confirmed high conductivity readings (lab result was 695 micromhos/cm). Total nitrogen and total phosphorus were both measured to be less than 1 mg/L. Sulfates, chlorides and TSS levels were also found to be within acceptable limits.

Geomorphology

Geomorphology is the study of landforms and the processes that shape them. The slope of a hill, for example, and the way the sediment erodes after a rain or wind event and then deposits on the streambank are geomorphic factors that affect the watershed. Because sediment can be a source of pollution, the geomorphology is important to overall water quality and quantity.

There are not a lot of watershed specific geomorphology data for Darby Creek. A visual assessment by Third Rock Consulting has helped characterize the area generally. Most of the stream banks are well covered with vegetation and appear to be relatively stable. Erosion is occurring to some degree at all sites, but it is slight to moderate at all sites except near the mouth of the creek. The site located at the mouth naturally experiences higher flows, but it is eroding at a faster rate than expected. Sedimentation and embeddedness do not appear to be an issue in the watershed. These data, however, were influenced to some degree by the prevailing dry conditions (Third Rock Consulting, 2008).

Water Quality Data Gaps

Between the Salt River Watershed Watch, KDOW, and Third Rock Consulting, there is a decent amount of general water quality data available for Darby Creek. The types of data missing are more site-specific data such as erosion rates from specific reaches, private lands, construction sites, or other land use activities. The NRCS Stream Visual Assessment Protocol, which provides instruction on rating these types of parameters without laboratory equipment, may be a useful tool for obtaining more specific data in the future. During the course of this project, NRCS Visual Assessments were performed in some reaches. These are discussed in Chapter 3.

2.2 Natural Features of the Watershed

2.2.1 Geology and Topography

The topography (terrain) of Darby Creek Watershed is an important feature to consider. How flat or steep the land is impacts how fast water drains. The faster the drainage, the more potential for flooding and increased soil erosion there is. The water quality and quantity in Darby Creek is greatly affected by filter/buffer strips, wildlife habitat, wetlands, and riparian areas around the water because these things slow down and filter the runoff from the surrounding watershed. According to the Kentucky Geological Survey, the topography in Oldham County varies from rolling to hilly (See Figure 2.14). In the western part of the county, the highest elevations are around 650 feet (higher elevations are found in the eastern part of the county, ranging up to around 900 feet). Western Oldham County has wide areas of gently rolling, or almost flat land, which is broken up by valleys carved by streams, which are 150 to 200 feet lower than these rolling uplands (KGS 2006). The highest point in the watershed is a hill of approximately 750 feet above sea level. It is not a source of sediment or other known pollutants to Darby Creek.

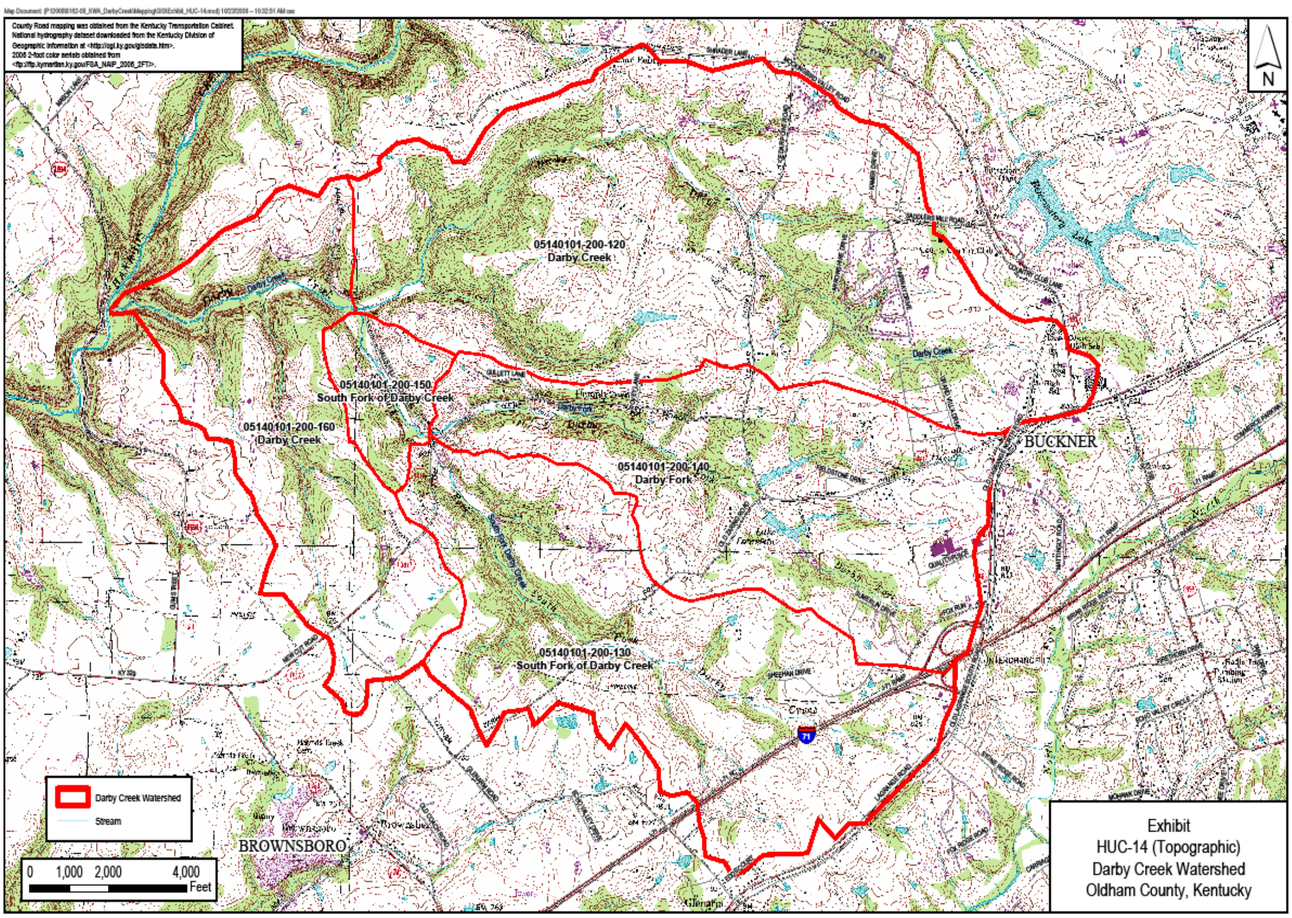

Figure 2.14: Topographical map for Darby Creek Watershed (USGS, 2008).

2.2.2 Soils

Soil type in the watershed is important because it affects a variety of things from water infiltration to septic system function. For example, sandy soils allow the ground to soak up water faster. This reduces surface runoff, but can affect ground water quality and quantity. Clay soils, on the other hand, are more compact and do not allow as much water infiltration. This can lead to more runoff and soil erosion. If a septic system is installed in an area with clay subsoil, it will not work properly. This can cause water quality degradation and threaten public health. Well drained, deep soils are more optimal. The Brownsboro Master Plan addressed septic tank absorption within its area (Figure 2.16).

As mentioned previously, most of the Darby Creek Watershed is located in the South East portion of the Brownsboro planning area. In the Darby Creek Watershed, the Oldham County Environmental Authority (OCEA) identifies that Beasley-Caneyville soil associations are steep and shallow to bedrock with low urban potential and high woodland potential. Crider-Beasley is also found in the watershed area as a soil type that is identified as being optimal for urban development, although has a high erosion potential.

Data from a Harrods Creek Watershed study showed that the area lies within the Outer Bluegrass Section of the Interior Low Plateau Physiographic Province of central Kentucky (see Figure 2.15). This area consists of rolling farmland with steep banks along rivers and creeks. The soils are predominantly Beasley-Caneyville association in the riparian zones. They are moderately deep, well-drained, rocky soils with a clayey subsoil (KDOW, 2004).

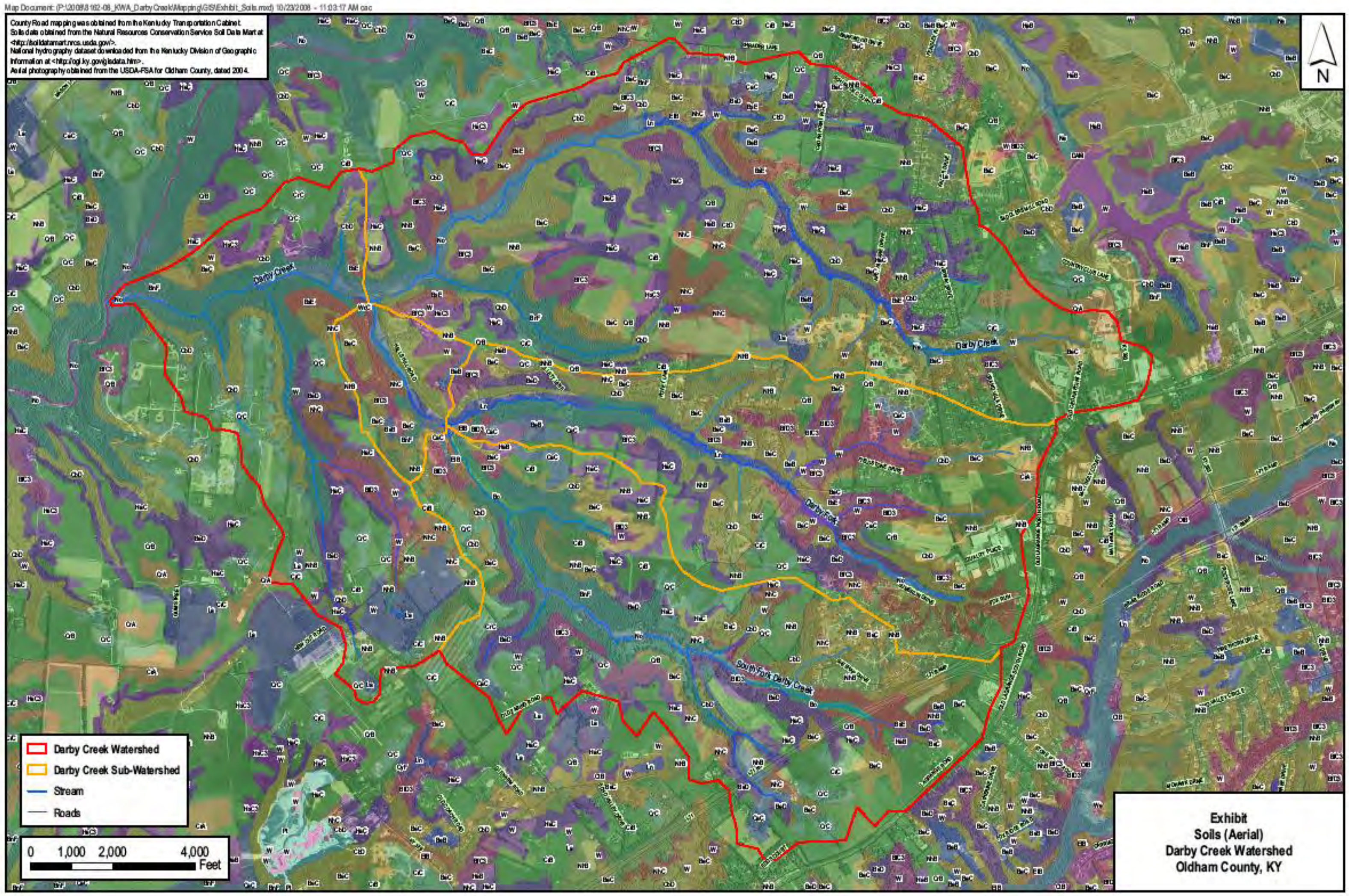

Figure 2.15: Soils of the Darby Creek Watershed (Third Rock Consulting, 2008).

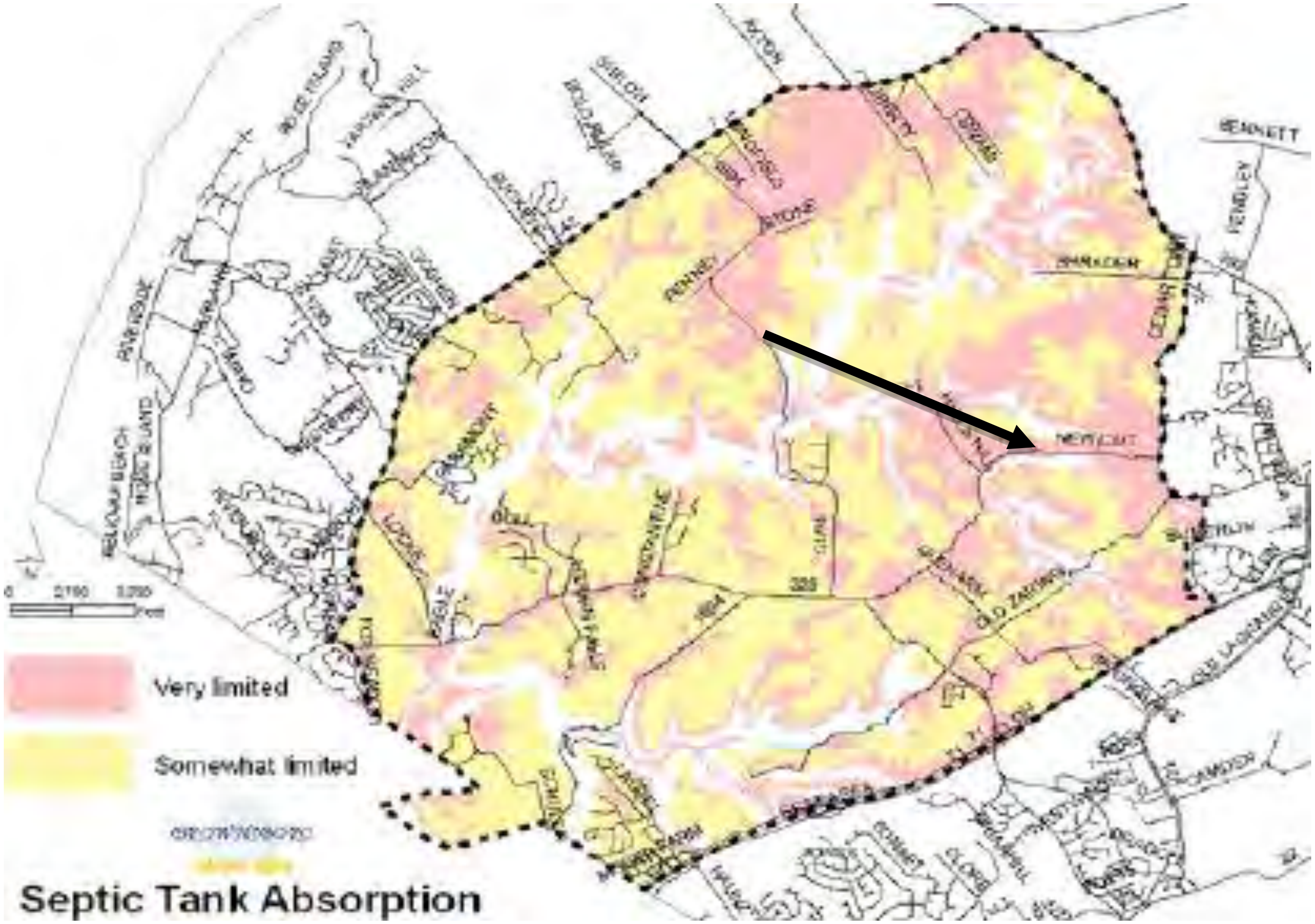

Figure 2.146: Limitations of Septic Tanks in Brownsboro Master plan area (Brownsboro Master Plan, 2009).

2.2.3 Riparian Ecosystem

The riparian zone is the region of natural vegetation that grows adjacent to a waterway. Plants in this area function as filters that trap sediment and absorb nutrients carried by water draining over the land (runoff). Additionally, riparian vegetation provides shade, maintaining water temperatures at levels necessary for certain species of plants and animals. Riparian ecosystems also function as critical habitat for wildlife, a travel path for migratory birds, reduce runoff, and provide stream bank stability. For all of these reasons, a healthy riparian ecosystem can greatly benefit a stream.

As part of the Darby Creek Watershed Legal Service-Learning Project, University of Louisville Law students studied the riparian ecosystem within 50 feet in both directions of all streams in the watershed. Using 2001 land cover data for their analysis, they compiled the following table showing land use within a 50 foot buffer of the stream. More than 80 percent of land surrounding streams in the watershed is forested. This is an encouraging figure, paired with the fact that just over one percent of the land in the same area is developed in some fashion. Table 2.9 describes the land use in stream buffers as observed in 2008 and Figure 2.17 shows an aerial view of the watershed and the forested riparian buffers (Barkley et al, 2008).

Table 2.9: Land use in stream Buffers (Barkley et al, 2008).

Land Use	***Acres***	***Percentage***
Cultivated Crops	2.16	.63
Deciduous Forest	272.3	79.7
Developed, Low	1.73	.51
Developed, Open	8.99	2.63
Emergent Herbaceous	1.11	.33
Evergreen Forest	11.37	3.33
Grassland/Herbaceous	4.03	1.18
Mixed Forest	1.21	.35
Open Water	7.54	2.21
Pasture/Hay	27.23	7.96
Woody wetlands	.8	.23

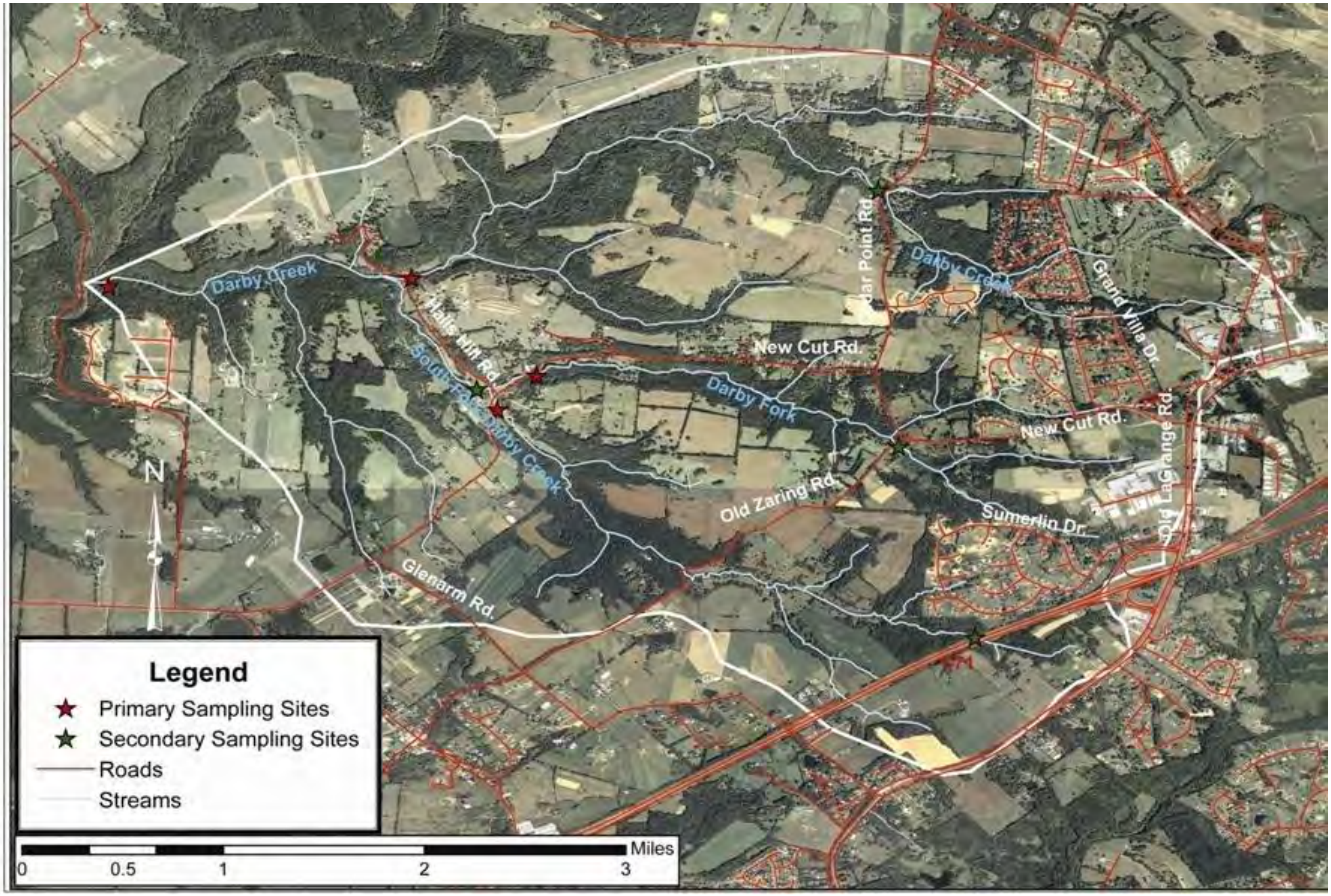

Figure 2.17: Map showing aerial view of Darby Creek Watershed and its largely forested riparian buffers (Third Rock Consulting, 2008).

2.2.4 Flora and Fauna

The Kentucky State Nature Preserves Commission produces a Report of Endangered, Threatened, and Special Concern Plants, Animals, and Natural Communities for each county of the state, last updated in August 2014. Table 2.10 below includes federally listed endangered species whose occurrence is currently reported (E) or reported from the county but not seen in the past 20 years (H). This includes one species of freshwater mussels, one crustacean and one insect. There are multiple other species of mussels, birds, plants and insects that are listed as threatened or of special concern.

Table 2.10: Federally Endangered Species in Oldham County (KSNPC, 2014).

Common Name	***Scientific Name***	***Number of Occurrences***
Sheepnose Mussel	*Plethobasus cyphyus*	Endangered
Louisville Crayfish	*Orconectes jeffersoni*	Historic
Sedge Sprite	*Nehalennia irene*	Endangered

2.3 Human Activities Affecting Water Resource Quality

2.3.1 Point Sources

Municipal, Industrial, Wastewater Dischargers

Point sources of pollution are those that have a known discharge point, such as a pipe. In most cases, point sources are required to operate under a Kentucky Pollutant Discharge Elimination System (KPDES) permit issued by KDOW. Examples of point source discharges include industrial and wastewater treatment plants that discharge directly to a stream and certain livestock facilities.

According to the KPDES Branch of the Kentucky Division of Water, there are three permitted discharges in the Darby Creek Watershed (see Table 2.11).

Table 2.11: KPDES permits in Darby Creek Watershed (Environmental Protection Agency, 2015).

KPDES Permit Number	*Discharge Name*	*Type of Discharge*
KYG400037	The Rice Residence	Household Sanitary Wastewater
KYG402125	The Smith Residence	Household Sanitary Wastewater
KY0076813	Mockingbird Valley Sewage Treatment Plant	Sanitary Wastewater

The Mockingbird Valley Sewage Treatment Plant is currently the only WWTP that discharges into Darby Creek. The 2009 final edition of the Brownsboro Master plan refers to this plant as "aged" and it is acknowledged to have multiple violations. The former Buckner WWTP was of far more concern since it was operating over capacity and had frequent violations (Buckner and 2 other plants were responsible for 67% of violations). It became a priority to decommission this plan as soon as possible (OCEA, 2013). Bucker had 209 violations in 2008 whereas Mockingbird had 20.

Through open records requests, any violations and DMRs can be obtained. During multiple inspections, Mockingbird was listed to have "impending trends towards violation." Sometimes this was related to the state of the facility and/or nearly empty containers of disinfectant. In November 2008, they were given a NOV for permit violation. In this instance they were cited for high pH, TSS, TRC and BOD in March of that year along with failure to meet DO permit limits in April-June. In January 2009, the *E. coli* 7-day geometric mean was 1,600 colonies/100mL in comparison with permit limits of 240 colonies/100mL. In September 2011, the plan was once again out of compliance. Since the flow meter was off line, the chemicals used to disinfect/de-chlorinate the water were not being added. The inspector noted that dark, sewage smelling discharge was coming out of the outfall.

In 2006, it was noted that the Rice residence has not submitted a DMR since 1989. This residence received a NOV on February 7th, 2011 after a strong sewage odor with black septic discharge was discovered draining into the watershed. By April 25th, these issues had been addressed, although it was found to exceed the limit for TRC in May. In 2013, the home appeared vacant. The Smith residence has not been given any NOV although one document cited that the residence was unsuitable for onsite sewage disposal due to a lack of sufficient soil depth.

Stormwater Dischargers

Stormwater management has grown and developed with the passage of the Clean Water Act by Congress in 1972. The Environmental Protection Agency (EPA) is the enforcement arm of the Federal government of the Clean Water Act. In Kentucky, the enforcement has been delegated to KDOW. The EPA has categorized MS4s into the three categories of small, medium, and large based on population served.

The municipal separate storm sewer system (MS4) is defined as follows:

(1) a conveyance, or series of conveyances, that include roadways with drainage systems, streets, catch basins, curbs, gutters, ditches, man-made channels or storm drains that are owned and/or operated by the government, state, city, town, county, district or other association or public body or utility having jurisdiction over disposal of storm water that discharges into the waterways of the Commonwealth of Kentucky.

(2) is designed or utilized for collecting or conveying storm water;

(3) is not a combined sewer and is not part of a publicly owned treatment facility.

The Phase I Storm Water Program regulates the medium and large categories.

- Final Rule Phase I, Nov. 16, 1990, *Federal Register*.
- Large Systems 250,000 or greater population (e.g., Louisville).
- Medium Systems 100,000 to less than 250,000 (e.g., Lexington).
- Both systems are in the second five-year permitting cycle.
- Annual update reports required.

The Phase II Storm Water Program regulates the small categories.

MS4 Phase II component began enforcement in March of 2003. These “Phase II” communities are located near urban areas and/or with certain population densities. Oldham County is a Phase II community. Under the Phase II requirements, Oldham County and four of the incorporated cities – Crestwood, Goshen, River Bluff, and Orchard Grass became “co-permittees” in order to act as a single body.

Phase II regulates storm water discharges from two categories:

First, the regulation covers storm water discharges to certain municipal separate storm sewer systems (MS4). Public entities which operate these systems (MS4s), such as cities, counties, states and the Federal government are regulated under this rule.

The regulation also covers storm water discharges from construction activity generally disturbing more than one acre. This would include the site owner, developer, contractor or subcontractor.

Small MS4 Phase II Requirements

1. Public Education and Outreach
2. Public Involvement and Participation
3. Illicit Discharge Detection and Elimination
4. Construction Site Storm Water Runoff
5. Post-Construction Storm Water Management
6. Pollution Prevention & Good Housekeeping

404 Permits

The Army Corps of Engineers permits construction in or along streams. These permits are public record. Freedom of Information Act request number 09-53, made by the Kentucky Waterways Alliance, details the public notices of 404 permits for Oldham County, KY, for the years 2005-2015. As of 2015, there was only one 404 permit for the Darby Creek Watershed. A standard permit was issued from the 13th of December 2005 to the 13th of March 2006 for the Heather Green Subdivision (USACE and KWA personnel, 2009).

2.3.2 Nonpoint Sources

Land Use

The most recent land use data for the Darby Creek Watershed are from 2001. The watershed has experienced increased development since this time, but the data still provide a relatively accurate picture of land use in the watershed. Table 2.12 shows the land uses by acreage and percent cover for the watershed. Only approximately 12 percent of the watershed is "developed," while approximately 45 percent of the watershed remains in deciduous forest. Approximately 39 percent of the watershed is used for pasture or hay and cultivated crops (see Figure 2.18).

Table 2.12: Land Use in the Darby Creek Watershed (US Geologic Seamless Server, 2008).

Land Use	*Acres*	*Percentage*
Deciduous Forest	2977.24	44.63
Pasture/Hay	2065.07	30.95
Cultivated Crops	560.01	8.39
Developed, Open Space	397.49	5.96
Grassland/Herbaceous	188.13	2.82
Evergreen Forest	168.14	2.52
Developed, Medium Intensity	128.05	1.92
Developed, Low Intensity	85.96	1.29
Open Water	25.80	.37
Mixed Forest	25.80	.37
Developed, High Intensity	23.61	.35
Scrub/Shrub	16.81	.25
Emergent Herbaceous Wetlands	1.78	.03
Barren Land	1.33	.02

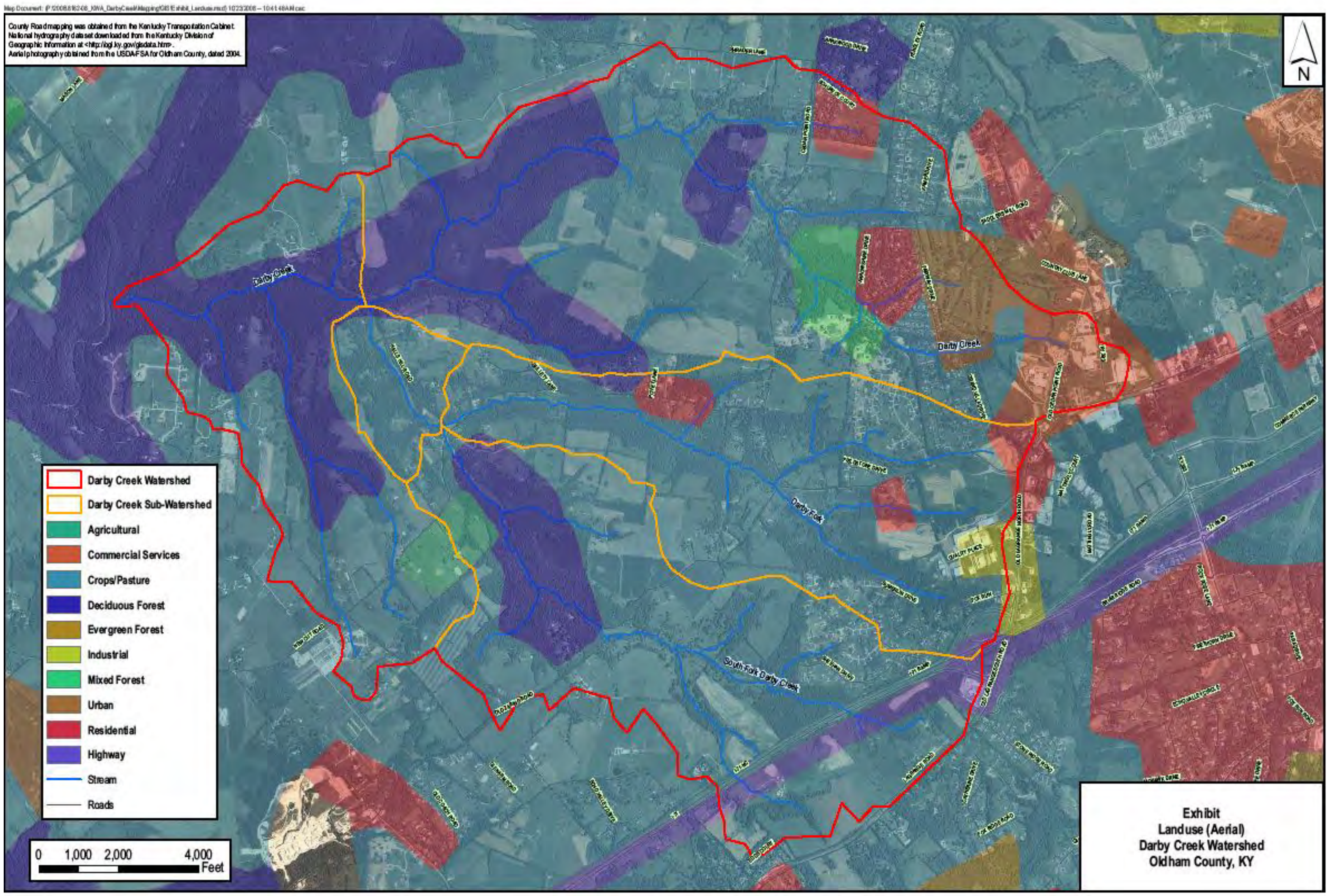

Figure 2.18: Land cover in Darby Creek Watershed (Third Rock Consulting, 2008).

To enhance these land use data from 2001, Oldham County Planning and Zoning has contributed current data that help paint a clearer picture of development in the watershed. Table 2.13 demonstrates subdivisions and the year they were built.

Table 2.13: New subdivision development in the Darby Creek Watershed from 2001-2006 (Oldham County Planning and Zoning, 2008).

Subdivision or Phase	***Year***
Morgan Place I	2001
Stonefield Trace 2	2001
Darby Pointe 3	2001
Darby Pointe 4	2003
Harrods Crossing	2004
Stonefield Trace 3	2004
Heather Green 1A	2005
Stonefield Trace 4	2005
Heather Green 1B	2005
Cedar Point Condos	2006
Morgan Place 2	2006

Impervious Surfaces

Impervious surfaces are those surfaces that prevent the infiltration of water into the soil. Examples are roads, parking lots, sidewalks, and rooftops. Impervious surfaces affect water quality in a number of ways. Generally the higher the percentage of impervious surfaces in an area, the greater the amount of stormwater runoff. This can lead to increased flooding and erosion, reduced infiltration, and reduced groundwater recharge. Stormwater runoff often transports pollutants with it as it makes its way to the nearest waterway. There is also an issue of increased stream temperatures due to increased runoff temperatures, which affects aquatic life. Due to these impacts, imperviousness can be an indicator of the effect of land development on water resources quality and quantity. Much of the developed areas in the Darby Creek Watershed are clustered in the eastern section. Much of the impervious surfaces, therefore, occur in the same areas (see Figure 2.19).

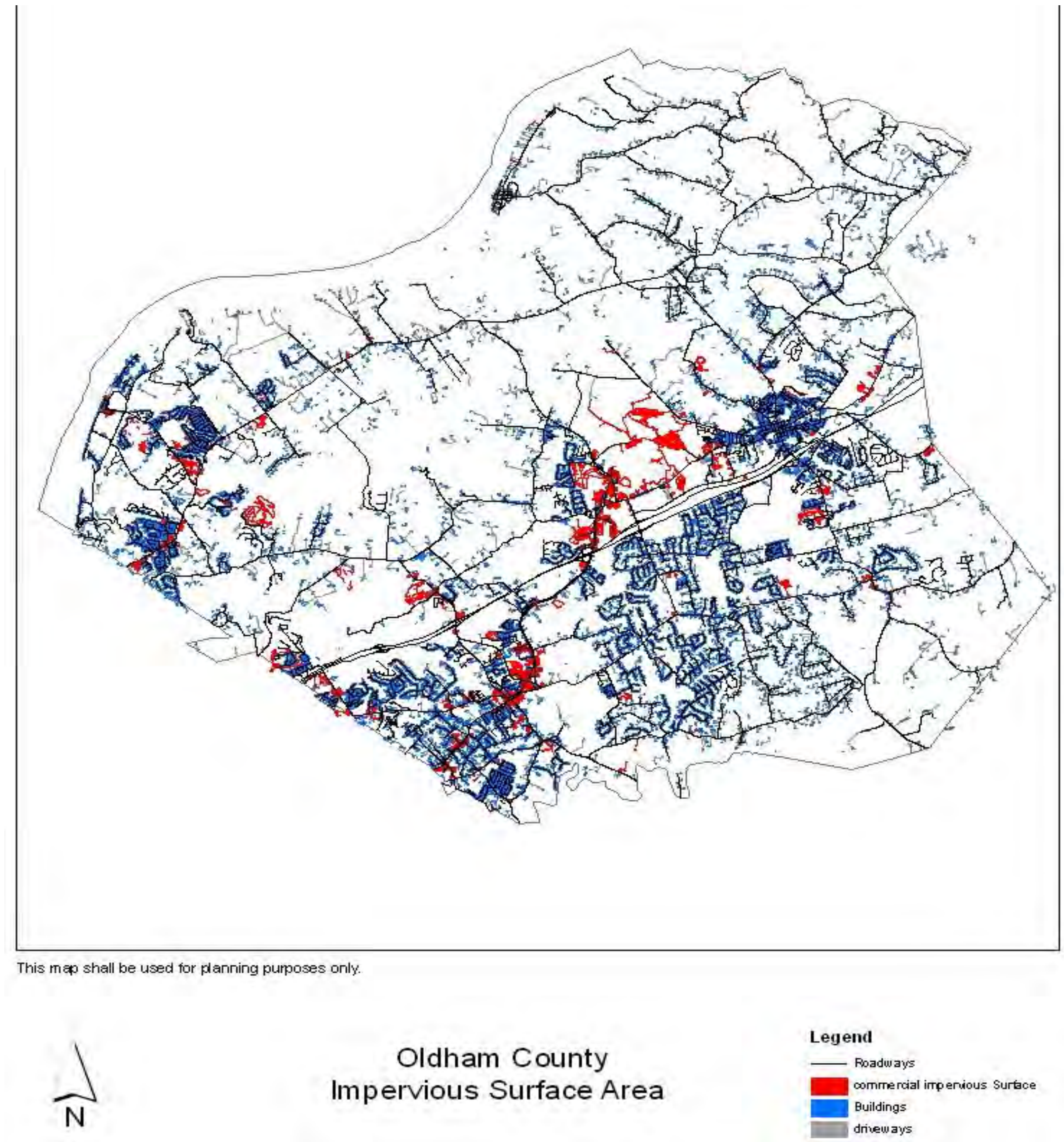

Figure 2.19: Impervious Surfaces Darby Creek Watershed (Oldham County Planning Office, 2009).

Unsewered Areas

In the Darby Creek Watershed, homes are either connected to a wastewater package treatment plant by a sewer system or they have onsite waste treatment systems (usually septic systems). According to information from the OCEA, there were approximately 585 homes in the Darby Creek Watershed in 2009, only half of which were on sewers. As of 2015, Veolia Water estimated that there are currently about 300 sewer hookups in the Darby Creek Watershed with 400 still on septic systems (personal communication with Ed Basquill, 2015). These figures will change somewhat due to the Oldham County Environmental Authority's twenty year Facilities Plan, which plans to expand sewers in some areas of the watershed (see the Wastewater Authorities section of this chapter for more information).

According to the Oldham County Health Department, from 1999-2009 there were ten complaints about suspected failing septic systems in the watershed: four in the Darby Pointe subdivision, three in the Grand Villa subdivision, one in the 3900 block of Glenarm Road, and two on Halls Hill Road. The property on Glenarm Road is pending resolution, though the house is vacant at this time, and the rest of the problems have been abated, or the complaints were determined to be invalid.

2.4 Demographics and Social Issues

According to the Oldham County Sewer District, the 2005 population of the Darby Creek Watershed was 1,668. Currently, 2010 US Census data for the Darby Creek Watershed are not accessible by watershed. Until these data are available, the following data from the Draft Brownsboro Master Plan can provide some insight.

The Brownsboro Master Plan area is shown in Figure 2.12 and includes most of the Darby Creek Watershed. It encompasses 15,099 acres, but the Darby Creek Watershed is only 6,017 acres. It includes a broader area than the Darby Creek Watershed, but can give background on trends in the area.

In 2000, the population of the Brownsboro Master Plan area was 1,334. The median yearly household income was $85,000. In the planning area in 2000, there were 512 housing units. Of these housing units, 94 percent were occupied. Of these occupied houses, eighty-two percent (419) were owner-occupied, and twelve percent (63) were renter-occupied. Single-family, detached housing accounts for 97 percent of housing units in the planning area. There are no structures with three or more units. The median value is $218,000 (Oldham County Planning and Zoning, 2008).

The largest industry in Oldham County is the Carriage House Companies, Incorporated, which is located in the Darby Creek Watershed. Carriage House Companies employs approximately 350 people and produces salsa, sauces, syrups, jams, and jellies at its facility (Oldham County Planning and Zoning, 2008). Table 2.14 shows a list of Buckner's major industries and businesses, some of which are located in the Darby Creek Watershed.

Table 2.14: Major Industries and Businesses in Buckner (OCSD, 2007).

Firm	Product(s)/Services	Number of Employees
Aggressive Tool & Die Inc.	Tools & die, molds	7
Caibe & Co.	Solid surface counter tops and granite	8
Carriage House Companies, Inc.	Mexican salsas, barbeque steak sauces, chocolate and pancake syrups, jams and jellies	350
Clayton & Lambert Manufacturing Co.	Grain bins, storage silos, stainless steel panels for in-ground pools and spas and pool structures, outdoor poster panels, standing seam roofs, above-ground containment basins	9
Fastline Publications	Monthly magazine publishing	155
Hartlage Manufacturing	Injection molded plastic parts	15
Metro Window Co.	Custom windows and doors	7
OCTA Inc.	Tube specialist – cutting, bending, forming, etc. (i.e., copper, aluminum, etc.)	17
Pearce Brothers Ready-Mix Concrete & Supply Co.	Ready-mixed concrete	25
Toolcraft Co.	Foil container dies, special machinery, precision CNC machining, tool and die, jigs and fixtures, cutting, boring, drilling, grinding, lathe and mill work	8
Tri-County Steel, Inc.	Sheet, structure and ornamental steel fabricating	9

2.5 Plan for collecting more data

Continued data collection for the Darby Creek Watershed is planned by the Salt River Watershed Watch group. This will be very important as the area becomes more developed in the coming years.

2.6 Summary and conclusions

The Darby Creek Watershed faces many challenges in the future. Concerns for the Darby Creek Watershed include: pathogens, some suspected sources are highway, road and bridge runoff (non-construction related); package plants, other small flow discharges, septic line leakage, stormwater runoff, agricultural waste, and impending development. The development of the area will require the use of BMPs to reduce and improve the quality of the stormwater runoff and to reduce the amount of impervious surfaces.

There are areas of the watershed that have noteworthy challenges. The team is still in the process of pinpointing the source of contaminants impacting water quality levels.
Meeting the challenges for the watershed will require a continued commitment to educate the public, developers, and contractors on stormwater and environmental BMPs to improve and maintain the quality of the environment and water.

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Chapter 3 Darby Creek Impairment Analysis

Watershed Plan Update Note: The bulk of this chapter remains as it was written in 2009 with the exception of a new section added at the end on page 90. This section covers the *E. coli* monitoring conducted by Kentucky Division of Water in 2014.

Chapter 3 examines the existing conditions of the Darby Creek Watershed.

Darby Creek has not been assessed by KDOW. As such, its default regulatory status is high quality, which means any discharge permits should be strict enough to preclude any stream degradation. This is in keeping with Chapter 2's observation that much of the stream is in good condition. However, water quality sampling has revealed high levels of *E. coli.* While Darby Creek has not been assessed for water quality, it is an area of concern because it may be impacting water quality in its receiving stream, Harrods Creek, which is impaired for PCR due to high levels of *E. coli*.

In order to better understand the condition of Darby Creek, Third Rock Consulting was contracted to conduct a water quality study on the creek in 2008. Samples were collected at eight locations (see Figure 3.1) in the watershed, six times from August to December. Additional sampling by the Kentucky Division of Water in 2014 quantified more recent pathogen levels in Darby Creek.

This chapter reviews these data to best determine impairments and their causes and sources. First, regulatory and other standards are introduced. Second, data are presented. Third, data are examined according to the area of the watershed with which they correspond and compared to standards. Fourth, pollutant loading calculations are provided. Fifth, data analysis is applied to draw conclusions about impairments, causes, and sources. Finally, conclusions are summarized for the whole of Darby Creek Watershed.

The data collected in 2008 are reviewed first, along with the pollutant loads calculated with those data. Then, in a new data section starting on page 37, *E. coli* data collected by the Kentucky Division of Water in 2014 are reviewed.

3.1 Background on Darby Creek Data, Data Analysis, and Regulatory Standards

3.1.1 Types of Data Analysis

Monitoring data can be categorized into three categories: biological, physical, and chemical.

Biological data

Biological data examine the structure and function of aquatic communities, habitat, and health and abundance of aquatic species or fish populations. Due to budget and time constraints, Third Rock Consulting did not complete a biological assessment of Darby Creek. They did record observations and perform some habitat monitoring at each sampling site, using a method developed by the U.S. EPA for stream assessment: *Rapid Bioassessment Protocol (RBP)*. Since Third Rock Consulting used the portions of RBP monitoring instruments only related to habitat, the rest of Chapter 3 refers only to habitat data and results (see Appendix E for RBP results).

Table 3.1 shows describes the parameters examined with the RBP:

- *Epifaunal Substrate/Available Cover* refers to available cover for aquatic life.

- *Embeddedness* refers to amount of sediment between rocks in the stream bottom.

- *Velocity/Depth Regime* refers to variation in flow, e.g. pools vs. riffles.

- *Sediment Deposition* refers to deposition, e.g. sand bars.

- *Channel flow Status* refers to the flow level.

- *Channel Alteration* refers to amount of channelization.

- *Frequency of Riffles* refers to distance between riffles.

- *Bank Stability* refers to the condition of the stream bank and measures whether stream banks are eroded or have the potential for erosion. Steep banks, for example, are more likely to collapse and experience erosion (EPA, 2009).

- *Vegetative Protection* measures the amount of streamside and riparian area vegetation. The roots of streamside plants help hold soil in place, and so, reduce erosion.

- *Riparian Vegetative Zone Width* refers to the width of the adjacent vegetated zone.

Table 3.1: Parameters for Rapid Bioassessment Protocols, with indications of scoring rates (USEPA, 2009).

	Epifaunal Substrate	Embededness	Velocity/ Depth	Sediment Deposit	Channel Flow	Channel Alter.	Freq. Riffle	Bank Stability		Veg. Protect.		Riparian width	
								LB	RB	LB	RB	LB	RB
Best Possible Score	20	20	20	20	20	20	20	10	10	10	10	10	10
Minimum Score for suboptimal rating	10	10	10	10	10	10	10	5	5	5	5	5	5

RBP reflects observations at a sampling site. To get a more comprehensive idea of some of these parameters as well as to examine adjacent land use and practices, team members also conducted Visual Assessment Protocols, or stream walks. These protocols have been designed by the Natural Resources Conservation Service, as a tool for laymen to provide more information. Visual Assessment Protocols collect information similar to RBP, but stream walks overcome the limitations of collecting RBP information only collected at a specific sampling site.

Physical data
A second type of monitoring data are water quality parameters measured in stream which include conductivity, dissolved oxygen, flow, pH, temperature, turbidity, and total suspended solids. Third Rock Consulting collected physical data at each of eight sampling sites in 2008.

Specific conductance is a measure of how well water can pass an electrical current. Conductivity increases with increasing amount and mobility of ions. These ions, which come from the breakdown of compounds, conduct electricity because they are negatively or positively charged when dissolved in water.

Flow measurements reveal the correlation of stream dynamics with storm events and provide clues as to whether pollutants are from nonpoint or point sources. For example, if *E. coli* concentrations increase during rain events, the source is likely surface runoff like livestock, wildlife, or failing septic systems. However, if concentrations increase during low flows, the source is more likely point source such as straight pipes or package treatment plants.

Total Suspended Solids (TSS) are solids suspended in water that can be trapped by a filter, such as silt, decaying plant and animal matter, industrial wastes, and sewage. High concentrations of suspended solids can cause many problems for stream health and aquatic life. TSS can block light from entering the stream and decrease rates of photosynthesis. TSS can also clog the gills of fish and create low visibility conditions for aquatic life. High TSS in a stream can mean higher concentrations of bacteria, nutrients, pesticides, and metals in the water.

Chemical monitoring data
The third type of monitoring data is chemical monitoring data, which measure the presence of pollutants such as pathogens, pesticides, organics, metals, and nutrients. Due to land use characterization and other aspects of the watershed, chemical monitoring by Third Rock Consulting was conducted for phosphorus, nitrogen, and *E. coli.*

Salt River Watershed Watch volunteers also conduct chemical monitoring in the watershed.

Nutrients are chemicals that enrich algae and other growth in waterbodies. High levels of nutrients can cause health problems in drinking water and can support algae growth that in turn causes problems, like low dissolved oxygen. Two nutrients of concern are nitrogen and phosphorus. Both are common components of fertilizers, wildlife, pet or livestock waste, and human waste. Soil erosion is a major contributor of phosphorus and nitrogen to streams along with overgrazed pasture land, stream bank erosion, and wastewater treatment plant discharge. Nitrogen is of special concern due to health risks associated with drinking water and by-products of treating drinking water that contains high nitrogen. For this project, nitrogen was monitored as Total Kjeldahl Nitrogen (TKN), due to budgetary restraints that prohibited the monitoring of total nitrogen. TKN is a combination of the organically bound nitrogen and ammonium.

Bacteria

Bacteria are commonly measured by monitoring *E. coli*, which is a type of bacteria found in the digestive tracts of humans and animals. Most strains of *E. coli* are harmless, but they can act as indicators of other, harmful pathogens found in untreated human or livestock waste. Such waste, released into water, can expose people to bacteria, viruses, and protozoa. These bacteria have a relatively short survival period upon entering surface water, so information about adjacent or upstream land uses and discharges provides key evidence to sources. Sources can include wildlife, livestock, pet, and human sources (typically from failing wastewater sources).

3.1.2 Regulatory standards

In order to evaluate the water quality in the Darby Creek Watershed, standards are drawn from three sources: numeric criteria for warm water Aquatic Habitat, mean parameter concentrations from Reference Reaches in the Bluegrass Bioregion, and surface water quality regulatory standards for the Commonwealth of Kentucky (Table 3.2).

Parameters such as total phosphorus and TKN are important to consider, but there are no numeric water quality standards for them. Instead, standards were developed by the Division of Water using data from comparable Reference Reach Streams. Conditions in these comparatively non-impacted streams provide a correlation to other streams within the same or similar ecoreigon or bioregion.

Since grab samples were collected monthly, instantaneous limits for *E. coli* and dissolved oxygen were used for comparison. There is no standard for conductivity, so a 500 µS/cm was used as a standard. The EPA has found that levels higher than this may not be suitable for macroinvertebrates and fish (USEPA, 2009). It should be noted the geology typical of the area does exhibit high conductivity due to calcium carbonate ions that readily dissolve in limestone.

Table 3.2: Water Quality Evaluation Standards.

Parameter	Unit	Water quality standards	Source
Conductivity	µS/cm	500	USEPA 2009: Levels above may not be suitable for macroinvertebrates and fish
Dissolved Oxygen	mg/L	4.0	401 KAR 10:031 – Instantaneous minimum
pH	SU	6.0 – 9.0	401 KAR 10:031 – Lower and Upper Limits
Temperature	°F	89	401 KAR 10:031 – Upper Limit
Turbidity	NTU	32.1	USEPA 2006: Interior Plateau Ecoregion Average (based on 1732 samples)
Total Kjeldahl Nitrogen	mg/L	0.320	KY DEP: Mean parameter concentrations from Reference Reaches in the Bluegrass Region
Total Phosphorus	mg/L	0.132	KY DEP: Mean parameter concentrations from Reference Reaches in the Bluegrass Region
Total Suspended Solids	mg/L	9.82	KY DEP: Mean parameter concentrations from Reference Reaches in the Bluegrass Region
E. coli	CFU/100mLs	240	401 KAR 10:031 – Instantaneous Limit

References: USEPA. 2009b. Website: "EPA> OWOW> Monitoring and Assessing Water Quality> Volunteer Stream Monitoring: A Methods Manual>Chapter 5> 5.9 Conductivity." http://www.epa.gov/volunteer/stream/vms59.html Accessed September 1, 2009. United States Environmental Protection Agency (USEPA). 2006. STORET database. Accessed on August 2006, for all surface water quality data collected by Kentucky Division of Water through August 2006. 401 KAR 10:031. EPA Nutrient Criteria Database: http://www.epa.gov/pub0hecd/index.html

3.1.3 Pollutant Loading

In order to effectively set goals for reducing pollutants, the Darby Creek Watershed plan must be able to tie the amount of each pollutant of concern to the causes and to the amounts of those pollutants the stream can carry and still remain within regulatory standards (or other guidelines). For example, data may show that *E. coli* levels in a stream must be reduced by 50% per day, and if the sole cause is proven to be cattle grazing adjacent to the stream, watershed team members can work with the landowner to take management measures that have been shown to reduce input by 50% on a daily basis. The amount of pollution is referred to as a "pollutant load." This watershed plan calculates daily and annual loading for pollutants of concern and determines the pollutant load reduction needed to meet state standards (or other standards) for water quality.

Loading can be calculated using monitoring data or literature values, or it can be calculated using models that incorporate land use information and therefore potential sources. For this project, Third Rock Consulting calculated loads. For these calculations, they used only data they collected. Salt River Watershed Watch data were not integrated into these analyses because of timing intervals, location differences, and lack of Third Rock Consulting Q/A on those data.

To calculate loads, sample concentrations were first multiplied by flow, which provides the load at a specific time, an *instantaneous load*. This was directly adjusted to an annual load calculation using time factors, e.g. seconds/day etc. An annual load enables (1) comparison of the existing load to acceptable loads, (2) target alterations for achieving acceptable loads, and (3) projections of land use and discharge changes necessary to achieve load reductions. Projections are made using literature values for impacts of specific changes in land use and discharge practices.

The calculation of existing loads in Darby Creek, using the limited amount of data Third Rock Consulting was able to collect under budget and time constraints, is somewhat rough. More data points would produce more specific, accurate loading information, relating concentrations to flow, and may reveal more information. But these methods are not feasible under the budget and timeframes of this project. Nonetheless, the load calculations, augmented by local knowledge and other existing data, provide enough information for the Darby Creek project to effectively set reasonable priorities, action items, and standards.

There are many ways to analyze data, and part of creating a watershed plan is deciding upon the details of the analysis. After some discussion, it was decided that in calculating loads, the arithmetic mean (the average) would be used instead of the geometric mean. The geometric mean tends to remove outliers from a dataset. This can be very important in maintaining the integrity of data in some instances. For this project, with the small data set (only six collection dates at eight locations), it was determined that the arithmetic mean was more appropriate.

3.2 Data Collected

Data were collected specifically for this project at sites selected based on their proximity to pertinent land use features, tributary confluences, and available access. Third Rock Consulting collected water samples at each station six times, between August and December 2008 (see Figure 3.1). Watershed team members contributed to the data by conducting three stream walks in the watershed. Team members who are Salt River Watershed Watch volunteers provided other monitoring data. These data are discussed in the sub-basin analyses below when applicable.

Third Rock Consulting collected physical data to measure temperature, conductivity, dissolved oxygen (DO), pH (acidity), turbidity, and total suspended solids. Data are shown below, with a site characterization for each site.

Third Rock Consulting also collected chemical data, for pathogens (*E. coli*), and nutrients (TKN and total phosphorus). Data for each site are shown below with a description and discussion. Additionally, the expected TSS load was calculated. Loading results for all sites are compiled in the section following the site-specific analyses below.

3.3 Sub-basin Analyses

In order to best understand the implications of these data, they must be examined within the context of the relevant watershed area. Therefore, the rest of this chapter is organized by watershed sub-basin. A sub-basin is the watershed area upstream of the sampling location. Sampling sites in the headwater areas of the watershed, UDC2, DF2, DF3, and USF2 represent the entire area above that sampling point. Sampling sites in the lower reaches of the watershed, DF1, USF1, and DC1, represent the cumulative area from the headwaters to that point. These sites can also indicate differences between the upper reaches and downstream sampling site. The site at the mouth of Darby Creek, DC1, represents the entire watershed and thus, its contribution to Harrods Creek (see Figure 3.1).

Each sub-basin discussion includes the habitat data, physical and chemical data, an overall characterization of the stream, the adjacent land-uses (with discussion of possible sources and causes of pollutants), pollutant loading, and a sub-basin map.

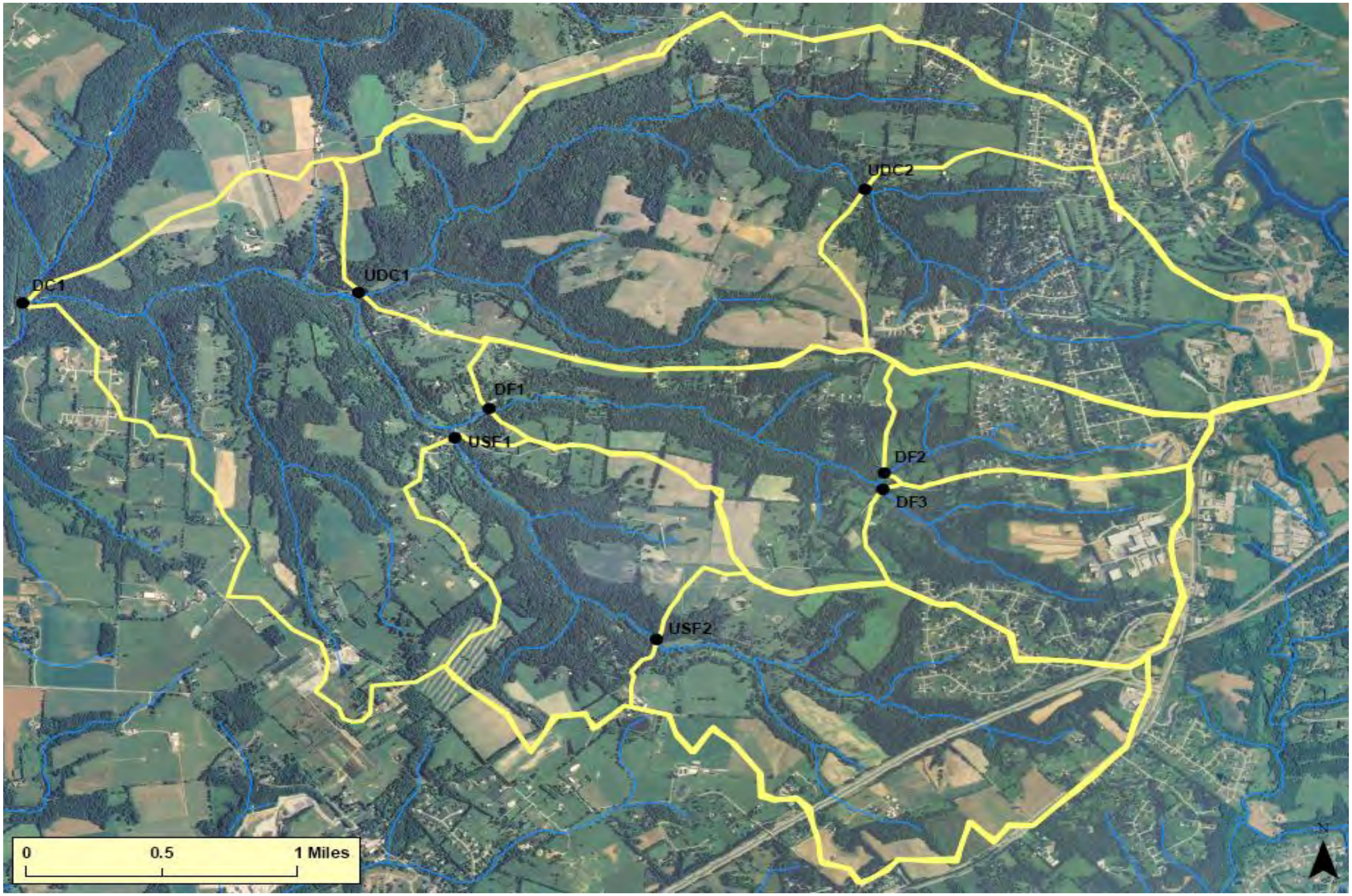

Figure 3.1: Darby Creek Watershed sub-basins (KDOW, 2009).

3.3.1 Upper Darby Creek (Headwaters), UDC2

This area of the watershed is located in the east-northeast corner. Sampling results may reflect inputs from at least five tributaries (Figure 3.2)

Figure 3.2: Sub-basin map of UDC2 (KDOW, 2009).

Habitat Results

Rapid Bioassessment Protocols (RBP) work by Third Rock Consulting rated the sampling site to be partially supporting. Lower scores are attributed to lack of riparian vegetation and lack of instream cover (epifaunal substrate). See Table 3.3.

Table 3.3: Rapid Bioassessment Protocols Ratings at UDC2 (Third Rock Consulting, 2008).

	Epifaunal Substrate	Embed-edness	Velocity/ Depth	Sediment Deposit	Channel Flow	Channel Alter.	Freq. Riffle	Bank Stability		Veg. Protect.		Riparian width	
UDC2								LB	RB	LB	RB	LB	RB
RBP Score	11	15	13	15	13	13	16	9	9	8	8	5	4

RBP was conducted near the sampling site. In contrast, Darby team members' Visual Stream Assessments provided observations in a longer stretch of stream. Two stream walks were conducted in this sub-basin by Darby Creek Team member groups. The first was conducted September 16, 2009 by Tessa Edelen and Beth Stuber. They gave the reach they walked a habitat score of 6.3, which is "fair." They observed vegetated stream banks and no obvious signs of erosion or stream degradation. The riparian area was wooded, but mowed to the stream bank in many locations. They did not complete the macroinvertebrate portion of the survey, but observed fish and aquatic insects in the stream. While the score was fair, both team members thought the stream stretch was good habitat.

The other stream walk in this area was conducted by Brooke Shireman and Carolyn Gessner on September 26, 2009 (Figure 3.3-3.5). They surveyed four reaches. The walk proceeded from west to east, ending at the high school. To view each individual stream reach map, photos, and score sheet, see Appendix C. The reach scores are as follows:

- Reach 1 - Culvert at old sewage plant access road to Heather Hill Road, scored 7.4 = Fair. Comments: Debris damns behind culvert; Upstream portion exposed to sunlight due to no riparian – lawn mowed to stream edge more observed algae growth in this section

- Reach 2 - Heather Hills Road to Grand Villa Drive, scored 6.2 = Fair. Comments: Downstream left bank armored with a concrete wall adjacent to a driveway; compacted detention basin (noted in aerial); some observed light recreational impacts.

- Reach 3 - Along Grand Villa Drive, scored 4.3 = Poor. Comments: Increased human impacts including runoff drainage, impervious surface close to stream, mowed to stream edge, houses close to stream.

- Reach 4 - Grand Villa Drive to headwaters at school complex, scored 8.2 = Good. Comments: Majority of reach was very nice. Upstream portion of stream at school is highly imperviousness and channelized.

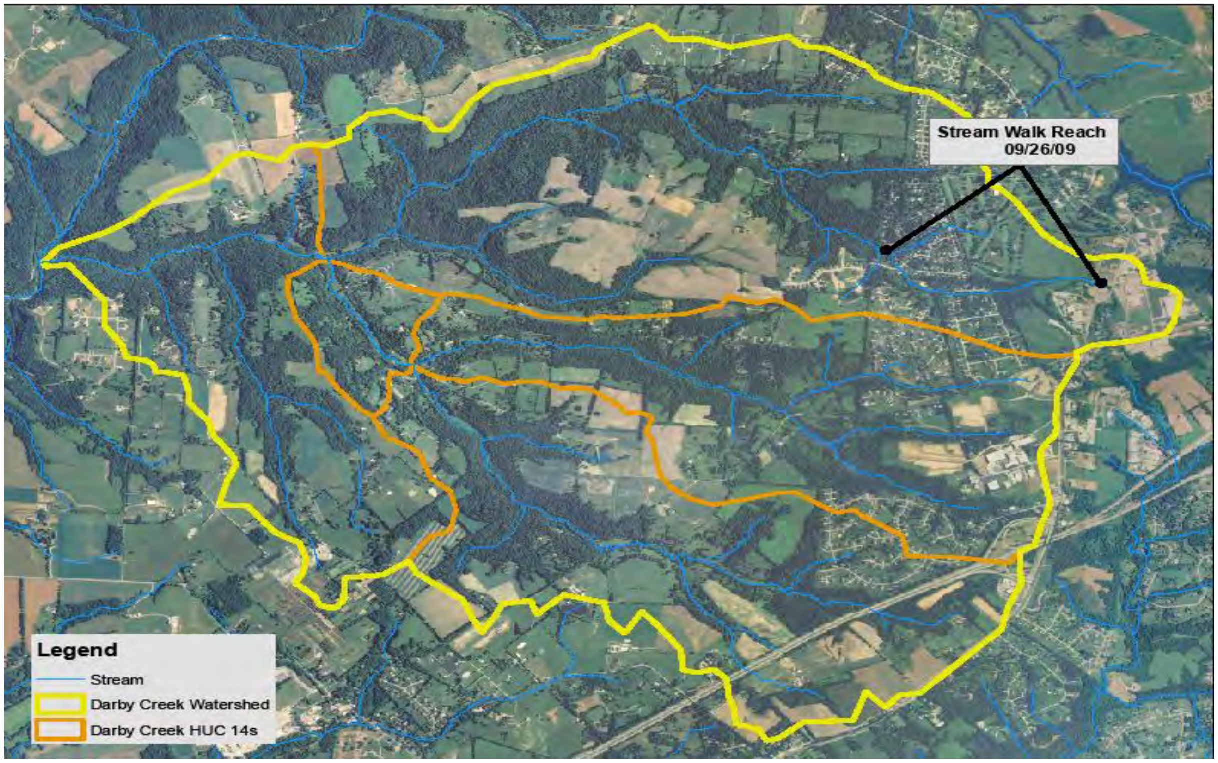

Figure 3.3: UDC2 Stream walk map (KDOW, 2009).

Figure 3.4: UDC2 Reach 4 (Shireman and Gessner, 2009).

Figure 3.5 : UDC2 Reach 1 (Shireman and Gessner, 2009).

Physical and Chemical Results

Physical and chemical monitoring results are shown in Table 3.4.

Table 3.4: Physical and Chemical Monitoring at UDC2 (Third Rock Consulting, 2008).

Site	Date	Water Quality									
		Temp	Cond	DO	pH	Turbidity	Flow	TKN	TP	TSS	*E. coli*
		°F	uS	mg/L	SU	NTU	Cfs	mg/L	mg/L	mg/L	CFU/100ml
UDC2	8/19	66	518	4.58	8.27	-	0.04	0.35	-	3.8	5600
	9/15	66.6	588	8.04	7.77	0.8	0.01	0.59	0.041	4.6	450
	10/13	60	524	8.21	7.59	Clear	0.07	0.10	0.033	1.0	620
	10/27	47.5	584	9.49	7.62	Clear	0.03	0.49	0.023	1.8	300
	11/24	41.2	557	11.32	7.29	Clear	0.39	0.67	0.048	20	2100
	12/9	41.5	494	11.87	7.67	20.3	1.96	0.59	0.049	13	1300
Mean		**53.8**	**544.17**	**8.92**	**7.70**		**0.42**	**0.465**	**0.039**	**7.4**	**1728.33**

Conductivity consistently exceeded Bluegrass Bioregion Standards level of 500 uMHOS in all but one sampling event. However, it is probable that these higher numbers are due to the local geology. Dissolved oxygen, while low in one sample (4.58), did not fall below the minimum of 4.0. TKN exceeded the standards 0.320, both in mean (0.465) and in five samples. TSS exceeded the standards mean of 9.82 twice (13 and 20), but the mean (7.4) was lower than the standards. *E. coli* consistently exceeded the instantaneous standards limit of 240 cfu, with samples varying from 125% to 875% above that standard.

Salt River Watershed Watch and Darby Creek Watershed team volunteer Carolyn Gessner collects a sample in this sub-basin. Her site ID is S203, and her site is located at the Old Heather Hill Sewage Treatment Plant. For the summer 2008 *E. coli* sampling day on July 12, 2008, *E. coli* = 4092 cfu, well above state standards. For summer 2009 *E. coli* sampling day on May 16, 2009, *E. coli* = 6488, again, well above state standards.

Loadings

Third Rock Consulting made loading calculations for site UDC2, as explained in section 3.1.3, to estimate annual loads of TKN, TP, TSS and *E. coli*. The results are shown in Table 3.5.

Table 3.5: Load Calculations for UDC2.

	Loading				Maximum Acceptable Loading				% Reduction to Reach Standards			
	TKN	TP	TSS	*E. coli*	TKN	TP	TSS	*E. coli*	TKN	TP	TSS	*E. coli*
Site	lbs/year	lbs/year	lbs/year	Trillion cfu/year	lbs/year	lbs/year	lbs/year	Trillion CFU/year				
UDC2	477	46	10,996	5.40	262	108	8,032	0.892	45%	0	27%	83%

Red highlighting indicates values that exceed state standards or standards; blue means value is below state standards or water quality standards (Third Rock Consulting, 2008).

Documented Issues and Source

The watershed area upstream of sample site UDC2 is acting as a geographic source of TKN, TSS, and *E. coli.* Therefore, documented issues of concern in this subwatershed include:

- Habitat (protection where conditions where good; improvement where poor)
- Nitrogen
- Suspended solids
- Pathogens/*E. coli*

Land use and practices

This sub-basin is mostly made up of residential housing, farms, and forested land. One subdivision located partially in the sub-basin, the Grand Villa, is the only area unsewered. According to county information, the subdivision is 10-15 years old and not an obvious source of septic issues. The Oldham County Golf Course is located in this area, but does not appear to be a significant source of nutrients or pollutants. There were some incidents of high sediment loads, perhaps from the upstream sports field construction. There were no reports of large congregations of wildlife.

Conclusions, Upper Darby Creek (headwaters)

Except for near the school and where landowners mow up to the streambank, habitat is an issue mainly with respect to protecting its future. Excessive TSS appears to be a result of streambank erosion from excessive flows.

It is unclear what the sources of pathogens and nitrogen are. Based on the clustering of homes without sewer upstream of this site, it is possible that human waste (from septic and/or sewer) is the cause of the measured pollutants - specifically from homes along Grand Villa Drive, Fairway Drive, Sadler Mill Road, and all the respective satellite roads in the rural residential community. It was hoped that the microbial source tracking would provide insight into the source, but it did not.

3.3.2 Middle Darby Creek, UDC1

This area of the watershed is located in the central northern section (Figure 3.6). The Third Rock Consulting sampling site was directly upstream of the confluence of Darby Creek and South Fork. Sampling results reflect conditions in Darby Creek from UDC2 to the confluence with the South Fork, and inputs from four or five significant tributaries.

Figure 3.6: Sub-basin map of UDC1 (KDOW, 2009).

Habitat Results

Rapid Bioassessment Protocols (RBP) work rated the sampling site to be non- supporting. Lower scores are attributed to lack of bank stability, vegetative protection, riparian vegetation and lack of instream cover (epifaunal substrate). See Table 3.6. No stream walk was conducted.

Table 3.6: Rapid Bioassessment Protocols Ratings at UDC1 (Third Rock Consulting, 2008).

	Epifaunal Substrate	Embed-edness	Velocity/ Depth	Sediment Deposit	Channel Flow	Channel Alter.	Freq. Riffle	Bank Stability		Veg. Protect.		Riparian width	
								LB	RB	LB	RB	LB	RB
Score UDC1	11	15	13	15	13	15	15	5	9	5	8	8	6

However, these observations only reflect conditions at the sampling site. Third Rock Consulting also reported: “This drainage reach represents the most intact/least fragmented riparian habitat in the Darby Creek Watershed.” As apparent from Figure 3.6, there are large tracts of forested land throughout the watershed.

Physical and Chemical Results

Physical and chemical monitoring results are shown in Table 3.7. As expected because of conditions in the riparian zone of this reach, only two parameters were of concern. TKN mean (0.327) barely exceeded the mean standards of 0.320, although one sample (0.64) was twice the mean, and *E. coli* exceeded the instantaneous standards limit of 240 twice (260, 270).

Table 3.7: Physical and Chemical Monitoring at UDC1 (Third Rock Consulting, 2008).

Site	Date	Water Quality									
		Temp °F	Cond uS	DO mg/L	pH SU	Turbidity NTU	Flow cfs	TKN mg/L	TP mg/L	TSS mg/L	*E. coli* CFU/100 mls
UDC1	8/19/2008	70	338	7.81	8.91	0.1	0.01	0.64	-	4.4	160
	9/15/2008	66.9	415.9	9.81	8.32	0.1	0.08	0.46	0.013	2.6	270
	10/13/2008	64.7	475.7	10.09	8.15	0.1	0.19	0.1	0.079	1	100
	10/27/2008	46.5	434.9	12.47	8.41	0.1	0.01	0.1	0.018	2.3	30
	11/24/2008	37.8	404.8	13.07	8.06	2.6	1.30	0.44	0.071	1	260
	12/9/2008	39.9	325.1	12.55	7.8	10	1.57	0.22	0.024	1.7	90
Mean								*0.327*	*0.041*	*2.17*	

Loadings

Third Rock Consulting made loading calculations for site UDC1, as explained in section 3.1.3, to estimate annual loads of TKN, TP, TSS and *E. coli*. The results are shown in Table 3.8.

Table 3.8: Load Calculations for UDC1.

	Loading				Maximum Acceptable Loading				% Reduction to Reach Standards			
Site	TKN lbs/year	TP lbs/year	TSS lbs/year	*E. coli* Trillion cfu/year	TKN lbs/year	TP lbs/year	TSS lbs/year	*E. coli* Trillion CFU/year	TKN	TP	TSS	*E. coli*
UDC1	317	57	1203	0.77	330	136	10,128	1.13	0	0	0	0

Red highlighting indicates values that exceed state standards or standards; blue means value is below state standards or water quality standards (Third Rock Consulting, 2008).

Documented Issues and Source

The data indicate that the watershed upstream of sample site UDC1 is not a significant geographic source of pollutants of concern, although *E. coli* is sometimes higher than desirable.

Land use and practices

Team members noted that in this area, there are three working farms that have fenced cattle out of Darby Creek.

Conclusions, Middle Darby Creek

The differences between results at site UDC2 and here, at UDC1, are almost certainly due to the forest that occupies most of the area. In fact, this middle stretch of Darby Creek serves as a sink of excess nitrogen and *E. coli* observed at UDC2. For example, *E. coli* at UDC2 on August 19th was 5,600, but downstream at UDC1 (2 hours later), concentration was only 160. Due to the intact riparian zone and the good water quality, this will be a good area to target for protection.

3.3.3 Upper Darby Fork, DF2 and DF3

This subwatershed is in the eastern end of the Darby Creek Watershed, draining an area north and east of the intersection of I-71 and Rte. 393. Two sampling sites provide insight into conditions in this subwatershed by providing information just above the confluence of tributaries. These two sites are analyzed separately below, but will be combined in Chapter 4's discussion of actions and remedies.

Figure 3.7: Sub-basin map of DF2 (KDOW, 2009).

DF2, Headwaters of Darby Fork, upstream of confluence with unnamed headwater tributary

Habitat Results

Rapid Bioassessment Protocols (RBP) work by Third Rock Consulting rated the sampling site to be nonsupporting. Lower scores are attributed to lack of riparian vegetation and lack of instream cover (epifaunal substrate). See Figure 3.7 and Table 3.9. There was no stream walk conducted in this area.

Table 3.9: Rapid Bioassessment Protocols Ratings at DF2 (Third Rock Consulting, 2008).

	Epi-faunal Sub-strate	Embed-edness	Velocity/ Depth	Sedi-ment Deposit	Channel Flow	Channel Alter.	Freq. Riffle	Bank Stability		Veg. Protect.		Riparian width	
								LB	RB	LB	RB	LB	RB
Score DF2	15	13	13	12	8	10	16	8	8	8	8	9	9

Physical and Chemical Results

Physical and chemical monitoring results are shown in Table 3.10.

Table 3.10: Physical and Chemical Monitoring at DF2 (Third Rock Consulting, 2008).

Site	Date	Water Quality									
		Temp °F	Cond uS	DO mg/L	pH SU	Turbidity NTU	Flow cfs	TKN mg/L	TP mg/L	TSS mg/L	*E. coli* CFU/100mls
DF2	8/19/2008	67.2	343	3.03	8.09	0.1	0.02	0.19	-	1	<10
	9/15/2008	69.1	381.7	4.01	3.1	0.1	0.03	0.38	0.011	2	60
	10/13/2008	63.7	229	4.15	7.64	0.1	0.04	0.1	0.015	5.4	40
	10/27/2008	54.4	392.8	7.97	8.1	0.1	0.02	0.3	0.003	10	10
	11/24/2008	42.6	327.5	10.52	7.74	2.1	0.02	0.54	0.013	4.8	250
	12/9/2008	41.3	411	11.96	7.5	25	0.22	0.55	0.053	50	20
Mean								*0.343*	*0.019*	*12.2*	

One DO sample (3.03) is below the standards of 4.0, and two are near the minimum. One pH sample (3.1) is below the minimum pH standards of 6.0. The mean TKN (0.343) was higher than the standards 0.320; two samples (0.54 and 0.55) were well above it. TSS mean (12.2) was above the standards mean of 9.82; only one sample (50) exceeded that mean, 500% of that standards. *E. coli* was generally low, but one sample (250) was above the standards.

Loadings

Third Rock Consulting made loading calculations for site DF2, as explained in section 3.1.3, to estimate annual loads of TKN, TP, TSS and *E. coli*. The results are shown in Table 3.11.

Table 3.11: Load calculations for DF2.

	Loading				Maximum Acceptable Loading				% Reduction to Reach Standards			
Site	TKN lbs/year	TP lbs/year	TSS lbs/year	*E. coli* Trillion cfu/year	TKN lbs/year	TP lbs/year	TSS lbs/year	*E. coli* Trillion CFU/year	TKN	TP	TSS	*E. coli*
DF2	50	5	3,732	0.019	36	15	1,113	0.124	27%	0	70%	0

Red highlighting indicates values that exceed state standards or standards; blue means value is below state standards or water quality standards (Third Rock Consulting, 2008).

Documented Issues and Source

The watershed upstream of sample site DF2 is acting as a source of nitrogen and suspended solids. The excess nitrogen is likely responsible for some samples of low oxygen and pH. *E. coli* presence is also of moderate concern. Therefore, issues of concern in the watershed above this sampling site include:

- Habitat
- Nitrogen
- Suspended Solids
- Pathogens/*E. coli* (moderate)

Land Use and Practices

Team members noted that in this area there is one area of unsewered homes in the Grand Villa (partially located in this sub-basin) subdivision. As stated previously, this subdivision is approximately 10-15 years old. The agricultural areas of this sub-basin have steep topography areas. Cattle do graze in this area.

Conclusions, Upper Darby Fork (DF2)

Because the sampling site was below a small impoundment, it is also possible that pollutants were flushed from the impoundment prior to sampling. This could have impacted nitrogen, *E. coli*, low pH, and low dissolved oxygen samples. It is most likely that TSS excesses come from a combination of streambank erosion (from excessive flows attributed to land cover imperviousness) and new construction. It is likely that the excessive *E. coli* comes from existing and developing residential areas upstream of the sampling site and/or wildlife. Specifically, human sources of bacteria could potentially come from the new Stonefield Lane development or the Grand Villa Drive subdivision. Because the sampling site was below a small impoundment, it is also possible that *E. coli* was flushed from the impoundment prior to sampling.

<u>DF3, Headwaters of Darby Fork, unnamed headwater tributary</u>

The DF3 subwatershed is located just south of DF2, in the eastern part of the watershed (see Figure 3.8).

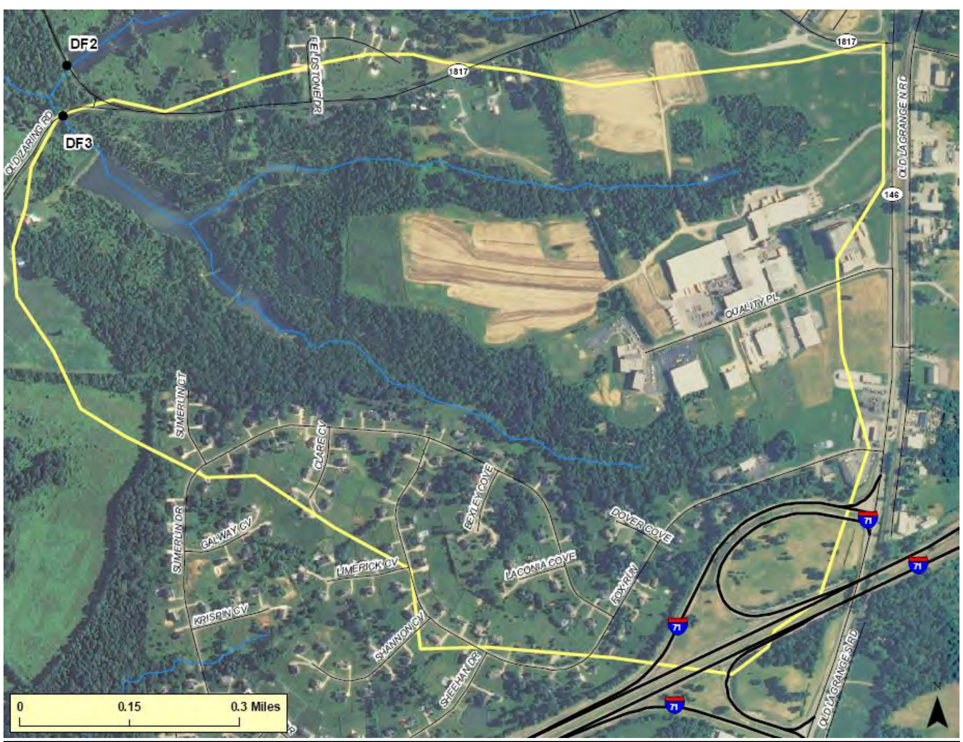

Figure 3.8: Sub-basin map of DF3 (KDOW, 2009).

Habitat Results

Rapid Bioassessment Protocols (RBP) work by Third Rock Consulting rated the sampling site to be non- supporting. Lower scores are attributed to lack of riparian vegetation, channel flow, and infrequency of riffles. See Table 3.12. No stream walk was conducted in this area.

Table 3.12: Rapid Bioassessment Protocols Ratings at DF3 (Third Rock Consulting, 2008).

	Epifaunal Substrate	Embed-edness	Velocity/ Depth	Sediment Deposit	Channel Flow	Channel Alter.	Freq. Riffle	Bank Stability		Veg. Protect.		Riparian width	
								LB	RB	LB	RB	LB	RB
Score DF3	11	16	13	16	7	13	10	9	9	7	7	9	9

Physical and Chemical Results

Physical and chemical monitoring results from Third Rock Consulting samples are shown in Table 3.13.

Table 3.13: Physical and Chemical Monitoring at DF3 (Third Rock Consulting, 2008).

Site	Date	Water Quality									
		Temp °F	Cond uS	DO mg/L	pH SU	Turbidity NTU	Flow cfs	TKN mg/L	TP mg/L	TSS mg/L	*E. coli* CFU/100mls
DF3	8/19/2008	65.1	420.7	7.75	7.98	0.1	0.03	1.3	-	14	60
	9/15/2008	68.3	465.2	7.38	8.52	0.1	0.01	0.43	0.012	1	60
	10/13/2008	60.5	529	10.83	7.74	0.1	0.01	0.1	0.014	1.2	90
	10/27/2008	48.7	533	12.21	7.85	0.1	0.03	0.1	0.024	1.3	60
	11/24/2008	42.6	551.1	12.1	7.85	2.6	0.09	0.86	0.029	15.9	320
	12/9/2008	42.9	501.1	12.12	7.04	10	0.25	0.45	0.003	10	3000
Mean								*0.222*	*0.016*	*7.08*	

Conductivity exceeded the standards of 500 in four of the samples. TKN mean (0.222) is below the standards mean of 0.320, but several samples exceeded the mean and one (0.86) was more than twice as high. TSS mean (7.08) was below the standards mean of 9.82, but several samples were high. Most of the *E. coli* samples were below the standards limit of 240, but two samples (320, 3000) exceeded it, with one exceeding it more than tenfold.

Loadings

Third Rock Consulting made loading calculations for site DF3, as explained in section 3.1.3, to estimate annual loads of TKN, TP, TSS, and *E. coli*. The results are shown in Table 3.14.

Table 3.14: Load Calculations for DF3.

	Loading				Maximum Acceptable Loading				% Reduction to Reach Standards			
Site	TKN lbs/year	TP lbs/year	TSS lbs/year	*E. coli* Trillion cfu/year	TKN lbs/year	TP lbs/year	TSS lbs/year	*E. coli* Trillion CFU/year	TKN	TP	TSS	*E. coli*
DF3	76	2	1,124	1.17	43	18	1,331	0.148	43%	0	7%	87%

Red highlighting indicates values that exceed state standards or standards; blue means value is within state standards or water quality standards (Third Rock Consulting, 2008).

Documented Issues and Source

The watershed upstream of site DF3 is acting as a source of nitrogen, suspended solids, and pathogens/*E. coli*. Documented issues of concern in this subwatershed include:

- Habitat
- Conductivity (not tied to low-flow events)
- Nitrogen
- Suspended Solids
- Pathogens/*E. coli*

Land Use and Practices

Land uses in the DF3 sub-basin consist mostly of a small industrial development including the Torbitt and Castleman shop which has a land farming application. Much of the stream side riparian area is fairly wooded. There are a couple of subdivisions, including part of Darby Pointe. Darby Point is currently unsewered and is approximately 15 years old. There are a number of livestock in the subwatershed consisting mostly of cows and horses.

Conclusions, Upper Darby Fork (DF3)

TSS is probably a result of streambank erosion (from excessive flows attributed to land cover imperviousness) but could also be due to surface erosion from new construction. For nitrogen and *E. coli,* potential sources of excessive pollutants include Fox Run Road and Summerlin Drive subdivision (human), pets, and/or wildlife. As with DF2, this sampling station is below an impoundment, and it seems as though it is a nutrient sink, not source.

3.3.4 Darby Fork Mainstem, DF1

This subwatershed is in the central area of the Darby Creek Watershed (Figure 3.9). Sampling results at DF1, which just upstream from the confluence with South Fork Darby, reflect input from areas draining into the mainstream and changes between sites DF2 and DF3 and DF1.

Figure 3.9: DF1 sub-basin (KDOW, 2009).

Habitat Results

Rapid Bioassessment Protocols (RBP) work by Third Rock Consulting rated the sampling site to be non-supporting. Lower scores are attributed to channel alterations, vegetative protections, and almost complete lack of riparian vegetation. See Table 3.15.

Table 3.15: Rapid Bioassessment Protocols Ratings at DF1 (Third Rock Consulting, 2008).

	Epifaunal Substrate	Embed-edness	Velocity/ Depth	Sediment Deposit	Channel Flow	Channel Alter.	Freq. Riffle	Bank Stability		Veg. Protect.		Riparian width	
								LB	RB	LB	RB	LB	RB
Score DF1	12	16	13	16	13	11	8	9	9	5	5	2	2

A group of Darby Team members conducted a stream walk through this area (Figures 3.10 and 3.11). On October 12, 2009 Gary Keibler, Brooke Shireman, Margi Jones, and Jenny Howard walked a stretch of stream in subwatershed DF1, the Demplytown section. The group surveyed four reaches. The walk proceeded from west to east. To view each individual stream reach map, photos, and score sheet, see Appendix C. The reach scores are as follows:

- Reach 1 scored 5.4 = Poor. Comments: Past channelization is evident. Most likely occurred when road was constructed. Stream is wide with a bedrock bottom (lots of head cutting). Good riparian area on left bank. Noticed foam in many area.
- Reach 2 scored 7.1 = Fair. Comments: More pools than in Reach 1. Overall, less confined stream channel. Stream bottom was a mix of different substrates, not just bedrock.
- Reach 3 scored 8.4 = Good. Comments: Overall nice reach of stream. One small area at beginning of reach had little riparian area and noticeable presence of livestock. This would be an excellent site for livestock exclusion. Upper portions of reach had intact riparian areas with noticeable signs of stream channel recovery. Some areas on hillsides appeared to be small dumping sites in the past.
- Reach 4 scored 6.8 = Fair. Comments: Large log jam in middle of reach. Downstream from log jam – noticeable oil sheen, immediately upstream from log jam – stagnate water with brown foam. Overall bedrock bottom and more fish barriers than Reach 3.

Figure 3.11: DF1 Stream walk Reach 1 (Keibler, 2009).

Figure 3.10: DF1 Stream walk Reach 3 (Keibler, 2009).

Physical and Chemical Results

Physical and chemical monitoring results are shown in Table 3.16.

Table 3.16: Physical and Chemical Monitoring at DF1 (Third Rock Consulting, 2008).

Site	Date	Water Quality									
		Temp °F	Cond uS	DO mg/L	pH SU	Turbidity NTU	Flow Cfs	TKN mg/L	TP mg/L	TSS mg/L	*E. coli* CFU/100mls
DF1	8/19/2008	69	520	9.74	8.85	0.1	0.64	0.43	-	4.8	1100
	9/15/2008	65.6	495.2	10.01	8.36	0.1	0.12	0.37	0.041	1	280
	10/13/2008	62.3	597	12.25	8.28	0.1	0.25	0.1	0.037	1	40
	10/27/2008	45.9	582.6	12.94	8.35	0.1	0.45	0.1	0.052	1	10
	11/24/2008	35	598.7	13.56	8	0.2	0.95	1.2	0.19	18	3200
	12/9/2008	33.9	397.8	13.82	7.78	29	0.84	0.44	0.091	11	1800
Mean								*0.44*	*0.082*	*6.1*	

Conductivity exceeded the standards minimum of 500 in four of the six samples. TKN mean (0.44) exceeded the standards mean (0.320), and four samples exceeded that standard. One TP sample exceeded the standards mean (0.132), but the sampling mean (0.082) was below that standards. *E. coli* in four samples exceeded the instantaneous standards limit of 240, several counts being quite high (1800, 1100, 3200); 3200 is more than ten times the standards limit. This reach has the biggest *E. coli* load in the watershed.

Loadings

Third Rock Consulting made loading calculations for site DF1, as explained in section 3.1.3, to estimate annual loads of TKN, TP, TSS and *E. coli*. The results are shown in Table 3.17.

Table 3.17: Load Calculations for DF1.

	Loading				Maximum Acceptable Loading				% Reduction to Reach Standards			
	TKN	TP	TSS	*E. coli*	TKN	TP	TSS	*E. coli*	TKN	TP	TSS	*E. coli*
Site	lbs/year	lbs/year	lbs/year	Trillion cfu/year	lbs/year	lbs/year	lbs/year	Trillion CFU/year				
DF1	611	116	9,802	7.91	341	141	10,466	1.16	44%	0	0	85%

Red highlighting indicates values that exceed state standards or standards; blue means value is below state standards or water quality standards (Third Rock Consulting, 2008).

Documented Issues and Source

The watershed area upstream of DF1 is acting as a source of TKN and pathogens/*E. coli*. Documented issues of concern include:

- Habitat
- Conductivity
- Nitrogen
- Pathogens/*E .coli*

Land Use and Practices

The general land use of this area is forested residential or farmland. The riparian areas are mostly wooded for the entirety of the sub-basin. The topography is steep along the creek. Also, there is a stretch of houses called Demplytown that is unsewered. This area sits on a ridge above the creek. Most of these houses are thought to be between 15 to 20 years old. Cattle have been seen in Darby Creek through this stretch.

Conclusions, Darby Fork Mainstem (DF1)

The mainstem of Darby Fork does not appear to mitigate nitrogen concentrations received from headwaters area, especially from Upper Darby Fork, DF3; rather, there must be additional sources. Based on the concentrated residential areas, the absence of sewer service in this drainage reach, and observed cattle behavior, it can be surmised that the *E. coli* originates both from the homes adjacent to Darby Fork along New Cut Road in Demplytown and the cattle grazing in the creek.

3.3.5 Headwaters and Upper South Fork Darby Creek, USF2

This subwatershed is in the southern section of the Darby Creek Watershed (Figure 3.12). Sampling results reflect input from two main and several minor tributaries. This subwatershed drains a section along I-71.

Figure 3.12: Subwatershed USF2 (KDOW, 2009).

Habitat Results

Rapid Bioassessment Protocols (RBP) work by Third Rock Consulting rated the sampling site to be nonsupporting. Lower scores are attributed to channel flow, low bank stability, lack of vegetative protection, and lack of riparian vegetation on the right bank. See Table 3.18.

Table 3.18: Rapid Bioassessment Protocols Ratings at USF2 (Third Rock Consulting, 2008).

	Epifaunal Substrate	Embed-edness	Velocity/ Depth	Sediment Deposit	Channel Flow	Channel Alter.	Freq. Riffle	Bank Stability		Veg. Protect.		Riparian width	
								LB	RB	LB	RB	LB	RB
Score USF2	13	15	13	14	10	13	13	4	6	4	6	8	3

Physical and Chemical Results

Physical and chemical monitoring results are shown in Table 3.19.

Table 3.19: Physical and Chemical Monitoring at USF2 (Third Rock Consulting, 2008).

Site	Date	Water Quality									
		Temp °F	Cond uS	DO mg/L	pH SU	Turbidity NTU	Flow cfs	TKN mg/L	TP mg/L	TSS mg/L	*E. coli* CFU/100mls
USF2	8/19/2008	63	343	5.52	8.19	0.1	0.03	0.39	-	3	430
	9/15/2008	65.7	367.7	6.98	7.77	22.1	0.01	0.9	0.072	24	750
	10/13/2008	No Flow									
	10/27/2008	46.5	510.1	8.04	7.82	0.7	0.01	0.1	0.015	18	120
	11/24/2008	39.2	546.5	10.66	7.84	3.8	0.09	0.84	0.032	3.4	2100
	12/9/2008	39.6	572.1	11.9	7.17	25	0.27	0.45	0.039	9.5	1000
mean								*0.536*	*0.040*	*11.58*	

SRWW and Darby Creek Watershed Team volunteer, Gary Keibler, samples in this sub-basin. For summer 2008 *E. coli* sampling day, his results yielded *E. coli* = 406 cfu on July 12, 2008. This level does exceed state standards (240 cfu/100ml). For the 2009 summer *E. coli* sampling day, his results yielded *E. coli* = 7270 on May 16, 2009. This is well above state standards. His site is located on Old Zaring Road, 1.2 miles north on highway 329.

Conductivity in three samples exceeded the standards minimum of 500. TKN mean (0.536) exceeded the standards mean of 0.320; only one sample (0.1) was below that standards mean. TSS mean (11.58) exceeded the standards mean of 9.82; three samples exceeded that standards mean. Only one *E. coli* sample met the instantaneous standards limit of 240; others range from almost double the limit (430) to a sample of 2100 that was almost nine times the limit.

Loadings

Third Rock Consulting made loading calculations for site USF2, as explained in section 3.1.3, to estimate annual loads of TKN, TP, TSS and *E. coli*. The results are shown in Table 3.20.

Table 3.20: Load Calculations for USF2.

	Loading				Maximum Acceptable Loading				% Reduction to Reach Standards			
Site	TKN lbs/year	TP lbs/year	TSS lbs/year	*E. coli* Trillion cfu/year	TKN lbs/year	TP lbs/year	TSS lbs/year	*E. coli* Trillion CFU/year	TKN	TP	TSS	*E. coli*
USF2	86	7	1,321	0.855	52	18	1,318	0.176	40%	0	0	79%

Red highlighting indicates values that exceed state standards or standards; blue means value is below state standards or water quality standards (Third Rock Consulting, 2008).

Documented Issues and Source

The watershed area upstream of USF2 is acting as a source of TKN and *E. coli*. Documented issues of concerning this subwatershed include:

- Habitat
- Conductivity (not related to low flows)
- Nitrogen
- Suspended Solids (mild)
- Pathogens/*E. coli*

Land Use and Practices

This area consists of mixed land uses including part of an unsewered subdivision, Darby Pointe. Darby Pointe is currently unsewered and is approximately 15 years old. There are a number of livestock in the subwatershed consisting mostly of cows and horses.

Conclusions, Headwaters and Upper South Fork Darby Creek
Potential sources of nutrients and *E. coli* in this reach are scattered rural residences, pets, wildlife, livestock, and a portion of the Summerlin Drive development adjacent to I-71.

3.3.6 Middle Section South Fork Darby Creek, USF1

This section is in the southwest/central area of the watershed (Figure 3.13). Sampling station USF1 is located just upstream of the South Fork's confluence with Darby Fork. Sampling results reflect input along the South Fork below sites USF2 and USF3 and two significant tributaries.

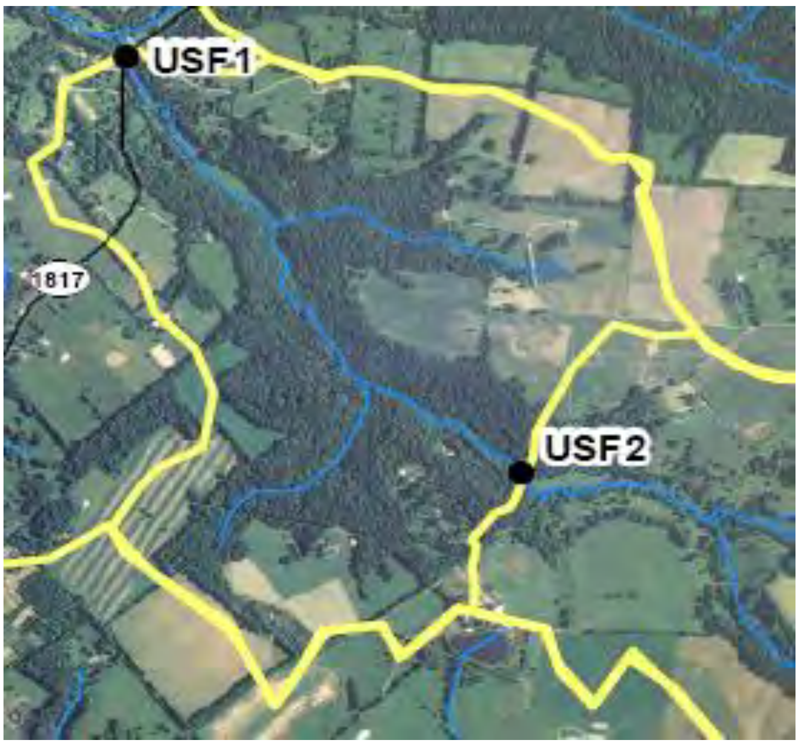

Figure 3.13: Subwatershed USF1 (KDOW, 2009).

Habitat Results
Rapid Bioassessment Protocols (RBP) work rated the sampling site to be nonsupporting. Lower scores are attributed to lack of epifaunal substrate and riparian vegetation, and poor bank stability, vegetative protection on the left bank. See Table 3.21.

Table 3.21: Rapid Bioassessment Protocols Ratings at USF1 (Third Rock Consulting, 2008).

	Epifaunal Substrate	Embed-edness	Velocity/ Depth	Sediment Deposit	Channel Flow	Channel Alter.	Freq. Riffle	Bank Stability		Veg. Protect.		Riparian width	
								LB	RB	LB	RB	LB	RB
Score USF1	10	15	14	14	15	14	15	6	8	6	8	2	5

Physical and Chemical Results

Physical and chemical monitoring results are shown in Table 3.22.

Table 3.22: Physical and Chemical Monitoring at USF1 (Third Rock Consulting, 2008).

Site	Date	Water Quality									
		Temp °F	Cond uS	DO mg/L	pH SU	Turbidity NTU	Flow cfs	TKN mg/L	TP mg/L	TSS mg/L	*E. coli* CFU/100mls
USF1	8/19/2008	66.7	319	6.3	8.56	0.1	0.16	0.28	-	1	90
	9/15/2008	67.8	314.2	10.25	8.49	0.1	0.23	0.5	0.009	6.4	250
	10/13/2008	63.1	356.1	11.25	8.21	0.1	0.16	0.1	0.016	1.1	30
	10/27/2008	47.1	371.7	12.53	8.38	0.1	0.33	0.1	0.003	1.3	30
	11/24/2008	38.2	340.8	12.9	8.05	0.1	0.25	0.82	0.034	1	260
	12/9/2008	39.3	345.1	12.91	7.92	3.4	0.73	0.26	0.021	3.4	240
Mean								*0.34*	*0.017*	*2.4*	

TKN mean (0.34) somewhat exceeded the standards mean of 0.32; one sample (0.82) was almost two and a half times the mean. Two *E. coli* samples (250, 260) exceeded the instantaneous standards of 240; one sample met the limit at 240.

Loadings

Third Rock Consulting made loading calculations for site DF1, as explained in section 3.1.3, to estimate annual loads of TKN, TP, TSS, and *E. coli*. The results are shown in Table 3.23.

Table 3.23: Load Calculations for USF1.

	Loading				Maximum Acceptable Loading				% Reduction to Reach Standards			
	TKN	TP	TSS	*E. coli*	TKN	TP	TSS	*E. coli*	TKN	TP	TSS	*E. coli*
Site	lbs/year	lbs/year	lbs/year	Trillion CFU/year	lbs/year	lbs/year	lbs/year	Trillion CFU/year	%	%	%	%
USF1	191	11	1,591	0.488	195	81	5,990	0.665	0	0	0	0

Red highlighting indicates values that exceed state standards or standards; blue means value is below state standards or water quality standards (Third Rock Consulting, 2008).

Documented Issues and Source

The watershed area upstream of the sample site USF1 is acting as a source of *E. coli* and as a moderate source of nitrogen. Documented issues of concerning this subwatershed include:

- Habitat
- Nitrogen (mild)
- Pathogens/*E. coli*

Land Use and Practices

The USF1 sub-basin is mostly forested in the riparian zone and agricultural fields in the rest of the area. This area does not have sewer lines.

Conclusions, Middle Section South Fork Darby Creek

Nitrogen concentrations from upper South Fork diminish in this middle section. Potential sources of *E. coli* at this site are scattered houses in the reach, livestock, pets, and wildlife.

3.3.7 Lower Darby Creek, DC1

This station is located at the mouth of Darby Creek, the most downstream point in the watershed (Figure 3.14). Sampling results reflect input from along Darby Creek below upstream sampling sites UDC1 on Upper Darby Creek, DF1 on Darby Fork, and USF1 on South Fork Darby, plus contributions from several important tributaries. Sampling results also reflect the contribution made by this watershed to Harrods Creek, immediately downstream of the sampling site (Table 3.24).

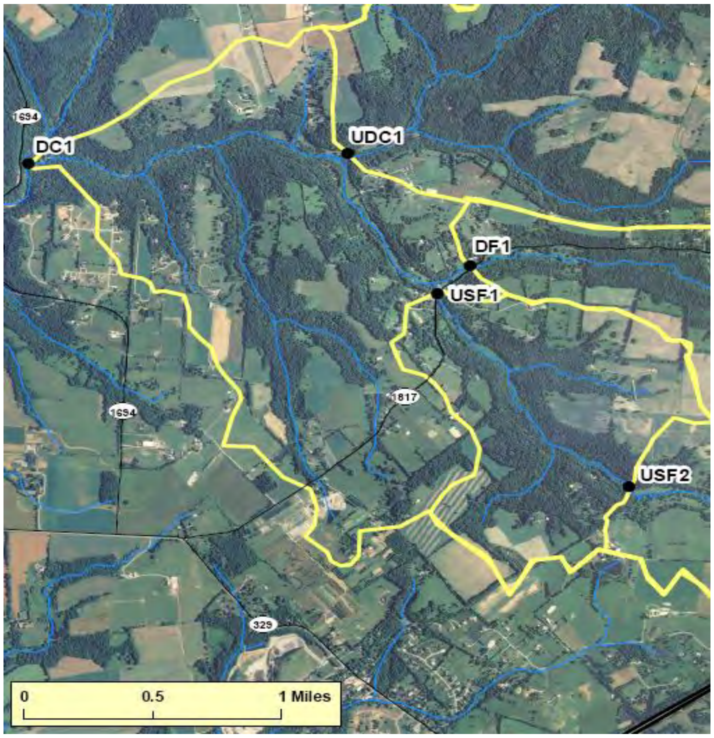

Figure 3.14: Subwatershed DC1 (KDOW, 2009).

Table 3.24: Rapid Bioassessment Protocols Ratings at DC1 (Third Rock Consulting, 2008).

	Epifaunal Substrate	Embed-edness	Velocity/ Depth	Sediment Deposit	Channel Flow	Channel Alter.	Freq. Riffle	Bank Stability		Veg. Protect.		Riparian width	
								LB	RB	LB	RB	LB	RB
Score DC1	11	15	13	15	13	15	15	5	9	8	8	8	6

Physical and Chemical Results

Physical and chemical monitoring results are shown in Table 3.25.

Table 3.25: Physical and Chemical Monitoring at DC1 (Third Rock Consulting, 2008).

		Water Quality									
Site	Date	Temp °F	Cond uS	DO mg/L	pH SU	Turbidity NTU	Flow Cfs	TKN mg/L	TP mg/L	TSS mg/L	*E. coli* CFU/100mls
DC1	8/19	71.2	439	5.03	7.97	-	0.48	0.36	-	<2.0	60
	9/15	67.8	476	7.01	8.16	2.8	0.38	0.17	0.005	2.4	320
	10/13	64	550	6.64	7.91	55	0.25	<0.10	0.008	61	140
	10/27	48.6	536	10.86	8.31	Clear	1.19	<0.10	0.006	1.4	110
	11/24	38.5	528	11.73	8.01	Clear	1.43	0.36	0.009	1	300
	12/9	39.7	517	12.32	7.31	21.4	11.32	0.21	0.031	10	630
Mean								*0.217*	*0.012*	*13.0*	

Four out of six conductivity samples exceeded the standards limit of 500. TSS mean (13) exceeded the standards mean of 9.82, but the exceedance was almost completely due to one very high sample (61). *E. coli* exceeded the instantaneous standards limit of 240 in half of the samples, once doubling (630) the standards.

Loadings

Third Rock Consulting made loading calculations for site DC1, as explained in section 3.1.3, to estimate annual loads of TKN, TP, TSS, and *E. coli*. The results are shown in Table 3.26.

Table 3.26: Load Calculations for DC1.

	Loading				Maximum Acceptable Loading				% Reduction to Reach Standards			
	TKN	TP	TSS	*E. coli*	TKN	TP	TSS	*E. coli*	TKN	TP	TSS	*E. coli*
Site	lbs/year	lbs/year	lbs/year	Trillion cfu/year	lbs/year	lbs/year	lbs/year	Trillion CFU/year				
DC1	1,049	147	43,587	11.7	1,577	651	48,403	5.38	0	0	0	54%

Red highlighting indicates values that exceed state standards or standards; blue means value is below state standards or water quality standards (Third Rock Consulting, 2008).

Documented Issues and Source

The watershed area upstream of DC1 is acting as a source of *E. coli.* Documented issues of concern in this subwatershed include:

- Habitat
- Conductivity
- Pathogens/*E. coli*

Land Use and Practices

Land uses in the DF1 sub-basin consist mostly of a rural residential and agricultural. This section of the watershed has a well-developed riparian area. It is unknown how many head of livestock have access to Darby Creek throughout this subwatershed. It is unsewered.

Conclusions, Lower Darby Creek

Potential sources of *E. coli* at the mouth include scattered rural residential areas, pets, wildlife, and cattle.

3.4 Summary of Analytical Conclusions for the Darby Creek Watershed

Pathogens

The pollutant of highest concern in the Darby Creek Watershed is *E. coli*, indicating an overload of pathogens. In the four areas where load reductions are indicated, reductions required are greater than 78%. *E. coli* levels were consistently elevated in areas with concentrated residences - specifically upstream of sampling sites DF1, UDC2, and USF2. The two sampling sites with the most excessive *E. coli* loadings (DF1, UDC2) were immediately below concentrated residential areas.

There was discussion at watershed team meetings about the possibilities of the source being a combination of human (through failing septic systems) and agricultural (through livestock in the stream and runoff from adjacent agricultural fields). There are few reliable methods for determining whether pathogen sources are human or animal. One method is “microbial source tracking.” The Darby Creek Watershed Team, working with Veolia Water, conducted microbial source tracking in the fall of 2009 with a lab at the University of Kentucky to further ascertain the sources of bacteria in the watershed. Ultimately, the results were not conclusive, but did seem to indicate that the bacteria source were a mix of human and animal. See Appendix B for the results and short discussion.

Nitrogen

The next highest pollutant of concern is nitrogen. Concentrations of total Kjeldahl nitrogen (TKN) were found to be in excess at four of the eight sampled sites in the Darby Creek Watershed (DF1, DF3, UDC2, and USF2). Elevated TKN can come from a variety of sources, including excessive human and animal waste. If waste related, it is most probable that these values, as with the other pollutants, are elevated due to human fecal sources since there are no concentrated animals feeding operations in the watershed. The sites with the elevated values are directly downstream of subdivisions with septic tanks or suspected failing sewage collection systems.

Total Suspended Solids

Excess total suspended solids indicate erosion, either from runoff, disturbance in the channel such as livestock crossing, upstream development, from instream flows that reduce streambank stability with excess force, or even - at DF2 and DF3 - from small reservoirs which can contribute sediment accumulated from past disturbances that are reentering the stream during storms.

Headwaters areas had the most significant loadings of TSS, with the need for load reductions indicated at 27% in Upper Darby Creek and 7% in Upper Darby Fork.

3.5 Additional *E. coli* Monitoring Efforts

As identified in previous sections of this plan, Darby Creek has not been assessed for Kentucky's Water Quality 305(b) Reports to Congress. The data collected by Third Rock in 2008 indicate potential impairments, but additional monitoring was needed to determine segments that do not meet their PCR designated use.

In June and July of 2014, KDOW conducted *E. coli* monitoring at selected sites within the Darby Creek Watershed (Figure 3.15). This monitoring was done in accordance with a KDOW approved Quality Assurance Project Plan (QAPP) (Quality Assurance Project Plan: Water Quality Monitoring in Support of a Watershed-based Plan, KDOW 2014) and study plan (Study Plan: *E. coli* Sampling in the Darby Creek Watershed, KDOW 2014). There were two goals of this monitoring effort. One was to collect sufficient data to identify the PCR status along the mainstem and selected tributaries of Darby Creek. The second was to enhance the watershed plan by using the results to calculate loads and reductions needed to support the PCR designated use in any impaired segments that are identified.

Sampling Sites

For comparability, the original Darby Creek sites were used with one modification. Site DOW12051006 was added downstream of original sites DF2 and DF3 (Figure 3.15). Sites DF2 and DF3 were directly below impoundments, and therefore not ideal locations for assessing the segments. They were not sampled in this round of sampling. The new site is still influenced by the impoundments, as seen in data results, but may be more representative than the original sites. Table 3.27 displays the selected sites, the original site numbers, KDOW database numbers (EDAS #), latitude and longitude, and catchment area.

Table 3.27: KDOW 2014 Sampling Site Locations in Darby Creek.

SITE NAME	EDAS #	ORIGINAL #	LAT	LONG	Catchment Area (mi^2)
Darby Creek	DOW12051002	DC1	38.390289	-85.521444	10.48
Darby Creek	DOW12051003	UDC1	38.390565	-85.500000	3.78
Darby Creek	DOW12051004	UDC2	38.397018	-85.464815	1.30
Darby Fork	DOW12051005	DF1	38.383360	-85.490645	2.11
Darby Fork	DOW12051006	*New Site	38.378914	-85.464905	1.20
South Fork Darby Creek	DOW12051007	USF1	38.381763	-85.493056	2.51
South Fork Darby Creek	DOW12051008	USF2	38.369129	-85.479300	1.56

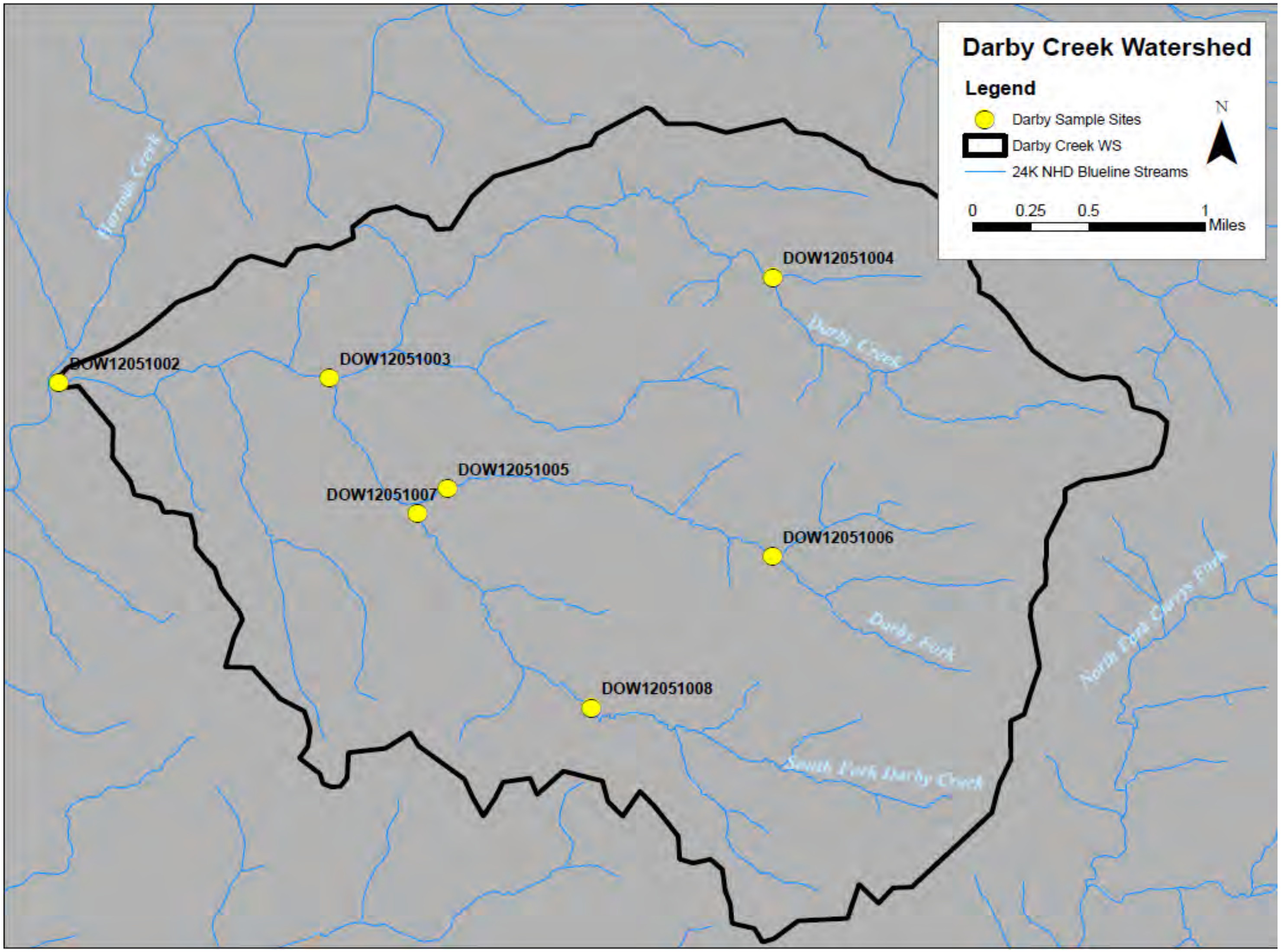

Figure 3.15: KDOW 2014 Sampling Site Locations.

***E. coli* Results – Concentrations**

Kentucky has a Water Quality Standard for *E. coli* during the PCR season which spans from May 1st – October 31st (401 KAR 10:031). *E. coli* shall not exceed 240 colonies per 100 mL in twenty percent or more of all samples taken during a thirty day period and/or shall not exceed 130 colonies per 100 ml as a geometric mean based on not less than five (5) samples taken during a thirty day period (Table 3.28). Table 3.29 and Figure 3.16 display the results of the 2014 *E. coli* monitoring efforts from KDOW.

In the following sections, the unit for *E. coli* is reported as Most Probable Number (MPN). MPN is used for samples processed using the IDEXX© Method. MPN is equivalent to the Colony Forming Units (CFU) reported in the 2008 samples.

Table 3.28: Kentucky Primary Contact Recreation Standard.

Kentucky Primary Contact Recreation Standard (May 1 - Oct. 31)		
Bacteria	Geometric Mean (colonies/100 mL)	Maximum (colonies/100 mL)
E. coli	**130** (from 5 samples collected within 30 days)	**240** (number not to be exceeded in more than 20% of the samples)

The sites that have twenty percent or more of the samples exceeding 240 colonies/100 mL have been highlighted in Table 3.29 and the 240 colonies/100mL maximum is indicated with the red line on Figure 3.16.

Table 3.29: *E. coli* Results KDOW

EDAS #	SITE NAME	6/12/2014 *E. coli* (MPN/100mL)	6/18/2014 *E. coli* (MPN/100mL)	6/25/2014 *E. coli* (MPN/100mL)	7/2/2014 *E. coli* (MPN/100mL)	7/9/2014 *E. coli* (MPN/100mL)	% > 240 (MPN/100mL)
DOW 12051002	Darby Creek	488	57	>2,420*	82	59	40
DOW 12051003	Darby Creek	921	214	1,986	411	214	60
DOW 12051004	Darby Creek	921	326	>2,420*	649	285	100
DOW 12051005	Darby Fork	326	135	649	488	199	60
DOW 12051006	Darby Fork	101	112	816	72	145	20
DOW 12051007	South Fork	727	190	>2,420*	238	248	60
DOW 12051008	South Fork	1,203	435	>2,420*	488	770	100

*The maximum MPN using the IDEXX© Method without diluting is 2420(MPN/100mL).

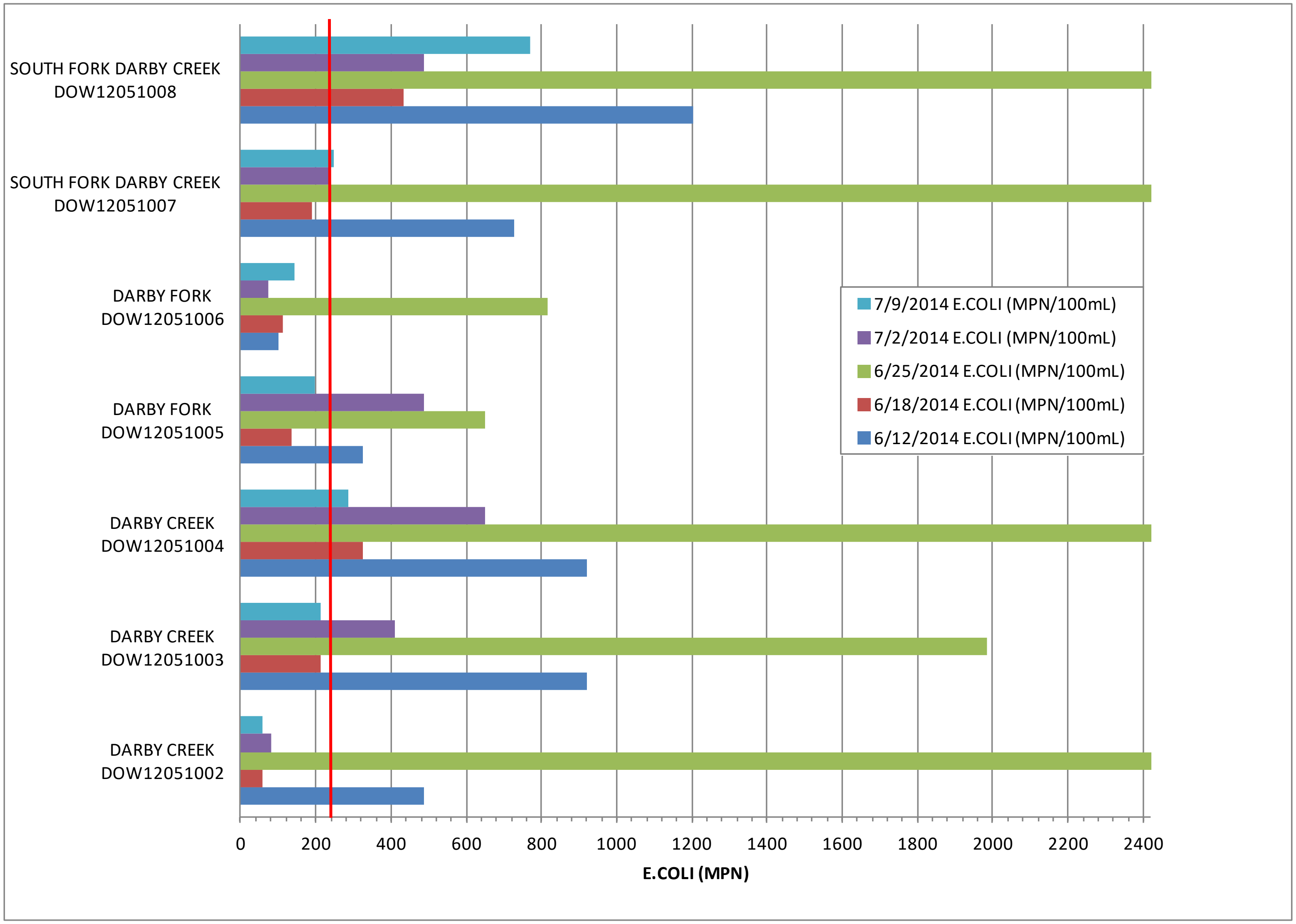

Figure 3.16: *E. coli* results from KDOW.

Table 3.30: *E. coli* results and Geometric Mean.

		6/12/2014	6/18/2014	6/25/2014	7/2/2014	7/9/2014	
EDAS #	**Site Name**	***E. coli* (MPN/100mL)**	***E. coli* (MPN/100mL)**	***E. coli* (MPN/100mL)**	***E. coli* (MPN/100mL)**	***E. coli* (MPN/100mL)**	**Geometric Mean**
DOW 12051002	Darby Creek	488	57	>2,420*	82	59	200.70
DOW 12051003	Darby Creek	921	214	1,986	411	214	509.78
DOW 12051004	Darby Creek	921	326	>2,420*	649	285	669.39
DOW 12051005	Darby Fork	326	135	649	488	199	308.04
DOW 12051006	Darby Fork	101	112	816	72	145	157.32
DOW 12051007	South Fork	727	190	>2,420*	238	248	456.06
DOW 12051008	South Fork	1203	435	>2,420*	488	770	861.98

*The maximum detection limit for MPN using the IDEXX© Method without diluting is 2420(MPN/100mL).

Table 3.30 shows the Geometric Mean of the samples collected. The highlighted values exceed the standard of 130 colonies/100mL. Since the five samples were collected under a KDOW approved QAPP and meet the frequency required for assessing the results based on the 130 colonies/100 mL standard, the results can be used for the Integrated Report. It is possible that stream segments containing the sites with a geometric mean exceeding the standard (highlighted in yellow) will be listed as not supporting Primary Contact Recreation in a future iteration of the Integrated Report.

Figure 3.17 shows the precipitation amount preceding the sampling events. The data are from Western Kentucky University's Mesonet site and were collected at the La Grange station in Oldham County, Kentucky. Most sites show higher concentrations following rain events of 0.25 inch or more (06/12/14, 06/25/14). However, sites DOW12051008 and DOW12051004 exceeded 240 MPN/100mL for all five events.

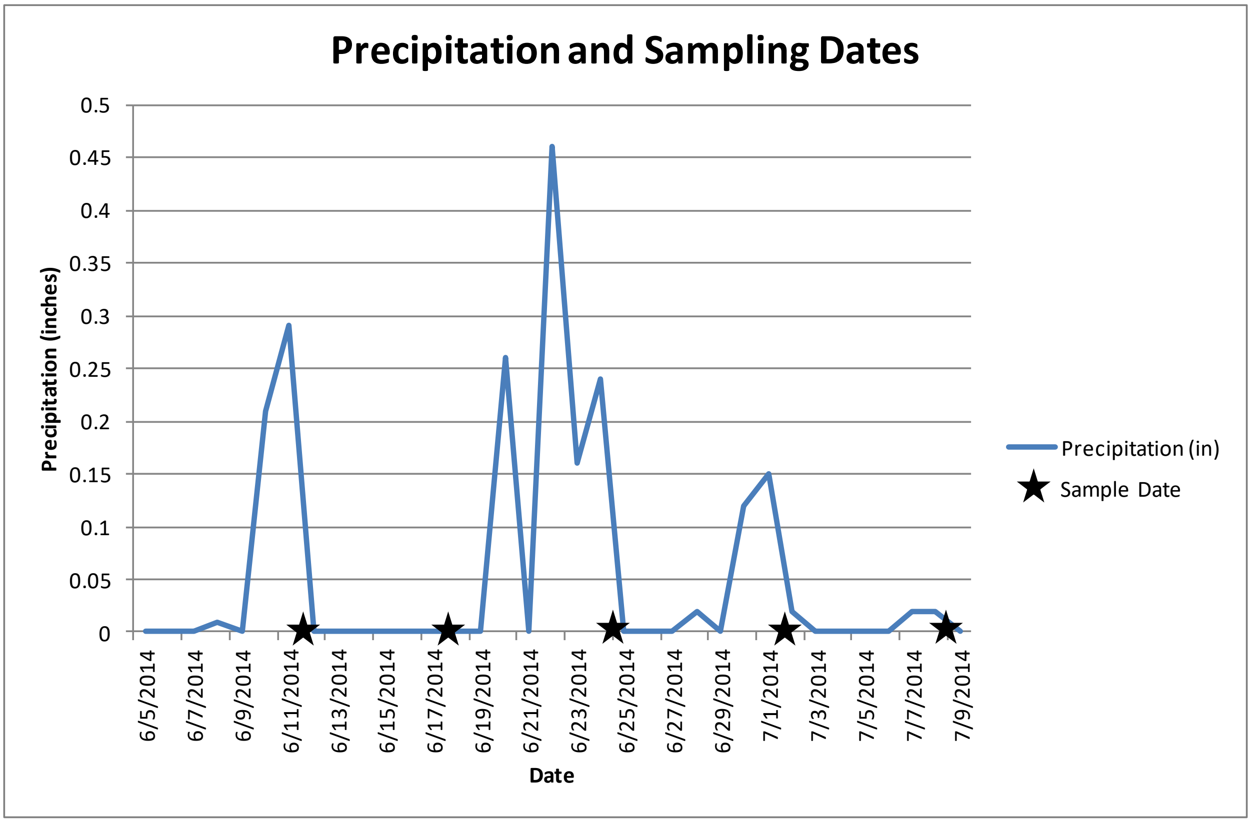

Figure 3.17: Precipitation Amounts Prior to Sampling Events.

E. coli **Results – Loads**

Pollutant loads, target loads, percent load reductions needed to achieve the standard, and pollutant yields were calculated for each site sampled (Table 3.31 and Figure 3.18). Due to the incomplete record of flow data, Mean Annual Flow was used for the load calculations. The Mean Annual Flow values were obtained from the Low Flow Mean Annual Flow GIS layer. The values generated by this layer have been calculated using the equation in the USGS Water-Resources Investigations Report 02-4206 "Estimating Mean Annual Streamflow of Rural Streams in Kentucky" (Martin 2002).

Table 3.31: *E. coli* Pollutant Load Results from KDOW results using 240 CFU/100mL PCR Standard.

EDAS #	Site Name	Average *E. coli* (MPN/100mL)	MAF (ft^3/s)	Annual Load (MPN/year)	Target Annual Load (MPN/year)	Load Reduction Needed (MPN/year)	% Load Reduction Needed	Annual Yield (MPN/year/mi^2)
DOW 12051002	Darby Creek	621.20	12.3	6.81E+13	2.63E+13	4.18E+13	61%	6.49E+12
DOW 12051003	Darby Creek	749.20	4.5	3.00E+13	9.62E+12	2.04E+13	68%	7.95E+12
DOW 12051004	Darby Creek	920.20	1.5	1.23E+13	3.21E+12	9.09E+12	74%	9.46E+12
DOW 12051005	Darby Fork	359.40	2.6	8.32E+12	5.56E+12	2.77E+12	33%	3.95E+12
DOW 12051006	Darby Fork	249.20	1.5	3.33E+12	3.21E+12	1.23E+11	4%	2.77E+12
DOW 12051007	South Fork Darby Creek	764.60	3.0	2.04E+13	6.41E+12	1.40E+13	69%	8.14E+12
DOW 12051008	South Fork Darby Creek	1063.20	1.9	1.80E+13	4.06E+12	1.39E+13	77%	1.15E+13

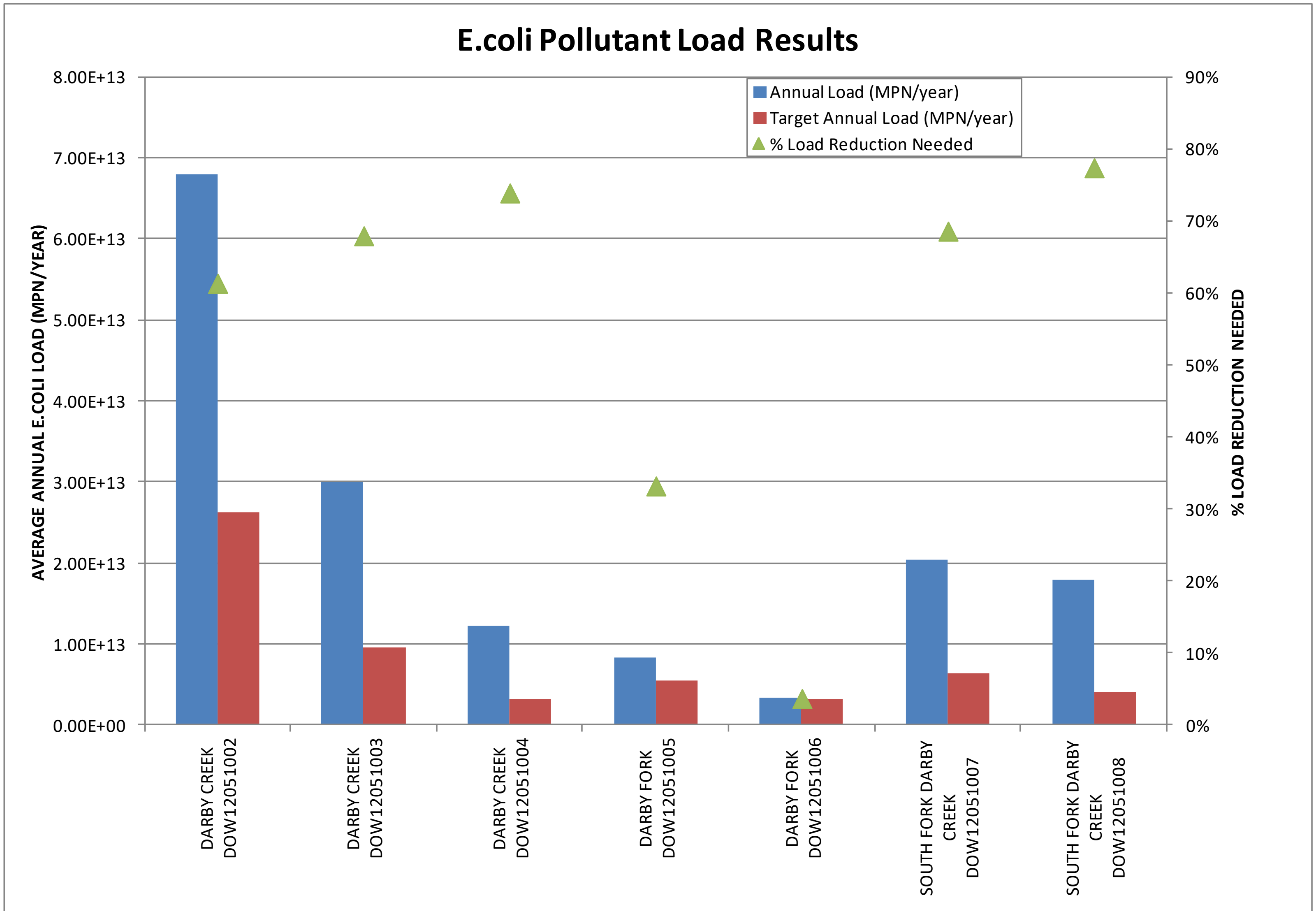

Figure 3.18: ***E. coli*** **Pollutant Load Results from KDOW using 240 CFU/100mL PCR Standard.**

Pollutant loads, target loads, percent load reductions needed to achieve the standard, and pollutant yields were also calculated using the geometric mean of the five samples and comparing them to the 130 CFU/100mL PCR Standard (Figures 3.19 and Table 3.32). There are multiple reasons for looking at the loads and reductions needed for this subset of data. As previously noted, this subset of data will be used in the Integrated Report to determine the PCR use support of the segments sampled.

Table 3.32: *E. coli* Pollutant Load Results from KDOW Sampling using Geometric Mean and 130 CFU/100mL PCR Standard.

Site and EDAS number	SITE NAME	Geomean *E. coli* (MPN/100mL)	MAF (ft^3/s)	Annual Load (MPN/year)	Target Annual Load (MPN/year)	Load Reduction Needed (MPN/year)	% Load Reduction Needed	Annual Yield ($MPN/year/mi^2$)
DC1 DOW12051002	Darby Creek	200.70	12.3	2.20E+13	1.42E+13	7.75E+12	35%	2.10E+12
UDC1 DOW12051003	Darby Creek	509.78	4.5	2.04E+13	5.21E+12	1.52E+13	74%	5.41E+12
UDC2 DOW12051004	Darby Creek	485.45	1.5	6.49E+12	1.74E+12	4.75E+12	73%	4.99E+12
DF1 DOW12051005	Darby Fork	308.04	2.6	7.13E+12	3.01E+12	4.12E+12	58%	3.38E+12
New site DOW12051006	Darby Fork	157.32	1.5	2.10E+12	1.74E+12	3.65E+11	17%	1.75E+12
USF1 DOW12051007	South Fork Darby Creek	300.49	3	8.03E+12	3.47E+12	4.56E+12	57%	3.20E+12
USF2 DOW12051008	South Fork Darby Creek	665.91	1.9	1.13E+13	2.20E+12	9.07E+12	80%	7.22E+12

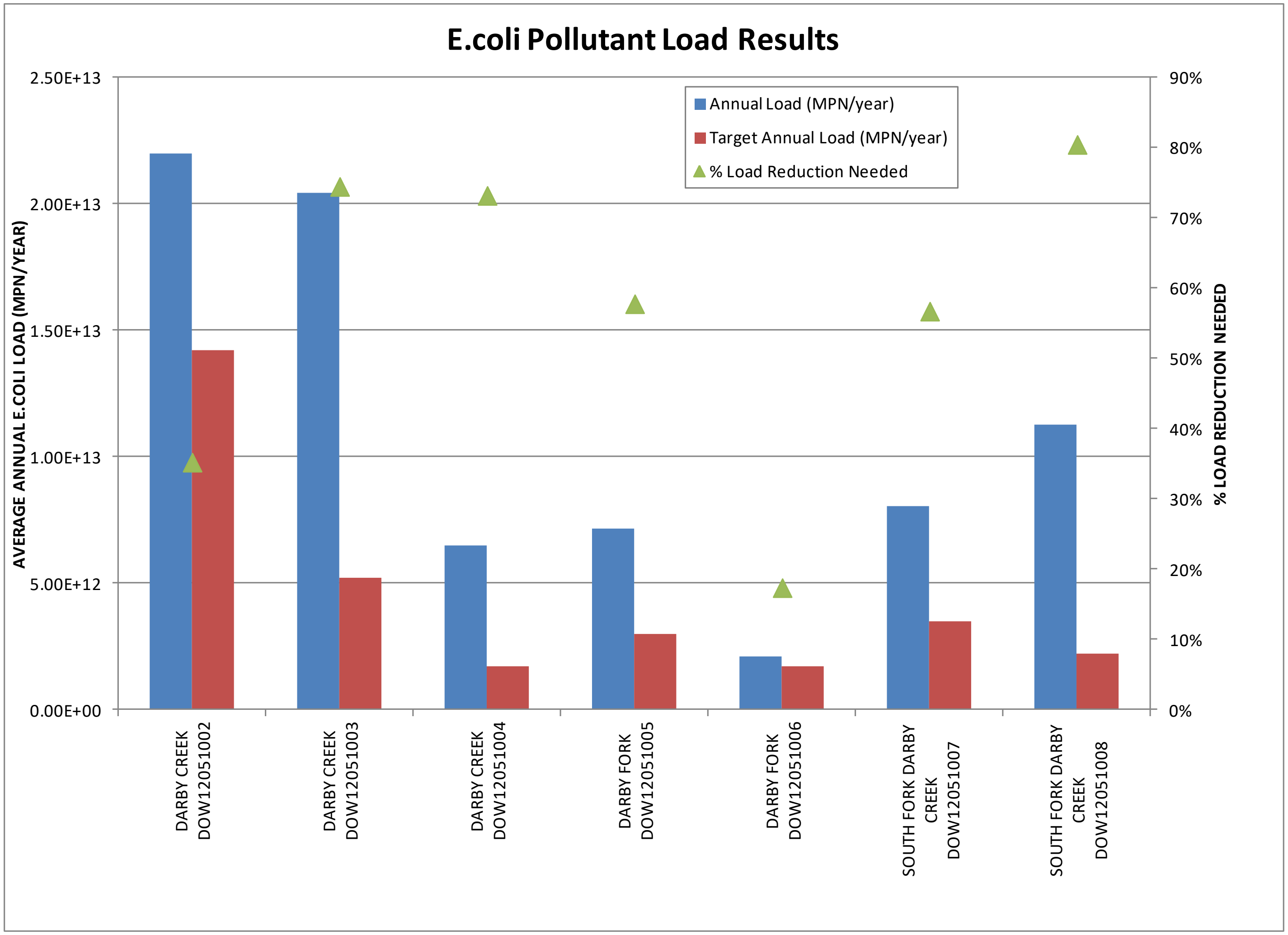

Figure 3.19: ***E. coli*** **Pollutant Load Results from KDOW using Geometric Mean and 130 CFU/100mL PCR Standard.**

E. coli Results – Overall Analysis

As noted previously, the goal of the analysis is to identify potential sources of *E. coli* and prioritize subwatersheds for implementation to address these sources.

As indicated in the results, all sites may be listed in future Integrated Reports as non-support for PCR with the exception of Darby Fork DOW12051006. This site has impounded tributaries directly upstream which may be impacting the results.

To better isolate potential source areas, the following summaries are organized by the three subwatersheds. Table 3.33 includes the load reductions needed from the 2008 data collected by Third Rock as well as the 2014 data collected by KDOW. Figure 3.20 reports the load reductions needed at each site.

Table 3.33: Percent Load Reductions Needed and Concentrations Exceeding 240 CFU/100mL from 2008 and 2014 Monitoring Efforts.

Site Name	EDAS #	ORIGINAL #	% Reduction Needed (2008 data)	% of Samples > 240 MPN/100mL during PCR season (2008 data)	% Reduction Needed based on 240 MPN/100mL (2014 data)	% Reduction Needed based on 130 MPN/100mL (2014 data)	% of Samples > 240 MPN/100mL during PCR season (2014 data)
Darby Creek	DOW 12051002	DC1	54	25 (1 of 4)	61	35	40 (2 of 5)
Darby Creek	DOW 12051003	UDC1	0	25 (1 of 4)	68	74	60 (3 of 5)
Darby Creek	DOW 12051004	UDC2	83	100 (4 of 4)	74	73	100 (5 of 5)
Darby Fork	DOW 12051005	DF1	85	50 (2 of 4)	33	58	60 (3 of 5)
Darby Fork	DOW 12051006	New Site*			4	17	20 (1 of 5)
		DF2	0	0			
		DF3	87	0			
South Fork Darby Creek	DOW 12051007	USF1	0	25 (1 of 4)	69	57	60 (3 of 5)
South Fork Darby Creek	DOW 12051008	USF2	79	67 (2 of 3)	77	80	100 (5 of 5)

*Downstream from Original Site # DF2 and DF3

South Fork Darby Creek

The highest *E. coli* concentrations and loads were observed in the headwaters of this subwatershed above site USF2 (DOW12051008), with the results exceeding the standard for each event. Levels were still elevated at site USF1 (DOW12051007) but only exceeded the standard following the rain events. Interstate 71 and an unsewered subdivision are located in the headwaters along with undeveloped farmland which makes up the majority of the South Fork subwatershed. Information from the Health Department, Conservation District, landowners, and stakeholders is needed to help determine the possible sources. The subwatershed above site DOW12051008 should be a high priority for implementation to address the identified sources.

Darby Fork

The two sites in this subwatershed, DF1 (DOW 12051005) and New Site DOW12051006, had lower concentrations and loads than the other areas. Although exceedances were observed, especially following rain events. It's likely that the two impoundments upstream of site DOW12051006 are influencing the results. Both impoundments are downstream from the sewered and unsewered subdivisions and industry. Much of the mainstem of Darby Fork has an intact riparian corridor between the two sites. Additional information about the current land use and potential sources is needed for this subwatershed. This area is a lower priority for implementation compared to the headwaters of the South Fork and Darby Creek.

Darby Creek

The highest concentrations and loads were observed at sites UDC2 (DOW12051004) and DOW12051003 which are located above the confluence with Darby Fork and the South Fork of Darby Creek. The area upstream of UDC2 (DOW12051004) contains sewered and unsewered subdivisions and a golf course. Much of the watershed directly above UDC1 (DOW12051003) is undeveloped farmland with an intact riparian corridor along the mainstem. Concentrations and loads at the mouth of the watershed, site DC1 (DOW12051002), were only elevated following rain events. Some elevated levels are likely due to the loadings from the headwaters. Like the South Fork, information from the Health Department, Conservation District, landowners, and stakeholders is needed to help determine the possible sources. The subwatershed above site UDC2 (DOW12051004) should be a high priority for implementation to address the identified sources.

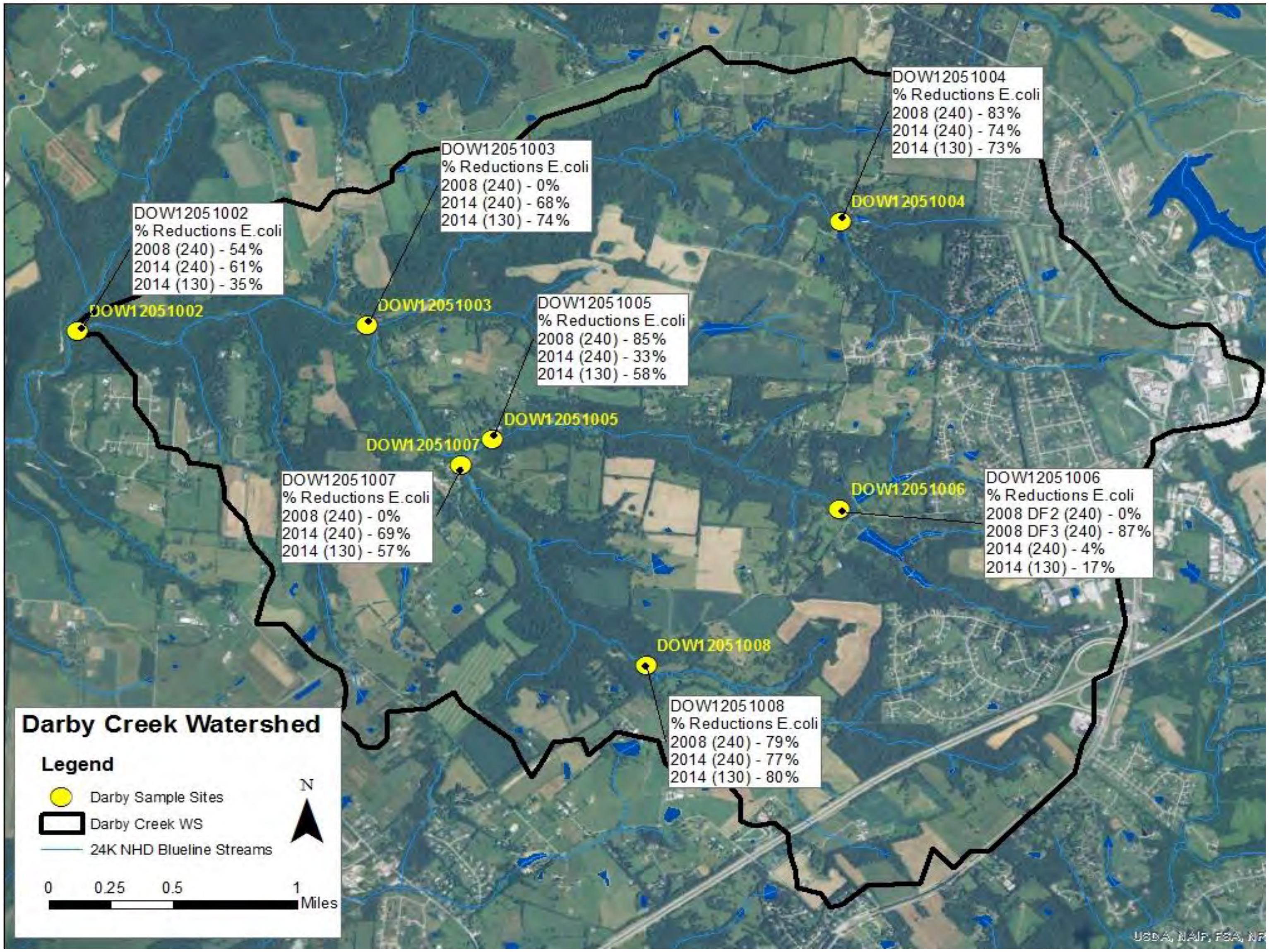

Figure 3.20: Percent Load Reductions needed for *E. coli* based on 2008 and 2014 data for PCR standards.

Chapter 4 Action Planning

In Chapter 1, the Darby Creek Watershed Team set four goals. This chapter uses these goals to translate data analyses into Best Management Practices (BMPs) and Action Items. The goals are reorganized here to help guide BMP planning.

1. Protect high quality areas.
2. Decrease water pollution.
3. Increase wildlife, fish, and aquatic life.
4. Educate the public.

Working from those goals, this chapter considers sample sites and subwatersheds, indicators and pollutants, BMPs and associated expected pollutant load reductions, and action items for based on needs presented in Chapter 3. The expected pollutant load reductions per each BMP are an important way to gauge the scope of the issue and the impact the BMP can have.

The triage map shown in Figure 4.1 conveys the following information in order to assess the areas in most need of BMP implementation: land use, subwatershed boundaries, unsewered areas, planned expansion of wastewater services, water quality data from samplings events in 2008 and 2014, and populated areas. Reviewed together, this information illustrates the areas most in need of mediation.

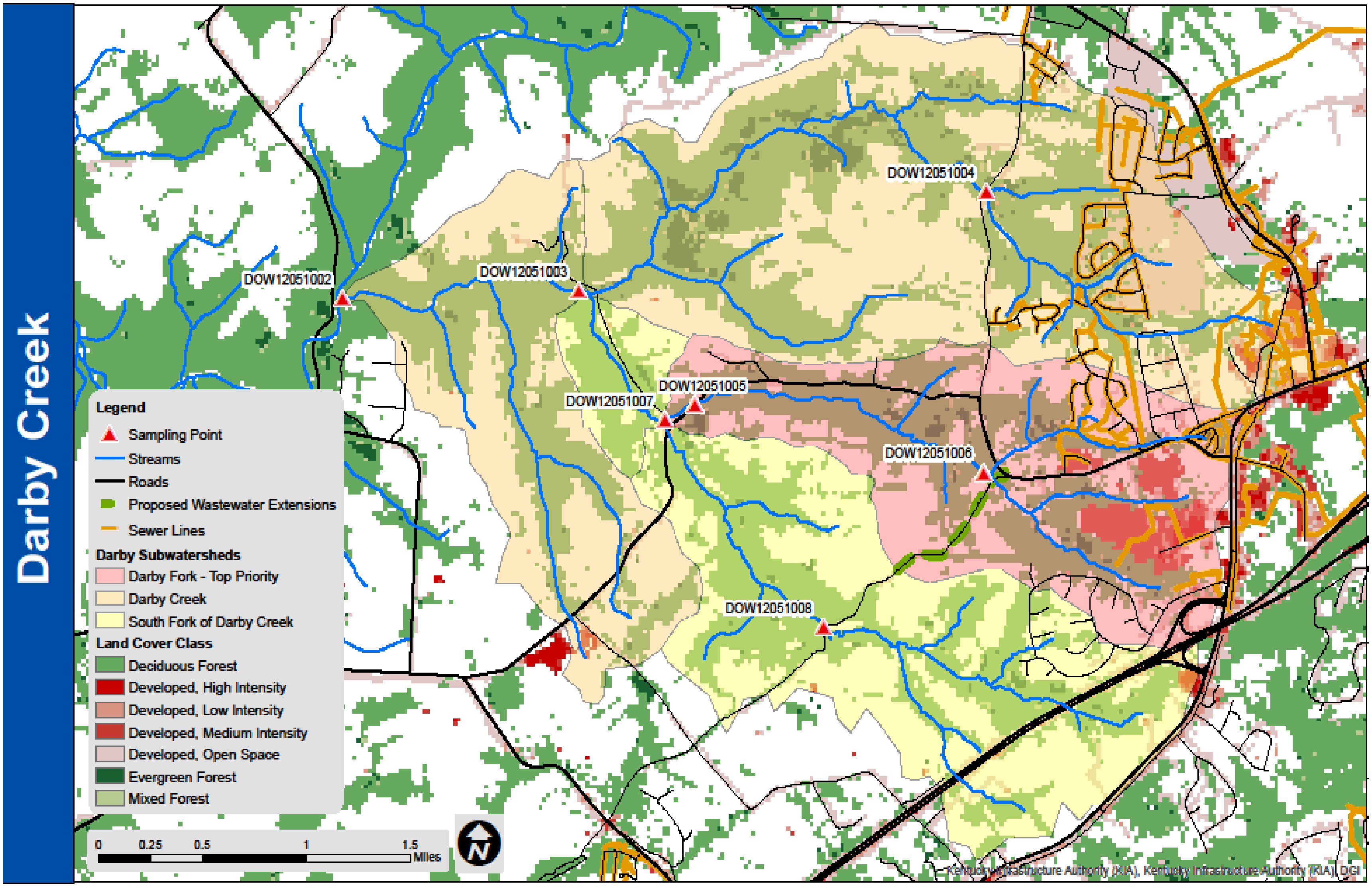

Figure 4.1: Triage map of the Darby Creek Watershed.

4.1 Description of Best Management Practices

Best Management Practices

BMPs are land use practices, educational initiatives, and policies that impact watersheds. Action items are the steps needed to encourage, plan, install, maintain, and monitor BMPs to create changes in the real world of Darby Creek Watershed necessary to meet the goals.

The following is a list of BMPs that have the potential to mitigate specific watershed problems in Darby Creek. Not all of the possible BMPs can be implemented at this time due to funding, political will, and other feasibility factors. Thus, from this list, a subset of recommended BMPs has been chosen. These are discussed in relation to water quality issues they help mitigate starting on page 110. The BMPs and associated action items include the local information gathered in Chapter 2 and what we have learned about the watershed in Tables 4.1-4.4.

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 Darby 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 or festivals, or outreach materials for dissemination.

Ordinance assessment: Oldham County has reviewed many stormwater-related ordinances such as curb and gutter restrictions, street and/or sidewalk width, and impervious surface cover. Further ordinance assessment may be useful in promoting water quality friendly design and retrofit and riparian area health. Often, removing restrictions can create options for the county, developers, businesses, and homeowners to become better stewards of our watershed.

Salt River Watershed Watch: This volunteer water quality sampling program serves to involve communities in their watershed. Volunteers are trained to sample water and understand the results. More samplers and sample sites in the watershed would contribute to the knowledge base about the water quality of Darby Creek and empower citizens to work on its behalf.

Soil Testing: Soil testing is a strategy to education ourselves on soil components and needs. It can help reduce nutrient overload by predetermining the need for N, P & K applications based on existing plant or forage stands and applying fertilizer to the extent that they are needed or can be utilized by the existing or planned crop (forages, lawns, gardens, or row crops).

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 Darby 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.

Grassed Waterways: A graded channel established with vegetation to convey surface water at a non-erosive velocity using a broad and shallow cross section to a stable outlet. A grassed waterway conveys runoff from terraces, diversions, or other water concentrations without causing erosion or flooding, prevent gully formation, and protect and improve water quality.

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.

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.

Habitat Protection:

Conservation Easements: Conservation easements are a way to preserve certain features of a landscape in perpetuity while keeping the property available for other activities, including changing ownership. For example, a landowner may want to sell his or her land, but make sure it remains in pasture land. Setting up a conservation easement could make this possible.

Riparian Buffers: see above.

4.2 Project Goal 1: Protect High Quality Areas

The objective for protecting high quality areas is to see no reduction in water quality over time. Indicators for high quality areas include water quality parameters such as *E. coli*, dissolved oxygen, TSS, TP, TKN, and conductivity, as well as habitat quality. All of the sampling sites have issues with *E. coli,* but most sites have forested areas and/or intact stream buffers.

Recommended BMPs:

Forested land and a good riparian zone can greatly contribute to high quality water. Therefore, recommended BMPs are directed towards retaining and improving the forested streamside areas and vegetated riparian areas:

- Create or improve existing riparian areas
- Conservation Easements to further protect high quality areas by specifying healthy riparian areas, not just undeveloped areas
- Ordinance assessment: Follow progress on County Comprehensive Plan objectives concerning riparian areas, tree canopy initiatives, and the MS4 program

4.3 Project Goal 2: Decrease Water Pollution

Pathogens, Nitrogen, and Conductivity

Pathogens, as measured by *E. coli,* are by far the most excessive pollutant concern in the Darby Creek Watershed. Elevated nitrogen, measured as TKN, is also of concern. It is probable that elevated TKN comes from the same sources as *E. coli.* Therefore, concerns about these two pollutants have been combined in terms of recommending BMPs and selecting action items.

High conductivity measurements are most likely the combination of the significant limestone geology in the watershed and dissolved ions associated with the same sources that cause high concentrations of pathogens. Thus, concerns about high conductivity have also been combined with pathogens in recommending BMPs and action items.

The objective for decreasing pathogen and nitrogen concentrations and lowering conductivity is to reduce loads enough to meet water quality standards for contact recreation. *E. coli* pollution in the watershed is thought to be a combination of human and animal sources. The recommended BMPs address both of these as wastewater and agricultural, respectively.

Recommended BMPs:

- Public education relating to septic tank maintenance
- Financial cost-share program to assist with septic tank inspection, pump out, maintenance and repair, and replacement

- KY Agricultural Water Quality Plans
- Nutrient management plans
- Financial cost-share for agricultural BMPs: pasture management, heavy use area protection, exclusion fencing and alternative watering systems, and riparian buffers

Total Suspended Solids (TSS)

The objective for decreasing solids suspended in streams is to reduce the loads enough to approach the standards mean in locations identified by monitoring. Targets are set using load reduction needs calculated by Third Rock Consulting. Sites of concern, in order of highest need, include Upper Darby Fork, DF2, Upper Darby Creek (headwaters), UDC2, and Upper Darby Fork tributary, DF3. The *indicator* for suspended solids is TSS.

***Recommended BMPs*:**

- Create or improve existing riparian areas
- Fencing livestock out of streams and provide alternative watering systems
- Pasture renovation BMPs.

There are many agricultural BMPs that address unhealthy pastures to prevent soil erosion. They are best selected for specific sites in consultation with landowners and NRCS experts. Also, upstream hydromodification impacts downstream sediment loads. Most development in the watershed is actively taking place in the headwaters. This is also the area that was found to have the most significant TSS loadings. Riparian buffers can address multiple sources of sediment. Either through livestock stream access, construction runoff, and/or stream bank erosion from excessive flows (due to increased impervious area), levels of TSS in excess of state standards are entering Darby Creek at sampling stations DF2, DF3, and UDC2. One complicating matter is that DF2 and DF3 are directly below small reservoirs, which could be contributing sediment accumulated from past disturbances that are re-suspended during storm flows.

4.4 Project Goal 3: Increase Wildlife, Fish, and Aquatic life

Since intact, functional habitat appears to be the limiting factor for healthy aquatic biology, the objective for this goal is to increase and improve habitat in locations identified by monitoring. All sites have need of improvements. Upper Darby Creek (headwaters, UDC2) is generally in good shape, except near the school and where landowners mow up to the stream.

Potential indicators include biological monitoring, but in this situation it is also reasonable to use physical habitat scores as key indicators. Because loss of habitat is frequently related to land uses adjacent to streams and to excessive stormwater, the BMPs under this goal also address these concerns.

***Recommended BMPs*:**

- Create or improve existing riparian buffers
- Conservation easements
- Grassed waterways

4.5 Project Goal 4: Educate the Public

The objective for educating the public is to have adequate public support for each aspect of the watershed plan and increased citizen and public governance understanding of the necessity for and methods of watershed protection.

Several of the education components are the first steps towards the implementation. For example, in order to implement an effective on-site sewage treatment campaign, we first need to identify and reach out to landowners. Later, informational workshops will be used to educate landowners in the watershed about proper septic maintenance and give them the opportunity to sign up for the septic pump-out/repair program. Education may also take the form of public events like stream cleanups, tree plantings, and community round tables. Indicators of public support and understanding will be measured by public involvement in these events. In addition, the project will reach out to the community through social media. Finally, the project will encourage increased monitoring by the Salt River Watershed Watch (SRWW) organization and recruit new citizen scientists to expand data collection capacity in the region.

***Recommended BMPs*:**

- Incorporate watershed educational themes into other BMPs
- Recruit new volunteers for SRWW
- Host creek cleanups, tree plantings, and other events to foster understanding

4.6 Action Item Planning

Action items are tasks that serve to complete recommended BMPs. The action items and other details in the following tables were arrived at together in discussions with community partners and watershed team meetings. Tables 4.1 and 4.2 address septic system BMPs, Table 4.3 addresses agricultural sources of *E. coli,* and Table 4.4 addresses TKN, TSS, and education.

With the high levels of *E. coli* from the 2008 and 2014 water quality sampling events, it is likely that there is a combination of agricultural and septic systems issues in the watershed. The recommended agricultural BMPs have their associated estimated pollutant load reductions from the U.S. EPA and the Natural Resources Conservation District. For septic system work, the expected pollutant load reductions need to be calculated.

Table 4.1: Septic system BMPs and Pollutant Loads

BMP	Indicator	Subwatershed Name-HUC #	Load Reduction Needed (CFU/year)	# systems needing replacement (34% failure rate)	Load reduction if all systems replaced	% Necessary load reduction accomplished if all failing systems replaced
Education on residential septic system function and maintenance	n/a	All unsewered areas of watershed and areas highlighted on triage map	n/a	n/a	Not measureable	n/a
Financial incentive program for septic system inspection and tank pump out	*E. coli*	All unsewered areas of watershed and areas highlighted on triage map	n/a	n/a	Not measureable	n/a
Financial incentive program for septic system tank repair or replacement	*E. coli*	Darby Creek-120	3.14E+12	21.8	1.0902E+12	35%
		South Fork Darby Creek-130	6.82E+12	5.3	2.6777E+11	4%
		Darby Fork-140	2.06E+12	1.8	9.43E+11	46%
		Darby Creek-160	7.75E+12	15.8	7.9174E+11	10%

Bacteria reduction estimated using 10^4.57 CFU/100ml Fecal Coliform per failing septic system, an average household production of 150 gal/day of wastewater (from the EPA Onsite Wastewater Treatment Manual, 2002) which is the equivalent of 2.11 x 10^8 CFU Fecal coliform/day or ~1.37x10^8 CFU E. coli/day.

Table 4.2: Septic system BMPs and Action Items.

BMP	Action Items	Responsible Party	Technical assistance	Cost	Funding Mechanism
Education on residential septic system function and maintenance.	Develop mailer and create targeted mailing list for areas on septic	Project Watershed Coordinator and Watershed Team	Health Department of Oldham County, KOWA, and KDOW	Fees for facility rental, printed materials, and other supplies.	319 grant
Financial incentive program for septic system inspection and tank pump out	Reach out to homeowner in unsewered areas about incentive program	Project Watershed Coordinator, Watershed Team, and homeowner	Health Department of Oldham County, KOWA, and KDOW	Inspections and pump outs depend on contractors, but may be $150-$300	319 grant Matching funds from homeowners
Financial incentive program for septic system tank repair or replacement	Reach out to homeowner in unsewered areas about incentive program	Project Watershed Coordinator, Watershed Team, and homeowner	Health Department of Oldham County, KOWA, and KDOW	$2,000 to $7,000 per septic system	319 grant Matching funds from homeowners

Table 4.3: BMPs and Action Items for agricultural sources of *E. coli* (and associated pollutants)

Target Pollutants	BMP	Specific sites or watershed area	Cost	Estimated Load Reduction*	Action Items	Responsible Parties	Technical Assistance	Funding Sources
E. coli, TKN, and conductivity	KY Ag. Water Quality Plans	Agricultural areas in whole watershed	n/a	Not measurable	Work with NRCS and County Extension to promote completion or updating of plans	Land owner, Watershed Coordinator, Watershed Team	NRCS, Conservation District	319 grant
E. coli, TKN, and conductivity	Nutrient management plan	Agricultural areas in whole watershed	n/a	Not measurable	Work with NRCS and County Extension to promote completion or updating of plans	Land owner, Watershed Coordinator, Watershed Team	NRCS, Conservation District	319 grant
E. coli	Exclusion fencing and alternative watering	Agricultural areas in Darby Fork – 140	Fencing: $4 -$5 per foot. Watering: $250-$600 ea. Site dependent	Fencing = 50-90% Watering = n/a	Work with NRCS and County Extension to develop cost-share program	Land owner, Watershed Coordinator, Watershed Team	NRCS, Conservation District	319 grant, matching funds from landowners
E. coli	Pasture renovation BMPs	Agricultural areas in Darby Fork - 140	Site and practice specific	Site and practice specific	Work with NRCS and County Extension to promote completion or updating of plans	Land owner, Watershed Coordinator, Watershed Team	NRCS, Conservation District	319 grant
E. coli	Heavy use area protection	Agricultural areas in UDC2, New site, DF1, USF2	$2000-$4000 each depending on size	85%	Work with NRCS and County Extension to develop cost-share program	Land owner, Watershed Coordinator, Watershed Team	NRCS, Conservation District	319 grant, matching funds from landowners
E. coli	Riparian buffers	Agricultural areas in UDC2, New site, DF1, USF2	$400/acre	55%	Work with NRCS and County Extension to develop cost-share program	Land owner, Watershed Coordinator, Watershed Team	NRCS, Conservation District	319 grant, matching funds from landowners

* Estimated Load Reduction: provides a gross estimate of practice effectiveness as reported in research literature. The actual effectiveness of a practice will depend on site-specific variables such as soil type, crop rotation, topography, tillage, and harvesting methods. http://water.epa.gov/polwaste/nps/guidance.cfm

Table 4.4: BMPs and Action Items for TKN, TSS, habitat issues, and community education.

Target Pollutant or Protection Object	BMP	Specific sites or watershed area	Cost*	Estimated Load Reduction*	Action Items	Responsible Parties	Technical Assistance	Funding Sources
Total Kjeldahl Nitrogen	KY Ag. Water Quality Plans	Agricultural areas in UDC2	n/a	Not measurable	Work with NRCS and Conservation District to promote	Land owner, Watershed Coordinator, Watershed Team	NRCS, Conservation District	319 grant, matching funds from landowners
Nitrogen and Phosphorus	Nutrient Management Plan	Agricultural areas in UDC2	n/a	TN= 15% overall reduction TP= 35% overall reduction	Work with NRCS and Conservation District to promote	Land owner, Watershed Coordinator, Watershed Team	NRCS, Conservation District	319 grant, matching funds from landowners
Total Kjeldahl Nitrogen	Exclusion fencing and alternative watering	Agricultural areas in UDC2	Fencing = $3 -$5 per foot. Waterer = $250-600/ea. Water line install site dependent	65% reduction in TN load	Work with NRCS and Conservation District to develop cost-share program	Land owner, Watershed Coordinator, Watershed Team	NRCS, Conservation District	319 grant, matching funds from landowners
Total Suspended Solids	Create or improve riparian buffer	UDC2 and New site	90 lbs/yr/dollar 10 per linear foot of stream	50% removal of sediment and nutrients	Plant native plants along streams. Reach out to community about riparian areas	Land owner, Watershed Coordinator, Watershed Team	NRCS, Conservation District	319 grant, matching funds from landowners
Total Suspended Solids	Grassed waterways	UDC2	$440 per acre	80% removal	Work with NRCS and Conservation District to develop cost-share program	Land owner, Watershed Coordinator, Watershed Team	NRCS, Conservation District	319 grant, matching funds from landowners

(Table continued on next page)

Table 4.4: BMPs and Action Items for TKN, TSS, habitat issues, and community education (continued).

Target Pollutant or Protection Object	BMP	Specific sites or watershed area	Cost	Estimated Load Reduction*	Action Items	Responsible Parties	Technical Assistance	Funding Sources
Habitat Protection	Conservation Easements	Sites depend on landowner willingness and site assessment	$10,000 per acre**	Over 70% nutrient and TSS reduction per acre converted	Work with area land trust groups on programs to promote and maintain easements	Watershed Coordinator, Watershed Team	Oldham Ahead, River Fields	319 grant
Habitat Protection	Create or improve riparian buffers	Watershed-wide	$10,000 per acre**	50% removal of sediment and nutrients	Plant native plants along streams. Encourage do not disturb and no mow areas near streams. Reach out to community about riparian areas	Watershed Coordinator, Watershed Team	NRCS, County Extension, Oldham Ahead	319 grant
Habitat Protection	Follow County Comprehensive Plan progress	Watershed-wide	n/a	50% removal of sediment and nutrients	Check regularly with officials on plan progress Encourage officials to follow initiatives	Watershed Coordinator, Watershed Team	DOW, NRCS, County Extension	n/a
Community Outreach and Education	Creek cleanups	Watershed-wide	$100-300 per cleanup	Not measurable	Find suitable cleanup sites, spread the word, and pick up trash	Watershed Coordinator, Watershed Team	County Solid Waste	319 grant, community partners

* Estimated Load Reduction: provides a gross estimate of practice effectiveness as reported in research literature. The actual effectiveness of a practice will depend exclusively on site-specific variables such as soil type, crop rotation, topography, tillage, and harvesting methods. http://water.epa.gov/polwaste/nps/guidance.cfm and ** Literature source: http://www.oldhamcountyky.gov/currys-fork-plan

Milestones

To assist with the implementation plan, it is important to develop indicators and milestones for each BMP. Table 4.5 describes these indicators and milestones. The grant secured from KY Division of Water in 2014 will fund many of the short term milestones BMPs, and the number of BMPs to be completed is based on the total amount of funding received. Implementation in the short term will begin in Darby Fork and then expand to Darby Creek and South Fork of Darby Creek as funding and capacity allows. The medium term and long term BMP goals, additional funding will be needed.

Table 4.5: Indicators and Milestones for each BMP.

BMP	Indicators to Measure Progress	Milestones		
		Short term (1 to 5 years)	Medium term (5 to 10 years)	Long term (+10 years)
Financial incentive program for septic system inspection and tank pump out	Homeowners making necessary upgrades to failing septic systems	20-30	20	20
Financial incentive program for septic system tank repair or replacement	Homeowners making necessary upgrades to failing septic systems	3	3	5
Create or improve riparian buffers	Total number of stream segments protected or enhanced	2	5	20
Agricultural water quality plans	Number of plans completed or updated	5	10	20
Livestock exclusion/riparian fencing	Number of segments fenced	4	5	10
Other agricultural BMPs recommended in this plan	Number of BMPs completed	4	4	4
Conservation Easements	Number of conservation easements created in watershed	1	3	10
Creek Cleanups	Number of cleanups	2	1 annual event	2 annual events
Watershed Education	Number of participants in educational events/programs	25	50	100

Chapter 5 Cost Predictions

The US EPA provides funding through Section 319 (h) of the Clean Water Act to the Kentucky Nonpoint Source Pollution (NPS) Control Program. These funds will be matched by BMP participants and watershed team and community involvement. Additional sources of match will be sought by the KDOW from cooperating agencies.

Table 5.1. Estimated costs of onsite sewage disposal systems BMPs.

Subwatershed	# Septic Systems to Replace	Estimated cost per BMP	Total Cost
Darby Creek-120	22	$5,000	$110,000
South Fork Darby Creek - 130	5		25,000
Darby Fork - 140	2		10,000
Darby Creek - 160	16		80,000
Total Cost	**45**		**$225,000**

Table 5.2. Estimated costs of agricultural BMPs.

Best Management Practice	Quantity	Cost Per BMP	Total Cost
4-Hole Waterer	1	$2,376 each	$2,376
Heavy use area protection	2000 sq. ft	$2.07/sq. ft	$4,140
Water pipeline	Site-dependent	$3.87/ft	Site-dependent
Exclusion fencing	Number of feet site-dependent	$2.67/ft	Site-dependent
Pasture Renovation	BMP and site-dependent	$150-$300/ac	Site-dependent
Conservation Easement	Site-dependent	$10,000/acre	Site-dependent
Riparian Buffer	Site-dependent	$10,000/acre	Site-dependent
Total cost			

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Chapter 6 Implementation organization, monitoring, and evaluation

Organization

Successful implementation and monitoring of the BMPs recommended will depend on the continued work of the Darby Creek Watershed team, public and local government officials, and key partners such as the Kentucky Department of Fish and Wildlife Resources, the Kentucky Division of Water, Oldham County Health Department, and OCEA. The project partners in the watershed will work closely to implement the BMPs that will achieve primary contact recreation standards in the watershed. The strategy will include the watershed evaluation identifying areas to target, public outreach, project implementation and effectiveness monitoring.

The watershed coordinator will keep the watershed team updated on progress through e-mail, web site postings and periodic meetings, including public roundtables and presentations to the Oldham County Fiscal Court and other community organizations.

Success Monitoring

This plan does not provide for water quality monitoring to assess project success; however, future work involving either subsequent grants or sampling by the Kentucky Division of Water should be undertaken after BMP implementation. Success of educational BMPs will be evaluated through event attendance, social media engagement, and volunteer recruitment.

Adaptive Management

The ultimate, long-term goal of the Darby Creek Watershed-based Plan is to improve water quality, preferably to the point where Darby Creek can be removed from the KDOW impaired waterways list (i.e., the Integrated Report Volume I). The watershed team will use adaptive management strategies as needed. In this strategy we will use the information available to choose best management options and regular committee meetings to solicit feedback and review new information.

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References

Barkley, C., Brookes, L., Caston, C., Clust, M., Eldridge, J, Lasley, C.B., Patterson, J., Nordin, G., Sanders, A., Siripurapu, S., & Stein, A. (2008). *Darby Creek Watershed Legal Service-Learning Project.* Retrieved June 9, 2008 from http://www.kwalliance.org/Portals/3/pdf/darby_creek_codes_and_ordinances.pdf

Chaubey,I., L. Chiang, M.W. Gitau, and S. Mohamed. (2010.) *Effectiveness of best management practices in improving water quality in a pasture-dominated watershed.* Soil and Water Conservation Society, 65(6):424-437.

Currens, J.C. (2002). *Kentucky is Karst County! What You Should Know About Sinkholes and Springs.* Kentucky Geological Survey Information Circular 4: Series XXII. Retrieved June 5, 2008, from http://kgsweb.uky.edu/olops/pub/kgs/ic04_12.pdf

Davis, A., Hunt, W., Traver, R., and Clar, M. (2009). *Bioretention Technology: Overview of Current Practice and Future Needs.* Journal of Environmental Engineering, 135(3), 109–117.

Environmental Protection Agency. Enviromapper for Water. Retrieved June 18, 2008 from http://www.epa.gov/waters/enviromapper/

FEMA. (2014, July 24th). *Flood Zones*. Retrieved March 3rd, 2015, from https://www.fema.gov/floodplain-management/flood-zones

Hagerty Consulting (2013). *OCEA Regional Facility Plan.*

Hunt, W., Smith, J., Jadlocki, S., Hathaway, J., and Eubanks, P. (2008). ”Pollutant Removal and Peak Flow Mitigation by a Bioretention Cell in Urban Charlotte, N.C..” Journal of Environmental Engineering, 134(5), 403–408.

Kentucky Atlas and Gazetteer. http://www.kyatlas.com/21185.html. Accessed February, 2015.

Kentucky Climate Center at Western Kentucky University. (n.d.). Climatography of Kentucky. Retrieved June 18, 2008, from http://kyclim.wku.edu/climatography.htm

Kentucky Division of Conservation (KDOC). Agriculture Water Quality Act. Energy and Environmental Cabinet, Frankfort, Kentucky. http://conservation.ky.gov/pages/agriculturewaterquality.aspx Accessed February 2015.

Kentucky Division of Water (KDOW). 2012. *Integrated Report to Congress on the Condition of Water Resources in Kentucky, 2012*. Commonwealth of Kentucky, Environmental and Public Protection Cabinet, Department for Environmental Protection, Division of Water.

Kentucky Division of Water. (n.d.). Drinking Water Watch. Retrieved June 24, 2008, from http://dep.gateway.ky.gov/DWW/

Kentucky Geological Survey. (2006). Groundwater Resources of Oldham County, Kentucky. Retrieved June 30, 2008, from www.uky.edu/KGS/water/library/gwatlas/Oldham/Topography

Kentucky Geonet. (2015). Kentucky Wastewater Water Mapping Kentucky Infrastructure Authority. Retrieved March 26th, 2015 from http://kygeonet.ky.gov/kia/cw/index.html

Kentucky Hydrology Viewer. (2009). United States Geological Survey Hydrology of Kentucky.

Kentucky Mesonet. Retrieved March 1st, 2015. http://www.kymesonet.org/

Kentucky Onsite Wastewater Association. 2001. A KY homeowner's guide to septic systems.

Kentucky State Nature Preserves Commission. (2009). *County Report of Endangered, Threatened, and Special Concern Plants, Animals, and Natural Communities of Kentucky.* Retrieved May 19, 2010 from http://www.naturepreserves.ky.gov/NR/rdonlyres/91E0A271-E42F-45E1-B8D8-741D45366EB2/0/countylist2009.pdf

Kentucky Watershed Viewer. (n.d.). Retrieved 2015 20th-February from http://gis.gapsky.org/watershed/

Kentucky Waterways Alliance and Kentucky Division of Water. 2010. *Watershed Planning Guidebook for Kentucky Communities*. Kentucky Department for Environmental Protection, Division of Water, Frankfort, KY.

Mayer, Peter W. et. al. 1999. Residential End Uses of Water. American Water Works Association Research Foundation. 90-92 pp.

McKee, Kyna, et al. 2012. Modeling support of Attoyac Bayou watershed initial SELECT model outputs. Texas A&M Biological and Agricultural Engineering and Texas Water Resources Institute. 6-18 pp.

National Small Flows Clearinghouse. 2013. Groundwater protection and your septic tank. www.nsfc.wvu.edu Accessed January 2015.

Natural Resources Conservation District (NRCS). 2011. *Conservation Practices*. http://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/technical/?cid=nrcs143_026849 Accessed February 2015.

Natural Resources Conservation District (NRCS). 2009. *RMS planning tool, identify resource problems and recommend practices.* http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/technical/econ/data/?cid=nrcs143_009740 Accessed February 2015.

Natural Resources Conservation District (NRCS). 2011. *EFOTG cost Development Data FY2011.* US Department of Agriculture, Natural Resources Conservation Service. Accessed February 2015. www.ky.nrcs.udsa.gov/technical

Oldham County Planning and Zoning (2008). Brownsboro *Master Plan Final Draft.*

Oldham County Sewer District. (2007). *Facilities Plan for Oldham County Sewer District.* Retrieved June 18, 2008 from http://www.oldhamcountysewer.com/facilities_plan.htm Protection Cabinet, Department for Environmental Protection, Division of Water.

Southeast Regional Climate Center. (n.d.). Louisville Area, Kentucky – Climate Summary. Retrieved March 1st, 2015 from http://www.sercc.com/cgi-bin/sercc/cliMAIN.pl?ky0155 systems.

United States Environmental Protection Agency. 1980. *Design Manual - Onsite Wastewater Treatment and Disposal Systems.* U.S. Environmental Protection Agency, Office of Water, Washington, DC.

United States Environmental Protection Agency. 2002. Onsite wastewater treatment systems manual. Office of water, Office of Research and Development, U. S. Environmental Protection Agency. 87-99 pp.

United States Environmental Protection Agency. 2003. National Management Measures to Control Nonpoint Source Pollution from Agriculture. U. S. Environmental Protection Agency. http://water.epa.gov/polwaste/nps/agriculture/agmm_index.cfm Accessed February 2015. Chapters 2-7.

United States Geological Survey. (2007). USGS Surface-Water Monthly Statistics for Kentucky. Retrieved June 13, 2008 from http://waterdata.usgs.gov/ky/nwis/monthly/?referred_module=sw&site_no=03292470&por_03292470_2=261901,00060,2,1999-01,2007-09&format=html_table&date_format=YYYY-MM-DD&rdb_compression=file&submitted_form=parameter_selection_list

USGS. (2014, November 12th). *Floods: Recurrence intervals and 100-year floods*. Retrieved March 5th, 2015, from http://water.usgs.gov/edu/100yearflood.html

Water Resources in Kentucky, 2012. Commonwealth of Kentucky, Environmental and Public.

Appendix A - Roundtable Report

<u>Outline for Darby Creek Roundtable Report from 2008</u>

I. Executive Summary

II. Introduction

- A. Background Information
- B. Roundtable Agenda
- C. How Roundtable Information Will be Utilized

III. Responses from Roundtable

IV. Conclusion

- A. Impacts of the Roundtable on the Planning Process and the Community
- B. Roundtable Participant Evaluation Results

V. Appendices

- A. Map of Watershed
- B. Roundtable Agenda

Roundtable participants listen to presentations.

<u>I. Executive Summary</u>

The Darby Creek Watershed Roundtable was held on February 26, 2008 at the John Black Community Center in Buckner. The event attracted 54 participants, most previously not involved with the Darby Creek Watershed Planning Project.

A tributary of Harrods Creek, the Darby Creek watershed is a 6017 acre area located in Oldham

County, Kentucky. To address point and non-point source pollution and protect quality areas in Darby Creek, the Darby Creek Watershed Planning Team, Oldham County Government, the University of Louisville, and the Kentucky Waterways Alliance are working together, with community input, to create a watershed plan.

The roundtable was held to draw more stakeholders into the watershed planning process, increase the public visibility, educate the public on issues facing the Darby Creek watershed, and to gain stakeholders' input for the planning process.

Several roundtable participants volunteered to serve on the Watershed Planning Team, several others indicated interest in being trained to test water quality in Darby Creek, and some participants were interested in being part of a Clean-Up Day for Darby Creek. Furthermore, according to the roundtable evaluations, participants learned about issues facing the watershed. Finally, the publicity received and the high attendance indicate that public visibility was enhanced by the event.

The overall project to develop a watershed plan is funded in part by a grant from the U.S. Environmental Protection Agency under §319(h) of the Clean Water Act through the Kentucky Division of Water to the Kentucky Waterways Alliance *(Grant # C9994861-04).* The Darby Creek Watershed Planning Team will continue to work to develop the plan through early 2010. A second Watershed Roundtable will be held in 2009, once a draft watershed plan has been completed, to present the plan to the public.

A small group gives input for the watershed plan.

II. Introduction

A. Background Information

A tributary of Harrods Creek, the Darby Creek watershed is a 6017 acre area located in Oldham County, Kentucky. Most of the watershed is forested (50%), with approximately 13% developed. The rest is in pasture and cultivated crops. The developed portion of the watershed is located in the upper watershed near Buckner, including the Oldham County Country Club, surrounding subdivisions, and commercial and institutional development along Kentucky Highway 146. Scattered homes are located along the roads crossing the watershed. Limited water quality sampling has been conducted in the stream. This preliminary data showed a potential pathogen problem and elevated nutrient levels, but overall a high quality stream.

To address pollution and protect quality areas in Darby Creek, the Darby Creek Watershed Planning Team, Oldham County Government, the University of Louisville, and the Kentucky Waterways Alliance are working together, with community input, to create a watershed plan. The roundtable was held to draw more stakeholders into the watershed planning process, increase the public visibility, educate the public on issues facing the Darby Creek watershed, and to gain stakeholders' input for the planning process.

B. Roundtable Agenda

The Darby Creek Watershed Roundtable was held on the evening of Tuesday, February 26, 2008. As participants arrived at the event, they were asked to register, and if they lived in the watershed, they were asked to place a numbered sticker on a large map of the watershed to indicate their residence. This was done so that the Watershed Planning Team can, in the future, easily pinpoint interested citizens in a certain area where they need a testing spot or would like to gage interest in implementing Best Management Practices.

During the first 45 minutes of the event, participants were urged to look at the Non-Point Source Pollution Storyboards, information about the Salt River Watershed Watch, and information from the Oldham County Extension Office. Participants were also provided a catered dinner during this time period.

After registration and dinner, there were three presentations on various aspects of the Watershed Planning Project. Katie Holmes from the Kentucky Waterways Alliance presented background on watersheds, the watershed planning process, and ways to protect the watershed. Beth Stuber, the Oldham County Engineer and the Watershed Plan Facilitator, gave some background on why the Darby Creek watershed was chosen for this project. Finally, Russ Barnett from the University of Louisville Institute for the Environment and Sustainable Development, and Technical Assistant for the Watershed Plan, presented on Darby Creek's water quality.

Following the presentations, participants broke into four small groups, each led by a facilitator, to discuss the four questions listed below in Section III.

Following the small group discussions, participants were urged to turn in their evaluations of the roundtable, which were designed to measure their knowledge of watershed issues before and after the roundtable, as well as their opinions related to the watershed plan. (See Section IV B. for the results of the evaluations.) Participants were also urged to turn in a form if they were interested in any of the following:

- Receiving updates on the Darby Creek Watershed Plan Project (2008-2010)
- Joining the Darby Creek Watershed Planning Team
- Being trained to monitor water quality in Darby Creek
- Participating in a Darby Creek Clean Up

C. How Roundtable Information Will be Utilized

The Darby Creek Watershed Planning Team is in the beginning stages of working on a watershed plan for the Darby Creek watershed. At its next meeting, the team will consider the input from roundtable participants, and will decide which problems and goals should be incorporated into the scope of the plan.

All comments from participants in the roundtable have been included in this report to provide an accurate representation of the discussion that occurred. Some comments may not be appropriate to incorporate into the plan at this time, but all feedback will be reviewed by the team.

III. Responses from Roundtable

Participants at the roundtable were asked the following questions:

- Why is the watershed important to you?
- How do you use the watershed?
- What are the problems in the watershed?
- What are your goals for the watershed?

The following were the participants' responses:

Why is the watershed important to you?

1. Source of drinking water
2. A healthy stream equals a healthy county
3. Pond owner wants to know what pollutants are in his pond
4. Issues with soil erosion
5. Preservation
6. Beauty of the land
7. Drainage route
8. The creek increases property values
9. The view/aesthetics
10. Wildlife (deer, raccoons, etc.)
11. Rural character
12. Recreation
13. Because I care
14. Live on it
15. Study tool

16. Impact on Harrods Creek
17. Want to know how I impact stream
18. Natural habitat
19. Fishing potential
20. Protect

How do you use the watershed?

1. To collect water in ponds
2. For drinking water
3. To sustain wildlife
4. As drinking water for livestock
5. Recreation
6. Darby Creek runs through backyard – dogs drink out of the creek
7. For running livestock (cattle)
8. To irrigate crops
9. Enjoy looking at the stream and surroundings
10. Wading in stream
11. Agricultural life/wildlife watering/breeding ground
12. Collect fossils
13. Sound of running water
14. Indiana Brown Bat lives here
15. Home – we live and work here
16. In stream recreation/exploration

What are the problems in the watershed?

1. Pollution
2. Overuse of lawn care chemicals and pesticides (need proper application rates)
3. Litter
4. Garbage in sinkholes
5. Sinkhole pollution
6. Illegal dumps – New Cut Road towards Buckner
7. No recycling, no door-to-door collection
8. Substantial erosion – instream and bank
9. Poor construction management (poor development practices)
10. Contractor's implementation of erosion control
11. Increased development – planning of development
12. New developments need buffers
13. Policy change needs to occur
14. Enforcement of water quality standards and building codes
15. Livestock (need buffers and limited access to water)
16. Pet waste
17. Failing septic systems
18. Septic systems installed in floodplain

19. Straight pipes
20. Flooding
21. Building in floodplains
22. Stream alterations – restore meanders
23. Roof runoff – collection and discharge
24. Roads – salt and brine
25. Inappropriate usage issues – vehicles driven where they shouldn't be, possibility of new airport – low awareness of issues among community – education is needed
26. 4-wheelers
27. Old bridges
28. Mowing – right up to the stream

What are your goals for the watershed?

1. Discover ways to stop pollution and stop it from getting into the stream
2. Decrease pollution
3. Maintain water quality
4. Increase water monitoring
5. Increase aquatic life, fish, and wildlife diversity in stream/watershed
6. Improve aquatic habitat
7. Increase planting of trees, native plants, etc.
8. Protect springs (many springs feed creek)
9. Trace spring drainage basin
10. Survey riparian zones and protect or restore
11. Education about watershed for homeowners and others
12. Increase community involvement (education/outreach)
13. More use of "green" products in watershed – education
14. Promotion of green building (low impact design)
15. Better resources for the community if they are interested in low impact design
16. Reduce runoff from bridges
17. Survey agricultural users about runoff
18. Encourage residents and developers to mitigate stormwater runoff
19. Increase use of rain barrels (one participant suggested these may be free from MSD)
20. Smarter managed development
21. Ban development for a period of time
22. Impose stricter rules
23. Increase enforcement of laws
24. Implement BMPs
25. Increase access to stream (trails)

<u>IV. Conclusion</u>

A. Impacts of the Roundtable on the Community and the Planning Process

Publicity for the roundtable reached many watershed residents. Flyers advertising the event were mailed to all residents in the watershed, and Watershed Planning Team members let others in the surrounding community know about the event through e-mail lists and websites. Additionally, the roundtable was announced at two Oldham County Fiscal Court Meetings, footage of which then ran on Public Access television. Finally, a press release was sent to several media outlets. A reporter from *The Courier-Journal* attended the roundtable and wrote an article on it for the Oldham County Neighborhoods Section following the event. The *Oldham Era* ran a notice of the roundtable in its calendar of events.

The roundtable drew additional residents from the Darby Creek watershed and the surrounding area to be part of the planning process. Furthermore, two local elected officials, Elsie Carter, the Mayor of LaGrange, and Rick Rash, Oldham County Magistrate and member of the Watershed Planning Team, attended the roundtable. The Watershed Planning Team will benefit from the added knowledge of the watershed that these residents bring to the table, and will be strengthened with the support of additional local government entities.

Through discussions held at the roundtable, the Watershed Planning Team learned about additional issues to add to the plan, and has attracted a broad base of interested citizens to call upon when it is time to implement Best Management Practices in the watershed.

B. Roundtable Participant Evaluation Results

At the conclusion of the event, participants were urged to turn in their evaluations of the roundtable, which were designed to measure their knowledge of watershed issues before and after the roundtable, as well as their opinions related to the watershed plan. Twenty-seven out of fifty-four participants filled out evaluations. Many members of the Watershed Planning Team and presenters may have chosen not to fill out a survey. The results from the surveys show that the roundtable participants learned a great deal about watersheds and watershed planning and pollution in Darby Creek. Furthermore, the results show that the roundtable participants have a moderate-to-high expectation that the Darby Creek Watershed Plan will succeed, and they feel confident that their concerns and goals for the watershed had been heard and considered for the watershed plan. Results from the roundtable evaluations are below.

SCALE	1 Low	2 Low-to-Moderate	3 Moderate	4 Moderate -to-High	5 High	Total # of responses	Average Weight
Your understanding of activities that cause water pollution							
Before the Roundtable	1	2	10	6	8	**27**	**3.7**
After the Roundtable	0	0	1	12	14	**27**	**4.5**
Your understanding of the definition and processes of watershed planning							
Before the Roundtable	7	9	6	1	4	**27**	**2.5**
After the Roundtable	0	0	2	19	6	**27**	**4.1**
Your understanding of the activities that cause water pollution in Darby Creek watershed							
Before Roundtable	4	9	3	7	4	**27**	**3.3**
After Roundtable	0	0	5	11	11	**27**	**4.2**
Your understanding of the project to develop a watershed plan for Darby Creek watershed							
Before the Roundtable	11	6	2	4	3	**26**	**2.3**
After the Roundtable	0	0	4	11	11	**26**	**4.3**
Please rate your expectation for success for the watershed plan							
	0	2	5	11	7	**25**	**3.9**
Please rate confidence that your concerns about the watershed were heard at the Roundtable							
	0	0	3	12	10	**25**	**4.3**
Please rate your confidence that your contributions to the watershed plan project were heard							
	0	0	2	13	10	**25**	**4.3**

Appendix B – MST results and discussion

From: tricia.coakley@gmail.com [mailto:tricia.coakley@gmail.com] **On Behalf Of** Tricia Coakley
Sent: Thursday, December 10, 2009 9:28 PM
Subject: Darby creek source tracking results

Here are the Allbac (general) and Hubac (human specific) fecal DNA marker results from the Darby Creek study.

	Allbac	Hubac		Allbac	Hubac
Darby crk #2 11-18-09	159,000	17,440	Darby crk #2 11-3-09	2,556	<100
		11.0%			
Darby crk #1 11-18-09	60,180	2,646	Darby crk #1 11-3-09	23,280	341
		4.4%			1.5%
Darby fk 11-18-09	55,140	1,998	Darby fk 11-3-09	14,400	658
		3.6%			4.6%
			Darby fk dup 11-3-09	14,480	433
					3.0%

The values presented are as DNA marker copies/mL and the percentage below the Hubac concentration represents the value (Hubac/Allbac)*100 and is provided as a convenient tool for comparison of samples.

Please call me to discuss this data and to let me know if you want the samples analyzed for the bovine marker.

Thank You,
Tricia Coakley
ERTL
859-257-6757

-----Original Message-----
From: Evans, Steve
Sent: Thursday, December 17, 2009 3:35 PM
To: Miller, Tony
Cc: 8162-08_KWA_DarbyCreek
Subject: RE: Darby creek source tracking results

All this says is that the human influence is limited. Other contributions could be wildlife, could be cattle. Without seeing the bovine marker data, so there is no way of knowing which of these it is due to. That is a big difference between our samples and the ones analyzed on the Dix.

The AllBac is a marker for all bacteriodes regardless of source. The HuBac is the subset which have human markers. Basically Darby Creek #2 is most influenced by human.

Steven J Evans | Third Rock Consulting Consultants, LLC |Mobile 859.327.6601
-----Original Message-----
From: Miller, Tony
Sent: Thursday, December 17, 2009 4:32 PM
To: 'Tessa@KWAlliance.org'
Cc: 8162-08_KWA_DarbyCreek; Evans, Steve
Subject: FW: Darby creek source tracking results

I'm a little baffled here. Below are Steve's thoughts. In addition to his points, make sure you take into consideration the flow that was occurring during the sampling effort and the potential sources that can enter a stream as a result. But consequently, like Steve said, you have a source more significant than human but you don't know what it is. That's the major difference with our Dix study - we suspected cattle so we had a bovine marker in addition to the human. If they had the money, I would definitely recommend getting the bovine test. If that's not an option, use what you have. Combine this data with your land use information. I would guess that there has to be a major livestock concentration somewhere upstream of your sites (though I didn't think that really existed in the Darby Creek watershed). If not, then you have to suspect wildlife though it's going to take a pretty big concentration of geese, raccoons, dogs, cats, etc to overwhelm the human signature in the bacteroides. Combine what you know about specific aspects of the watershed land use and use it to determine the potential sources.

Hope this helps,
Tony
--
Tessa,
Tricia is right... this is a small sample, so the conclusions from it are limited. On our Dix River analysis, we also ran AC/TC ratio samples, an additional Human DNA analysis using Enterococcus, and 2 DNA analyses using a cattle marker. We also sampled most sites twice. These duplicate analyses gave more

confidence in the predictions of the sources. In addition to the duplicate analyses we also analyzed knowns for comparison. These results are hard to interpret because we are missing that other supporting data.

Please understand that you should not conclude that the 11% Hubac marker on Darby Creek #2 means there is only 11% human influence. The actual human contribution on that site or any other site is probably much greater than the percentages listed in the results below. The HuBac DNA marker is conservative. That means that every Bacteriodes in a human gut might not have the human marker, but the bacteroides in the stream which do carry the marker are definitely from humans. In this way, the chance of false positives (finding the marker when a human source is not there) is negligible, but the chance of false negatives (human sources are present but the human specific marker is not) is pretty high. What the data is telling you is that humans are part of the problem, but we do not know how much of the problem without some comparisons.

In our sampling we used a known human sources (influent from a sewage treatment plant) in order to aid in explaining what % HuBac vs AllBac is normal for a 100% human sample. Perhaps Tricia has done some such analyses which may help you in understanding how these percentages relate to known 100% human sources. If you know that a 100% human source has only 20% Hubac vs Allbac, that would tend to indicate that more than half of the source for Darby Creek #2 is due to human sources. If the known had a 80% HuBac vs Allbac, that is a different story.

Hope this helps to clarify these results a little bit more. Let me or Tony know if you have any other questions.

Steve

Steven J Evans | Third Rock Consulting Consultants, LLC |Mobile 859.327.6601
2526 Regency Rd | Ste 180 | Lexington, KY 40503 | 859.977.2000
511 Union St | Ste 1850 | Nashville, TN 37219 | 615.313.3996
403 North Court St | Marion, IL 62959 | 618.751.1048

Appendix C - Stream Visual Assessment Protocol

Owners name ___NA_____________ Evaluator's name G.Keibler, B.Shireman, M.Jones, J.Howard Date __10/12/09__

Stream name _Darby Fork (Reach 1,2,3,4)_____ Waterbody ID number ________________________________

Reach location See aerial photograph below

Ecoregion _Bluegrass Bioregion______________ Drainage area ____________________
Gradient_______________________

Applicable reference site
____

Land use within drainage (%): row crop ______ hayland ______ grazing/pasture _______ forest ______ residential _______

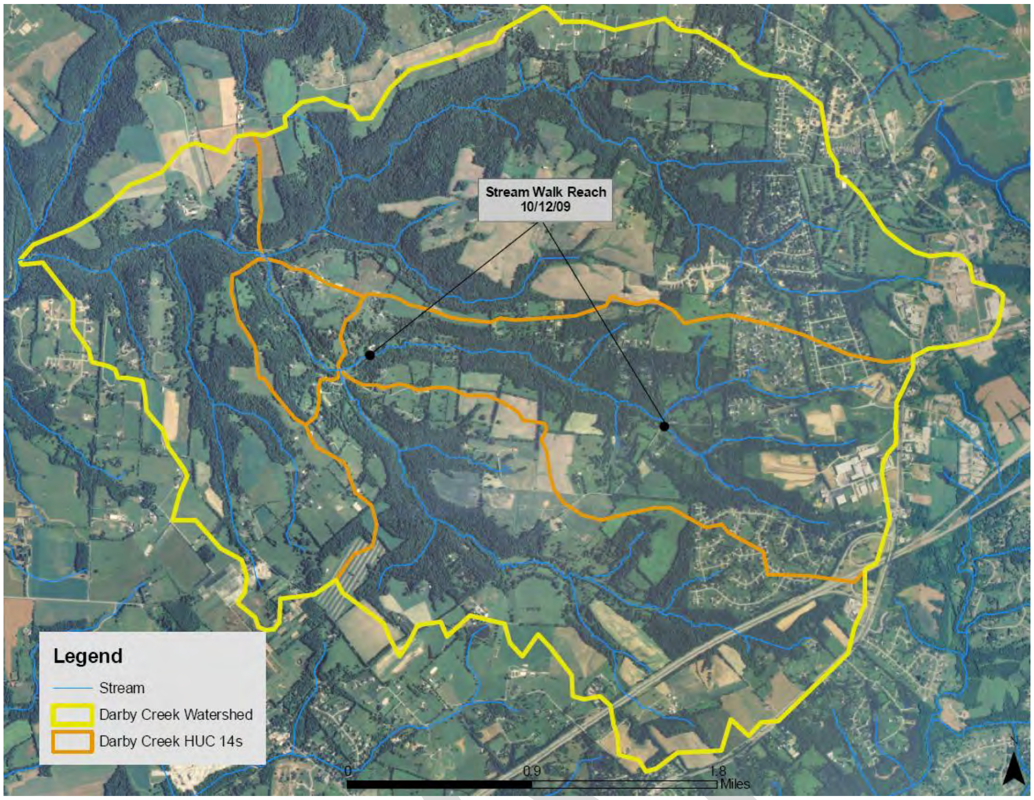
confined animal feeding operations ______ Cons. Reserve ________ industrial _______ Other: ____________

Weather conditions-today __Cool/Clear______________________ Past 2-5 days _Rain (2.75" Thurs – Fri)_______________

Active channel width ____________________ Dominant substrate: boulder ______ gravel ______ sand ______ silt ______ mud

Site Diagram and photographs

Aerial of Darby Creek watershed with identified entire stream segment from stream walk.



Aerial of entire stream segment from stream walk with each reach identified.

(NWCC Technical Note 99–1, Stream Visual Assessment Protocol, December 1998)

Reach 1

Assessment Scores

2

2

Channel condition		Pools	
Hydrologic alteration	8	Invertebrate habitat	5
Riparian zone	8	**Score only if applicable**	
Bank stability	7	Canopy cover	
Water appearance	7	Manure presence	
Nutrient enrichment	9	Salinity	
Barriers to fish movement	4	Riffle embeddedness	
Instream fish cover	2	Marcroinvertebrates Observed (optional)	

Overall Score (Total divided by number scored) **5.4**	<6.0 **Poor** 6.1-7.4 **Fair** 7.5-8.9 **Good**

Suspected causes of observed problems Past channelization is evident. Most likely occurred when road was constructed. Stream is wide with a bedrock bottom (lots of headcutting). Good riparian area on left bank. Noticed foam in many area.

Reach 2

Assessment Scores

Channel condition 2

Hydrologic alteration 8

Riparian zone 8

Bank stability 5

Water appearance 10

Nutrient enrichment 9

Barriers to fish movement 7

Instream fish cover 8

Pools

6

Invertebrate habitat 8

Score only if applicable

Canopy cover

Manure presence

Salinity

Riffle embeddedness

Marcroinvertebrates

Observed (optional)

Overall Score (Total divided by number scored)	<6.0 **Poor** 6.1-7.4 **Fair**

Suspected causes of observed problems More pools than in Reach 1. Overall, less confined stream channel. Stream bottom was a mix of different substrates, not just bedrock.

Reach 3

Assessment Scores

Channel condition	6
Hydrologic alteration	8
Riparian zone	10
Bank stability	8
Water appearance	6
Nutrient enrichment	9
Barriers to fish movement	10
Instream fish cover	10
Pools	7
Invertebrate habitat	

Score only if applicable

Canopy cover	
Manure presence	
Salinity	
Riffle embeddedness	
Marcroinvertebrates Observed (optional)	

10

Overall Score (Total divided by number scored)	<6.0 **Poor** 6.1-7.4 **Fair**

Suspected causes of observed problems Overall nice reach of stream. One small area at beginning of reach had little riparian area and noticeable presence of livestock. This would be an excellent site for livestock exclusion. Upper portions of reach had intact riparian areas with noticeable signs of stream channel recovery. Some areas on hillsides appeared to be small dumping sites in the past.

Reach 4 (Grand Villa Dr. to headwaters at school complex)

Assessment Scores

6

5

Channel condition	
Hydrologic alteration	8
Riparian zone	9
Bank stability	8
Water appearance	6
Nutrient enrichment	9
Barriers to fish movement	1
Instream fish cover	9
Pools	7
Invertebrate habitat	

Score only if applicable

Canopy cover ☐

Manure presence ☐

Salinity ☐

Riffle embeddedness ☐

Marcroinvertebrates ☐

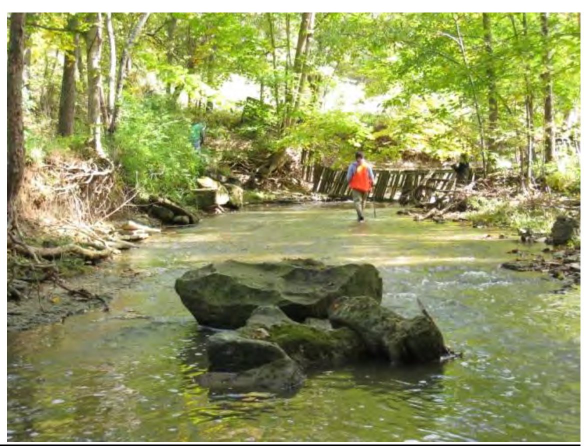
Overall Score (Total divided by number scored)	<6.0 **Poor** 6.1-7.4 **Fair**

Suspected causes of observed problems Large log jam in middle of reach. Downstream from log jam – noticeable oil sheen, immediately upstream from log jam – stagnate water with brown foam. Overall bedrock bottom and more fish barriers than Reach 3.

Photos

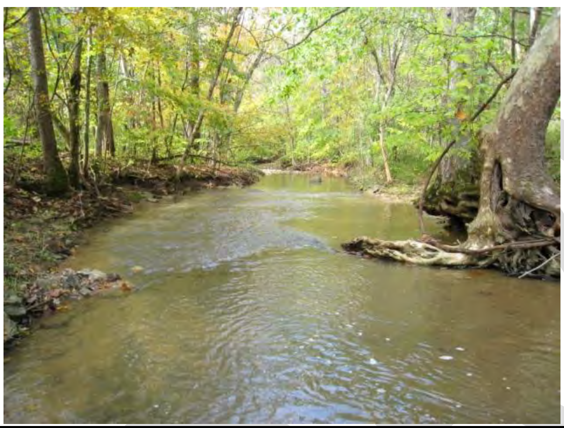
Reach 1

Reach 2



Reach 3

Reach 4



Appendix D - Comments from KY Division of Water on the Darby Creek Watershed Plan

Note: These comments were addressed for the March 2015 iteration of the plan.

The following comments were made by KY Division of Water personnel about the original 2010 draft Darby Creek Watershed Plan.

Chapter 1

1. Page 5 - Remember to update this partners list as planning and implementation continues. As new partners are added, they need to be included in this list.

Chapter 2

2. Page 23, paragraph 2 – samples taken at a frequency of less than five/30days should be compared to the 240 CFU/100mL standard.

3. Page 31 and 32, MS4 requirements- This section goes from discussing MS4 permits directly to 404 permits which are the Corp of Engineers permits for construction in/along a stream dredge and fill etc. Need a better transition from one topic to the next. Suggest explaining what a 404 permit is so it is not confused with the MS4 program.

4. Page 36, Section 2.4
    - It is unclear how many people there are in the watershed. The first paragraph says 1668 in 2005. The second and third paragraph talks about an area much larger (of which Darby Creek is under ½) and says 1334 people in 2000. Was there an increase in 1000 people in 5 years?

Chapter 3

5. This chapter does not have a reference section. Include a reference section for this chapter.

6. Page 53, Figure 3.10 – Why are averages missing for parameters other than TKN, TP, and TSS? This applies to the tables for the other sampling sites as well.

7. Page 59, second paragraph – Is it possible that Gary Keibler's SRWW sampling location is located at USF2 instead of DF2? The road description (old Zaring Rd., 1.2 miles north on HWY 329) is not in DF2.

Chapter 4

8. Page 75, Third paragraph- the load reductions expected from the BMPs will need to be completed prior to KDOW fully accepting this plan and allowing 319(h) funding to be used for implementation.

BMP Tables

9. The TBD placeholders in the tables will need to be addressed prior to KDOW fully accepting this plan and allowing 319(h) funding to be used for implementation.

Appendix E – Darby Creek RBP Results Summary

Darby Creek 2008 RBP Results Summary												
			Habitat									
Site	Date	Temp F	Epif/ Sub	Chan Flow	Bank Stab LB	Bank Stab RB	Veg Prot LB	Veg Prot RB	RipWid LB	RipWid RB	Total Habitat	
DC1	8/19 9/15 10/13 10/27 11/24 12/9	71.2 67.8 64 48.6 38.5 39.7	15	11	7	2	7	2	10	9	135 Supporting, but threatened	
DF1	8/19 9/15 10/13 10/27 11/24 12/9	69 65.6 62.3 45.9 35 33.9	12	13	9	9	5	5	2	2	121 Not supporting	
DF2	8/19 9/15 10/13 10/27 11/24 12/9	67.2 69.1 63.7 54.4 42.6 41.3	15	8	8	8	8	8	9	9	128 Not supporting	
DF3	8/19 9/15 10/13 10/27 11/24 12/9	65.1 68.3 60.5 48.7 42.6 42.9	11	7	9	9	7	7	9	9	136 Not supporting	

UDC1	8/19 9/15 10/13 10/27 11/24 12/9	70 66.9 64.7 46.5 37.8 39.9	11	13	5	9	5	8	8	6	138 Partially supporting
UDC2	8/19 9/15 10/13 10/27 11/24 12/9	66 66.6 60 47.5 41.2 41.5	11	13	9	9	8	8	5	4	139 Partially supporting
USF1	8/19 9/15 10/13 10/27 11/24 12/9	66.7 67.8 63.1 47.1 38.2 39.3	10	15	6	8	6	8	2	5	132 Not supporting
USF2	8/19 9/15 10/13 10/27 11/24 12/9	63 65.7 No Flow 46.5 39.2 39.6	13	1	4	6	4	6	8	3	113 Not supporting