Triplett Creek Watershed Based Plan
Section 1

Introduction

The Triplett Creek Watershed Based Plan (WBP) will outline point and nonpoint pollution sources in the Watershed, quantify the pollution coming from these sources, and make recommendations for Best Management Practices (BMPs) to improve the water quality of Triplett Creek and its tributaries.

The Triplett Creek Watershed

The Triplett Creek Watershed (Figure 1.1, page 2) comprises approximately 65% (about 180mi^2) of Rowan County, most of which lies within the Daniel Boone National Forest. The limited availability of private land and steep terrain has forced agriculture, housing, parking areas, and commercial development to be concentrated along Triplett Creek and its tributaries. This combined with limited community understanding and awareness of water quality issues and lack of BMP implementation has negatively impacted these waterways. The negative impacts of unplanned and unchecked development on water quality will continue to increase as more development extends along Triplett Creek and the North Fork of Triplett Creek.

The Kentucky Division of Water 2010 Integrated Report to Congress (Kentucky Division of Water (KDOW), 2010) identifies a portion of Triplett Creek, Christi Creek, Rock Fork, and Dry Creek as impaired. The North Fork of Triplett Creek, another major tributary, is not currently listed as an impaired stream. However, observations by citizens and measurements by Morehead State University scientists suggest that serious water quality issues exist, and stream bank instability is common. The North Fork of Triplett Creek is expected to experience rapid growth as a result of ongoing road construction and new commercial development.

Sedimentation (soil carried and deposited by water) has resulted in the degradation of the waterway's ability to support aquatic life. Likely sources of pollutants include illegal and failing household septic systems, farm animal waste, development, open construction projects, storm water runoff, and agriculture. These pollution sources are expected to increase as development expands along Triplett Creek and its tributaries. While land adjacent to the North Fork of Triplett Creek and Christy Creek will remain mostly agriculture; some of the farmland is being sold and partitioned for housing developments. Tracts of timber are also being sold and logging pressures are likely to increase, in addition to the growth in cattle farming. Growth along Dry Creek and Christy Creek is expected to be much slower than along Triplett Creek and the North Fork of Triplett Creek and will most likely be restricted primarily to residential development.

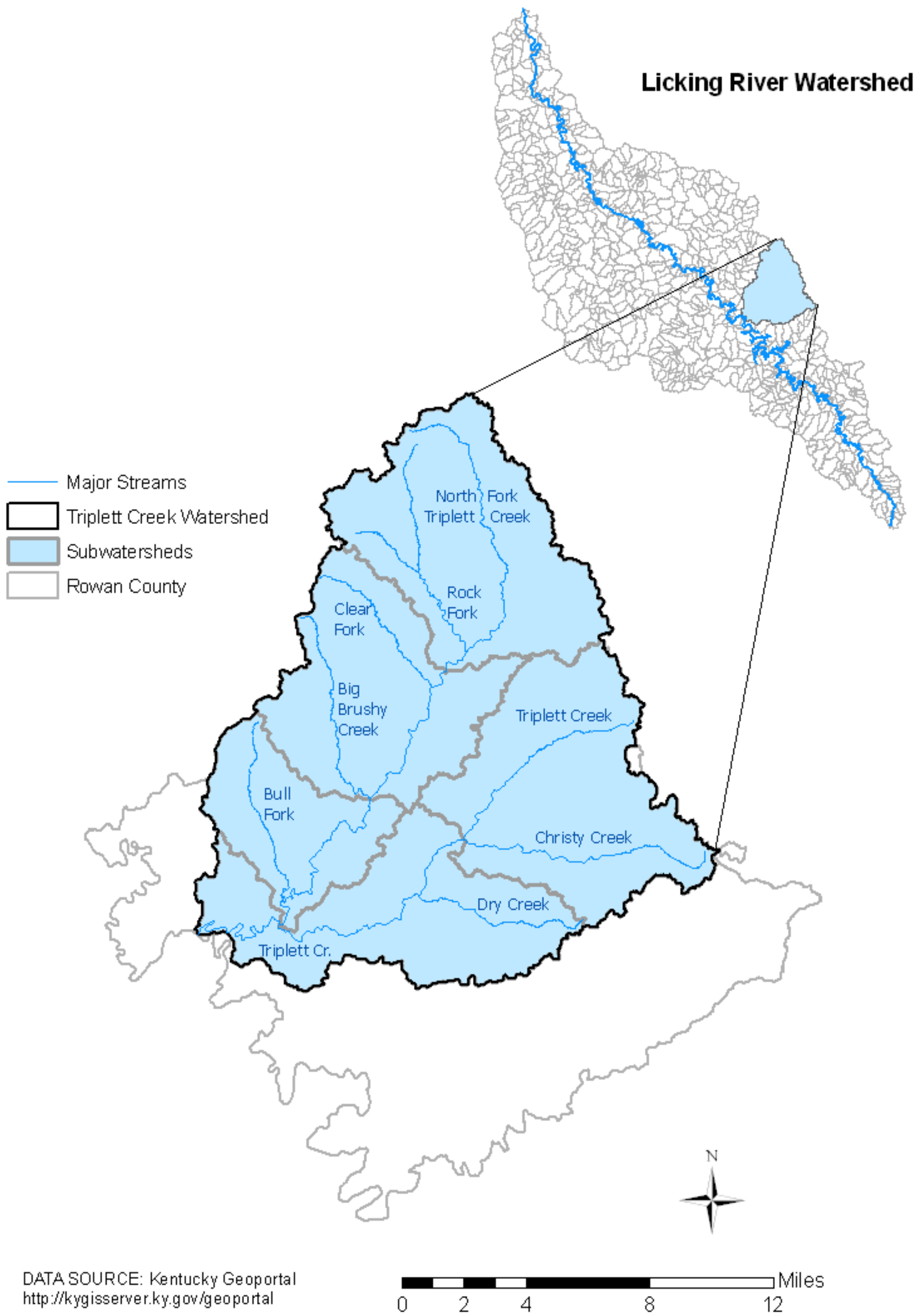

Figure 1.1. Location of the Triplett Creek Watershed in Rowan County, Kentucky.

Project Goal
The goal of this project is to improve the water quality of Triplett Creek and its tributaries through the development of a WBP. As part of the scope of this project, the Triplett Creek Watershed Committee and other potential partners will implement selected components of the plan and Best Management Practices in cooperation with responsible stakeholders.

The nine elements of a WBP as defined by the United States Environmental Protection Agency (EPA) serve as the primary objectives of this project. The Watershed Planning Guidebook for Kentucky Communities has more details on the 9 elements (http://water.ky.gov/watershed/Pages/WatershedPlanningGuidebook.aspx). To accomplish these objectives, the following activities and objectives are either in process or planned for the duration of the 319 grant implementation. The activities and objectives will be a guide for the community after the 319 grants ends as they move forward with the implementation. The objectives have not been modified from the original 319(h) grant application; however, the original Quality Assurance Program Plan (QAPP) was modified. Modifications in the QAPP were approved by the KDOW.

1. Identify impaired waters and causes/sources of impairments.
    a. Acquire, review, and summarize existing water quality data from the Triplett Creek Watershed. This activity was coordinated with the KDOW, listed partners, and other identified partners.
    b. After review of existing data, a pre-monitoring plan was developed and implemented for the project. Simultaneous monitoring was a coordinated effort involving multiple parameters (bacteria, nutrients, sediment, bank and channel instability, and discharge).
    c. To address sedimentation, bank/channel instability, and subsequent habitat alteration, a geomorphologic assessment of the Triplett Creek Watershed was performed by MSU geologists.
    d. MSU environmental scientists will collect water samples for nutrients and total suspended solids (TSS), and to record pH, dissolved oxygen, temperature, and conductivity.
2. Identify threats to waterways.
    a. Acquire, review, and summarize existing water quality data for the Triplett Creek Watershed. This activity was coordinated with KDOW and partners to identify previously collected data.
    b. After reviewing the data, additional stream monitoring was initiated in order to fill data gaps and to better evaluate identified threats and impairments.
    c. Field data was used to help develop load reduction models.

3. Identify point source controls and nonpoint source management measures needed to attain and maintain water quality standards.
    a. Review and evaluate the point source and nonpoint source control measures that already exist or that will be implemented in the future. This was coordinated with the Triplett Creek Watershed Committee and other potential partners.
    b. After a review and analysis of previous and new monitoring data, identified threats, and existing control measures, control measures will be suggested to maintain water quality standards for unimpaired stream reaches and to improve impaired stream reaches. Activities were recommended based on their ability to prevent or reduce pollutant loading, improve habitat, and on their cost-effectiveness and feasibility.
    c. Use field data to implement an Environmental Protection Agency (EPA) approved model for estimating load reductions and costs associated with user-selected BMPs. The KDOW was consulted regarding the EPA approved model.
4. Identify responsible parties for implementation of control measures.
    a. Through discussions with partners and government officials and careful scientific review, appropriate stakeholders will be identified for the necessary remediation activities within the Triplett Creek Watershed.
5. Estimate load reductions that will be achieved.
    a. Based on literature review, modeling, and field monitoring data will be used to estimate the load reductions that will result from proposed BMPs within the Triplett Creek Watershed.
6. Provide an implementation schedule with interim milestones.
    a. A quarterly report will be provided to the KDOW outlining the status of the milestones listed in the QAPP and MOA.
7. Estimate implementation costs and identify funding sources.
    a. Costs for proposed activities will be estimated and presented in summary. Funding agencies will be informed of the WBP results and proposed implementation schedule. Partners will be especially important in efforts to obtain future funding for BMP implementation.
8. Identify technical assistance, outreach and education needed.
    a. Technical assistance was provided by the partners to develop a feasible, effective, and cost-conscience plan. Other stakeholders may be identified if needed. Partnerships include people with a range of skills, from scientists to city planners with backgrounds in private industry, government, and academia.
    b. Throughout the development of the WBP, MSU will allocate resources for necessary outreach efforts. This will include involving interested stakeholders in the process as well as marketing the results of the plan to the public, government agencies, and potential funding sources.
    c. The WBP will identify and possibly develop educational programs that will augment existing water quality education efforts in Rowan County.

d.

9. Establish a monitoring plan and adaptive implementation process.
    a. Post-implementation monitoring will occur for remediation activities implemented during the project. Monitoring will balance cost with sufficient data collection to assess the overall effectiveness of BMPs in improving water quality.
    b. To be effective, the WBP must be flexible enough to adapt to unanticipated changes in the economic and political environment.
    c. Evaluate the GIS-based modeling and its effectiveness as a monitoring tool.
    d. Initial improvements in water quality are expected. It is unknown at this time what water quality parameters will show improvement until the BMPs are identified and implementation begins. The goal is to delist the impaired waterways.
10. Implement selected activities of the WBP.
    a. Identify components of the WBP that can be implemented within the scope and timeframe of this project and the approved budget.
    b. Solicit and work with necessary partners to ensure effective implementation.
    c. Implement BMPs according to the WBP and a KDOW-approved BMP Implementation plan.
    d. Ensure that all participating landowners with agricultural BMPs have completed an Agricultural Water Quality Plan.
11. Develop a plan to continue the implementation of the WBP.
    a. Identify stakeholders interested in serving on the Triplett Creek Committee.
    b. Develop periodic assessment recommendations to ensure that the WBP is implemented properly and evolves as necessary in response to changes in growth and land use.

Partners and Stakeholders

The Watershed planning effort 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 Morehead State University.

MSU’s faculty and staff involved in the community have supported and initiated a number of extensive ongoing and new projects focused on improving the water quality in the Triplett Creek Watershed. MSU’s most recent projects include the monitoring before and after municipal sewer installation and a focus study on the Triplett Creek Watershed. This research conducted as part of the 319 grant, which is presented in the Watershed Based Plan, has built upon this knowledge and has resulted in a greater understanding of the water quality issues within the Triplett Creek Watershed. Although some data gaps still exist, this research has produced quality data that may be used in the development of a comprehensive Watershed Based Plan.

After a flood in 2002, a group of citizens complained about an increase in the frequency and severity of flooding on the west end of Morehead and in the Clearfield area (Figure 1.2, page 6). As citizens and local officials began to discuss the issue and possible solutions, it became apparent that no simple, one-time fix existed. In response, the City of Morehead formed the Triplett Creek Committee, which consists of citizens from Rowan County; a biologist, geographer, educator and geologist from MSU; the Rowan County Solid Waste and Flood Plain Manager; representatives from the United States Forest Service, KDFWR, US Division of Agriculture Natural Resources Conservation Service; and the Licking River Basin Coordinator. This committee has served and assisted with the development of the Triplett Creek WBP. As the flooding issues have continued since 2002 (Figure 1.3, page 7), this work is an important priority for the citizens and local leaders.

Figure 1.2. Flood photos from 2002. Clearfield (left) and Morehead (right).

Figure 1.3. Sample photos from May 2010 flood. Route 32 in front of Wal-Mart (top left), First Street and Route 32 intersection (top right), and the town of Farmers, KY (bottom center).

Since a Triplett Creek Watershed Committee had already been established in Rowan County, these members were asked to participate in creating the Triplett Creek WBP. The official representation on the team is Morehead State University (faculty, staff and students), Morehead Utility Plant Board, Licking River Basin Coordinator, Rowan County Fiscal Court, City of Morehead, USFS, Rowan County Extension Service, citizens living in the Triplett Creek Watershed, and community representatives. This list may grow as the planning process continues and the Watershed team identifies more partners and stakeholders. In addition to the stakeholder list, the Rowan County Fiscal Court and City Council have been regularly updated on the planning process via briefings during regularly scheduled meetings.

Kentuckians for the Commonwealth and the New City Morehead committees will also be provided with regular updates on the WBP process.

Most of the communication for the watershed project has been conducted via emails. The core committee has been provided all documents for everyone who has requested them. Committee members and participants and the community have been encouraged to express their concerns and comments regarding all documents. The Triplett Creek Committee originally tried to operate the committee with a minimum number of participants for a quorum; however, it was difficulty obtaining consistent numbers or participants at the meetings. Therefore the committee moved to a more informal communication format, which has worked well.

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REFERENCE

Kentucky Division of Water. 2010. 2010 Integrated Water Quality Report. http://water.ky.gov/waterquality/Pages/IntegratedReport.aspx

Triplett Creek Watershed Inventory
Section 2

THE NATURAL ENVIRONMENT: LAND AND WATER
Geology and Topography

Streams in the Triplett Creek watershed have eroded through nearly horizontal layers of sedimentary rock (for details see Hoge and Chaplin, 1972). Most of the highest elevations around the boundary of the watershed are capped by pebbly, cliff-forming sandstone. Higher ridges and spurs between major tributaries within the watershed are capped by limestone, dolostone, and shale. The steep valley walls of hollows (Figure 2.1, page 10) are primarily underlain by siltstone and thin shale.

The valley floors of Triplett Creek and the major tributaries are dominated by sediment deposited by streams during floods (alluvium). Near the valley edges, alluvium is mixed with deposits derived from steep, adjacent slopes by slow down-slope soil movement (creep) and debris flows (landslides). Structures such as faults and folds are absent in the watershed. Bedrock, however, is extensively fractured throughout the entire watershed.

The highest elevation is Limestone Knob (1,435 feet) is about 3 miles southwest of the city limits of Morehead. The lowest elevation is where Triplett Creek empties into the Licking River (approximately 623 feet). The flat land in the watershed is concentrated along the North Fork of Triplett Creek, Bull Fork and in Farmers area (where the North Fork of Triplett and Triplett merge together).

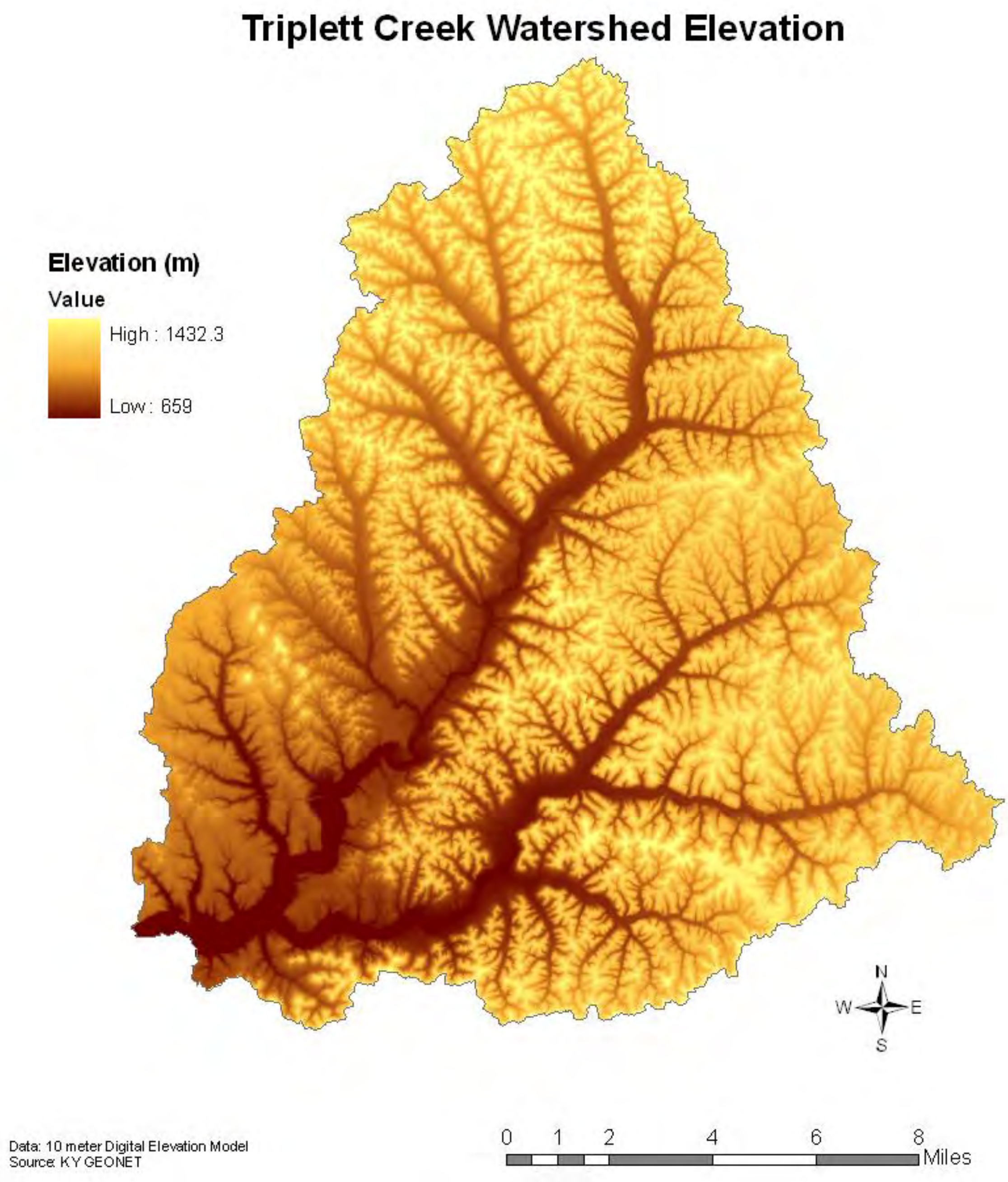

Figure 2.1. Map showing the distribution of elevation in the Triplett Creek Watershed. See appendix E for an enlarged map.

Soils

Soils on slopes and along steep stream banks erode rapidly when vegetation is removed. This has led to gullying on unprotected slopes and has enhanced slumping (small landslides) along stream banks. Figure 2.2 (page 12) shows the distribution of major soil units in the watershed. Silt loams (50-80% silt, 0-50% sand, 0-27% clay) dominate the entire watershed. These soils generally drain well but not too rapidly. As a result the silt loams are good for agriculture and properly installed septic systems. Coarser soils (e.g., sandy and gravely loams) tend to occupy lower slopes and floodplain areas adjacent to major tributaries. These coarser grained soils drain more quickly, are still quite fertile, and probably still allow septic system installation except in areas too close to streams. Rocky soils (rocky sandy loams) tend to occupy steep slopes below eroding sandstone cliffs, are quite thin and drain very rapidly – usually too rapidly for successful installation of septic systems.

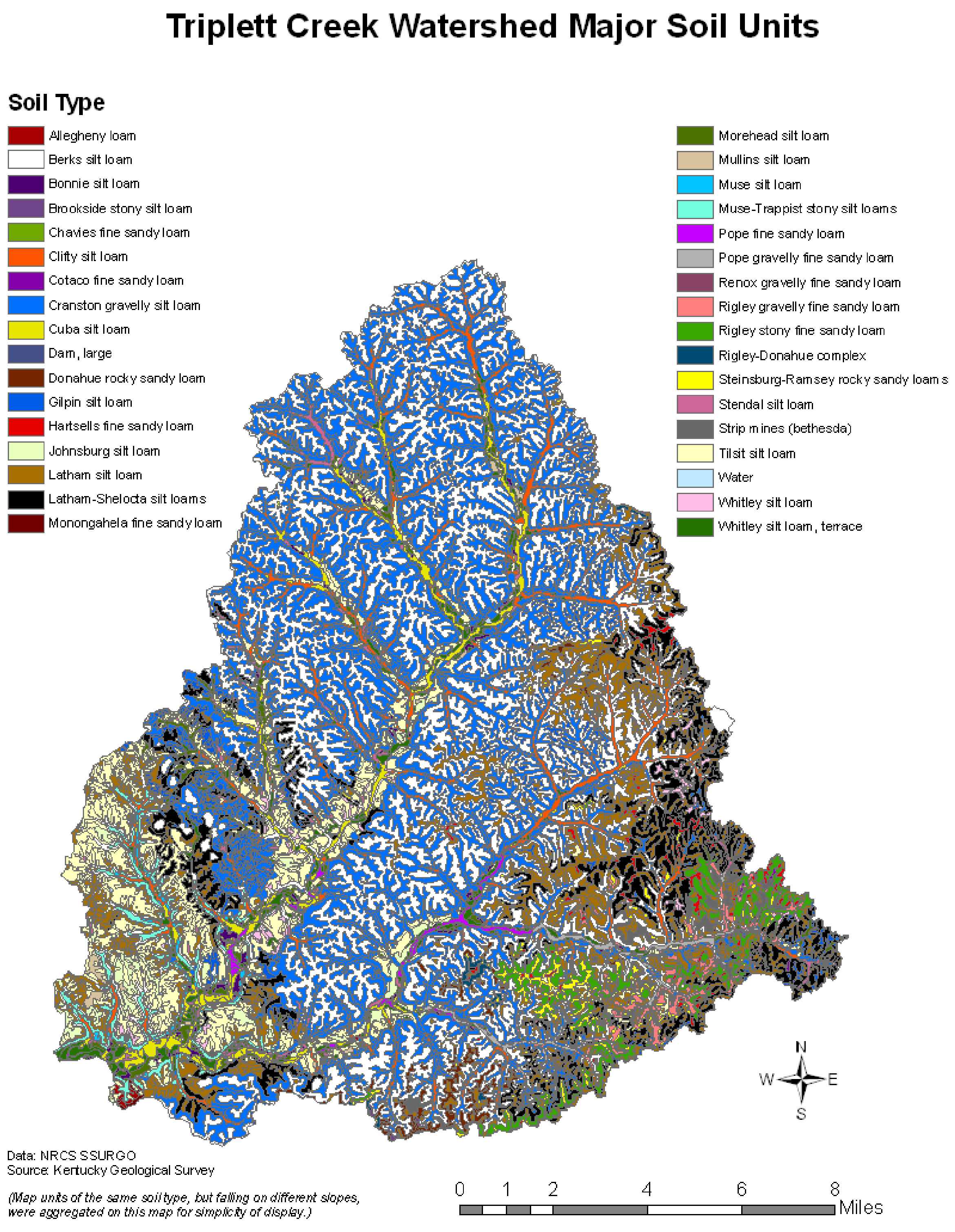

Figure 2.2. Map showing the distribution of major soil units in the Triplett Creek Watershed. See appendix E for an enlarged map.

Hydrology

Triplett Creek is mostly surrounded and fed by small streams in "hollows" (steep, narrow valleys), which lack bottomland (floodplains). When flowing, streams in these hollows have small waterfalls, some pools, and long stretches of rapids. These small streams join like tree branches to form larger, slower, winding (meandering) streams, which flow through wider valleys with well-developed floodplains (good bottomland). The streams in these larger valleys flow in ditch-like (entrenched) channels with eroding banks.

In order to accomplish the goals of this WBP, flow in Triplett Creek and its tributaries must be measured. Stream gages are stations that measure the amount of water that flows past a point in a stream during a given period of time. No working state or federal government stream gages exist in the Triplett Creek watershed. Instead, MSU geologists have installed "rulers" (standard, enameled steel staff gages) on bridges at fifteen sites in the Triplett Creek Watershed and have been measuring flow at thirteen of these sites for approximately one year. Flow measurements will be used to determine the amount of contaminants (loads) flowing through Triplett Creek and its tributaries.

Ultimately, flow in the Triplett Creek watershed is controlled by climate and precipitation. Monthly average air temperatures in the watershed range from a low of approximately 31º F in January to a high of nearly 74º F in July. Annual average precipitation is approximately 43 inches. Flow is highly variable in summer due to the intermittent nature of precipitation. Late August through October tends to be the driest period. During this time, most tributaries, and sometimes even main stem of Triplett Creek is ponded.

Many of the small tributaries in the Triplett Creek Watershed stop flowing. Steadier, lighter rains occur frequently from about late November to April, a period when soil moisture is replenished, the ground remains moist to saturated, and groundwater almost continuously feeds all but the smallest tributaries. An average of nearly six inches of intermittent snow falls between rain events from December through March. The snow usually melts quickly, which further contributes to soil moisture, groundwater, and overland flow.

Flooding along Triplett Creek can be major at times, especially in the Farmers area (south west portion of the watershed). Flooding in the watershed is minor and infrequent in other areas. Much of the watershed experiences flash flooding only during high intensity storms, especially where small bridges and culverts are not sized properly to handle high flows. Flash flooding is largely due to rapid runoff over the steep slopes in and around hollows. Heavy forest cover tends to slow or completely intercept water flowing over the land during all but the most intense storms. Some homes are constructed in flood prone areas that are vulnerable to flash flooding.

Flooding along Triplett Creek and its larger tributaries is less frequent and less severe than one might expect. The primary reason is that larger streams are deeply entrenched and seldom flow out onto their floodplains anymore. Several reaches of Triplett Creek and its tributaries have also been channelized. Many of the smaller tributaries have been artificially confined by rock basket (gabion) walls (for example, near Ravenswood Bridge in the Dry Creek Watershed) and crude walls of stacked concrete debris, appliances, tires, etc. The net effect is that the most severe flooding is confined to the lowest reaches of Triplett Creek.

During dry periods, groundwater seepage (baseflow) is the only reason Triplett Creek and its tributaries continue to flow. Groundwater is pushed downhill by gravity through fractured rocks, soil, and sediment and feeds all but the highest headwater streams in the watershed. The fact that bedrock in the Triplett Creek watershed is highly fractured greatly enhances groundwater flow. The combination of steep terrain and highly fractured bedrock causes the groundwater contribution to streams to change fairly rapidly, within hours to at most a few days.

Sinkholes and karst cave systems probably do not directly feed long stream reaches anywhere in the watershed. The distribution of potential karst in the Triplett Creek watershed is shown in Figure 2.3 (page 15). The more detailed map of Hoge and Chaplin (1972) shows that limestone occurs on or near the tops of ridges in the blue-shaded areas of Figure 2.3 (page 15) and that no karst features recognizable at the 1:24000 scale exist. Small sinkholes and minor caves are common in similar settings south of Morehead, however, so springs and seeps on steep slopes at the base of sandstone cliffs and at the base of limestone outcrops may be fed by small, discontinuous cave systems. These springs, in turn, may feed the heads of small, intermittent streams.

Figure 2.3. Map showing potential karst areas in the Triplett Creek Watershed. See appendix E for an enlarged map.

THE NATURAL ENVIRONMENT: LIFE

Flora and Fauna

The flora and fauna (plants and animals) of the Triplett Creek Watershed are diverse. According to the Kentucky State Nature Preserves Commission's *County Report of Endangered, threatened, and Special Concern Plants, Animals, and Natural Communities of Kentucky* (2011), there are a number of endangered, threatened, or special concern (declining) plant and animal species in Rowan County. The ecosystems in the watershed range from Oak Pine ridge top forest to riparian ecosystems. Kentucky State Nature Preserves Commission's (KSNPC) has listed Bottomland hardwood forest (riparian ecosystem) communities as a special concern since it is considered vulnerable. The Spotted Bee-balm (*Monarda punctata*) has been listed as extirpated (no longer found) since the 2007 report. This flowering plant was associated with sandy areas, such as those found in bottomland forest.

The number of species listed on the KSNPC report for Rowan County has increased from the 2007 report. Table 2.1 (below) shows the number of each flora for 2012 and 2007. The biggest changes were in the vascular plants (i.e. trees, brushes, and perennial flowers) and breeding birds. The number of vascular plants on the list of concern increased from 14 to 39. Two of the vascular plants (not listed in the table) have been reported in the county, but have not been seen in at least 20 years. Most of these plants are associated with bottomlands.

Table 2.1. Summary of the number of each floral and faunal group listed as endangered, threatened, or special concern in Rowan County. There was no data reported for the blank spaces.

Group	**Endangered**		**Threatened**		**Special Concern**	
	2012	2007	2012	2007	2012	2007
Amphibians	1	0			0	1
Breeding Birds			3	0	4	2
Fishes					2	0
Insects	1	0	1	1	4	2
Mammals	2	2	1	0	4	5
Mosses	1	1	3	3		
Reptiles					1	1
Vascular Plants	13	2	14	2	10	10

The report by the KSNPC (2013) lists a number of wildlife species that are extremely dependent on healthy riparian ecosystems (vegetated areas along creeks and rivers) for survival. Examples of species dependent on riparian ecosystems include Eastern Hellbender Salamander (*Cryptobrandrus alleganiensis*), Least Weasel (*Mustela nivalis*), Jointed Rush (*Juncus articulatus*), Filmay Angelica (*Angelica triquinata*), Yellow Screwstem (*Bartonia virginica*), Kentucky Ladyslipper Orchid (*Cypripedium kentuckiense*), and Waterplantain Spearwort (*Ranunculus ambigens*). Much of the native vegetation along the creek banks has been disturbed. As a result, nonnative plant species such as Japanese Knotweed (*Fallopia japonica*), Japanese honeysuckle (*Fallopia japonica*) have successfully invaded the area.

Most of the riparian ecosystems in the Triplett Creek watershed have been extremely altered. Floodplain ridges/terrace forest and Bottomland Hardwood Forest are listed as special concern in the state because of their rarity due to a very restricted natural range, very few populations (often 20 or fewer), steep declines, or other factors making them very vulnerable to extirpation from the state (KSNPC, 2011). The threat to these communities in the Triplett Creek Watershed is that the deeply entrenched streams in this basin have become disconnected from their floodplains. When the stream becomes disconnected it increases channelization and bank erosion. In addition, vital habitats such as wetlands and bottomland forest are stressed or disappear without the influx of floodwaters.

THE REGULATORY ENVIRONMENT

Floodplain Regulation

Flooding is a simple natural phenomenon that occurs regularly with any waterway. Flooding can be worse if an area has a lot of land surfaces that don't allow water to sink in or infiltrate back into the soil. These types of surfaces are called impervious surfaces, and include areas like parking lots and rooftops. Impervious surfaces causes more water from a rain or snow event to runoff to the lowest point of town instead of infiltrating. A healthy riparian zone and an undeveloped floodplain can help decrease the severity of flooding. As an area becomes more developed with more impervious surfaces, more frequent and severe flooding may result.

The Triplett Creek watershed includes both 100-year floodplain and floodway designations. This document only contains a select section of the Triplett Creek floodplain (Figure 2.4, page 18). The floodplain is any area that is susceptible to being inundated by water from any source. The floodplains are areas adjacent to a river, creek, lake, stream, or other waterway that is subject to flooding when there is a significant storm event. The floodway represents the channel limits during a 100-year storm. This is where the main flow of the water is during a flood event. It is also where the most damage occurs because of the velocity of the flow. Detailed floodplain maps for Rowan County can be viewed by contacting the Rowan County Floodplain Department. The flood hazard areas are regulated by county ordinance and state regulations. The 100-year floodplain represents the area that would be flooded if a flood having a one percent chance of being equaled or exceeded in any given year occurred. The designated floodway refers to the stream and the portion of the adjacent 100-year floodplain, which is specified by a local ordinance or indicated on National Flood Insurance Program maps that must be kept free of obstructions during flood flows.

Triplett Creek Watershed Flood Hazard Zones, Floodway and Selected Roads

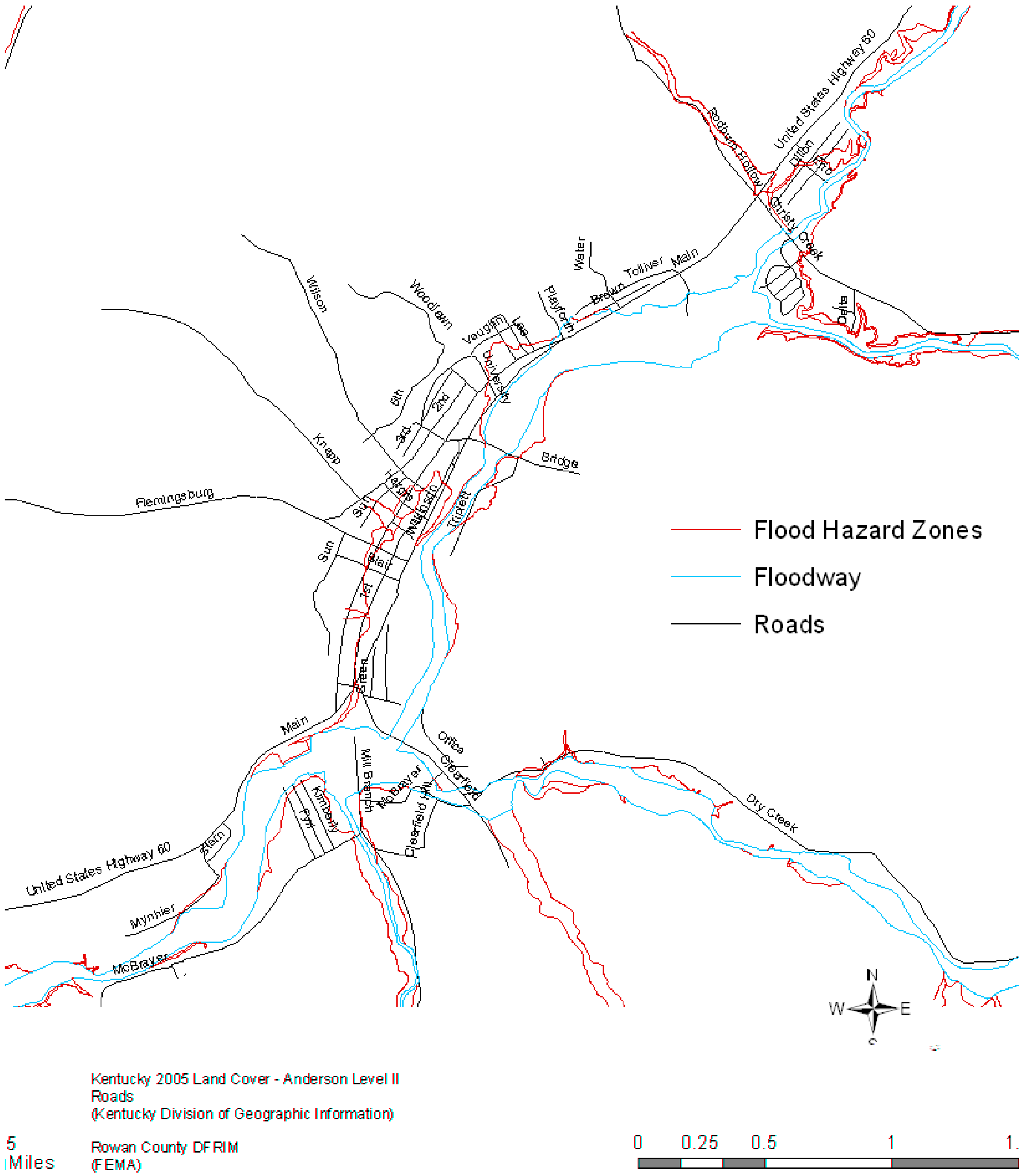

Figure 2.4. Flood hazard zones of the downtown Morehead and Clearfield area. See appendix E for an enlarged map.

Permits must be obtained from both the KDOW and the Rowan County Floodplain Department to fill and/or construct buildings in the floodplain. Filling or constructing in the regulatory floodway is prohibited. In addition to construction in the floodplain, permits must also be obtained from both the KDOW and Rowan County Floodplain Department to construct in or along a waterway. Before a permit can be issued the intent of the permit and the location must be advertised in the local paper to solicit public comment.

Since 2007, KDOW has approved 61 401 permits in Rowan County. Of these permits, 54 have had final construction reported approved. One application was withdrawn and six exemptions were issued. Two are in administration/technical review.

Water Supply

All residences in the watershed are connected to Rowan Water Incorporated waterlines (Figure 2.5, page20), any remaining wells are abandoned or used only for minor irrigation. Some minor withdrawals from streams for irrigation may also occur, but this is unconfirmed.

In Kentucky, the water withdrawal program administered by 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.

As of December 31, 2010, according to the Water Quantity Section of KDOW, there were no permitted water withdrawals in the Triplett Creek watershed. This means that large quantities of water are not being extracted from Triplett Creek. It is important to understand the amount of water flowing in a stream ("in stream flow" or "flow") because the flow impacts many aspects of the stream itself including water quality, habitat, flooding, and many others.

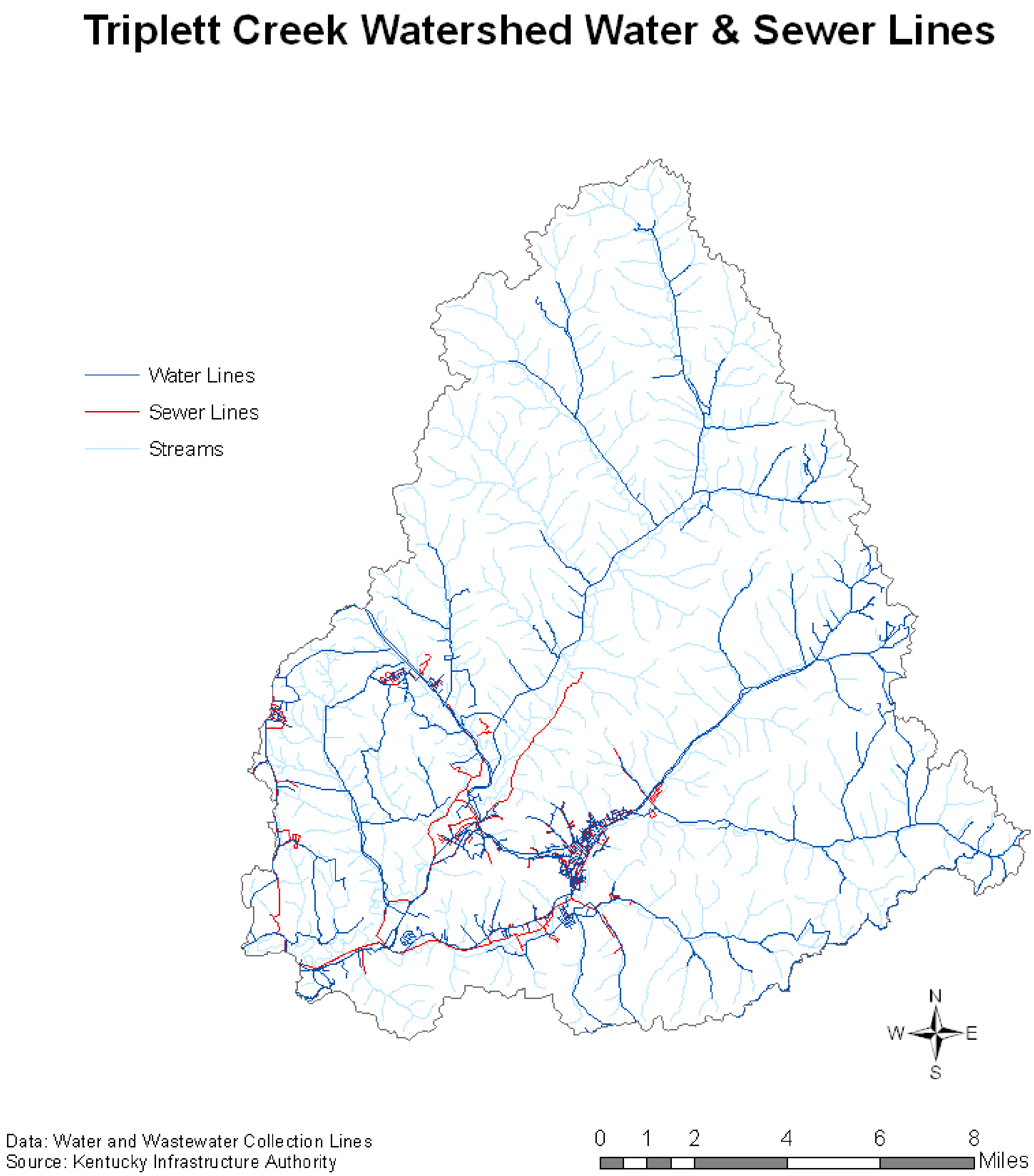

Figure 2.5. Map showing sewer and water lines in the Triplett Creek Watershed. See appendix E for an enlarged map.

Watershed Management Activities

Source Water and Protection Plans

A Source Water Area Protection Plan (SWAPP) is required under the Safe Drinking Water Act to assess the quantity of water used in a public water system, to identify protection areas and to list potential contamination sources. The plans do not have any state statutory authority to prevent actions within the area. Any actions taken to protect the area are to be done through local ordinances.

According to the KDOW Watershed Management Branch, Morehead State University (MSU) has a SWAPP upstream of the dam near the Greenhill City Park and upstream of Eagle Lake (Figure 2.6, below). This is the location where MSU takes in water from Triplett Creek for domestic use. This is the only SWAPP in the focus area of the Triplett Creek Watershed. The Gateway Area Development District prepared a Source Water Assessment and Protection Plan Susceptibility Analysis and Protection Recommendations for Rowan County in 2004.

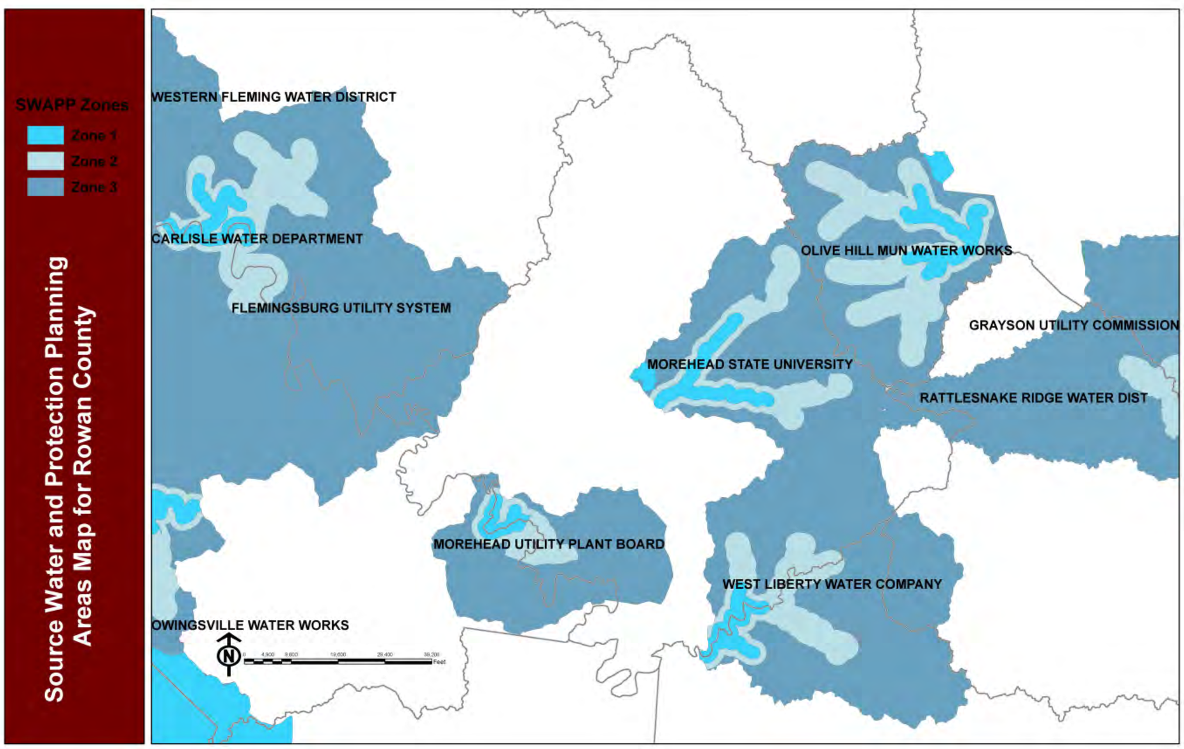

Figure 2.6. Map of the Source Water and Protection Plans for Rowan County.

The Gateway District Health Department, which covers Rowan County, requires inspection and approval of site-based septic systems before electrical service can be connected for new residences. This is designed to prevent non-point and point source pollution from residential sewage in the watershed. No other local regulation or ordinances exist to protect the area.

The GADD made the following recommendation:

> "It is recommended that the Rowan County Fiscal Court and the City of Morehead local governments and the officials at Morehead State University be provided a copy of the source water assessment for the MSU Water Supply and the water supply protection area map. The local government entities in Rowan County should be encouraged to include within their review criteria for new development whether or not the proposed project lies within a water supply protection area. It is also suggested that the local governments review their subdivision and development standards to determine if any further features need to be incorporated into those standards that might mitigate the chances for contamination in a supply protection area."

Wellhead Protection Plans

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 Rowan County because all public water sources in the county use surface water.

Groundwater Protection Plans

Groundwater Protection Plans (GPPs) are required for anyone engaged in activities that have the potential to pollute groundwater. Activities that would require a GPP include pesticide application or storage for commercial purposes, installation or operation of on-site sewage disposal systems, storing or handling of road oils, or any mining activity. According to the Groundwater Section of KDOW, the only GPP in the database for Rowan County within the 2005 – 2010 time frame is Morehead Wastewater Treatment Plant. No violations have been reported.

For more information on what types of facilities require GPPs or guidance on how to write a plan, visit the Groundwater Section of the KDOW website. It is part of this WSP to implement education and awareness campaigns on the need for groundwater protection and active GPPs.

Past or Current Watershed Based Plans

No watershed based plans have been developed for the Triplett Creek Watershed in the past. In June 2009, a watershed plan has been approved by the KDOW for Dry Creek Watershed, which is a major tributary to Triplett Creek. The implementation of the Dry Creek WBP falls under the current 319(h) grant (Project 08-07, #C9994861-08). The Triplett Creek Watershed committee has been implementing the WBP.

Wastewater Authorities

Wastewater 201 Plan

In 1998, Morehead Utility Plant Board completed a 201 Plan for sanitary sewer system improvements. The 201 Plan is developed to evaluate and identify a plan for sewage collection systems and wastewater treatment plant infrastructure, that a comprehensive plan to cost-effectively address problems can be developed. There is a copy on file at the Morehead Utility Plant Board office. The total capital cost of the 201 Plan is estimated to be $23,000,000 for the next 20 year plan. The purpose of a 201 Plan is to develop an effective planning tool that will provide an accurate forecast of future wastewater needs for Rowan County. The 201 Plan reflects areas that have been designated as needing sewer infrastructure. This determination is based on population density and economic feasibility of installing sewer infrastructure. Areas not included in the 201 Plan may still have wastewater problems that may need to be addressed through other alternatives. These alternatives include septic system maintenance and clean out. Public education and outreach efforts can be of assistance in these areas.

The 201 Plan includes the following information on existing and proposed sewer systems, flow projections, capacity analysis, alternative analysis for unsewered areas and expansion of Wastewater Plant, and financing strategies. The plan is designed for a 20 year projection.

Figure 2.7 (page 24) is a revised (current) map from the 1998 201 planning process. The original map is shown in Figure 2.8 (page 25). The green area represents currently sewered areas; the red represents the area were sewer is to be available 3 to 11 years; the blue represents the area that is planned for expansion in 11 to 25 years. Morehead Utility Plant Board can be contacted directly by residents that have questions regarding the 201 planning process. Figure 2.9 (page 26) shows the Morehead Utility Plant Board sewer infrastructure.

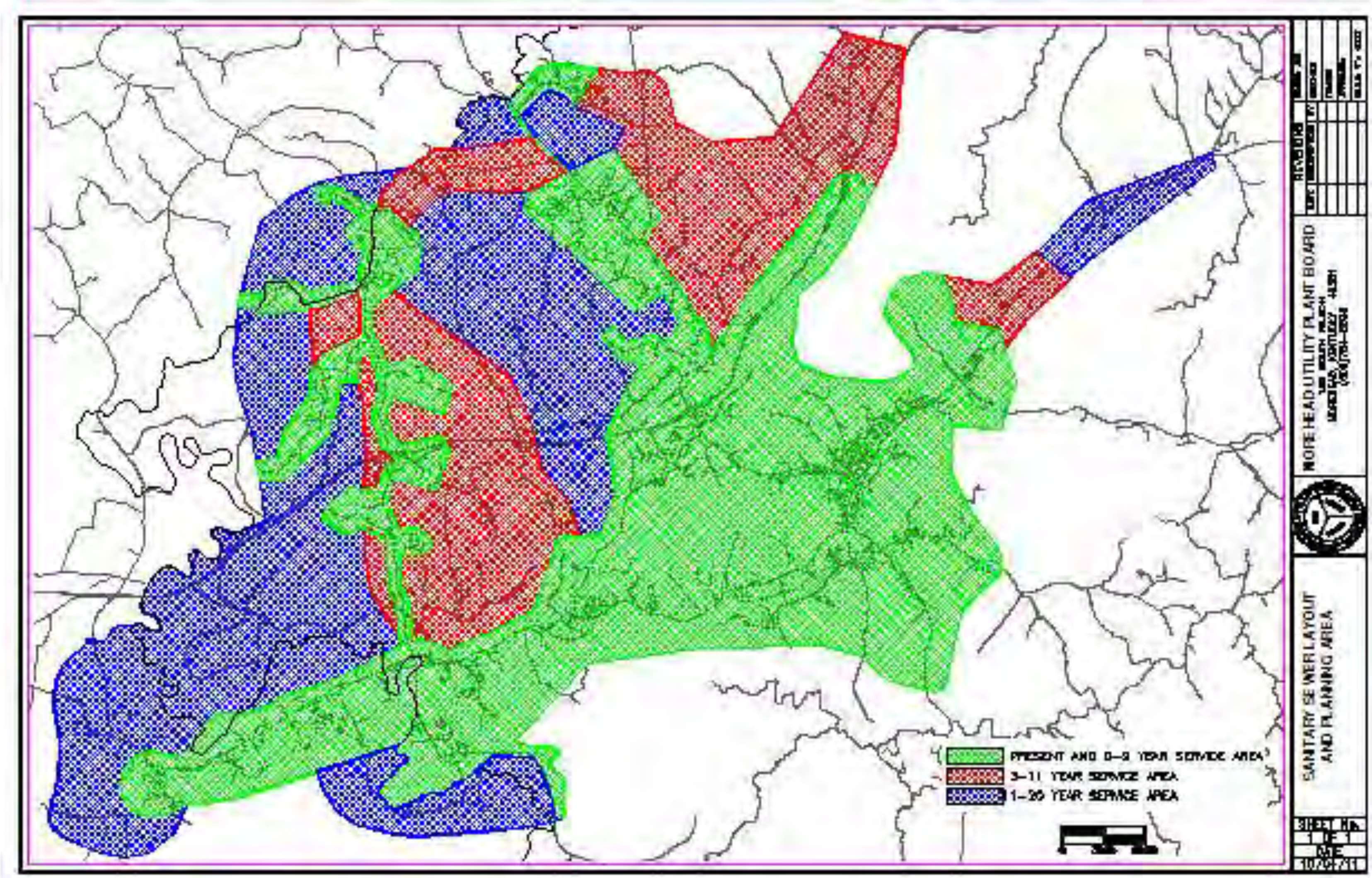

Figure 2.7. Revised map of the 201 plan. See appendix E for an enlarged map.

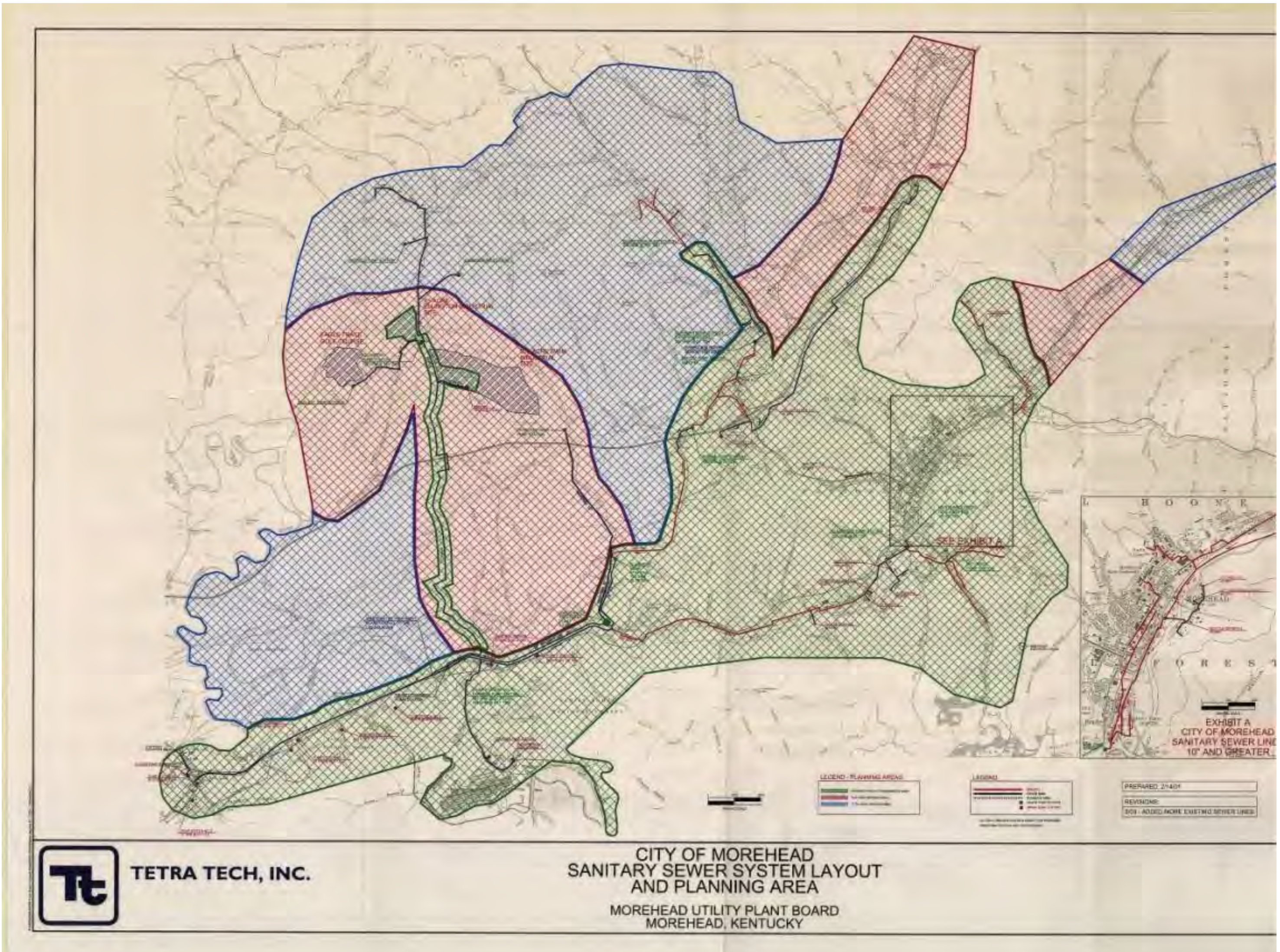

Figure 2.8. A map of showing the sanitation sewer planning area from the 201 planning process. See appendix E for an enlarged map.

Figure 2.9. Morehead Utility Plant Board existing Sanitary Sewer System. See appendix E for an enlarged map.

Agricultural Water Quality Plans

Since 1850, when minimum criteria defining a farm for census purposes were first established, the farm definition has changed nine times as the Nation has grown. A farm is currently defined, for statistical purposes, as any place from which $1,000 or more of agricultural products (crops and livestock) were sold or normally would have been sold during the year under consideration. This definition has been in place since August 1975—by joint agreement among USDA, the Office of Management and Budget, and the Bureau of the Census (USDA, 2012).

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 local County Extension Office if the owner/operator desires to do so. However, most are filed with the Soil Conservation Office since some of the cost share programs require an agriculture water plan to be on file with Soil Conservation. According to the Natural Resources Conservation Service, there are 317 Agriculture Water Plan Certificates on file. Of these only about 10 of them have utilized cost share programs.

Agricultural activities in the Triplett Creek Watershed include livestock and some row crop production. Beef cattle, tobacco, hay, and pasture land are found in the watershed and/or adjacent to waterways. According to the Agriculture Extension Office, there are an estimated 2000 cattle, 100 sheep, and 400 horses in the watershed. Forest activities including timber harvesting and firewood removal also occur in the watershed. The majority of producers in the watershed likely have completed an Agriculture Water Quality Plan. According to the Rowan County Extension Agent for Agriculture and Natural Resources, there are an estimated 125 working farms in the Triplett Creek Watershed. Several best management practices have been adopted. The practices are designed to decrease the amount of sediment, nutrients (such as fertilizer), and pathogens from entering waterways.

Agricultural best management practices that protect water quality and that have been adopted by producers in the watershed:

1. Construction and use of animal waste facilities that reduce manure movement into streams.
2. Adoption of rotational grazing practices that promotes adequate vegetative cover and reduces soil erosion/movement of sediment into streams.
3. Proper disposal of fallen livestock that eliminates movement of disease causing organisms into waterways.
4. Row cropping on the contour and use of buffer strips to reduce soil erosion.
5. Soil testing/fertilize application practices that reduce movement of excess nutrients into streams.
6. Planting winter cover crops that reduce bare soil and minimize soil erosion/stream sedimentation.
7. Grazing fields not fenced off from waterway.

Despite the implementation of best management practices several agricultural practices still exist that have a negative impact on the water quality in Triplett Creek Watershed. Observed practices include 1) stocking rates and poor soil fertility for some farms have resulted in some over-grazing and exposed soil; 2) limited row cropping on excessively steep slopes has resulted in some soil erosion; 3) removal of trees from stream bank to maximize crop and livestock production. These practices allow excess sediments and nutrients to enter the waterways. See chapter one for more information and the impact of sediments and nutrients.

Special Land Use Planning: Subdivision Regulations

The Triplett Creek Committee worked with Stand Associates, Inc. to help identify the current ordinances that most impacted water quality. Appendix A contains the complete report provide by Strand Associates. There are several sections that pertain to WBP:

1. Chapter 90, subsection 90.07. Removal of Dog Excrement.
2. Chapter 93. Guidelines for stormwater related to streets and sidewalks.
3. Chapter 151. Subdivision Regulations.
4. Chapter 154. Zoning Code.
5. Chapter 155. Flood Damage Prevention.

Stand Associates recommended that our ordinances provide more general language and include specifics in design manuals that can be easily amended to keep up with green stormwater technologies and Low Impact Development (LID). The ordinances lack guidance and definitions related to green stormwater infrastructure and LID. The green infrastructure and LIDs have difference maintenance requirements that will need to be addressed.

Regulations not included that would be helpful would be 1) the reduction of curbs to allow stormwater runoff to flow over pervious surfaces (non-paved), and 2) the creation of buffer zones between creeks and construction projects. Both of these actions would allow for the quantity of water entering our waterways to be reduced. In addition, the speed at which the runoff enters the waterway is reduced. As a result, the amount of water entering streams during a rain event is reduced, reducing the intensity of flooding in the area. These recommendations also reduce the amount of sediment entering the waterway, especially clay particles. A reduction in the amount of sediment entering the waterways also reduces the nutrients that "cling" to the sediment particles.

The elimination of cross connections between sanitary sewers and storm water drainage systems will reduce the amount of over flow occurring at the pumping stations and manholes. When the system overflows, the stormwater system discharges water which is a combination of stormwater and sewer into the waterways. These discharges have been a regular problem for Morehead Utility Plant Board, and documented by the Kentucky Division of Water (Morehead Office).

Regulatory Status of Waterways

The Kentucky Division of Water is required by the EPA to assign designated uses to each of the state's waterways, such as recreation, aquatic habitat, fishing 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. These criteria are used to determine whether a stream is listed as impaired and therefore needs a WBP or Total Maximum Daily Load (TMDL).

Designated Uses

Triplett Creek and its tributaries designated uses are warm water aquatic habitat (WAH), primary and secondary contact recreation, and drinking water supply.

Impairment Status

The Kentucky Division of Water 2010 Integrated Report to Congress (KYDOW, 2010) identifies a portion of Triplett Creek, Christi Creek, Rock Fork, and Dry Creek as impaired (Table 2.2, page 30; Figure 2.10, page 31). All of the waterways are impaired for the warm water aquatic habitat designation. WAH are ecosystems that support warm water aquatic habitats: vegetation, fish or wildlife, including invertebrates. As part of the Watershed Based Plan process, sample sites were selected in these impaired waterways.

Table 2.2. Summary of Impaired Waterways in the Triplett Creek Watershed.

Waterways	Segment (miles)	Impaired Use	Pollutant Cause	Suspected Source	Sample sites
Christy Creek	0.0 to 4.3	Warm Water Aquatic Habitat (Partial Support)	Cause Unknown; Sedimentation/Siltation	Non-irrigated Crop Production	CC-0.23 CC-4.11
Dry Creek	0.0-2.5	Warm Water Aquatic Habitat (Partial Support)	Nutrient/Eutrophication Biological Indicators; Sedimentation/Siltation Organic Enrichment (Sewage) Biological Indicators	Highway/Road/Bridge Runoff (Non-construction Related);Urban Runoff/Storm Sewers	DC-0.28 DC-1.89
Rock Fork	0.0 to 4.0	Warm Water Aquatic Habitat (Partial Support)	Nutrient/Eutrophication Biological Indicators; Sedimentation/Siltation	Crop Production (Crop Land or Dry Land); Dredging (E.g., for Navigation Channels)	RF-0.15
Triplett Creek	5.9 to 12.3	Warm Water Aquatic Habitat (Partial Support); Primary Contact Recreation Water (Nonsupport); Secondary Contact Recreation Water (Partial Support)	Nutrient/Eutrophication Biological Indicators; Sedimentation/Siltation; Organic Enrichment (Sewage) Biological Indicators; Fecal Coliform	Source Unknown; Unspecified Urban Storm water; Urban Runoff/Storm Sewers Agriculture; Highways, Roads, Bridges, Infrastructure (New Construction); Impacts from Hydrostructure Flow Regulation/modification; Municipal Point Source Discharges;	TC-12.27

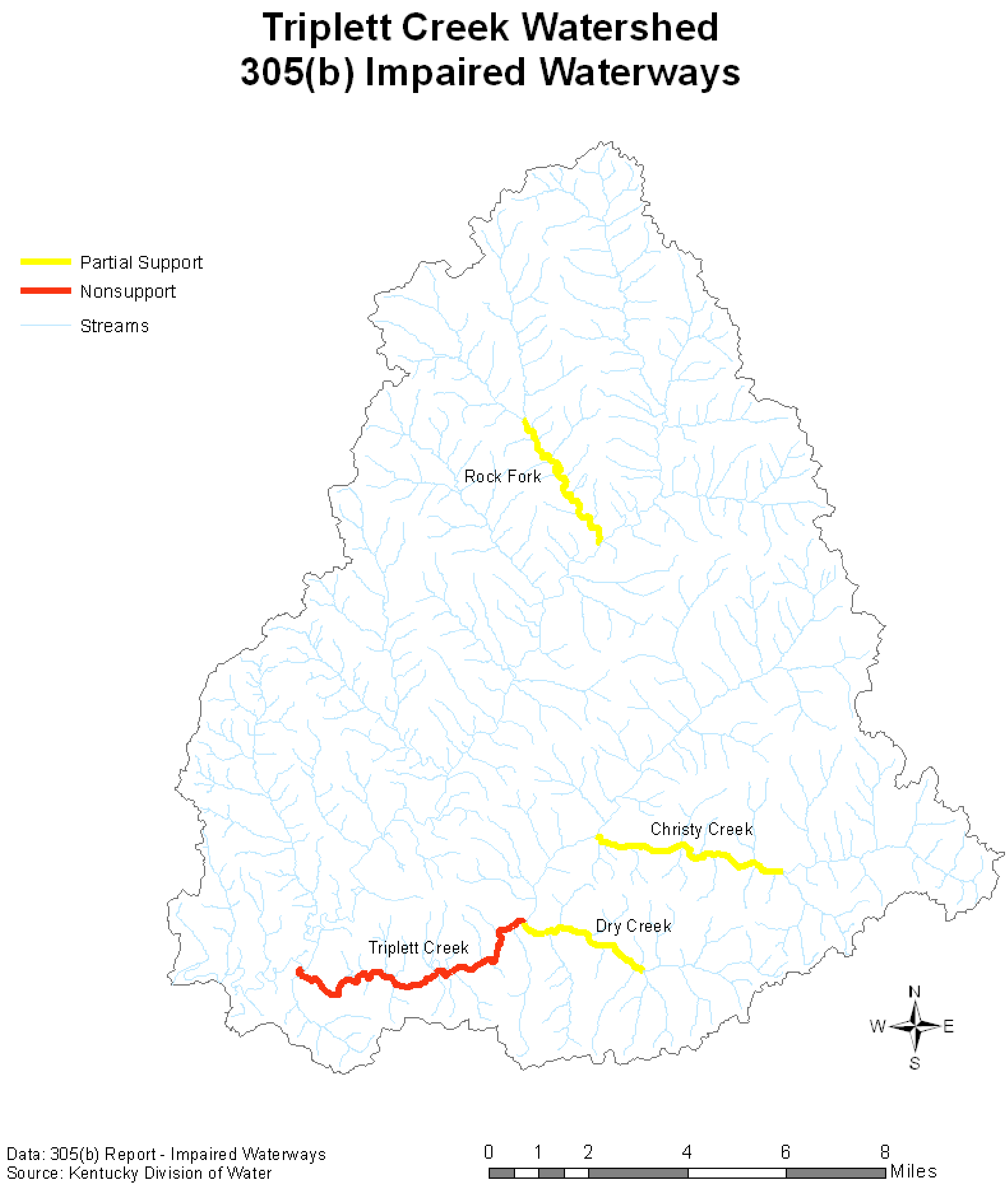

Figure 2.10. Map of the impaired waterways in the Triplett Creek Watershed.

Special Use Waters

Kentucky identifies certain Special Use Waters, and they receive greater protection. These waters include Outstanding State Resource Watershed, 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. As of January 15, 2011, there are no identified Special Use Waters in the Triplett Creek Watershed.

Total Maximum Daily Load Report

The Clean Water Act requires Kentucky to list streams that it finds 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 TMDL Report. These reports set limits on the pollutants that can be discharged into these waters and provide general guidance for implementation. Watershed plans act as useful tools to implement TMDLs. Currently, there is no TMDL Report for Triplett Creek Watershed.

HUMAN ACTIVITIES AFFECTING WATER QUALITY

Land Use

The Triplett Creek Watershed is mainly forested with residential development concentrated in downtown Morehead, Clearfield, and the Interstate 64 Exit 137 (Figure 2.11, page 33). Table 2 (pages 34-35) shows the distribution of land use and land cover types in the watershed in percent cover and total area for the year 2005. The watershed contains approximately 3.5% impervious surfaces with another 4.3% open development. Impervious surfaces are those surfaces like roads, parking lots and building roofs that do not allow water to pass through them. This means that when rain hit these surfaces, it does not infiltrate into the soil, but instead runs off rapidly into our waterways.

The runoff affects streams in many ways. First, runoff water will pick up and carry any pollution that it contacts on its way to the stream, such as oil and dirt from roads, pet waste, agricultural and lawn chemicals, and many other possible substances. These substances have the potential to degrade the water quality of the stream. The runoff will also increase the flow of the waterway, causing more rapid flooding and erosion issues. Additionally, if the water runs over hot pavement on its way to the waterway, it could increase the temperature of the water. This can harm aquatic organisms. High or increasing percentages of impervious surfaces in a community (usually from development) are increasingly seen as problematic for waterways for these reasons.

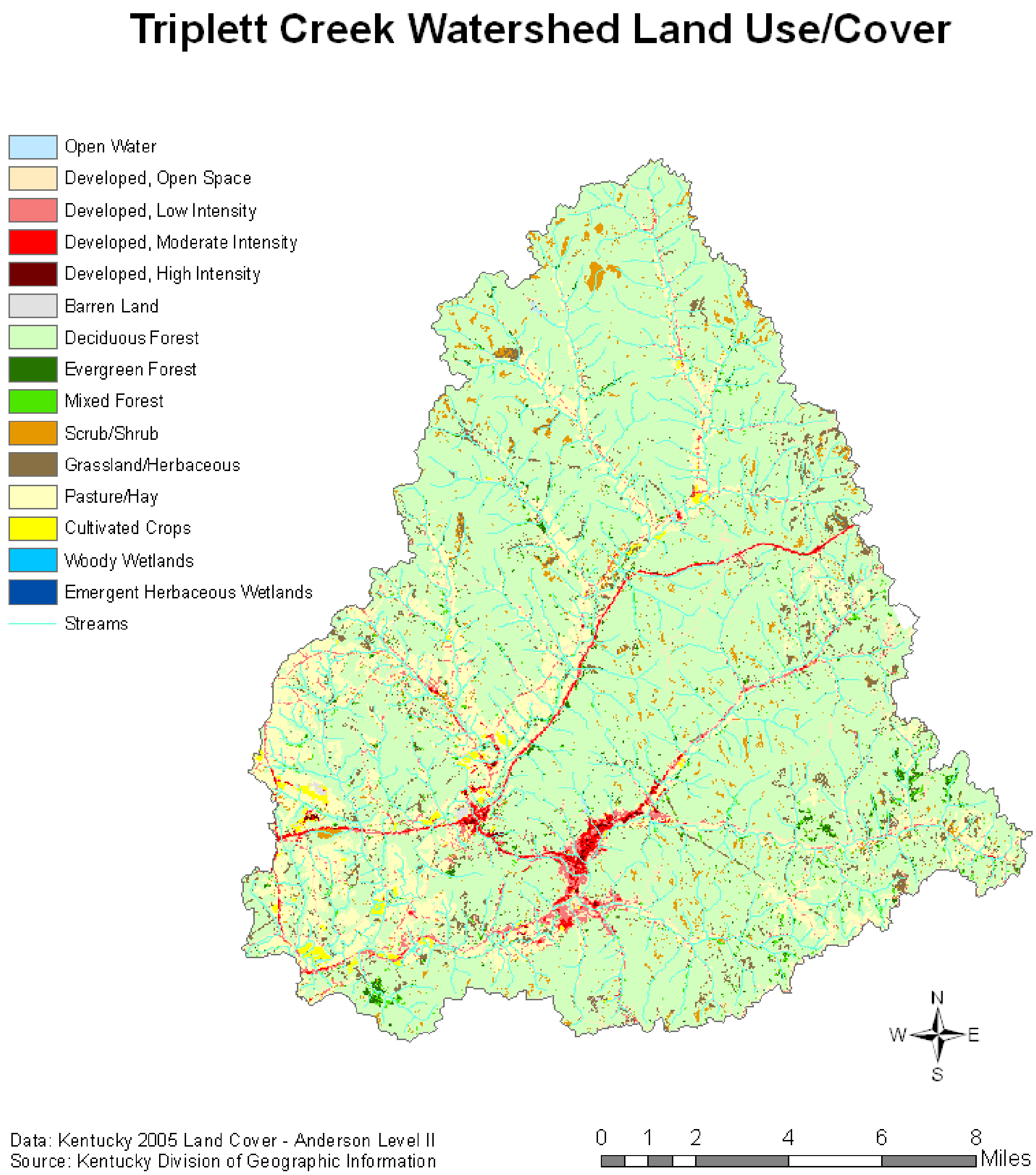

Figure 2.11. Map of the land use distribution in the Triplett Creek Watershed. See appendix E for an enlarged map.

Table 2.3. Land use type in the Triplett Creek Watershed.

Land Use Type	Description	Area (sq. miles)	% land cover
Open Water	All areas of open water, generally with less than 25% cover of vegetation or soil	0.240	0.13%
Developed, Open Space	Includes areas with a mixture of some constructed materials, but mostly vegetation in the form of lawn grasses. Impervious surfaces account for less than 20% of total cover. These areas most commonly include large-lot single-family housing units, parks, golf courses, and vegetation planted in developed settings for recreation, erosion control, or aesthetic purposes.	7.565	4.20%
Developed, Low Intensity	Includes areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 20-49% of total cover. These areas most commonly include single-family housing units.	4.139	2.30%
Developed, Moderate Intensity	Includes areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 50-79% of the total cover. These areas most commonly include single-family housing units	1.634	0.91%
Developed, High Intensity	Includes highly developed areas where people reside or work in high numbers. Examples include apartment complexes, row houses and commercial/industrial. Impervious surfaces account for 80-100% of the total cover.	0.250	0.14%
Barren Land	Areas characterized by bare rock, gravel, sand, silt, clay, or other earthen material, with little or no "green" vegetation present regardless of its inherent ability to support life. Vegetation, if present, is more widely spaced and scrubby than that in the "green" vegetated categories; lichen cover may be extensive.	0.512	0.28%
Deciduous Forest	Areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. More than 75% of the tree species shed foliage simultaneously in response to seasonal change.	133.362	74.09%
Evergreen Forest	Areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. More than 75% of the tree species maintain their leaves all year. Canopy is never without green foliage.	1.569	0.87%
Mixed Forest	Areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. Neither deciduous nor evergreen species are greater than 75% of total tree cover.	2.190	1.22%
Scrub/Shrub	Areas dominated by shrubs; less than 5 meters tall with shrub canopy typically greater than 20% of total vegetation. This class includes true shrubs, young trees in an early successional stage or trees stunted from environmental conditions.	4.278	2.38%

Table 2.3. Land use type in the Triplett Creek Watershed (continued).

Grassland/Herbaceous	Areas dominated by grasses or herbaceous vegetation, generally greater than 80% of total vegetation. These areas are not subject to intensive management such as tilling, but can be utilized for grazing.	5.277	2.93%
Pasture/Hay	Areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing of the production of seed or hay crops, typically on a perennial cycle. Pasture/hay vegetation accounts for greater than 20% of total vegetation.	24.316	13.51%
Cultivated Crops	Areas used for the production of annual crops, such as corn, soybeans, vegetables, tobacco, and cotton, and also perennial woody crops such as orchards and vineyards. Crop vegetation accounts for greater than 20% of total vegetation. This class also includes all land being actively tilled.	1.284	0.71%
Woody Wetlands	Areas where forest or shrubland vegetation accounts for greater than 20% of vegetative cover and the soil or substrate is periodically saturated with or covered with water.	0.059	0.03%
Emergent Herbaceous Wetlands	Areas where perennial herbaceous vegetation accounts for greater than 80% of vegetative cover and the soil or substrate is periodically saturated with or covered with water.	0.001	0.00%

Our watershed remains mostly forested (~74%), primarily because of land ownership by the United States Forest Service (USFS). The USFS land cover is illustrated in Figure 2.12 (page 36). The USFS property is focused in the upper reaches of the Triplett Creek Watershed. Very little of the land is adjacent to the main stem of Triplett Creek. The largest intact forest area is in the Big Perry area. This area is part of the Daniel Boone National Forest Service and is largely found on hill slopes in the central portion of the watershed. Within the Triplett Creek Watershed, the USFS has 3.5% of commercial and 5.5% non-commercial logging scheduled.

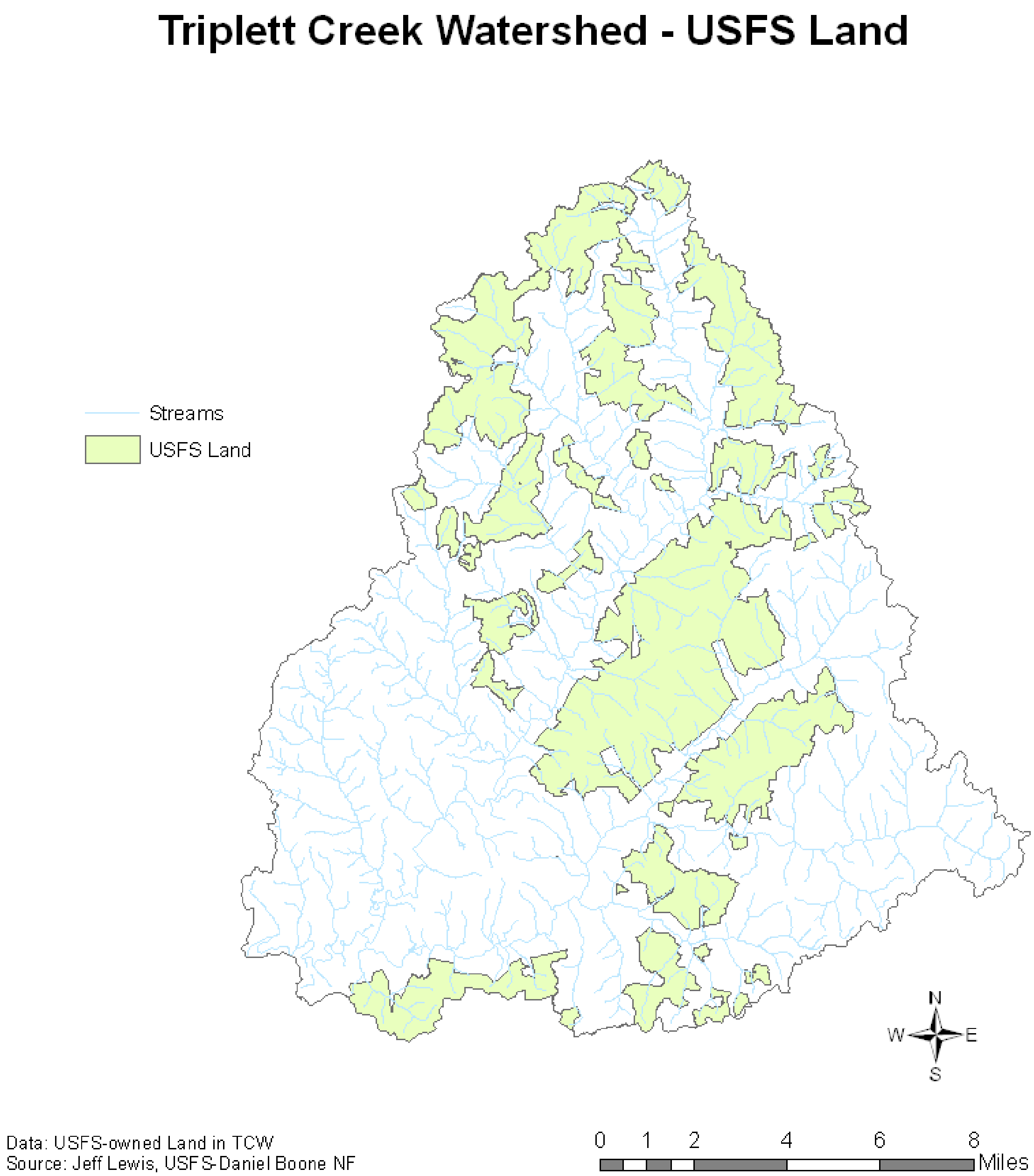

Figure 2.12. Map showing US Forest Service stands in the Triplett Creek Watershed. See appendix E for enlarged map.

On-site Waste Water Systems (Household Septic Systems)

Triplett Creek

The densely populated stream terraces of Triplett Creek are parallel to U.S. Highway 60 East. Tributaries of Triplett Creek include Big Perry, Little Perry, Hays Branch, Buffalo Branch and Open Fork Creek. These tributaries are moderately populated. The Rowan County Health Department estimates that 90% of these residences do not have permitted wastewater treatment systems. The method of sewage disposal employed by these residences quite frequently consists of a small catchment container and a short amount of leach line. The dominant soil series of this area is Clifty. "Clifty soil characteristics include rapid permeability in the substratum which could create a potential pollution hazard when this soil is used for sewage disposal due to the lack of retention time" (NRCS, 1974). The USDA rating for septic system function in this series is severe because of inadequate treatment and flooding.

The soil series of the side slopes of the Triplett Creek Watershed are Cranston and Latham. USDA rating for septic system function is slight to moderate in Cranston series; Latham is rated severe. The dense population, inadequate sewage treatment and close proximity of residences to the creek are reflected in the water quality of Triplett Creek.

North Fork of Triplett Creek

The North Fork of Triplett Creek is parallel to Cranston Road. Little Brushy (Big Woods), Big Brushy, and Rock Fork are the major tributaries of the North Fork of Triplett Creek. The Rowan County Health Department considers these areas as densely to moderately populated. Several smaller tributaries are moderately populated. The soil series of this area are Tilsit and Latham. Both series have restrictive horizons as limiting factors. The Health Department estimates that approximately 50% of the septic systems of this area are not permitted systems. The permitted septic systems serving this area are modified systems (shallow installation with additional soil cover). System repair in this area is limited due to inadequate drainfield area.

Permitted Point Sources

Point sources pollution can be associated with a specification, identifiable location, such as a pipe. A common example of a point source discharge would be a wasterwater treatment plant. In most cases, point sources are required to operate under a Kentucky Pollutant Discharge Elimination System (KPDES) permit issued by the Kentucky Division of Water. Examples of point source discharges include industrial discharges, wastewater treatment plants, and certain livestock facilities. KDOW maintains records on permits and related water quality monitoring, which can be obtained through FOIA. Information can also be obtained from the EPA's online Envirofacts Data Warehouse (www.epa.gov/enviro/html/em/index.html), a website used by KDOW to provide permit information. It is updated often and available for public use.

The Triplett Creek Watershed has 20 permitted discharge sites, based on visual observation and an internet search at the US EPA EnviroMapper for water. Most of the sites were permitted for construction projects. Construction sites often lack the proper installation of pollution runoff control for sediment. In 2010, according to the information on EnviroMapper, two of the sites showed that formal enforcement was taken.

Wetlands and In-stream Construction or Disturbance

Section 404 of the Clean Water Act regulates the discharges of dredged or fill materials into the waters of the United States, including small stream and wetlands adjacent or connected to regulated waters. Activities that result in physical disturbances to wetlands or streams are regulated by the US Army Corps of Engineers (USACE) under Clean Water Act Section 404 and require a 404 permit. Permits are required for the discharge of dredged or fill materials into navigable waters. Additionally, the Kentucky Division of Water requires 401 Water Quality Certifications under Clean Water Act Section 401, and a floodplains permit. Examples of projects are bridge and pipeline construction across a waterways and the filling of a wetland. As part of the permit application a public notice and opportunity for public input are required. The size and impact of the project will determine the type of mitigation that will be required.

Rowan County must also issue a permit for construction in or over a waterway. Before any permit of this type can be issued, the intent of the permit with the location must be advertised in the local paper. A request from the USACE for records of 404 permits for Rowan County for the years 2005 through 2010 yielded 56 permits. Of these permits 52 of them were in the Triplett Creek Watershed. One of the permits was for a vernal pond construction.

These regulations were developed to prevent pollutants such as sediment from entering waterways during construction and mining practices. In addition, the disturbances to wetlands (which act as sponges absorbing pollutants) have negatively impacted water quality and increased the severity of flooding.

Demographics and Social Issues

According to the 2010 US Census, the total population of the Triplett Creek Watershed (not the entire County) is 20,464 persons. The population density is 91.1 persons per square mile. There are a total of 8,631 housing units. Most of these are owner occupied (59%). Renter occupied units are 28%.

A majority of the population is between the ages of 15 and 24 (23%). The other age groups range from 2% to 6%. Black is the largest minority ethnic group in the watershed (729 person), followed by Hispanics (462 person). The household median disposable income is $29,235.

The estimated population over the age of sixteen and in the labor force is 11,325. Eleven percent is unemployed. Most of the employed population works in education services (24%) followed by Health Care Assistance (16%) and Retail trade (14%). Twenty-nine percent of the population over 25 years of age has attained a minimum of a high school degree. Seventeen percent has some college. Seven percent have an Associate Degree. Fourteen percent have a Bachelor's Degree, and 15% have a Graduate or Professional Degree.

Most housing in the watershed consists of single family units (240, or 58%). Mobile homes were the second most common housing type with 157 units (38%). Housing units are mostly rural (69%), with farms comprising only 13 of the 415 units. Rental units make up about 25% of the housing inventory.

EXISTING WATER QUALITY DATA

This section summarizes data that has been collected prior to the Triplett Creek Watershed Based Plan sampling and development. Data discussed includes (but is not limited to) Dry Creek Watershed based Plan, Licking River Watershed Watch, and MSU research data.

Bacteria

Certain bacteria, such as *Escherichia coli*, are normal inhabitants of the gastrointestinal tract of mammals and birds. Therefore, *E. coli* can be used as an indicator of fecal contamination of the watershed. Currently, there are bacterial data for ten locations along the Dry Creek watershed collected prior to the start of this watershed project. These data were used to establish a baseline database, to refine the identification of sampling sites, and to help determine the sources of fecal contamination. Nine of the samples sites were collected by faculty and students from MSU. The tenth location is sampled by a volunteer from the Licking River Watershed Watch (2010). The Licking River Watershed Watch (LRWW) bacteria samples, which are collected by volunteers following the LRWW protocol, indicated that the waterways bacteria levels were within acceptable limits for bacteria. More than likely this is the result of limited sampling and samples not immediately collected after a rainfall.

All bacterial counts, collected by MSU, varied over the range of the sampling sites and over time during the fall evaluation period (24 October to 14 November 2007). The *E. coli* count for the sampling sites tested ranged from 0 to 2,260 colonies per 100 mL. The highest counts were observed following a significant rain event on 23-24 October 2007, where seven of eight sites sampled exceeded Kentucky Criterias of 130 colonies per 100 mL for *E. coli* bacteria. Only one site, Nichol's Bridge, exhibited a geometric mean (312 colonies per 100 mL for all five sampling dates) that exceeded the Kentucky Criteria for primary recreational contact of 130 *E. coli* colonies per 100 mL. Fecal coliform (FC) to fecal streptococci (FS) ratios indicate that the possible sources of fecal contamination are animal (Fecal Coliform:Fecal Strep < 0.7) or a mix of animal and human (FC:FS = 0.7 – 4.0).

Spring data were collected between 31 March and 21 April 2008. The bacteria counts were lower than in the fall sampling. The *E. coli* count for the sampling sites tested ranged from 0 to 320 colonies per 100 mL. The sample site at Lambert Hollow was consistently higher than any other sampling location, ranging from 40 to 320 colonies per 100 mL. The *E. coli* counts on two sampling dates at Lambert Hollow exceeded the Kentucky criteria for primary recreational contact of 130 colonies per 100 mL.

Physicochemical

Morehead State University and the LRWW have been actively sampling for many years in the Triplett Creek Watershed. With consideration given to the rapid changes in land use and development in the past ten years, only the most recent data from the Dry Creek Watershed Based Plan and the last two years of LRWW data will be discussed. A detailed explanation of the parameters can be found in Section 3.

Poor habitat quality is the number one impact on temperature and dissolved oxygen (DO). Although there are many parameters that can impact DO, only temperature showed a negative relationship to DO levels in the Dry Creek Watershed. Temperature increases are likely the result of tree removal. Water samples collected downstream in the Dry Creek Watershed had increased temperatures. The amount of tree cover also decreases at the sampling locations downstream. High water temperature may also be caused by runoff from pavement since roads exist along most of Dry Creek and along major tributaries. In addition to temperature, low water velocity (more evaporation and decreased groundwater supply) also contributed to excessive DO loss, again due to habitat destruction.

Low DO is also associated with nutrient enrichment. The sampling sites in the Dry Creek Watershed that had the lowest DO also had higher nutrient concentrations. However, water temperature appears to be increasing as water moves downstream. In addition to impacting DO, temperature also affects conductivity: the warmer the water, the higher the conductivity. Instruments used to measure these parameters, the YSI and Hydolab, auto correct for DO and Conductivity. However, it is still correct to say that DO impacts conductivity. According to the LRWW 2008 data analysis completed by Dr. Rebecca Kelley, at Northern Kentucky University, both North Fork of Triplett Creek and Christy Creek had DO readings below 5.0 mg/L in the month of October.

The conductivity was also slightly elevated in Dry Creek. Conductivity is measured to assist with determining pollution sources. Higher conductivity measurements indicate higher levels of dissolved minerals, charged particles, and sediment. Certain physiological effects on plants and animals are often affected by the amount of ions in the water. A rise in the conductivity could indicate that a septic system is failing because of the presence of chloride, phosphate, and nitrate. Conductivity readings report by LRWW volunteer sampler at Dry Creek often reported slightly elevated conductivity readings (around 360). In addition, the North Fork of Triplett located in the upper reaches of the watershed had an October 2008 reported conductivity reading of 710.

Nutrients

The nutrient data discussed below is from the initial nutrient data collected in 1998 and 1999. These data were collected for the Gateway Health Department to assist with applications to get sewer infrastructure installed. Since then, only a few water samples have been collected for nutrient analysis. The most recent samples were collected in 2006, as part of a larger watershed sampling of the Triplett Creek Watershed. The limited numbers of samples provide some insight, although not conclusive, into some possible sources of pollutants. Data from the Dry Creek WBP sampling is the only data collected within the watershed that follows the same procedures being used in the Triplett Creek WBP.

Ammonia is the only nutrient investigated in this study with a numeric value for statutory Water Quality Criteria (WQC). The other nutrient parameters are based on reference reach data, which is an informal comparison. Of the 14 ammonia data points, five exceed the WQC of 0.05 mg/L. Sampling Point DC-1.89 had the most elevated and varied levels of ammonia, ranging from 0.002 to 2.062 mg/L. The reference reach data reported 0.05 mg/L at all sites. DC-1.89 is also located in an area that has had numerous unofficial complaints about sewer smells. Unofficial complaints are when residents complain to neighbors and others, but they do not contact representatives of organizations that are able to enforce the issue they are complaining about. All the sites with ammonia data had at least one sample that exceeded 0.05 mg/L. Conductivity is often associated with elevated bacteria, phosphate, and nitrate; however, no meaningful correlations were found between any of the nutrients and conductivity.

There does appear to be a strong correlation between the presence of sewer infrastructure and nutrients. The concentrations of dissolved phosphorus (P), total phosphorus (TP) and various forms of nitrogen decrease between Sampling Points DC-1.89 (Ravenswood Bridge) and DC-0.28 (Tile Storage Road Bridge). There appears to be some influence from Morgan Fork based on results from DC-0.28 but we cannot determine the impact of this tributary with our current data set. New data are being collected at Morgan Fork, DC-0.28, and DC-2.84 as part of the Triplett Creek 319(h) grant.

Habitat Assessment

Existing habitat assessment data within the watershed is limited to the Dry Creek Watershed and a few LRWW sites. The Habitat Assessments forms (located in appendix B) utilize a visual assessment of in-stream and riparian habitat quality including substrate, channel morphology, bank structure, and riparian vegetation. In the Dry Creek Watershed, the lowest average scores were assigned to riparian vegetation zones. In order to obtain a high score the vegetation cover would have to be 18 meters or more. The maximum score per bank is 10. The average vegetation zone scores for the assessment were 2 (left bank) and 3 (right bank). The lack of vegetation cover is a large contributor of bank erosion. Vegetative protection and velocity/depth regimes each had an average score of 4 out of 20. These scores are similar to previous assessment conducted prior to the Dry Creek Watershed study. Kentucky was in a drought at that time, which resulted in quite low habitat scores due to the lack of water in the streams. Values for vegetative protection and bank stability were consistently low.

LRWW volunteers reported habitat assessment data for Triplett Creek (upper reaches), Christy Creek (near mouth), and Dry Creek (near mouth). The maximum score is 200 and 130 is the minimum score that qualifies as supporting habitat. The higher the number the better the habitat assessment score. The habitat values reported were 154, 139, and 127, respectively.

Benthic Macroinvertebrates (Aquatic Insects)
Macroinvertebrates are primarily immature aquatic insects, crustaceans (crayfish), and other invertebrates that are visible without the use of magnification. Most live on the substrate of the waterway. Many of these organisms only live their teenage years (nymph stage) in the water. An example of an aquatic insect is a dragon fly. They are important food sources for fish and many are shredder (which means they break down organic materials such as leaves). Sediment deposits cover their habitat.

There is a limited amount of macroinvertebrate data available for the Triplett Creek Watershed. A study conducted by Rios and Bailey (2006) emphasize the importance of maintaining riparian zones. These zones are the most important factor in maintaining in-stream community structure. Therefore utilizing habitat data would be helpful in future studies to predict macroinvertebrate health.

The moderate indicator group consists of organisms that can exist in a wide range of water quality conditions. The poor water quality indicator group includes organisms that are generally tolerant of the effects of pollution, such as low dissolved oxygen and excessive sedimentation. The absence of certain macroinvertebrates does not provide information on the source of the pollution, but they are able to provide us with some insight to the extent pollutants are impacting streams. LRWW sampler reported macroinvertebrate data for four sites in June 2008. All four sites were rated as fair.

The United States Forest Service conducted a macroinvertebrate analysis near the mouth of Dry Creek on June 11, 1999. According to the results provided by Jon Walker, Hydrologist for the Daniel Boone National Forest, the macroinvertebrate rating was fair. Additionally, a score was provided using a biotic index rating. The biotic index is a rating of water quality based on organisms (such as insects) living in the streams. Scores for biotic index can range from 0 to 100. The higher the biotic index score the better the rating. The Macroinvertebrate Biotic Index rating for the mouth of Dry Creek was 57.96. More details of this study can be obtained from the USFS Daniel National Forest, Winchester Office.

Ichthyofaunal (fish)

Fish are valuable assessment tools for evaluating the health of streams and watersheds because of their long life spans (2-10 years) and reliance on water for habitat. As a result they can reflect both long-term and short-term water quality. In addition, fish are a visible and valuable component of waterways that the public can easily relate too.

The most recent ichthyofaunal study in the Triplett Creek Watershed occurred from May 1999 – January 2000 (McCafferty & Eisenhour, 2001). The assemblage of species found in Triplett Creek has not dramatically changed during the 1999 – 2000 sampling. However, there has been a loss of the more pollution sensitive species. Three fish species have been extirpated and three new species were recorded. Triplett Creek had higher species richness (83 species) than found in neighboring tributaries of the Licking River. According to Dr. David Eisenhour, the other tributaries have not been sampled as well as Triplett Creek, but the typical species richness is about 30-50 (personal conversation, May 22, 2013).

Geomorphic

MSU geologists are focused on efforts that primarily involve measuring stream flow in Triplett Creek, measuring turbidity of water (suspended sediment concentrations), and measuring bank erosion rates. These methods are detailed in the Quality Assurance Project Plan (QAPP) (Appendix B). Results of the geomorphic portion of the watershed inventory are preliminary, and data gaps, especially at moderate to high flow, still exist. Efforts to monitor bank instability include visual assessment and GPS location of actively eroding banks, bank pinning, and measurement of channel cross-sections. Description of the monitoring methods is outlined in the QAPP. So far, nearly 60 sites experiencing erosion or some form of mass wasting (for example, small slumps or landslides) have been identified along Dry Creek and Sugar Branch alone. Results and summaries of attempts to fill data gaps are discussed in Chapter 3 of this WBP.

Bank pinning and cross-section measurements are in their earliest stages. These methods measure the amount of bank material lost to erosion and mass wasting. Monitoring has begun on two sites, one in colluvium (landslide deposits) near the confluence of Sugar Branch and Dry Creek (3.03 stream miles from the mouth of Dry Creek) and another in alluvium (sediment deposited by streams during floods) at the Tile Storage Road Bridge (0.28 stream miles from the mouth of Dry Creek). Scouting for other easily accessible locations is ongoing. Results of these efforts and summaries of our attempts to fill data gaps will be discussed in Chapter 3 of this WBP.

DATA COLLECTION PLAN

The Triplett Creek Watershed Planning Team followed the data collection guidelines outlined in *Quality Assurance Project Plan for the "Triplett Creek Watershed Based Plan" NPS Project 08-07*. This QAPP, outlines all procedures for collecting and analyzing data for the Dry Creek monitoring plan, and was approved by the Kentucky Division of Water in June 2009 and is included as appendix B. The plan was modified and approved in December 2009. The modification was made to change sediment sampling methods that were better suited for sampling with in the Triplett Creek Watershed.

Pollutants that will be monitored as part of this project include pathogens, nutrients, organic enrichments/low dissolved oxygen (DO), total suspended solids (TSS) and suspended sediment concentration (SSC). Monitoring sites were selected to fill data gaps identified to date and to provide the aerial coverage required to meet the underlying premise of the experimental design. Water samples were collected at each site on the first Tuesday of every month from July 2009 to July 2010, except when weather and/or flow conditions are unsafe. These water samples were taken back to the labs for pathogens, nutrients, and TSS analysis. The pH, dissolved oxygen, temperature, and conductivity were collected at each site when water samples are collected. Additional sampling for nutrients and pathogens were conducted on July, October, and May (again depending on safety) in order to allow calculation of geometric means.

SUMMARY AND CONCLUSIONS

A number of problems negatively impact water quality within the Triplett Creek watershed. The lack of sewer infrastructure is probably of greatest concern because of the detrimental impact on humans who live throughout the watershed and improperly maintained septic systems impact the amount of bacteria in the water.

Less known pollutants such as nutrient and sediment have not been a concern for many citizens in the past. Recent floods have increased citizens' awareness of sediment and associated gravel. Although sediment is recognized as a problem, there is a lack of understanding as to why it is a pollutant, the source of the sediment, and how to prevent the source. The fact that the county has constructed gabion walls and that residents have armored stream banks with concrete debris, tires, etc. is vivid testament that bank instability is a serious issue. It is also a likely source for much of the sediment seen in Triplett Creek and its tributaries after storms.

Some residents notice times when excessive algae clogs streams, but most do not realize that nutrient pollution is the primary cause of this condition. Like sediment there appears to be a disconnect between development and land use practices and its impact on the water quantity and quality. Most of the residents look upstream to find reason to blame for increased flooding and poor water quality with little or no thought given to their individual land user impacts or how downstream land uses impact them as well. Education is discussed in the implementation section 4 and 5 of this report.

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Triplett Creek Analysis of Impairments
Section 3

INTRODUCTION

The Watershed Inventory Section described natural conditions, existing impairments, land use and infrastructure in the Triplett Creek Watershed. This section will present new data collected specifically for this study to identify pollutants, portions of the watershed most affected by these pollutants, and possible sources and causes of impairments. The data analysis and model results presented here will guide proposed best management practices (BMP's) and help set target values consistent with the goals of the watershed plan. Results presented below also define baseline (pre-BMP implementation) conditions in the watershed. After BMPs are implemented and funding permits, additional field data will be collected and compared to these baseline data in order to assess BMP effectiveness and to determine whether target values are met.

Understanding Water Quality Data

In order to identify impaired waters in the Triplett Creek Watershed, results from data collected in 2009-2011 must be compared to established water quality criteria (WQC) and established benchmarks. For pollutants or physical parameters with statutory, numerical WQC, this is a simple task. Identifying impairments caused by parameters with only narrative (descriptive, non-numerical) WQC is far more difficult. For some pollutants (for example *E. coli*) an enforceable, statutory WQC already exists.

If the amount of pollutant in a sample exceeds the WQC, something in the watershed upstream of the sampling site is causing the impairment and some action must be taken to correct the problem. Comparing data to the WQC can be as simple as constructing a bar graph with a line drawn at the WQC. Sites exceeding the WQC will have bars higher than the line. For other pollutants, the KDOW has not yet established WCQs. In these cases, we are forced to compare data to other criteria. One approach is to compare data for each potential pollutant to a WQC set by another community or state with similar climate, topography, geology and land use. Another approach is to compare the data to reference reach waters, which are examples of the least-impacted streams in the region. Even though they may not be pristine, reference reach streams serve as physical, chemical and biological benchmarks of the least-disturbed conditions attainable in the region. New data collected for this project and discussed later in this chapter are compared to WQC and reference reach data. Target values from reference reach data are based on values provided by the KDOW. The target values provide a way to prioritize streams for water quality improvements. The target value may actually be lower than the target value to restore the waterway to its designated uses.

Concentrations, Loads and Yields

Samples represent far more than the amount of pollutant in the small volume of water collected. The sample is assumed or designed to represent all water flowing past the monitoring site at the time of sampling. Since the water originally flowed over and under the ground to reach the stream, the sample also reflects conditions in the watershed (land area) above the site. Expressions of the amount of contamination in stream water must reflect this reality. The terms explained below convey this information and will be used to compare our data to WQC and other criteria.

Concentration is the amount of a pollutant in a given amount of water, for example pounds per gallon (lbs/gal) or milligrams per liter (mg/L). If a large amount of pollutant is contained in a small amount of water, concentration is high. If the amount of pollutant is decreased in the same volume of water or if more clean water is added, the concentration decreases (i.e., the concentration is diluted).

The pollutant load of a stream is the weight (or mass) of a pollutant that moves through the stream over some period of time. Example units are pounds per year (lbs/yr) or kilograms per day (kg/d). To calculate load, the concentration determined from water samples is multiplied by discharge, which is a measurement of the amount of water passing one place in the channel in a period of time (e.g., cubic feet/second). An example of the use of loads is the establishment of TMDLs by the KDOW. A TMDL is an enforceable limit and represents the amount of a pollutant that a water body can receive and still meet established water quality criteria for designated uses. TMDLs also allocate the load among the various sources (e.g., industries, public utilities, etc.) that release the pollutant into the water body.

The yield of a particular pollutant is the load produced, on average, by each acre of land above the sampling point over a period of time. In other words, yield is the pollutant load divided by the area of the sub-basin upstream of a sampling site. Typical units are pounds per year per acre (lbs/yr/ac) or tons per year per square mile (tons/yr/mi^2). For example, a suspended sediment yield of 100 lbs/yr/ac means that, on average, every acre above the sampling point contributes 100 lbs/yr to the load. If in the course of comparisons, we find that two apparently similar sub-basins have very different yields, we might look more closely at their land use in order to identify a possible cause for the discrepancy.

NEW DATA COLLECTED

Section 2 summarized the understanding of conditions in the Triplett Creek Watershed at the start of our efforts to develop this watershed based plan and also identified information gaps that could only be filled by collecting new data. This section contains a summary of the types of new data collected, where samples were taken, how measurements were made, and how this work was conducted.

The various types of new data collected, the procedures/equipment used to acquire these data and the targets based on WQC or benchmark data are summarized in Table 3.1 (page 50). For those who are interested, detailed descriptions of the methods used to collect and analyze these data are outlined in the QAPP approved by the Kentucky Division of Water on June 2009. The QAPP, entitled *Quality Assurance Project Plan for the "Triplett Creek Watershed Based Plan" NPS Project 08-07* outlines all procedures for collecting and analyzing data for the Triplett Creek monitoring plan and is included as appendix B. Collection sites are listed in Table 3.2 (page 51) and shown in Figure 3.1 (page 52).

Table 3.1. Type of data collected, procedures/equipment used, and target values for each parameter.

Parameter	**Procedure / Equipment**	**Target Value**	
		WQC	**Benchmark data**
Temperature	MS5 Datasonde and YSI 556	Not to exceed temperature guidelines, see section on temp.	NA
Dissolved oxygen	MS5 Datasonde and YSI 556	Min. 5.0 mg/L 24-hour avg., never below 4.0 mg/L	NA
pH	MS5 Datasonde and YSI 556	6 to 9 with less thana 1.0 change over 24-hrs	NA
Alkalinity	ASTM class A buret	NA	31.8 to 76.0 mg/L
Ammonia-N	SEALTM AQ2	0.05 mg/L	NA
Escherichia coli	Membrane filtration	Monthly geometric range of less than 130 cfu/100 mL or 240 cfu/100 mL in no more than 20% of samples	NA
Conductivity	MS5 Datasonde and YSI 556	NA	218 µs/cm max.
Total Kjeldahl nitrogen **(**TKN)	US EPA 351.2, Ver 2 (1993)/FOSS Tecator™ Digestor and SEALTM AQ2	NA	0.500 mg/L
Nitrite	EPA 353.2/SEALTM AQ2	NA	NA
Nitrate	SEALTM AQ2	NA	0.400 mg/L
Nitrogen, Total	SEALTM AQ2	NA	0.650 mg/L
Phosphorus, Total	US EPA 365.1/Manual persulfate digestion and SEALTM AQ2	NA	0.020 mg/L
Phosphorus, dissolved	EPA 365.1/SEALTM AQ2	NA	NA
Sulfate	US EPA method 375.4/DR 2800™ Portable Spectrophotometer	NA	13.8 mg/L
Habitat assessment	Habitat assessment form	NA	NA
Discharge (flow)	USGS Pygmy or AA flowmeter	NA	NA
Suspended sediment conc.(SSC)	Denver analytical balance, Gooch crucibles, 934-AH filters, vacuum, drying oven	NA	NA
Total suspended solids (TSS)	Denver analytical balance, filters, vacuum	NA	6.5 mg/L for April – Oct normal flow

Table 3.2.Triplett Creek Watershed Based Plan monitoring sites.

Site ID	Stream Name and Stream Miles from Mouth to Site	Latitude (NAD 83)	Longitude (NAD 83)	Measured Parameter
BB-0.23	Big Brushy Creek at 0.23 mi	38.211627	-83.470041	PNSQGT
BUB-0.03	Buffalo Branch at 0.03 mi	38.242186	-83.342212	PNQT
CB-0.38	Copperas Branch at 0.38 mi	38.216456	-83.489704	PNQT
CC-0.37	Christy Creek at 0.53 mi	38.19017	-83.40322	PNQT
CC-2.00	Christy Creek at 2.00 mi	38.190384	-83.378378	PNSQGT
CC-4.33	Christy Creek at 4.33 mi	38.183907	-83.341799	PNSQGT
CC-8.11	Christy Creek at 8.11 mi	38.183877	-83.280444	PNSQGT
CF-0.11	Clear Fork at 0.11 mi	38.26386	-83.434293	PNSQGT
DC-0.27	Dry Creek at 0.27 mi	38.164183	-83.434043	PNSQGT
DC-2.84	Dry Creek at 2.84 mi	38.154425	83.394536	PNSQGT
EB-0.04	Evans Branch at 0.04 mi	38.185747	-83.428853	PNQT
HB-1.36	Hays Branch at 1.36 mi	38.258768	-83.333012	PNQT
HF-0.09	Holly Fork at 0.09 mi	38.292404	-83.389398	PNSQGT
HUB-0.19	Hungry Branch at 0.19 mi	38.148103	-83.522905	PNQT
IF-0.05	Island Fork at 0.05 mi	38.315065	-83.442411	PNQT
MB-0.23	Martin Branch at 0.23 mi	38.198841	-83.410575	PNQT
MF-0.23	Morgan Fork at 0.23 mi	38.160928	-83.427004	PNSQGT
NF-1.61	North Fork Triplett Cr. at 1.61 mi	38.163606	-83.511938	PNSQT
NF-9.77	North Fork Triplett Cr. at 9.77 mi	38.24646	-83.437412	PNSQGT
NF-14.52	North Fork Triplett Cr. at 14.52 mi	38.293967	-83.390854	PNSQGT
OH-0.11	Old House Creek at 0.11 mi	38.182815	-83.341646	PNQT
PAL-0.02	Patty's Lick Branch at 0.02 mi	38.186315	-83.353189	PNQT
PB-0.42	Perry Branch at 0.42 mi	38.236751	-83.376758	PNSQT
PL-0.10	Pond Lick Branch at 0.10 mi	38.240915	-83.447308	PNQT
RF-0.15	Rock Fork at 0.15 mi	38.280315	-83.413318	PNSQT
SB-0.02	Seas Branch at 0.02 mi	38.186679	-83.3298	PNQT
TC-0.74	Triplett Creek at 0.74 mi	38.148593	-83.547471	PNQT
TC-2.27	Triplett Creek at 2.27 mi	38.14639	-83.51128	PNSQT
TC-12.27	Triplett Creek at 12.27 mi	38.166995	-83.436211	PNQT
TC-13.52	Triplett Creek at 13.52 mi	38.183197	-83.429999	PNSQT
TC-14.50	Triplett Creek at 14.50 mi	38.191578	-83.416008	PNSQGT
TC-14.99	Triplett Creek at 14.99 mi	38.19623	-83.40859	PNQT
TC-19.91	Triplett Creek at 19.91 mi	38.241561	-83.350386	PNSQT
TC-21.80	Triplett Creek at 21.80 mi	38.247317	-83.319777	PNQT
Measured parameters: P=Pathogens, N=Nutrients, S=SSC, Q=Discharge, G=Gage Height, T=TSS. Sites for monitoring of bank/channel instability will be selected after geomorphic reconnaissance. Other sites may be selected as the project proceeds. KDOW will be notified in such cases.				

Triplett Creek Watershed Sample Sites

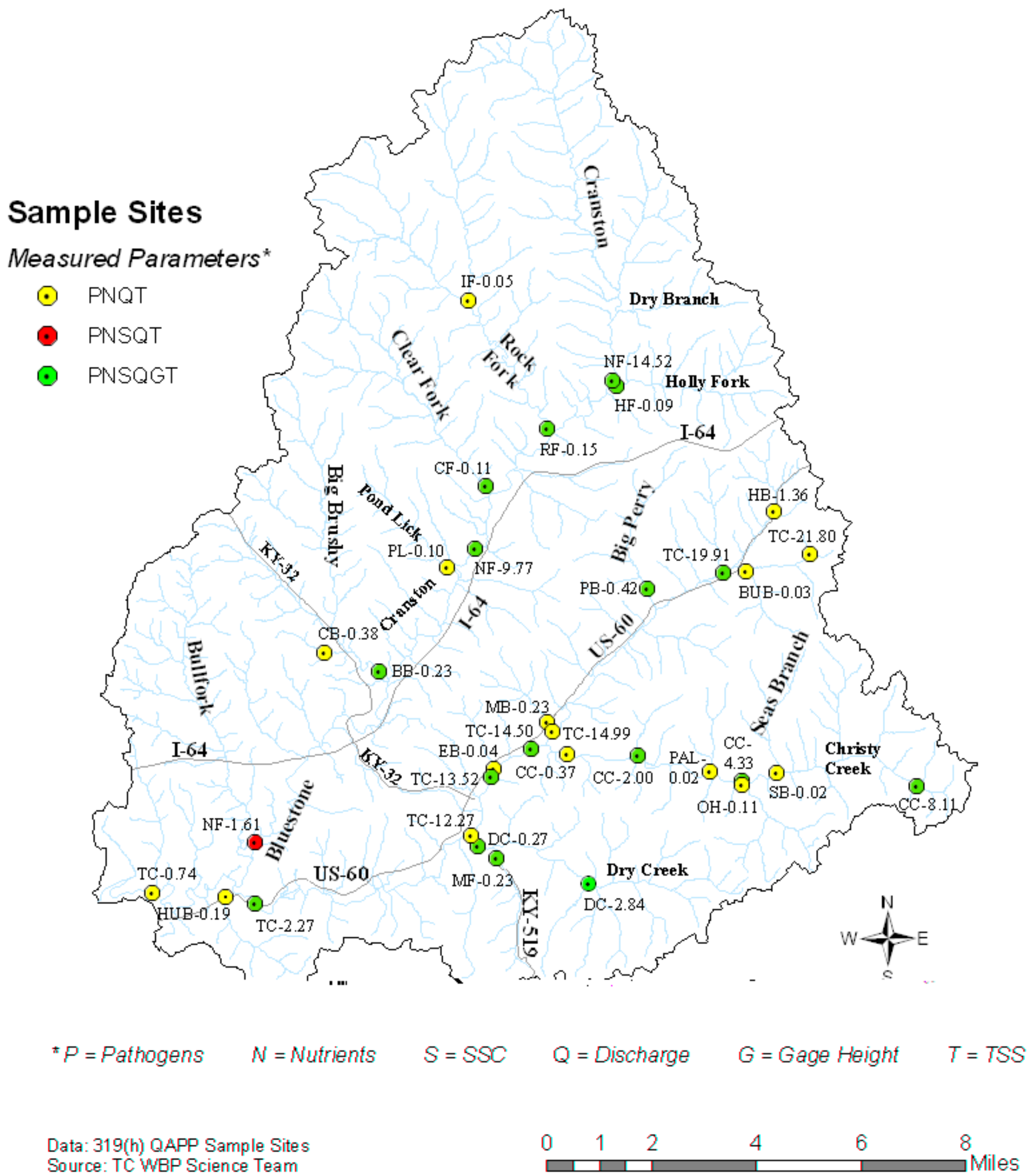

Figure 3.1. Monitoring sites where new samples and measurements were collected for this project. An enlarged map can be found in appendix E.

Subwatershed

The size of the Triplett Creek Watershed is rather large. For that reason, the results of each parameter are organized into subwatersheds. A subwatershed is a smaller watershed inside a larger watershed. For example the Christy Creek Watershed is part of the Triplett Creek Watershed, which is part of the Licking River Watershed, which is part of the Ohio River Watershed, which is part of the Mississippi Watershed. Sites were purposely selected to capture smaller subwatershed. These sites where selected near the mouth, but far enough upstream to reduce sampling water that might flow upstream from a larger waterway. Other considerations were upstream and downstream sites and accessibility. Each one of the sampling sites are named based on the name of the creek it is located. For example, sample sites on Christy Creek begin with a CC. The numbers that follow the two letter abbreviate of the waterway is the miles upstream from the mouth of the waterway. For example, 0.23 locates the site at 0.23 miles upstream from where the waterway ends (the mouth).

Appendix E contains figures showing sample sites located within each subwatershed. A subwatershed map can also be found in Modeling Prediction in this section. Figure 3.61 on page 171 shows all of the subwatersheds pieced together.

QA/QC of data

Excel worksheets summarizing the QA/QC data can be found in appendix D. Only the data the met QA/QC is included in the worksheets. Blank cells in the worksheets represent no data is available or that the data did not pass QA/QC. Data that did not pass QA/QC was left out of the spreadsheets because the spreadsheets were used to develop graphs and tables for the WBP. Examples of why samples did not pass QA/QC are 1) samples were not labeled properly; 2) samples were not refrigerated at the proper temperatures, or 3) the standards were mixed incorrectly.

Water samples were not collected if flow was not present. If no flow was present no data was entered for that sample site during the sampling event. No flow was noted on the C.O.C forms. Discharge data may also be missing if 1) the flow was to swift too measure, 2) the stream was covered with ice, 3) measurements were determined to be incorrect or 4) the flow was too low to measure. Reasons for incorrect numbers are the wrong units were used or the calculated discharge was not reasonable based on the discharge calculated at other sites. All field sheets and laboratory notebooks are kept by the respective researcher. Notes on the data are kept in the laboratory notebooks.

Flow and Precipitation

This weather data (temperature, rainfall and snow) comes from the United States Government's National Oceanic and Atmospheric Administration (NOAA), specifically, the National Climatic Data Center (NCDC) and the National Weather Service (NWS). The data was retrieved from weathersource.com. Data compiled from these government sources is widely regarded as reliable and authoritative and used in our industry as standard and acceptable to rely on. The data is quality controlled by both NCDC and Weather Source. The flow is indicated for each sampling event as being flooded (over banks, bank full, high flow, normal, low, and ponded. The sampler makes the judgment call for each sampling sites. Table 3.3 (page 55) is a representation of all the sampling sites in the Triplett Creek Watershed. The precipitation is represented in the table if there was a rain or snow event 48 hours prior to the sampling. The data is not included for zero rain or snow prior to sampling. The number of sampling sites makes it difficult to include data from every sampling site. The recorded flow rate for each individual site can be found by examining the C.O.C. forms, which are maintained by the Center for Environmental Education. Note that there was a severe flood event on May 2, 2010. We had planned on sampling May 3, 2010, but we were not able to access sampling sites because of road closure.

Table 3.3. Summary of precipitation and flow rates during sampling events.

Sampling Date	Precipitation				Flow
	Day of	24 hr prior	72 hr prior	1 wk prior	
7/7/2009	0	0.01	1.8	1.83	normal
7/14/2009	0	0	0.68	1.43	normal to low
7/21/2009	0	0	0.02	0.31	normal to ponded
7/27/2009	0.06	0.27	0.29	1.01	normal to ponded
8/6/2009	0.01	0.43	1.71	4.37	high
9/1/2009	0	0	0.01	0.02	normal to ponded
10/4/2009	0.02	0	0.01	0.15	normal to ponded
10/14/2009	0.42	0	0.01	1.4	normal to low
10/16/2009	0.03	0	0.59	1.62	normal
11/5/2009	0.01	0	0	1.07	normal
12/1/2009	0.02	0.49	0.51	0.69	normal to ponded
1/12/2010	0	0	0	0	normal to low
2/2/2010	0	0.01	0.02	0.04	normal
3/2/2010	0.01	0.06	0.11	0.19	normal to low
4/6/2010	0	0	0	0.01	normal to low
5/7/2010	0	0	0	9.1	low to high
5/11/2010	0.07	0	0.37	0.37	low to high
5/18/2010	0.01	0.78	1.32	3.77	normal to high
5/27/2010	0	0	0	0.88	normal
6/1/2010	0.05	0.81	0.81	0.81	low to ponded

Calculation of Loads

G*iven the time and funding constraints of the Triplett Creek Watershed Based Plan, annual loads for each potential pollutant were estimated using different approaches. Calculated loads are subject to bias. The first method is using instantaneous loads (loads at the time of sampling). The instantaneous loads are used to evaluate changes in concentrations. The discharge values are from field measurements at the time of sampling and from values calculated from staff gage readings and rating curves developed during this study.* The instantaneous loads are used to evaluate if the increase in loads are from rainfall events.

The second load calculation method used is *estimated by averaging concentrations of all samples per site and then multiplying the results by the mean annual flow (MAF).* The MAF are used to check and compare the results of the STEPL loads to field data collected at each subwatershed. The STEPL model was used to predict annual N, P and Sediment loads (and reductions based on BMPs) for each subwatershed, for streambanks, and for each of four land use types. Using gage data resulted in a greater difference between the STEPL model load predictions and field data. This is expected since the STEPL model is based on average weather and land use data.

The STEPL-based information/parameters were used in sediment estimates. Field data was used to estimate some model parameters related to streambank erosion. The sediment loads are calculated using instantaneous loads. The availability of local load measurements is limited to a one year time and is not complete for each site. The field data, gage, and load calculation are located in appendix D.

The third method used to calculate loads is the developing load duration curves using selected USGS gage sites as proxy data flow. Only USGS sites having similar watershed size, geology, physiography and a continuous flow record for the entire sampling period were selected. The load duration curves are included for *E.coli*, proxy watershed discharge data from the USGS gage readings were used. The proxy watershed discharge data used is from the same time period as our sampling events. The proxy watershed data and results are shown in appendix C. The proxy loads were generated using the geomean concentration of 130 *E.coli*. The proxy watersheds were chosen because they were close in size and topography to our watersheds.

For *E. coli* a more sophisticated approach was used to compare measured instantaneous loads to allowable loads based on the WQC and recorded flow data. The resulting graphs, called Load Duration Curves, are included and discussed in appendix C for those who are interested. These duration loads can be helpful in determining if the pollutants are primarily surface or groundwater in source. They also aid in the determination when the pollutant is at its highest concentration, especially with *E. coli*.

RESULTS AND SIGNIFICANCE OF NEW DATA

Water Quality Data for Parameters with Set Standards

All of the following parameters have statutory surface water WQC, which are listed in Kentucky regulations under 401 KAR 10:031. Impairments are indicated when values (e.g., concentrations) from field data fall outside of the numerical criterion. Parameters without straightforward, numerical criteria are presented and discussed separately subsection. Because of the large quantity of data points for each parameter, only the data that demonstrates water quality concerns is shown in the sections below. Dissolved Oxygen, pH, Conductivity, and temperature were collected both during the water sampling event, using a hand held YSI probe, and 24-hour monitoring, using Hydrolabs and YSI probes. The 24-hour monitoring devices measured every 30-minutes. The probes were set out seasonally if the water depth permitted. The probe did not work properly in frozen or near frozen water. The probes were vandalized at three sites (CC-0.37, CC-4.00 and DC-0.27). One of the probes was not able to be repaired. The probes were not set out at these locations again because of the expense of the equipment repair. In addition, one probe was lost during flooding.

Temperature

Background and General Importance for Water Quality

Temperature in stream water can be affected by many factors. A loss of tree cover and shade tends to increase temperature. Excess sediment in the water also tends to increase temperature since the sunlight will heat the cloudy water faster than clear water. Runoff from road ways and roof tops can collect and carry the heat from surfaces directly into water bodies. Increases in water temperature can adversely affect aquatic life since higher temperatures decrease DO.

According to 401 KAR 10:031 (2012), The WQC for temperature states, "Temperature shall not exceed thirty-one and seven-tenths (31.7) degrees Celsius (eighty-nine (89) degrees Fahrenheit).

1. The normal daily and seasonal temperature fluctuations that existed before the addition of heat due to other than natural causes shall be maintained.
2. The cabinet may determine allowable surface water temperatures on a site-specific basis utilizing available data that shall be based on the effects of temperature on the aquatic biota that utilize specific surface waters of the commonwealth and that may be affected by person-induced temperature changes. a. Effects on downstream uses shall also be considered in determining site-specific temperatures. b. Values in the following table [Table 3.4, page 58] are guidelines for surface water temperature."

Table 3.4. WQC guidelines for surface water temperatures.

Month/Date	Period Average		Instantaneous Maximum	
	(°F)	(°C)	(°F)	(°C)
January 1-31	45	7	50	10
February 1-29	45	7	50	10
March 1-15	51	11	56	13
March 16-31	54	12	59	15
April 1-15	58	14	64	18
April 16-30	64	18	69	21
May 1-15	68	20	73	23
May 16-31	72	24	80	27
June 1-15	80	27	85	29
June 16-30	83	28	87	31
July 1-31	84	29	89	32
August 1-31	84	29	89	32
September 1-15	84	29	87	31
September 16-30	82	28	86	30
October 1-15	77	25	82	28
October 16-31	72	22	77	25
November 1-30	67	19	72	22
December 1-31	52	11	57	14

Temperature was measured in three different ways. Temperature was measured using a hand held YSI probe during sampling events for instantaneous events. A hand held thermometer was used in some locations when the water was frozen. The YSI probes do not work well when the water temperature drops below or near freezing. The readings, recorded using the thermometer, are recorded as whole numbers. Hyrdolabs were used to monitor instantaneous readings over 24-hours or more. They were programmed to record every 30-minutes. Note, because of the large number of data points collected, only the data that exceeds the standard or that are within 10% of the temperature guideline for Month and date is included in the summary.

Results of Temperature Measurements

The Hydrolab and YSI recorded temperature over three days at several sites. Table 3.5 (page 59) shows the sites that exceeded the standard or were within 10% of the standard. Eight sites exceeded temperature standards (DC-0.27, MF-0.23, BUB-0.03, EB-0.04, HB-1.36, PB-0.42, TC-13.52, and TC-19.91). All of the exceeded temperatures were recorded on the April 6, 2010 sampling event. CC-0.37, IF-0.10, and TC-21.80 where within 10% of the temperature standard.

Table 3.5. Summary of YSI Probe date and site that exceed or come within 10% of temperature guidelines.

Site ID	Date Sampling	Exceeds standards (°C)	Within 10% of standard (°C)
Christy Creek Subwatershed			
CC-0.37	6/1/10		26.48
Rock Fork Subwatershed			
IF-0.05	6/1/10		26.63
Dry Creek Subwatershed			
DC-0.27	4/6/10	19.58	
Morgan Fork Subwatershed			
MF-0.23	4/6/10	18.78	
Main stem of Triplett Creek Subwatershed			
BUB-0.03	4/6/10	20.7	
EB-0.04	4/6/10	19.89	
HB-1.36	4/6/10	19.09	
PB-0.42	4/6/10	18.24	
TC-13.52	4/6/10	18.12	
TC-19.91	4/6/10	20.14	
TC-21.80	4/6/10		17.58

Analysis of Temperature Results

Evan Branch (EB-0.04) only exceeded maximum temperature guideline once in April; however, it regularly had noticeably higher temperatures (to the touch) than other sites. This was especially noticeable in the winter to the sampler while collecting the grab sample, which requires the sampler to submerse their hands into the water. A very notable example was on 12/1/11. EB-0.04 temperature was 12.22 °C. The next highest reading from the other sample sites that day was 9.61°C and the average was 5.09°C. Triplett Creek had several sampling locations that either exceeded or were within 10% of the WQC. A trend towards high temperatures is concerning since this impacts aquatic life and indicates a lack of riparian habitat. The lack of riparian habitat is a contributor to eroding banks, which are common throughout the watershed. Another concern is the possible impairment of flow in the summer time, which usually results in higher water temperatures.

The sites listed in Table 3.5 are sites that exceeded temperature standards or were within 10% during the sampling events. Based on the season and habitat assessments at the locations the most likely reason for the increased temperatures are the lack of canopy cover at the sites.

Dissolved Oxygen

Background and General Importance for Water Quality

Dissolved oxygen (DO) is a measure of the amount of oxygen in water. DO is affected by temperature and various biological processes. Cold water holds more oxygen that warm water. Flowing water also contains higher DO levels than standing water. DO is low in water containing high amounts of rotting organic matter (e.g., dead plants, sewage) since the microorganisms responsible for decomposition use oxygen. Aquatic animals are most vulnerable to lower DO levels in the early morning on hot summer days because water temperatures are higher in the summer, stream flows are low, and aquatic plants do not produce oxygen at night. According to 401 KAR 10:031 (2012), The WQC for DO in warm water aquatic habitats are: "a) dissolved oxygen shall be maintained at a minimum of five and zero-tenths (5.0) mg/L as a twenty-four (24) hour average in water with WAH use; b) the instantaneous minimum shall not be less than four and zero-tenths (4.0) mg/L in water with WAH use."

Results for DO Measurements

DO data was collected instantaneous and over a 24-hour period, using the Hyrolabs and YSI Probes. Given the large amount of sites and data collected (over 4500 data points) only the sites that did not meet WQC or are of concern are presented below. The instantaneous data was collected at each site when nutrients and bacteria data was collected. Data was collected monthly, when flow was present and water depth permitted. Table 3.6 (page 61) summaries dates and sites that had DO measurements during sampling events. Even though the standards are for an instantaneous minimum of 4 mg/L, table 3.6 shows values under 5.0 mg/L. Give the low DO mg/L recordings, it is likely that if continuously monitored the sites would likely have a low 24-hour average temperature. The date and time of the readings are given since DO changes seasonally with the flow, temperature, and plant growth. Table 3.7 (page 62) summaries the instantaneous and 24-hour readings collected every thirty minutes using the Hach Hydrolabs and YSI Probes. Summer data for the 24-hour monitoring is lacking because of the low water depths at many of the sites. The probes require at least six inches of water in the main flow of the stream for good readings.

Table 3.6 Sites of concern for instantaneous DO (mg/L) values below 5.0 collected with handheld YSI probes (readings recorded when water samples were collected).

Site ID	Date	Time	Minimum DO (mg/L)
Christy Creek Subwatershed			
CC-2.00	9/1/2009	8:05	4.63
CC-4.33	9/1/2009	7:56	4.73
Main stem of Triplett Creek Subwatershed			
HUB-0.19	7/6/2009	9:57	3.05
HUB-0.19	7/13/2009	10:21	3.14
HUB-0.19	7/15/2009	9:34	4.24
PB-0.42	7/27/2009	9:42	4.23
Upper North Fork of Triplett Subwatershed			
MB-0.23	7/15/2009	10:59	4.09
MB-0.23	7/20/2009	No data	4.83
MB-0.23	7/27/2009	1:07	4.91
RF-0.15	7/27/2009	10:33	3.60

Table 3.7 Sites of concern for instantaneous minimum DO (mg/L) and 24 hours average values collected with Hach Hydrolabs and YSI Probes.

Season Deployed	Site ID	Comments on DO (mg/L)
Christy Creek Subwatershed		
Fall 2009	CC-0.37	One 24-hour average under 5.0 mg/L
		Instantaneous readings below 4.0 mg/L in the early morning hours
Lower section of the North Fork of Triplett Creek Subwatershed		
Fall 2009	CF-0.11	Two of six 24-hour averages were under 5.0 mg/L
		Early morning hours under 4.0 mg/L **
Spring 2009	BB-0.38	All 24-hours averages were under 5.0 mg/L
		Instantaneous readings below 4.0 mg/L late evening/early morning*
Main stem of Triplett Creek Subwatershed		
Winter 2009	HUB-0.19	All Instantaneous readings under 4.0 mg/L
		All 24-hour data under 5.0 mg/L
Fall 2009	BUB-0.03	Two of the four 24-hour averages under 5.0 mg/L
		Instantaneous readings below because of low early morning DO levels**
Fall 2009	TC 13.52	Five of six 24-hour averages under 5.0 mg/L
		Early morning hours under 4.0 mg/L for instantaneous reading**

*Late evening/early morning covers the time period between 11:00pm and 6:00 am.
**Early morning hours covers the time period of 5:30 am to 7:30 am.

Graphs with the DO mg/L results for each site by watershed can be found in appendix E.

Analysis of DO Results

The combination of sampling and 24-hour monitoring provides a good picture of the DO levels in the streams. One third of the sampling sites do not meet WQC. It is important to note that many of the sites that were monitored over 24 hours had very low DO levels and were not meeting WQS. As expected the lowest DO levels for all the sites were in the summer and fall. This is when water levels are at their lowest, reducing the flow of the water. The combination of low flow and higher temperatures result in lower DO. DO levels were also lowest in the early morning. The site that dropped below 4.0

mg/L in the early morning was below 4.0 for several hours. The low DO levels can result in fish kills.
The DO levels in the summer and fall are also an indication that low summer flow and the lack of good riparian habitats (tree cover) contribute to the DO impairment in our streams. The direct sunlight is able to heat up the lower quantity of water, further decreasing the DO levels. HUB-0.19 is the exception. HUB-0.19 was the only site that had DO levels below the WQS, in the winter. HUB-0.19, PB-0.42, and BUB-0.03 all had algae growth reported on the chain of custody forms during the sampling events. TC-13.32 is the most exposed site on Triplett Creek; it is likely that the lack of tree cover is a contributing factor for the sites low DO readings.

The watershed that are of the greatest concern on Christy Creek, which has three of the sites on the main steam of Christy Creek under or close to the standards for DO. Triplett Creek and North Fork of Triplett were the other two watershed with DO levels there were under of close to the minimum standard.

pH

Background and General Importance for Water Quality

The acidity and alkalinity of surface waters are measured using pH. The pH of stream water is determined by rainwater pH, by interactions with rocks, sediment and soil, and by biological processes. The greatest diversity of aquatic species is found in waterways with a pH range of 6.5 – 8.0. According to 401 KAR 10:031 (2012), The WQC for WAH and recreational use states that "pH shall not be less than six and zero-tenths (6.0) nor more than nine and zero-tenths (9.0) and shall not fluctuate more than one and zero-tenths (1.0) pH unit over a period of twenty-four (24) hours."

Results for pH Measurements

pH data was collected instantaneous and over a 24-hour period. Given the large amount of sites and data collected (over 4500 data points) only the sites that did not meet WQC or are of concern are present below. Table 3.8 (page 64) is a summary of pH readings at or below 6.1 during sampling events. Table 3.9 (page 65) is a summary of instantaneous readings above 9.0. Table 3.10 (page 66) is a summary of instantaneous readings recorded every 30-minutes and 24-hour averages using the Hach Hydrolabs and YSI Probes that were deployed at the sites.

Table 3.8. A summary of pH readings at or below 6.1 recorded during sampling events.

Site ID	Date Sampled	pH
Christy Creek Subwatershed		
CC-0.37	9/1/2009	5.76
CC-2.0	9/1/2009	4.63
CC-2.0	5/11/2010	5.33
CC-4.33	9/1/2009	4.73
CC-8.11	9/1/2009	5.91
Dry Creek Subwatershed		
DC-0.27	7/20/2009	6.02
DC-2.84	9/1/2009	5.36
Morgan Fork Subwatershed		
MF-0.23	7/20/2009	5.47
Lower North Fork of Triplett Creek Subwatershed		
CF-0.11	2/2/2010	6.07
HF-0.09	5/18/2010	4.90
HF-0.09	7/20/2009	5.43
HF-0.09	5/11/2010	4.31
NF-1.61	7/20/2009	5.29
NF-1.61	9/1/2009	5.75
NF-1.61	12/1/2009	5.91
Upper North Fork of Triplett Creek Subwatershed		
NF-14.52	7/20/2009	5.63
NF-14.52	8/5/2009	5.73
RF-0.15	11/5/2009	6.10
Main stem of the Triplett Creek Subwatershed		
HUB-0.19	7/6/2009	5.87
HUB-0.19	11/5/2009	5.77
HUB-0.19	5/5/2010	5.28
HUB-0.19	7/13/2009	5.53
TC-0.74	7/20/2009	5.96
TC-2.27	7/20/2009	5.68
TC-2.27	2/2/2010	6.04
TC-12.27	7/20/2009	5.85
TC-12.27	11/5/2009	5.44

Table 3.9. A summary of instantaneous pH readings above 9.0.

Site ID	Date Sampled	pH
Christy Creek Subwatershed		
CC-0.37	2/2/2010	9.17
Dry Creek Subwatershed		
DC-2.84	2/2/2010	9.25
DC-0.27	2/2/2010	9.49
Upper North Fork of Triplett Creek Subwatershed		
HF-0.09	9/1/2009	9.78
Lower North Fork of Triplett Creek Subwatershed		
BB-0.23	9/1/2009	9.05
CB-0.38	9/1/2009	9.1
Morgan Fork Subwatershed		
MF-0.23	2/2/2010	9.56
Main stem of Triplett Creek Subwatershed		
HB-1.36	5/18/2010	9.56
TC-12.27	2/2/2010	9.72
TC-14.99	9/1/2009	9.03
TC-19.91	5/18/2010	9.49
TC-21.80	2/2/2010	9.13
TC-21.80	10/4/2009	9.16
TC-21.80	5/18/2010	10.27

Table 3.10. A summary of instantaneous pH readings recorded every thirty minutes over 24-hours.

Season Deployed	**Site ID**	**pH**
Christy Creek Subwatershed		
Spring 2009	CC-0.37	Had a greater than 1.0 change over a 24-hour period
		All of the instantaneous readings were within the 6 to 9 range
Winter 2009	CC-8.11	Had a greater than 1.0 change over a 24-hour period
		All of the instantaneous readings were within the 6 to 9 range
Main stem of Triplett Creek Subwatershed		
Winter 2009	HUB-0.19	All of the instantaneous readings were below 6.0
		The instantaneous readings ranged between 5.79 and 5.99
Upper North Fork of Triplett Creek Subwatershed		
Fall 2009	PL-0.10	Had a greater than 1.0 change over a 24-hour period
		All of the instantaneous reading were within the 6 to 9 range
Fall 2009	RF-0.15	34 of the 133 instantaneous readings were below 6.0
		The instantaneous readings range from 5.90 to 6.10

Graphs showing the recorded pH levels for each of the subwatersheds are located in appendix E.

Analysis of pH Results

Water measurements at most sites meet the WQC for pH. Thirteen of the 33 sites had readings below 6.0 (Table 3.8, page 64). Twelve of the sites had readings over 9.0. Only one of the sites (TC-21.80) had more than one reading above 9.0. HUB-0.19 was consistently lower than the other sites. Three sites (CC-0.37, CC-8.11, and PL-0.10) showed pH changes greater than 1.0 over a 24-hour period and therefore did not meet the WQC. As pH drops the biodiversity decreases, this impacts the fish and their food sources. These impacts are discussed under "Impairments Associated with Selected Physical and Chemical Parameters" in this section.

Alkalinity

Background and General Importance for Water Quality

Alkalinity is one of the best measurements for determining a stream's capacity to neutralize acidic pollution from rainfall or wastewater. The alkaline compounds in the water (carbonates, bicarbonates, and hydroxides) combine with hydrogen to neutralize acidic inputs (such as organic material and rain water). Without the ability to neutralize the acidic inputs, streams would become acidic very quickly. According to 401 KAR 10:031 (2012), The WQC for alkalinity states, "Natural alkalinity as $CaCO_3$ shall not be reduced by more than twenty-five (25) percent. If the natural alkalinity is below twenty (20) mg/L $CaCO_3$, there shall not be a reduction below the natural level." KDOW benchmark data range bounded between 25th and 75th percentiles was used to identify sites with possible elevated or decreased alkalinity. The 25th percentile is 31.8 mg/L and the 75th percentile is 76.0 mg/L $CaCO_3$.

Results for Alkalinity Measurements

Table 3.11 (pages 68-76) present the alkalinity results. Graphs showing the alkalinity levels for each watershed are located in appendix E.

Table 3.11. A summary of alkalinity less than 31.8 and greater than 76.0 mg/L CaCO.

Site Name	Date Sampled	Alkalinity (mg/L $CaCO_3$)
Christy Creek Subwatershed		
CC-0.37	3/2/2010	24
CC-0.37	5/24/2010	80
CC-0.37	10/4/2009	82
CC-0.37	9/1/2009	90
CC-2.0	5/24/2010	80
CC-2.0	10/4/2009	84
CC-2.0	9/1/2009	95
CC-4.33	1/12/2010	10
CC-4.33	4/6/2010	78
CC-4.33	7/7/2009	79
CC-4.33	10/16/2009	82
CC-4.33	10/4/2009	90
CC-4.33	5/24/2010	92
CC-4.33	9/1/2009	97
CC-8.11	8/5/2009	79
CC-8.11	7/20/2009	86
CC-8.11	5/24/2010	90
CC-8.11	10/4/2009	92
CC-8.11	7/27/2009	103
CC-8.11	9/1/2009	124
OH-0.11	5/24/2010	78
OH-0.11	6/1/2010	85
PAL-0.02	12/1/2009	29
PAL-0.02	10/4/2009	79
PAL-0.02	10/27/2009	130
SB-0.02	7/13/2009	87
SB-0.02	10/27/2009	136

Table 3.11. A summary of alkalinity less than 31.8 and greater than 76.0 mg/L CaCO (continued).

Dry Creek Subwatershed		
DC-0.27	10/16/2009	78
DC-0.27	11/5/2009	90
DC-0.27	12/1/2009	90
DC-0.27	2/2/2010	91
DC-0.27	10/14/2009	98
DC-0.27	6/1/2010	99
DC-0.27	7/20/2009	112
DC-0.27	9/1/2009	122
DC-0.27	7/7/2009	124
DC-0.27	7/13/2009	124
DC-2.38	4/6/2010	79
DC-2.38	10/16/2009	84
DC-2.38	9/1/2009	88
DC-2.38	6/1/2010	89
DC-2.38	10/27/2009	106
DC-2.38	10/14/2009	116
Rock Fork Subwatershed		
IF-0.05	7/15/2009	13
IF-0.05	7/6/2009	15
IF-0.05	11/5/2009	16
IF-0.05	8/5/2009	18
IF-0.05	5/18/2010	18
IF-0.05	5/5/2010	23
IF-0.05	7/27/2009	25
IF-0.05	5/11/2010	25
IF-0.05	4/6/2010	28
Morgan Fork Subwatershed		
MF-0.23	5/5/2010	100
MF-0.23	5/18/2010	102
MF-0.23	3/2/2010	104
MF-0.23	5/11/2010	108
MF-0.23	10/4/2009	110
MF-0.23	2/2/2010	110
MF-0.23	4/6/2010	110
MF-0.23	10/16/2009	118
MF-0.23	1/12/2010	132
MF-0.23	8/5/2009	159
MF-0.23	9/1/2009	160
MF-0.23	7/27/2009	164

Table 3.11. A summary of alkalinity less than 31.8 and greater than 76.0 mg/L CaCO (continued).

MF-0.23	7/15/2009	178
MF-0.23	7/20/2009	180
MF-0.23	7/7/2009	186
MF-0.23	7/13/2009	199
Lower North Fork of Triplett Creek Subwatershed		
BB-0.23	6/1/2010	78
BB-0.23	10/27/2009	80
BB-0.23	7/15/2009	82
BB-0.23	7/27/2009	83
BB-0.23	10/14/2009	88
BB-0.23	10/4/2009	94
BB-0.23	5/24/2010	96
BB-0.23	7/13/2009	100
BB-0.23	9/1/2009	112
CB-0.38	5/5/2010	25
CB-0.38	5/11/2010	26
CB-0.38	4/6/2010	30
CB-0.38	10/27/2009	78
CB-0.38	10/16/2009	84
CB-0.38	8/5/2009	86
CB-0.38	6/1/2010	87
CB-0.38	7/20/2009	91
CB-0.38	7/15/2009	92
CB-0.38	7/27/2009	92
CB-0.38	9/1/2009	102
CB-0.38	7/13/2009	113
NF-1.61	3/2/2010	14
NF-1.61	7/6/2009	22
NF-9.77	12/1/2009	10
NF-9.77	3/2/2010	10
NF-9.77	11/5/2009	12
NF-9.77	7/6/2009	20
NF-9.77	5/18/2010	28
NF-9.77	7/15/2009	30
Upper North Fork of Triplett Creek Subwatershed		
CF-0.11	4/6/2010	9
CF-0.11	5/5/2010	11
CF-0.11	10/16/2009	12
CF-0.11	10/27/2009	12

Table 3.11. A summary of alkalinity less than 31.8 and greater than 76.0 mg/L CaCO (continued).

CF-0.11	5/11/2010	12
CF-0.11	7/6/2009	15
CF-0.11	8/5/2009	17
CF-0.11	12/1/2009	18
CF-0.11	3/2/2010	18
CF-0.11	11/5/2009	20
CF-0.11	6/1/2010	21
CF-0.11	7/20/2009	22
CF-0.11	7/15/2009	24
CF-0.11	7/27/2009	25
CF-0.11	2/2/2010	28
CF-0.11	5/18/2010	30
NF-14.52	12/1/2009	11
NF-14.52	11/5/2009	12
NF-14.52	7/6/2009	18
NF-14.52	5/18/2010	22
NF-14.52	7/15/2009	29
RF-0.15	11/5/2009	0
RF-0.15	12/1/2009	1
RF-0.15	3/2/2010	9
RF-0.15	7/6/2009	14
RF-0.15	7/15/2009	18
RF-0.15	9/1/2009	20
RF-0.15	7/20/2009	23
RF-0.15	8/5/2009	23
RF-0.15	7/27/2009	28
RF-0.15	1/12/2010	30
RF-0.15	5/18/2010	30
PL-0.10	3/2/2010	7
PL-0.10	7/6/2009	17
PL-0.10	7/20/2009	26
PL-0.10	8/5/2009	26
PL-0.10	5/18/2010	28
PL-0.10	7/27/2009	29
PL-0.10	5/5/2010	29
PL-0.10	5/11/2010	31

Table 3.11. A summary of alkalinity less than 31.8 and greater than 76.0 mg/L CaCO (continued).

Main Stem of Triplett Creek Subwatershed		
BUB-0.03	7/20/2009	77
BUB-0.03	10/14/2009	78
EB-0.04	5/11/2010	77
EB-0.04	4/6/2010	80
EB-0.04	8/5/2009	83
EB-0.04	7/27/2009	84
EB-0.04	7/20/2009	87
EB-0.04	12/1/2009	91
EB-0.04	11/5/2009	100
EB-0.04	10/27/2009	102
EB-0.04	7/7/2009	106
EB-0.04	7/13/2009	106
EB-0.04	2/2/2010	110
EB-0.04	10/16/2009	120
HB-1.36	1/12/2010	78
HB-1.36	5/18/2010	78
HB-1.36	5/5/2010	98
HB-1.36	8/5/2009	99
HB-1.36	12/1/2009	99
HB-1.36	5/11/2010	100
HB-1.36	7/13/2009	104
HB-1.36	7/15/2009	105
HB-1.36	7/7/2009	108
HB-1.36	10/27/2009	110
HB-1.36	11/5/2009	111
HB-1.36	4/6/2010	111
HB-1.36	7/20/2009	112
HB-1.36	2/2/2010	113
HB-1.36	10/16/2009	114
HB-1.36	7/27/2009	117
HF-0.09	5/18/2010	12
HF-0.09	6/1/2010	12
HF-0.09	5/5/2010	15
HF-0.09	12/1/2009	18
HF-0.09	9/1/2009	80
HF-0.09	7/20/2009	131
HUB-0.19	3/2/2010	8
HUB-0.19	5/24/2010	10
HUB-0.19	10/14/2009	11

Table 3.11. A summary of alkalinity less than 31.8 and greater than 76.0 mg/L CaCO (continued).

HUB-0.19	1/12/2010	11
HUB-0.19	5/11/2010	11
HUB-0.19	7/15/2009	13
HUB-0.19	2/2/2010	18
HUB-0.19	11/5/2009	20
HUB-0.19	5/5/2010	30
MB-0.23	3/2/2010	8
MB-0.23	12/1/2009	14
MB-0.23	5/18/2010	28
MB-0.23	9/1/2009	82
MB-0.23	6/1/2010	112
MB-0.23	5/24/2010	115
TC-0.74	12/1/2009	28
TC-0.74	11/5/2009	30
TC-0.74	5/24/2010	98
TC-0.74	10/14/2009	102
TC-0.74	6/1/2010	110
TC-02.27	7/27/2009	80
TC-02.27	5/24/2010	97
TC-02.27	7/7/2009	98
TC-02.27	10/14/2009	98
TC-02.27	10/4/2009	100
TC-02.27	6/1/2010	100
TC-02.27	7/13/2009	116
TC-12.27	7/20/2009	78
TC-12.27	8/5/2009	78
TC-12.27	7/27/2009	81
TC-12.27	10/14/2009	87
TC-12.27	9/1/2009	88
TC-12.27	7/13/2009	90
TC-12.27	5/24/2010	92
TC-12.27	6/1/2010	93
TC-12.27	10/4/2009	96
TC-13.52	9/1/2009	77
TC-13.52	7/13/2009	85
TC-13.52	10/14/2009	85
TC-13.52	10/4/2009	88
TC-13.52	5/24/2010	88
TC-13.52	6/1/2010	92

Table 3.11. A summary of alkalinity less than 31.8 and greater than 76.0 mg/L CaCO (continued).

TC-13.52	7/20/2009	99
TC-14.50	10/14/2009	77
TC-14.50	9/1/2009	78
TC-14.50	7/13/2009	81
TC-14.50	7/20/2009	86
TC-14.50	5/24/2010	86
TC-14.50	10/4/2009	88
TC-14.50	6/1/2010	89
TC-14.99	7/13/2009	80
TC-14.99	7/15/2009	83
TC-14.99	10/4/2009	84
TC-14.99	7/20/2009	88
TC-14.99	6/1/2010	88
TC-14.99	5/24/2010	99
TC-14.99	10/14/2009	101
TC-19.91	8/5/2009	80
TC-19.91	6/1/2010	80
TC-19.91	7/13/2009	81
TC-19.91	7/27/2009	82
TC-19.91	7/7/2099	88
TC-19.91	9/1/2009	98
TC-19.91	10/27/2009	108
TC-19.91	2/2/2010	108
TC-19.91	10/4/2009	110
TC-19.91	5/24/2010	126
TC-19.91	10/14/2009	137
TC-21.80	1/12/2010	80
TC-21.80	12/1/2009	99
TC-21.80	11/5/2009	100
TC-21.80	7/7/2009	103
TC-21.80	7/20/2009	106
TC-21.80	10/27/2009	110
TC-21.80	5/24/2010	110
TC-21.80	2/2/2010	112
TC-21.80	7/15/2009	130
TC-21.80	8/5/2009	146
TC-21.80	7/27/2009	150
TC-21.80	10/4/2009	150

Table 3.11. A summary of alkalinity less than 31.8 and greater than 76.0 mg/L CaCO (continued).

Lower North Fork of Triplett Creek Subwatershed		
CB-0.38	5/5/2010	25
CB-0.38	5/11/2010	26
CB-0.38	4/6/2010	30
CB-0.38	10/27/2009	78
CB-0.38	10/16/2009	84
CB-0.38	8/5/2009	86
CB-0.38	6/1/2010	87
CB-0.38	7/20/2009	91
CB-0.38	7/15/2009	92
CB-0.38	7/27/2009	92
CB-0.38	9/1/2009	102
CB-0.38	7/13/2009	113
NF-1.61	3/2/2010	14
NF-1.61	7/6/2009	22
NF-9.77	12/1/2009	10
NF-9.77	3/2/2010	10
NF-9.77	11/5/2009	12
NF-9.77	7/6/2009	20
NF-9.77	5/18/2010	28
NF-9.77	7/15/2009	30
Upper North Fork of Triplett Creek Subwatershed		
CF-0.11	4/6/2010	9
CF-0.11	5/5/2010	11
CF-0.11	10/16/2009	12
CF-0.11	10/27/2009	12
CF-0.11	5/11/2010	12
CF-0.11	7/6/2009	15
CF-0.11	8/5/2009	17
CF-0.11	12/1/2009	18
CF-0.11	3/2/2010	18
CF-0.11	11/5/2009	20
CF-0.11	6/1/2010	21
CF-0.11	7/20/2009	22
CF-0.11	7/15/2009	24
CF-0.11	7/27/2009	25
CF-0.11	2/2/2010	28
CF-0.11	5/18/2010	30
NF-14.52	12/1/2009	11

Table 3.11. A summary of alkalinity less than 31.8 and greater than 76.0 mg/L CaCO (continued).

NF-14.52	11/5/2009	12
NF-14.52	7/6/2009	18
NF-14.52	5/18/2010	22
NF-14.52	7/15/2009	29
RF-0.15	11/5/2009	0
RF-0.15	12/1/2009	1
RF-0.15	3/2/2010	9
RF-0.15	7/6/2009	14
RF-0.15	7/15/2009	18
RF-0.15	9/1/2009	20
RF-0.15	7/20/2009	23
RF-0.15	8/5/2009	23
RF-0.15	7/27/2009	28
RF-0.15	1/12/2010	30
RF-0.15	5/18/2010	30
PL-0.10	3/2/2010	7
PL-0.10	7/6/2009	17
PL-0.10	7/20/2009	26
PL-0.10	8/5/2009	26
PL-0.10	5/18/2010	28
PL-0.10	7/27/2009	29
PL-0.10	5/5/2010	29
PL-0.10	5/11/2010	31

Analysis of Alkalinity Results

A majority of the recorded alkalinity levels fell either above or below the benchmarks. CF-0.11, HF-0.09, HUB-0.19, NF-1.61, NF-14.52, and RF-0.15 are of the greatest concern since these sites also have low pH. HUB-0.19 had the lowest alkalinity values. HUB-0.19 low pH and alkalinity is most likely a result of the shale in the watershed.

Ammonia

Background and General Importance for Water Quality

The WQC is based on unionized ammonia-N (mg/L). The existing 401 KAR 10:031 (2012) WQC states, "Ammonia is the concentration of the un-ionized form shall not be greater than 0.05 mg/L at any time in-stream after mixing. Un-ionized ammonia shall be determined from values for total ammonia-N, in mg/L, pH and temperature, by means of the following equation:

$Y = 1.2(\text{Total ammonia-N})/(1+10^{pKa-pH})$
$pKa = 0.0902 + (2730/(273.2 + T_c))$
where:
T_c = temperature, degrees Celsius (°C)
Y = un-ionized ammonia (mg/L)"

The benchmark for unionized ammonia-N (mg/L) provided by the KDOW for the Triplett Creek Watershed ecoregion is <0.001 mg/L. However, the main benchmark for screening is 0.05mg/L. It is recommended that sites routinely above 0.1 mg/L are reported to the Technical Assistant Officers at KDOW. Table 3.12 (below) summarizes the unionized ammonia-N data that exceeds WQC.

Results of Ammonia Measurements

Table 3.12. Summary of Unionized Ammonia-N.

Site Name	Date	Unionized Ammonia-N max	Unionized Ammonia-N median
Lower North Fork of the Triplett Creek Subwatershed			
BB-0.23	9/1/2009	0.341	0.001
CF-0.11	9/1/2009	0.06	0.001
Upper North Fork of the Triplett Creek Subwatershed			
HF-0.09	9/1/2009	0.075	0.002
Main stem of the Triplett Creek Subwatershed			
TC-0.74	9/1/2009	0.121	0.002
TC-13.52	9/1/2009	0.133	0.002
TC-14.50	9/1/2009	0.105	0.003
TC-14.99	9/1/2009	0.388	0.002
TC-21.80	10/4/2009	0.076	0.006

Graphs of the results for each watershed can be found in appendix E.

Analysis of Ammonia Results
Only eight sites had samples above 0.05 mg/L and each of these sites only exceed this level once. The median values for all the sites are well below the 0.05 mg/L. September – November had the highest values. This is also the lowest flow period. As a result, it is likely that most of the source is coming from groundwater as a result of failed septic systems and increased concentrations from flow. With the exception of TC-0.74 all of the sites were on small tributaries and the upper reaches of the watershed.

Escherichia coli
Introduction
Sections of the Triplett Creek Watershed in Rowan County, Kentucky (Figure 2.10, page31), are listed as impaired streams on Kentucky's 303d list (KDOW, 2010). Documented pollutants in the watershed include pathogens (*E. coli*), nutrients (nitrogen, phosphorus) and sediments (caused by erosion). *E. coli* is an indicator of fecal contamination of watersheds, and can be attributed to a number of sources including native wildlife, domesticated animals, and humans. Agricultural activities, primarily cattle production, can pollute the watershed with feces. Human fecal contamination is due to straight pipe sewage deposition into creeks or failed household septic systems or failed sewer lines that leach material into watersheds. The objective of this part of the project was to assess the occurrence and density of the fecal-associated bacterium *Escherichia coli* in the Triplett Creek Watershed. Data generated will guide the selection and implementation of appropriate best management practices to address pathogen-associated impairments in streams of the watershed.

Bacteriological Analysis
Thirty four sites in the Triplett Creek Watershed (Figure 3.1, page 52) were sampled monthly from July 2009 through June 2010. Additionally, five sampling events were conducted in 30-day period in each season (summer 2009, fall 2009, and spring 2010). Low water flow at some of the sites prevented the water samples from being collected for bacteria analysis. Low flow either resulted in the waterway being ponded or to shallow to obtain a sample. The geometric mean was collected for sites where five samples were able to be collected in a 30-day period. Geometric means were also collected for the fall 2009 sampling. Even though, five samples were collected within a 30 day period, the last sampling event occurred on November 5. This placed the sampling event outside of the recreational season. The results are still included in the narrative. Water samples of 100 mL were collected in sterile EPA-approved containers, transported on ice to the Microbiology Laboratory on the MSU campus, and then filtered within six hours of collection. The samples were analyzed by the membrane filtration method, utilizing modified mTEC medium for *Escherichia coli* analysis (USEPA, 2002). Three volumes from each sample, 1-, 5-, and 10-mL, were filtered through 0.45 μm pore size sterile membrane filters, then aseptically (using sterile tools) was transferred to mTEC agar plates. The cultures

were incubated at 37°C for 2 hours, followed by an overnight incubation at 44.5°C. The next day, cultures were assessed. All colonies exhibiting a dark red color were scored as *E. coli*. Colony counts were expressed as *E. coli* CFU/100 mL. Geometric means of five samples collected during the summer 2009, fall 2009, and spring 2010 collecting periods were calculated.

Results

Six hundred forty-four samples were collected in the Triplett Creek Watershed from July 2009 to May 2010. Of these, 151 samples (23% of the total) exceeded the KDOW limit of 240 *E. coli* CFU/100-mL. Nineteen of the 33 sites (57.6% of the total), exceeded the geometric mean of 130 *E. coli* CFU/ 100 mL sample during the summer 2009 season (Figure 3.2, page 80). Twelve of the 34 sites (35.3%) exceeded the geometric mean count of 130 *E. coli* CFU/ 100 mL sample during the fall 2009 season (Figure 3.3, page 81). Eighteen of 34 sites (52.1% of the total) exceeded the geometric mean count of 130 *E. coli* CFU/ 100 mL sample during the spring 2010 season (Figure 3.4, page 82).

On May 5th and 7th 2010, 33 samples were taken from the sites after the May 2010 flooding event. Ten of the samples (30.3% of the total) were at or exceeded the KDOW limit of 240 *E. coli* CFU/100-mL (Figure 3.5, page 83). For each subwatershed, *E. coli* density data collected from the most downstream sampling site was used to calculate the instantaneous loads. Instantaneous loads for five out of seven of the subwatersheds were below or just over the WQC. Several instantaneous loads for the Christy Creek subwatershed and a few from the Triplett Creek Main sub-basin were well above the WQC (see appendix C and the Load Reductions Table in this section for more details).

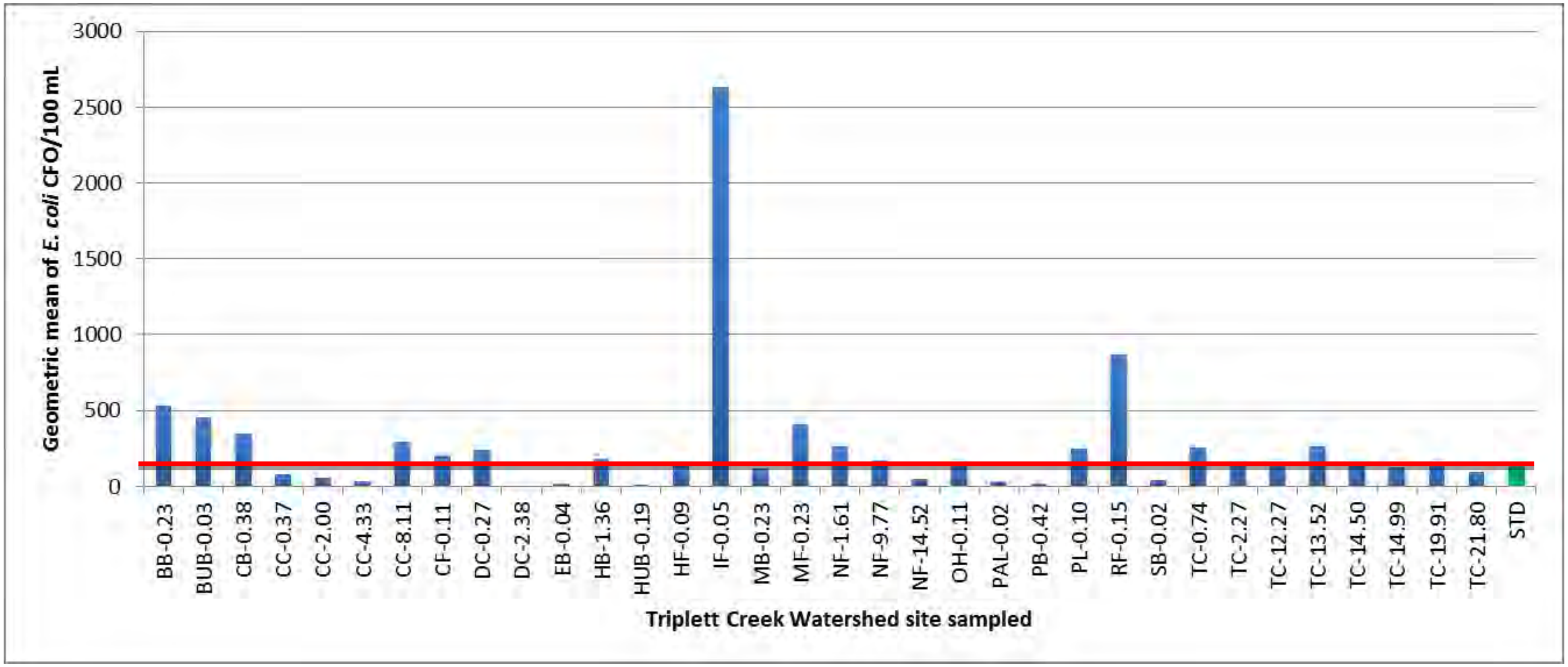

Figure 3.2. *E. coli* counts during the summer 2009 seasonal sample period. The counts represent geometric means of five samplings per site during the sampling period. The red line indicates the KDOW limit of 130 *E. coli* CFU/100 mL (geometric mean; Standard (STD), green bar) for waters designated as primary contact recreation.

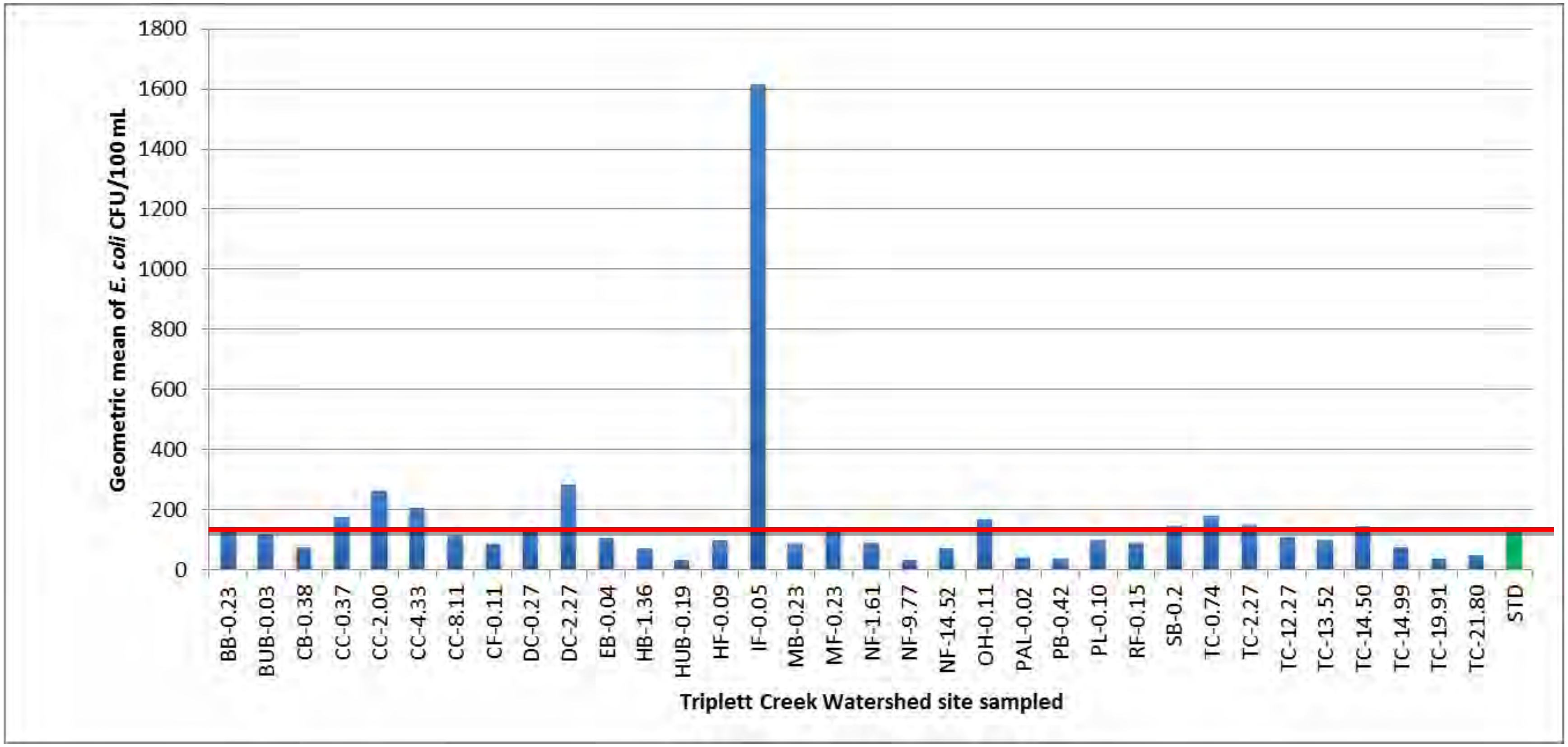

Figure 3.3. *E. coli* counts during the fall 2009 seasonal sample period. The counts represent geometric means of five samplings per site during the sampling period. The red line indicates the KDOW limit of 130 *E. coli* CFU/100 mL (geometric mean; Standard (STD), green bar) for waters designated as primary contact recreation.

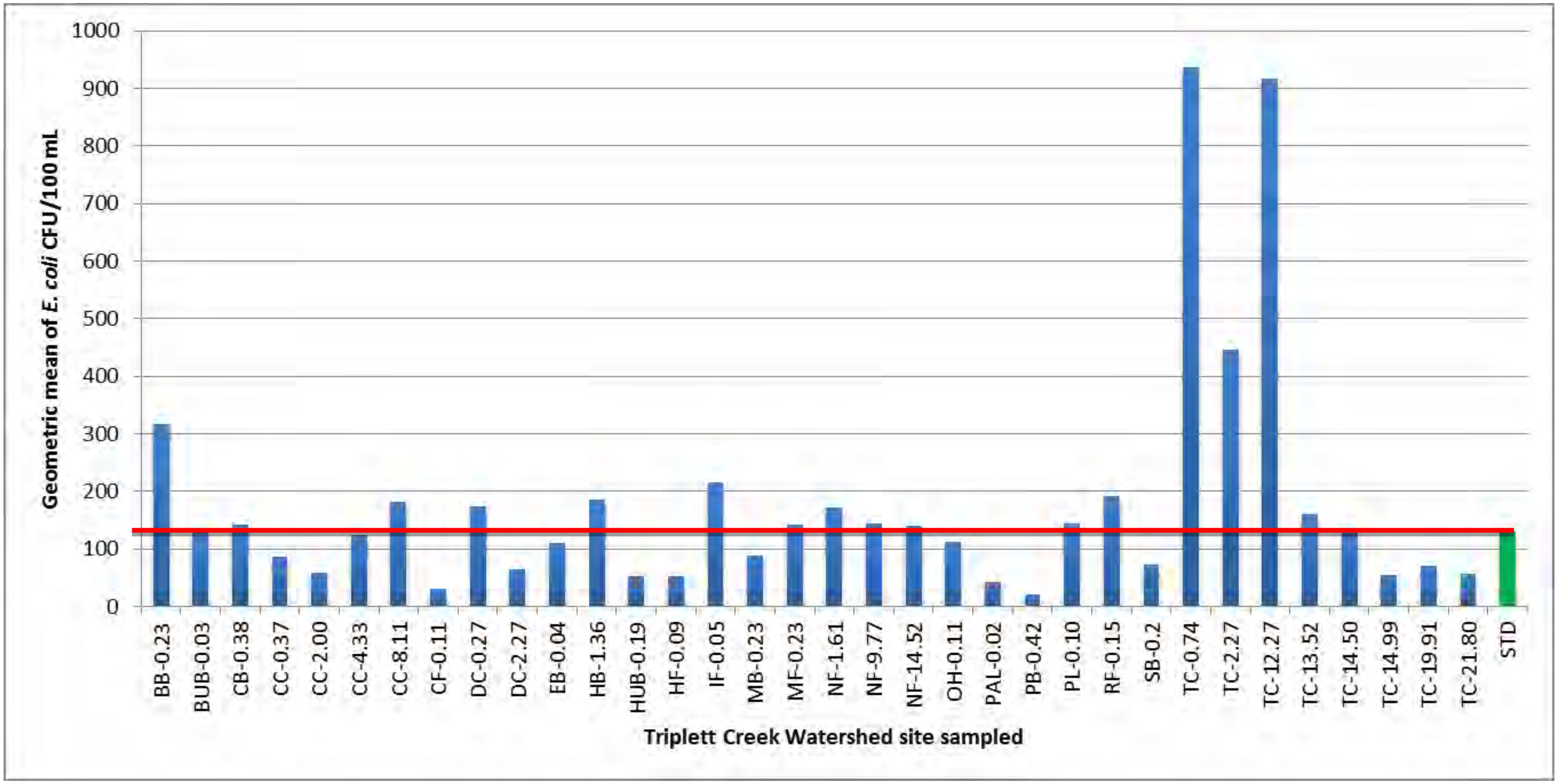

Figure 3.4. *E. coli* counts during the spring 2010 seasonal sample period. The counts represent geometric means of five samplings per site during the sampling period. The red line indicates the KDOW limit of 130 *E. coli* CFU/100 mL (geometric mean; Standard (STD) green bar) for waters designated as primary contact recreation.

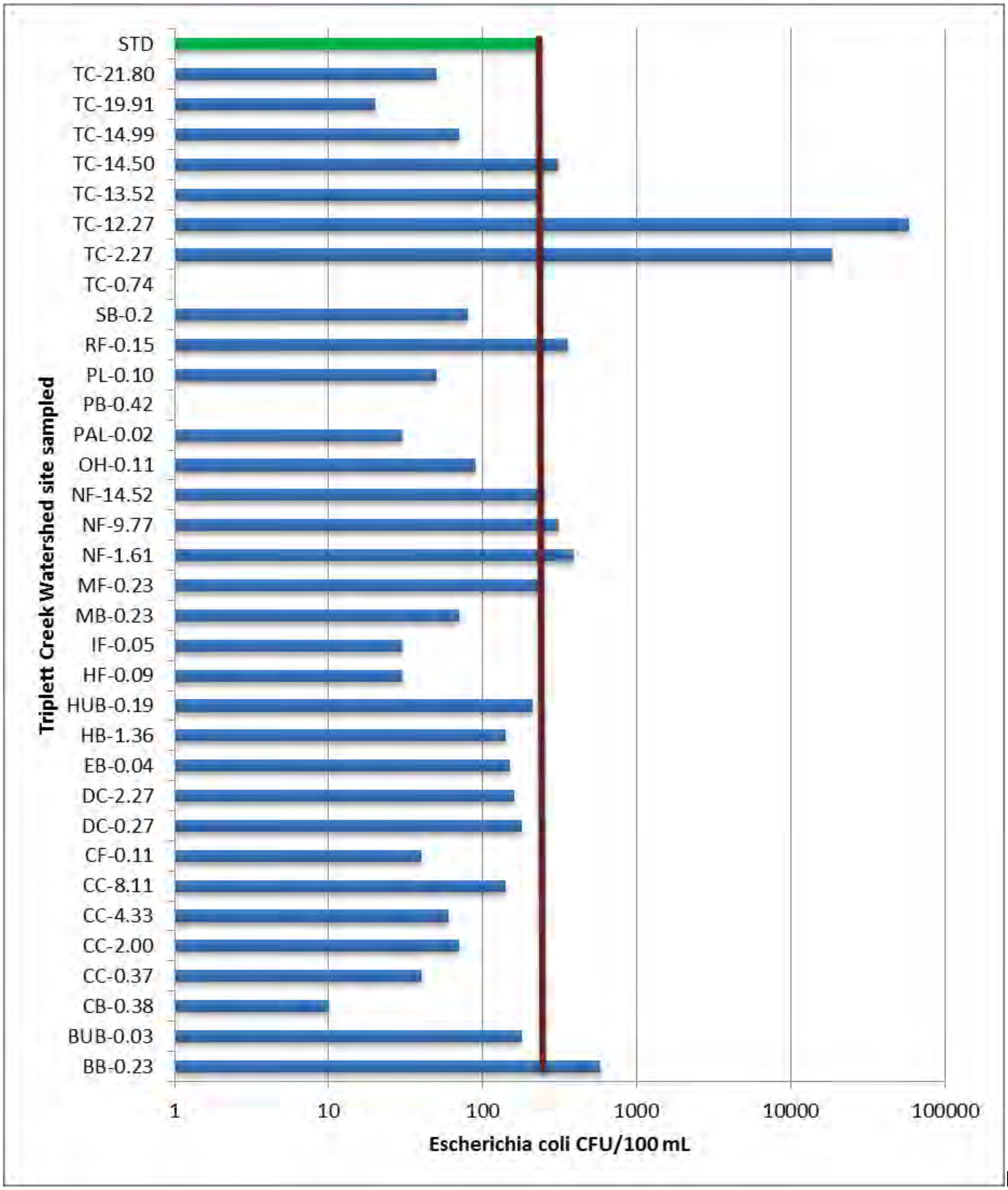

Figure 3.5. *E. coli* counts in Triplett Creek Watershed sampling sites, May 5-7 2010. The samples were collected just days after the major flood in the watershed. The dark blue line indicates the KDOW limit of 240 *E. coli* CFU/mL for single grab samples for waters designated as primary contact recreational use (Standard (STD), maroon bar). The green bar (STD) indicates *E. coli* counts that exceed the KDOW limit.

E. coli *Levels as Measured by Single Grab Sample Analysis*
Six hundred forty-four samples were collected from 34 sites in the Triplett Creek Watershed from July 2009 to May 2010. One sample was collected per month from each site throughout the study period. These are considered single grab samples, where the KDOW limit is 240 *E. coli* CFU/100 mL for primary contact recreation. Of the 644 samples analyzed, 151 (23%) exhibited *E. coli* counts that exceeded the KDOW limit of 240 *E. coli* CFU/100 mL.

The Triplett Creek Watershed can be divided into five subwatersheds: Christy Creek, Dry Creek, Upper North Fork, Lower North Fork, and Triplett Creek. All five sub-watersheds exhibited *E. coli* counts that exceeded KDOW limits at some time during the study period, indicating that *E. coli* pollution occurs throughout the watershed. The Upper North Fork subwatershed had persistently high *E. coli* counts as compared to the other four subwatersheds. Cattle production occurs in this subwatershed, and cattle have been observed in the creeks by samplers.

Single grab sample *E. coli* data was used to calculate Load Duration Curves. These analyses indicate that several instantaneous loads for the Christy Creek subwatershed and a few from the Triplett Creek subwatershed were well above the water quality criteria for bacteria (see Appendix C for more details). The subwatershed results are illustrated in figures 3.6 through 3.14 (pages 85-99) and tables 3.13 through 3.22 (pages 86-99).

E. coli *Levels as Measured by Geometric Means Analysis*
In addition to the monthly grab samples, five samples were collected from each site within a 30-day period for each of three seasonal periods: summer 2009, fall 2009 and spring 2010. Geometric means of the five *E. coli* counts from each site, and for each season, were calculated. The KDOW limit is a geometric mean of 130 *E. coli* CFU/100 mL for primary contact recreation. Again, all sites exhibit *E. coli* counts that exceeded the KDOW limit. When broken down by the five subwatersheds, seasonal and sub-watershed variation in *E. coli* levels were observed. The spring and summer seasons exhibited higher *E. coli* counts than the fall season in both of the North Fork subwatersheds, and to some extent in the Triplett Creek subwatershed. Sites near the mouth of Triplett Creek, representing the catchment of nearly the entire watershed, exhibited high *E. coli* counts throughout the year. The Dry Creek subwatershed also exhibited high *E. coli* counts throughout the year. On the other hand the Christy Creek subwatershed exhibited higher *E. coli* counts during the fall season, as compared to the spring and summer seasons.

Flood Event of May 2010
On May 5^{th} and 7^{th} 2010, 33 samples were taken from the sites after the May 2010 flooding event. Ten of the samples (30.3% of the total) were at or exceeded the KDOW limit of 240 *E. coli* CFU/100-mL. Some of the sites in the lower portion of the Triplett Creek subwatershed exhibited extraordinarily high counts. This likely due to the flooding of a nearby sewage lift station, as well as flood damaged sustained by the county's sewage treatment facility located near the lower portion of North Fork.

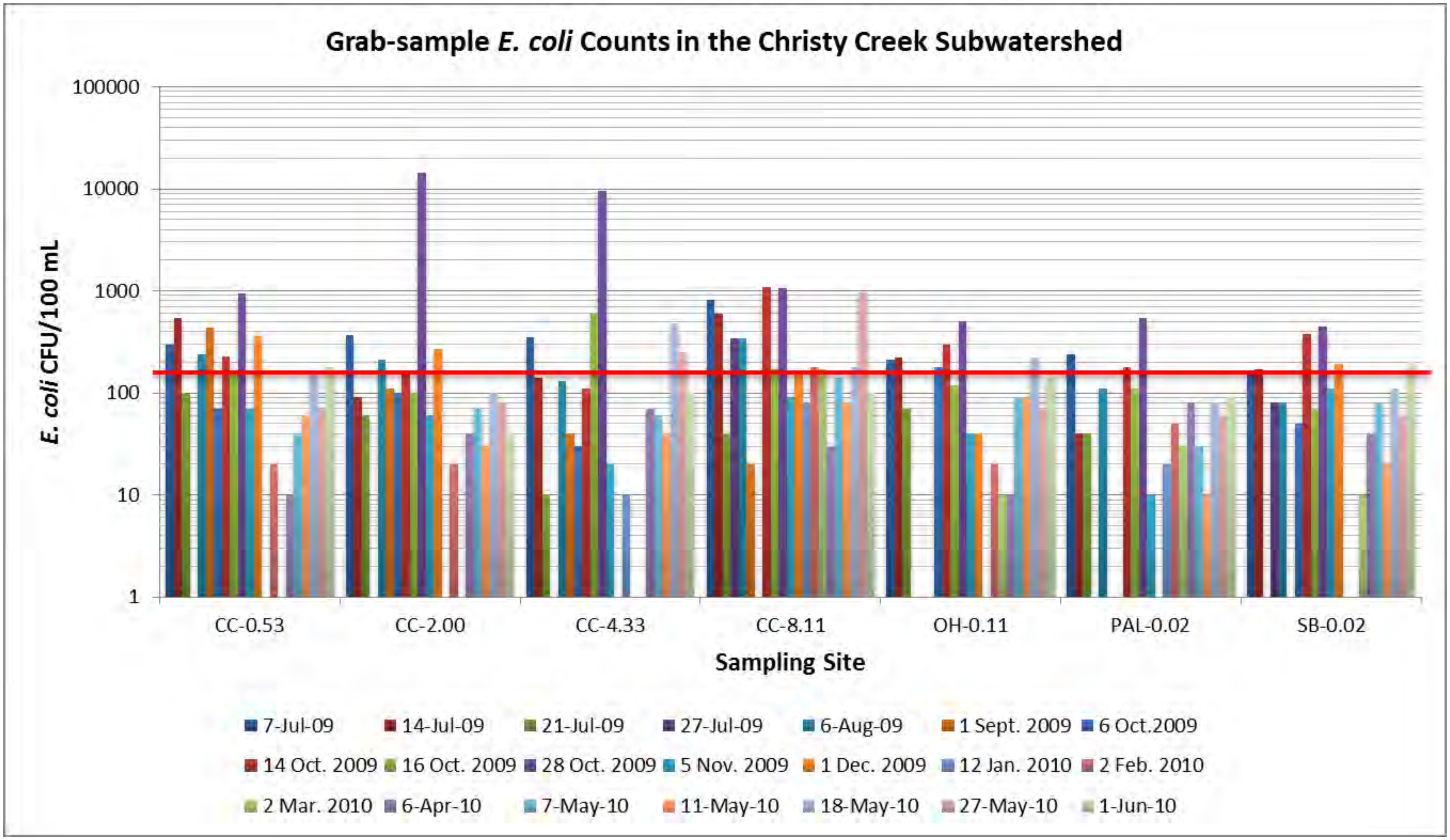

Figure 3.6. Grab sample *E. coli* counts in the Christy Creek Subwatershed. The red line indicates the KDOW limit for 240 *E. coli* CFU/mL for waters designated as primary contact recreation.

Table 3.13. Summary of *E. coli* counts in the Christy Creek subwatershed.

TCW SITE	Number of samples per site	Number of samples ≥240/100 mL	Percent of samples ≥240/100 mL
CC-0.37	20	6	30.0
CC-2.00	21	3	14.3
CC-4.33	20	5	25.0
CC-8.11	21	7	33.3
OH-0.11	17	2	11.8
PAL-0.02	20	2	10.0
SB-0.02	20	2	10.0

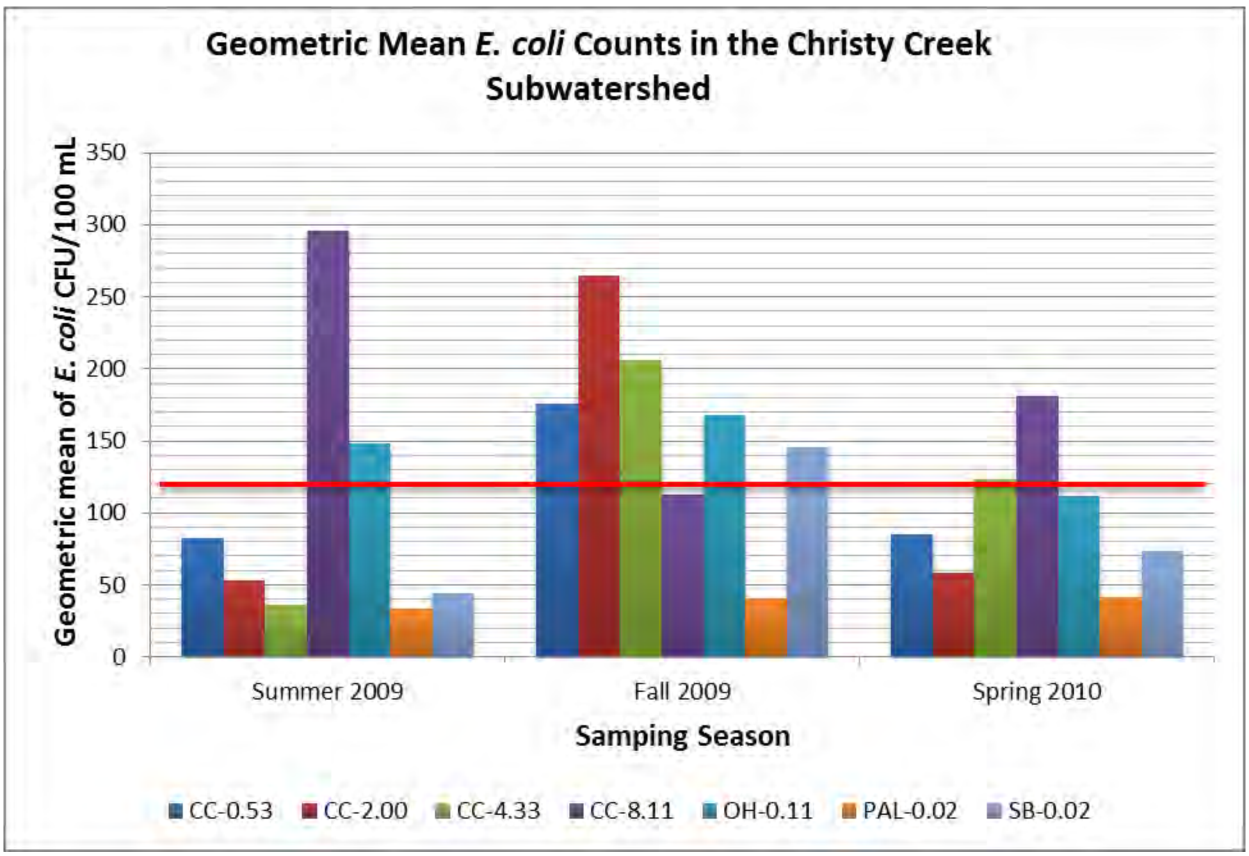

Figure 3.7. Geometric means of *E. coli* counts in the Christy Creek Subwatershed. The counts represent geometric means of five samples per site during the sampling season. The red line indicates the KDOW limit for 130 *E. coli* CFU/mL for waters designated as primary contact recreation.

Table 3.14. Geometric means of *E. coli* counts in the Christy Creek Subwatershed. The yellow highlighted cells indicate values that exceeded the KDOW limit for 130 *E. coli* CFU/mL for waters designated as primary contact recreation.

TCW SITE	Summer 2009	Fall 2009	Spring 2010
CC-0.37	83	176	85
CC-2.00	53	265	58
CC-4.33	36	206	124
CC-8.11	296	112	181
OH-0.11	148	168	112
PAL-0.02	34	40	42
SB-0.02	44	146	73

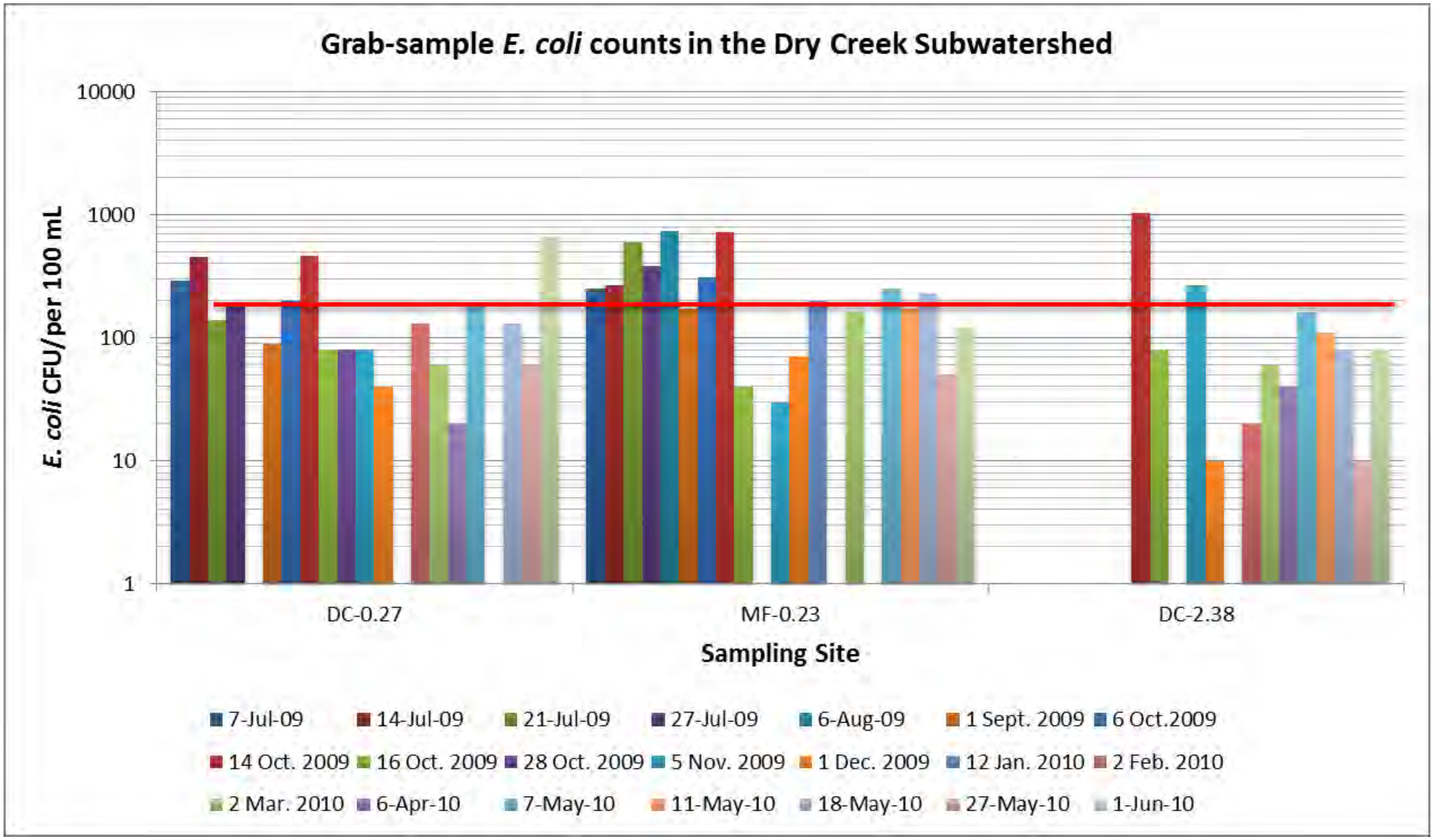

Figure 3.8. Grab sample *E. coli* counts in the Dry Creek Subwatershed. The red line indicates the KDOW limit for 240 *E. coli* CFU/mL for waters designated as primary contact recreation.

Table 3.15. Summary of *E. coli* counts in the Dry Creek Subwatershed.

TCW SITE	Number of samples per site	Number of samples ≥240/100 mL	Percent of samples ≥240/100 mL
DC-0.27	19	4	21.1
MF-0.23	20	8	40.0
DC-2.38	13	2	15.4

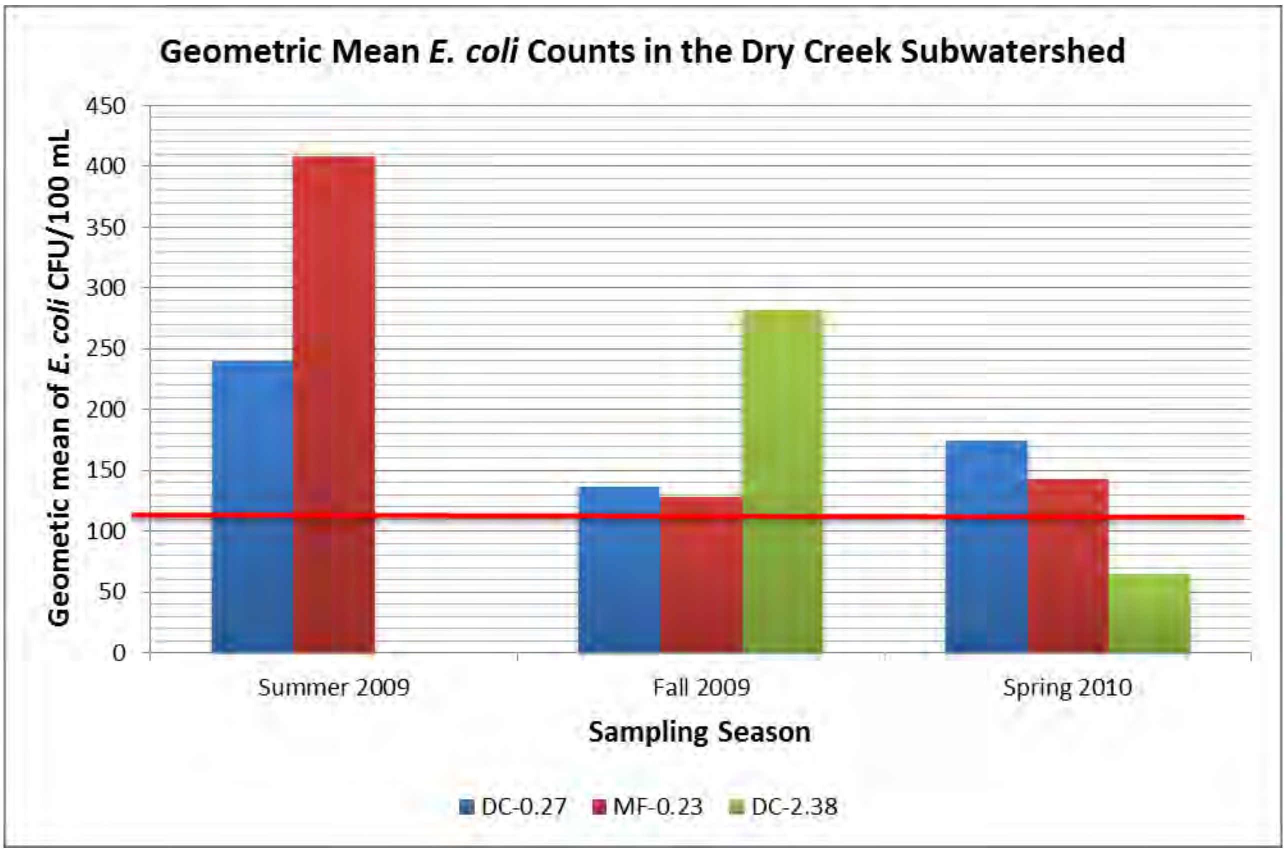

Figure 3.9. Geometric means of *E. coli* counts in the Dry Creek Subwatershed. The counts represent geometric means of five samples per site during the sampling season. The red line indicates the KDOW limit for 130 *E. coli* CFU/mL for waters designated as primary contact recreation.

Table 3.16. Geometric means of *E. coli* counts in the Dry Creek Subwatershed. The yellow highlighted cells indicate values that exceeded the KDOW limit for 130 *E. coli* CFU/mL for waters designated as primary contact recreation.

TCW SITE	Summer 2009	Fall 2009	Spring 2010
DC-0.27	239	136	174
MF-0.23	409	128	142
DC-2.38	*	282	65

*Not enough data collected to determine geometric mean.

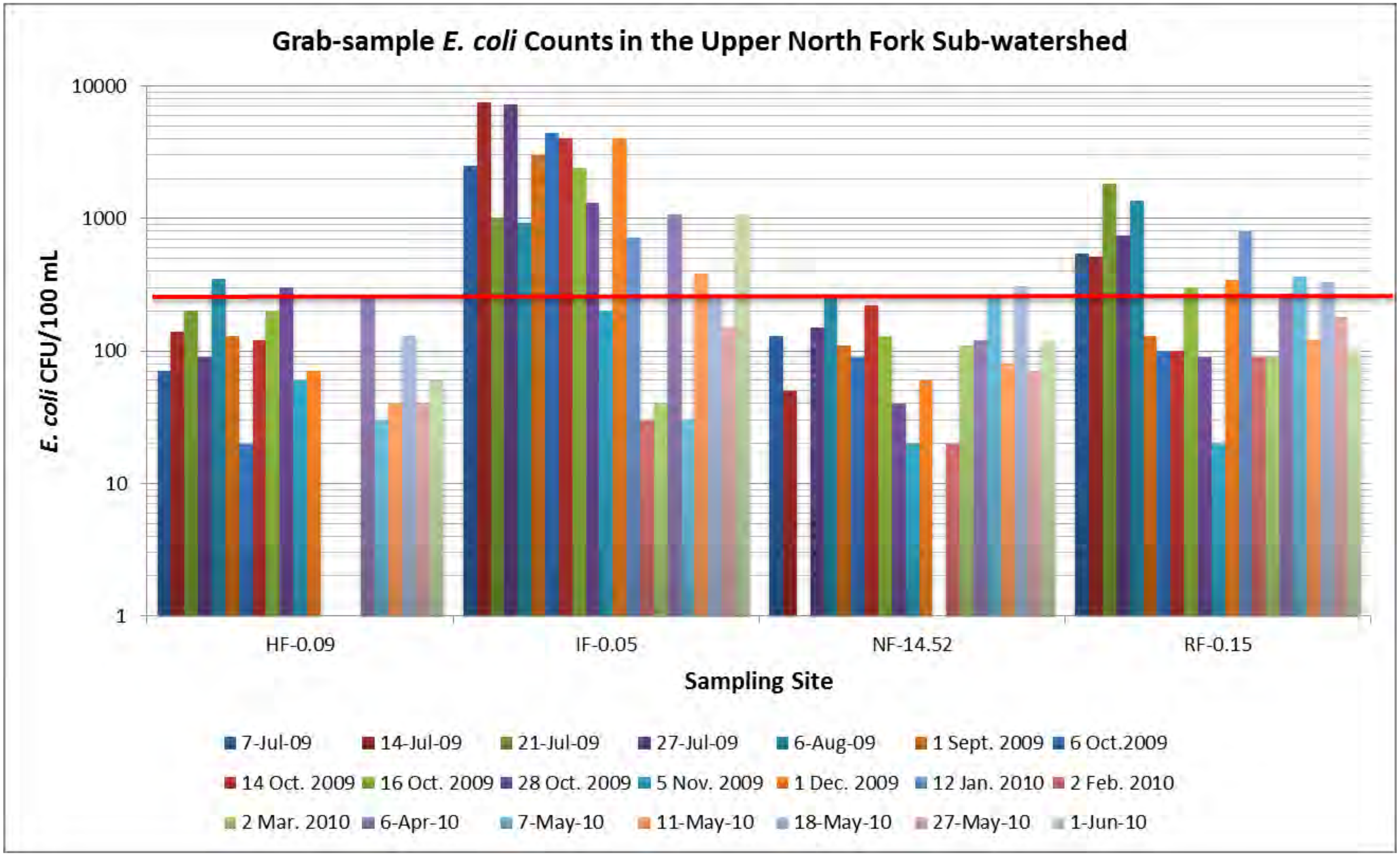

Figure 3.10. Grab sample *E. coli* counts in the Upper North Fork of Triplett Creek Subwatershed. The red line indicates the KDOW limit for 240 *E. coli* CFU/mL for waters designated as primary contact recreation.

Table 3.17. Summary of *E. coli* counts in the Upper North Fork of Triplett Creek Subwatershed.

TCW SITE	Number of samples per site	Number of samples >240/100 mL	Percent of samples >240/100 mL
HF-0.09	21	3	14.3
IF-0.05	21	16	76.2
NF-14.52	21	3	14.3
RF-0.15	21	11	52.4

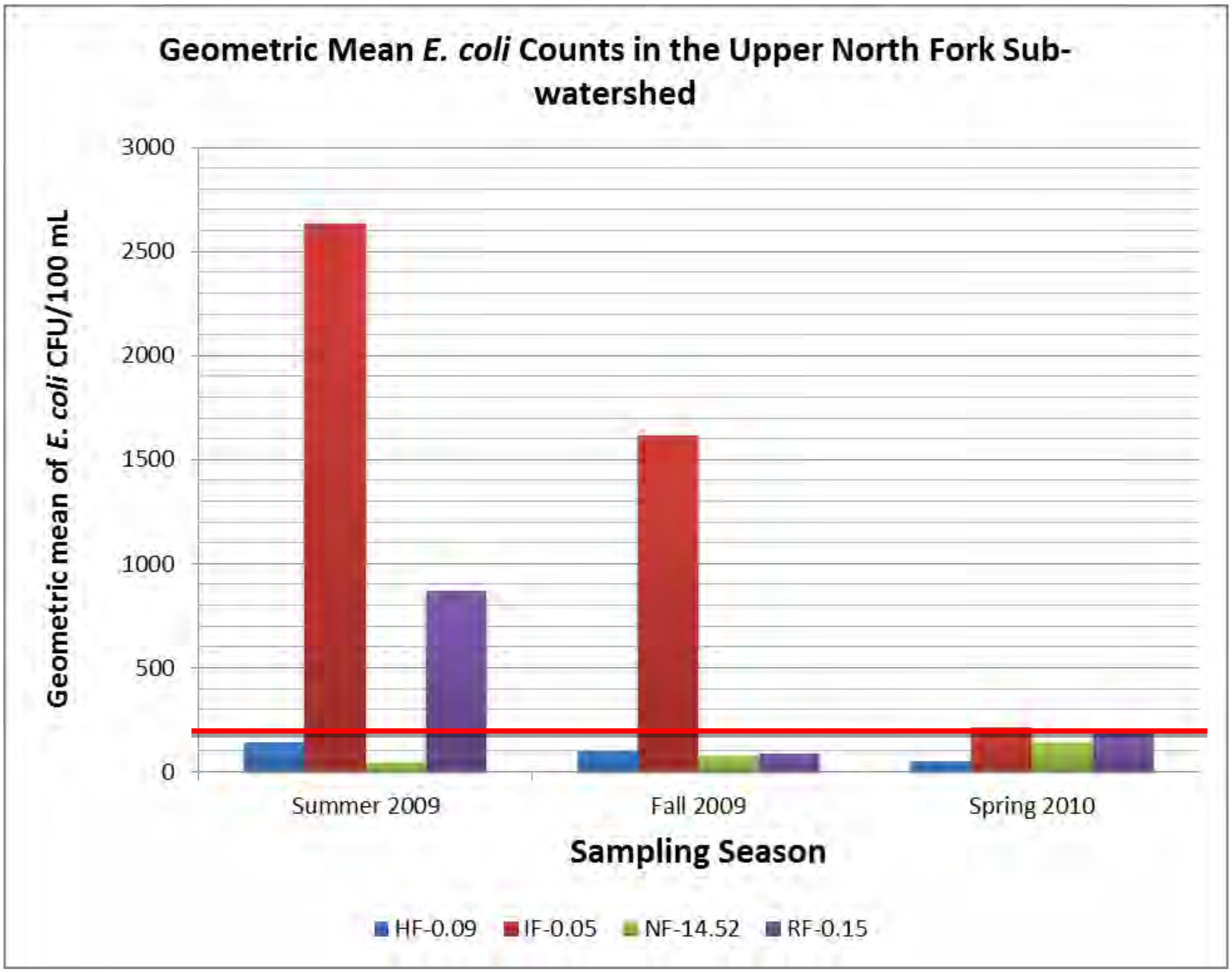

Figure 3.11. Geometric means of *E. coli* counts in the Upper North Fork of Triplett Creek Subwatershed. The counts represent geometric means of five samples per site during the sampling season. The red line indicates the KDOW limit for 130 *E. coli* CFU/mL for waters designated as primary contact recreation.

Table 3.18. Geometric means of *E. coli* counts in the Upper North Fork of Triplett Creek Subwatershed. The yellow highlighted cells indicate values that exceeded the KDOW limit for 130 *E. coli* CFU/mL for waters designated as primary contact recreation.

TCW SITE	Summer 2009	Fall 2009	Spring 2010
HF-0.09	144	97	52
IF-0.05	2630	1615	215
NF-14.52	48	73	139
RF-0.15	872	88	191

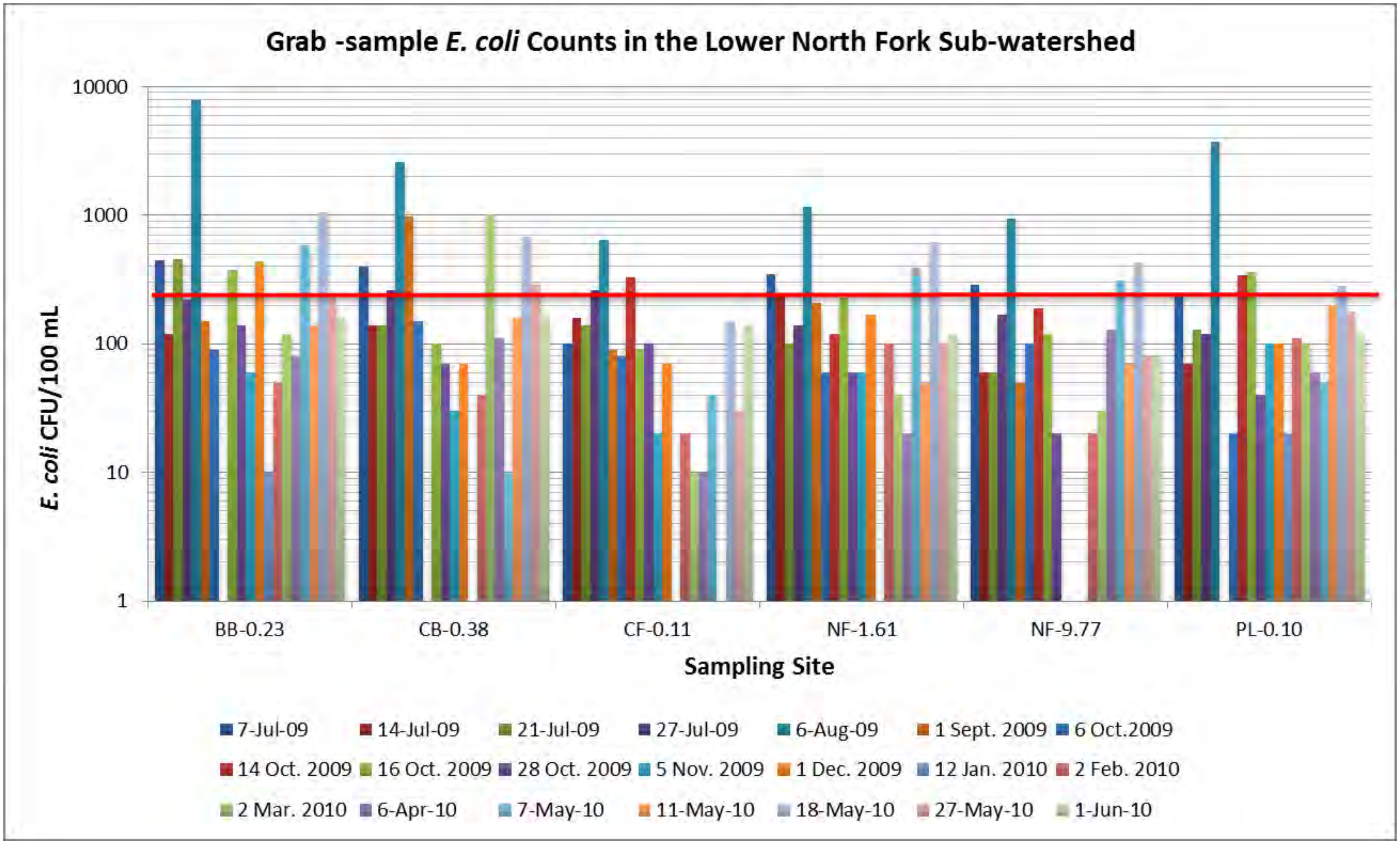

Figure 3.12. Grab sample *E. coli* counts in the Lower North Fork of Triplett Creek Subwatershed. The red line indicates the KDOW limit for 240 *E. coli* CFU/mL for waters designated as primary contact recreation.

Table 3.19. Summary of *E. coli* counts in the Lower North Fork subwatershed.

TCW SITE	Number of samples per site	Number of samples >240/100 mL	Percent of samples >240/100 mL
BB-0.23	20	7	35.0
CB-0.38	20	7	35.0
CF-0.11	21	3	14.3
NF-1.61	21	5	23.8
NF-9.77	20	4	20.0
PL-0.10	20	5	25.0

Table 3.20. Geometric means of *E. coli* counts in the Lower North Fork Subwatershed. The yellow highlighted cells indicate values that exceeded the KDOW limit for 130 *E. coli* CFU/mL for waters designated as primary contact recreation.

TCW SITE	Summer 2009	Fall 2009	Spring 2010
BB-0.23	533	130	316
CB-0.38	351	75	142
CF-0.11	206	86	30
NF-1.61	267	90	171
NF-9.77	176	34	143
PL-0.10	250	100	143

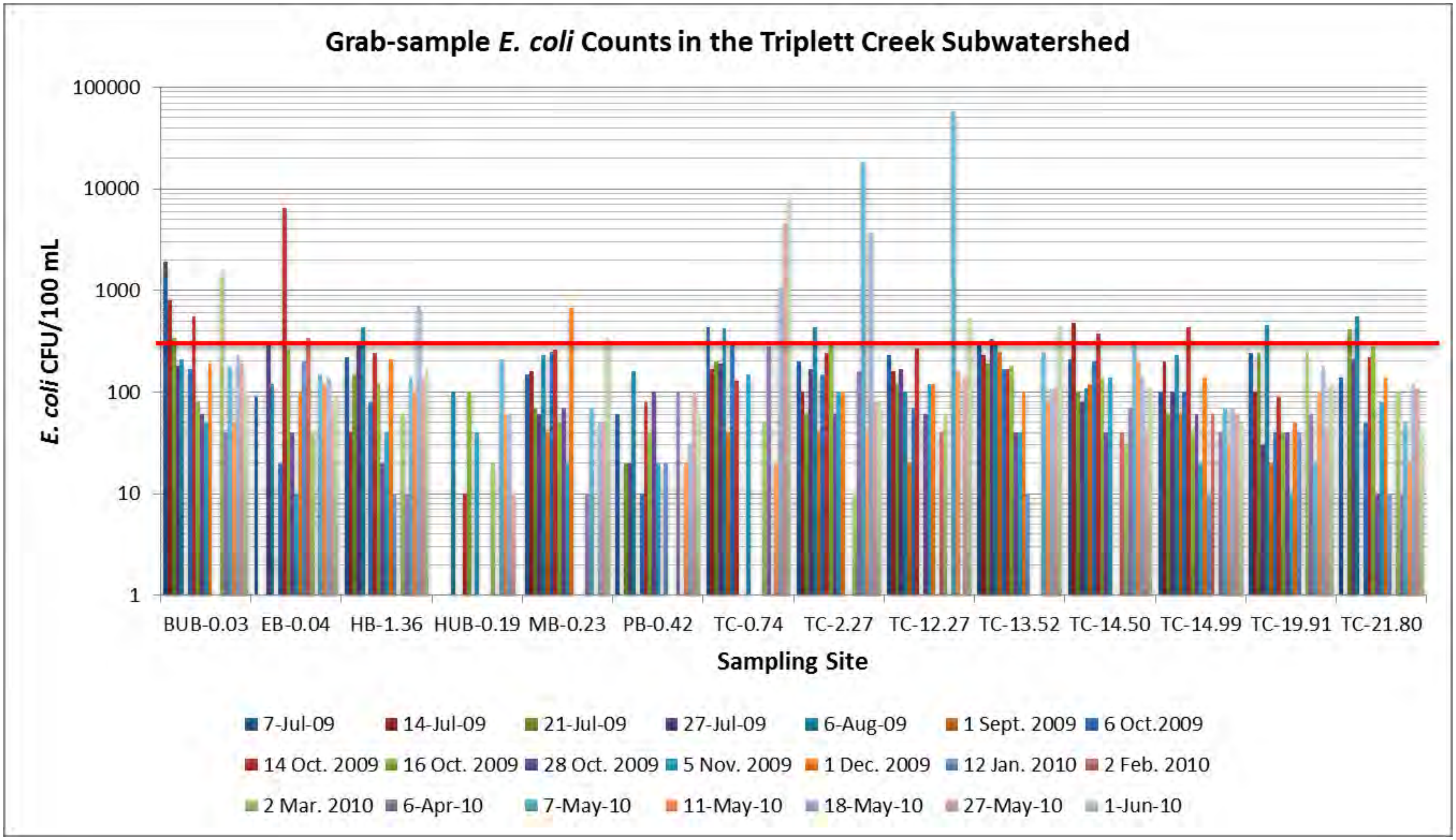

Figure 3.13. Grab sample *E. coli* counts in the Triplett Creek Subwatershed. The red line indicates the KDOW limit for 240 *E. coli* CFU/mL for waters designated as primary contact recreation.

Table 3.21. Summary of *E. coli* counts in the Triplett Creek Subwatershed.

TCW SITE	Number of samples per site	Number of samples >240/100 mL	Percent of samples >240/100 mL
BUB-0.03	19	5	26.3
EB-0.04	20	4	20.0
HB-1.36	20	4	20.0
HUB-0.19	14	0	0.0
MB-0.23	20	4	20.0
PB-0.42	19	0	0.0
TC-0.74	16	7	43.8
TC-2.27	20	5	25.0
TC-12.27	17	3	17.6
TC-13.52	21	6	28.6
TC-14.50	20	3	15.0
TC-14.99	20	1	5.0
TC-19.91	21	4	19.0
TC-21.80	20	3	15.0

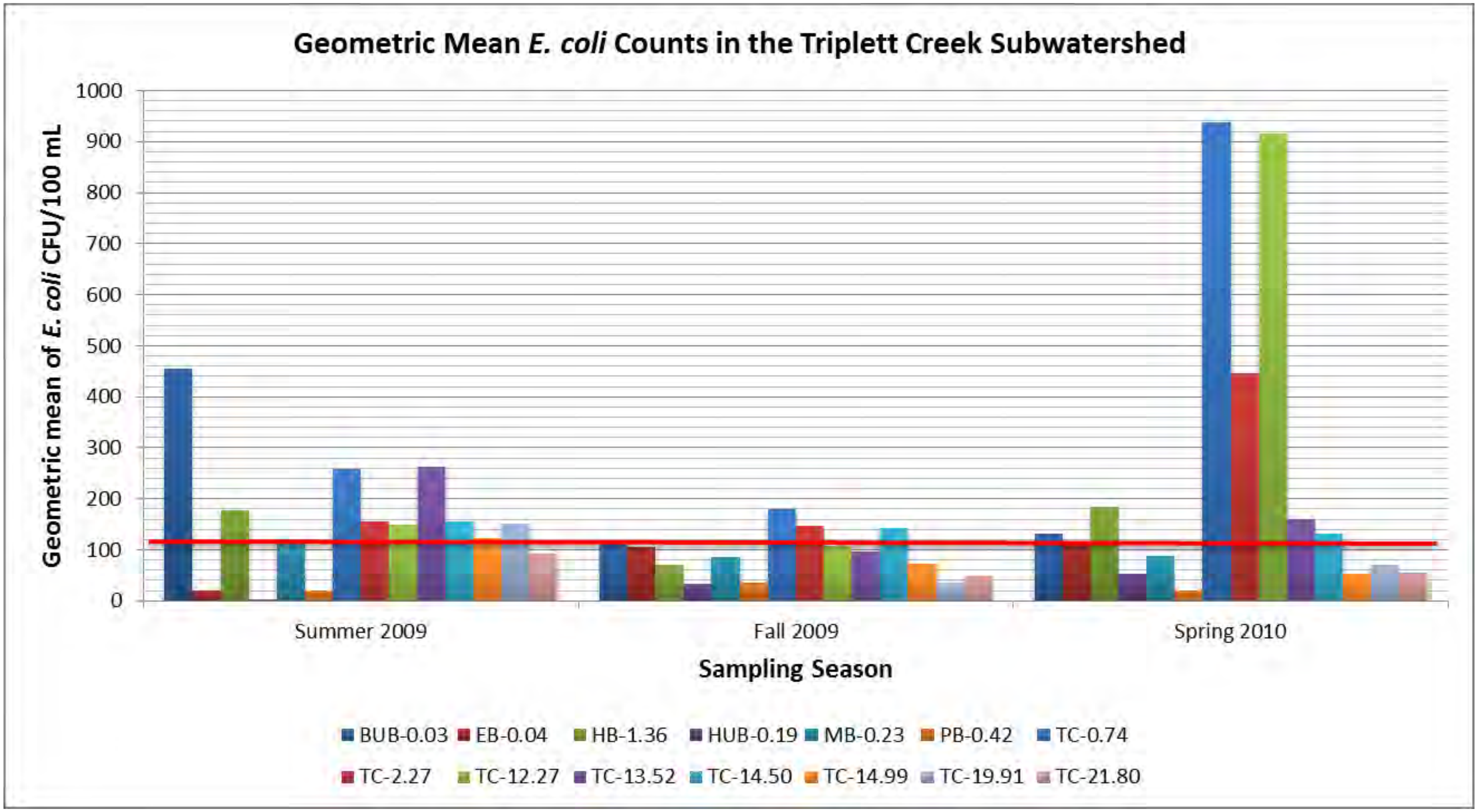

Figure 3.14. Geometric means of *E. coli* counts in the Triplett Creek Subwatershed. The counts represent geometric means of five samples per site during the sampling season. The red line indicates the KDOW limit for 130 *E. coli* CFU/mL for waters designated as primary contact recreation.

Table 3.22. Geometric means of *E. coli* counts in the Triplett Creek Subwatershed. The yellow highlighted cells indicate values that exceeded the KDOW limit for 130 *E. coli* CFU/mL for waters designated as primary contact recreation.

TCW SITE	Summer 2009	Fall 2009	Spring 2010
BUB-0.03	455	118	132
EB-0.04	20	106	110
HB-1.36	177	71	185
HUB-0.19	3	34	52
MB-0.23	118	85	88
PB-0.42	21	36	20
TC-0.74	259	180	938
TC-2.27	155	147	445
TC-12.27	150	108	916
TC-13.52	263	96	160
TC-14.50	155	143	131
TC-14.99	123	73	54
TC-19.91	151	36	70
TC-21.80	92	48	56

Water Quality Data for Parameters without Set Standards

The parameters presented in this section lack specific (numeric values) statutory criteria and must be compared to other criteria or interpreted within the general language of a narrative WQC. When possible, the benchmark data provided by the KDOW was used for comparison. Benchmarks for data screening and prioritization may be lower than those to be used ultimately as targets for reduction, since reference conditions may be well below reductions necessary to restore uses. As implementation and success monitoring is conducted, benchmarks will be re-evaluated in the future.

Specific Conductance (Conductivity)

Background and General Importance for Water Quality

Conductivity is an indirect measurement of the number of ions and other charged particles in water and is often associated with elevated bacteria, phosphate, and nitrate. An example of human impacts on conductivity is the salting of roads, which increase conductivity. Kentucky regulations under 401 KAR 10:031 states “total dissolved solids or specific conductance shall not be changed to the extent that the indigenous aquatic community is adversely affected”. Based on benchmark data from KDOW, 218 µs/cm should be used as a screening value for conductivity

*Results of Conductivity Measurements*The results of the conductivity measurements are presented below. Table 3.23 (page 101) summarizes the conductivity that was recorded during the sampling events. Graphs for each subwatershed can be found in appendix E.

Table 3.23. Summary of conductivity measurements (µs/cm) recorded during sampling events.

Site Name	Conductivity (µS/cm) Range above 218	Times exceeded
Christy Creek Subwatershed		
CC-0.37	222 - 350	4
CC-2.00	210 - 323	4
CC-4.33	218 - 356	6
CC-8.11	209 - 324	5
PAL-0.02	222-332	5
Dry Creek Subwatershed		
DC-0.27	254 - 345	5
Morgan Fork Subwatershed		
MF-0.23	278 - 847	15
North Fork of Triplett Creek Subwatershed		
BB-0.23	210 - 335	7
CB-0.38	210 - 339	9
NF-1.61	285	1
NF-9.77	310	1
HF-0.09	281 - 497	4
RF-0.15	310	1
Main stem of the Triplett Creek Subwatershed		
EB-0.04	270 - 362	9
HB-1.36	289 - 491	6
HUB-0.19	376	1
TC-0.74	291 - 390	2
TC-2.27	315	1
TC-12.27	278 - 327	2
TC-13.52	335	1
TC-14.50	291 - 332	2
TC-14.99	435	1
TC-19.91	274 - 410	4
TC-21.80	378 - 547	10

The Hydrolab and YSI probes' conductivity data support the data collected during monthly sampling. The same sites that exceeded monthly sampling also exceeded conductivity benchmarks during 24-hour monitoring. The exceptions were NF-1.61 and RF-0.15. The conductivity values of the samples at each site had little variation while being monitored every 30-minutes.

Analysis of Conductivity Results

The sites that had conductivity measurements above 218 (µs/cm) are listed in Table 3.23 (page 101). Conductivity levels in Triplett Creek decreased from the headwaters (TC-21.80) to the mouth (TC-0.27). This appears to be dilution from Christy Creek and Dry Creek. The conductivity levels dropped at each site below these tributaries. Even though the tributaries often had high conductivity levels the levels were slightly lower than those of Triplett Creek. It is possible that the increased water volume diluted the concentration of the pollutants associated with conductivity. This indicates that most of the pollutants associated with conductivity are from the watershed around Triplett Creek and not from the tributaries. Christy Creek remained fairly consistent throughout the watershed. In the Dry Creek Watershed Plan (2008), DC-0.27 exceeded conductivity benchmarks. Morgan Fork was the source of most of the pollutants. This study also showed MF-0.23 (a tributary to Dry Creek) is also a source of pollutants. MF-0.23 exceeded conductivity benchmarks more frequently than any other sites, followed by TC-21.80. Conductivity is discussed more in the section of this report called "Impairments Associated with Selected Physical and Chemical Parameters".

Total Nitrogen

Background and General Importance for Water Quality

Nitrogen occurs in the environment in several forms, most of which are major nutrients for plants and algae. Nutrient enrichment of surface waters may cause excessive algae and aquatic plant growth. The resulting, often explosive, plant and algae growth can cause large DO fluctuations. During daylight hours, this growth causes excessive DO production but at night, when photosynthesis ceases, plants and decomposers use up much of the oxygen. After seasonal die-off, rotting of excessive vegetation produced by nutrient enrichment may create large oxygen demands thus reducing DO and suffocating fish and other aquatic organisms. The recommended benchmark for Total Nitrogen (TN) is 0.650 mg/L.

Results of Total Nitrogen Measurements

Six hundred eighteen of the six hundred twenty-one samples exceed the benchmark of 0.65 mg/L of TN. The values ranged from 0.65 to 8.06 mg/L. The 10 sites with the highest average TN are listed below in Table 3.24 (page 103). Appendix E contains graphs of TN concentrations for each subwatershed.

Table 3.24. Sites with the highest average TN.

Site ID	Average TN (mg/L)
Christy Creek Subwatershed	
CC-8.11	2.66
CC-4.0	2.42
Morgan Fork Subwatershed	
MF-0.23	2.48
Main stem of Triplett Creek Subwatershed	
HB-1.36	2.58
PB-0.42	2.62
TC-2.27	2.48
TC-13.50	2.41
TC-14.99	2.42
TC-19.91	2.43
TC-21.80	2.49

Analysis of Nitrogen Results

All of the instantaneous combined nitrogen concentrations were lower than Total Nitrogen levels of 10 mg/L. “The MCLG for nitrate is 10 mg/L or 10 ppm. EPA has set this level of protection based on the best available science to prevent potential health problems. EPA has set an enforceable regulation for nitrate, called a maximum contaminant level (MCL), at 10 mg/L or 10 ppm.” (US EPA, May 21, 2012). However, all but three of the samples exceeded benchmark data. The high TN levels are associated with agriculture, urban and suburban land use. In addition to the TN, all of the other forms of nitrogen are high. In the Christy Creek watershed, TN levels remain relatively constant throughout the watershed, with the exception of the lowest flow periods in July and August of 2009. At this point the concentration of TN increase and CC-0.37 concentration become higher than the upper portions of the watershed. This fact, combined with the *E. coli* data, strongly suggests that improper septic systems are a major source of polluted. The TN values in the North Fork of Triplett appear to be more influenced by livestock. With a few exceptions there is little housing near the creek and cattle concentrations are higher in these areas. In the lower portions the land use near the creek is mostly crops and livestock. There was little variation in the main stem of Triplett Creek. The other forms of nitrogen are not included in this watershed report since they are included in the TN and ammonia values. Nitrogen is discussed more in the section of this report called “Impairments Associated with Selected Physical and Chemical Parameters”.

Total Phosphorus

Background and General Importance for Water Quality

Total phosphorus (TP) is made up of soluble and non-soluble phosphorus. Soluble phosphorus (dissolved phosphate or ortho-phosphorus) is more readily available for use by organisms and is more likely to lead to rapid algal growth. Therefore, this nutrient can lead to low DO and higher pH. Non-soluble phosphorus is sediment-bound and is less likely to promote rapid algal growth but remains available for organisms’ use for longer time periods. The TP recommended benchmark is 0.020 mg/L.

Results of Phosphorous Measurements

The average TP of the reference reach streams is 0.020 mg/L. All of the sites (and all but one sample) in this study exceeded 0.020 mg/L of TP. The TP values ranged from 0.020 to 0.837 mg/L. The ten sites with the highest average TP are listed below in Table 3.25 (page 105). Graphs illustrating TP concentrations in the Triplett Creek Watershed for each subwatershed can be found in appendix E.

Table 3.25. Sites with the highest average TP.

Site ID	Average TP (mg/L)
Christy Creek Subwatershed	
CC-2.00	0.270
OH-0.11	0.279
Dry Creek Subwatershed	
DC-0.27	0.269
Rock Fork Subwatershed	
IF-0.05	0.274
Lower North Fork of the Triplett Creek Subwatershed	
NF-9.77	0.266
PL-0.10	0.303
Main stem of Triplett Creek Subwatershed	
MB-0.23	0.285
PB-0.42	0.279
TC-0.74	0.275
TC-13.52	0.265

Analysis of Phosphorous Measurements
TP concentrations greatly exceed the 0.020 mg/L benchmark data. No clear patterns were established in the watersheds. Christy Creek TP values are general higher in the lower portions of the watershed. This supports that septic systems are thought to be a source of pollutants. Phosphorus is discussed more in the section of this report called "Impairments Associated with Selected Physical and Chemical Parameters".

Sulfate
Background and General Importance for Water Quality
Sulfate (SO_4) occurs naturally in water. Non-natural sources of sulfate are the atmosphere from air pollution (combustion of coal and biomass). Ingestion of water containing very high levels of sulfate can cause diarrhea. The benchmark data for sulfate is 13.82 mg/L.

Results of Sulfate Measurements
Five hundred eighty seven of the six hundred seventy five samples exceeded the 13.82 mg/L benchmark. The sulfate concentrations ranged from 5 mg/L to 81 mg/L. The highest concentrations were found in TC-21.80 (headwaters of Triplett Creek) and TC-19.91, 81 and 68 mg/L respectively. Of the 20 highest values 9 were from TC-21.80 and 4 from TC-19.91.

Analysis of Sulfate Results
None of the values exceeded the National Drinking Water Regulations of 250 mg/L. In general all of the sulfate concentrations were higher upstream and upwind of the MSU Heating Plant. If the burning of fossil fuels is the source of higher sulfate levels, these levels should drop since MSU is no longer burning coal at its Heating Plant. The plant was converted in the summer of 2011.

STREAM AND WATERSEHD LAND USE ASSESSMENTS
As discussed in Section 2, various land use practices negatively impact the water quality of Triplett Creek and its tributaries. We conducted different land use assessments. The first was a visual assessment of the watershed. The second was the habitat assessment of the sampling sites.

Visual Assessments of subwatersheds
The visual assessment was conducted by photographing the land use practices in and around the streams in each subwatershed to represent common and dominant land use practices. Figures 3.15 through 3.46 (pages 107-134) are sample photographs from each subwatershed. All of the watersheds had obvious land use practices that negatively impact the water quality and quantity of water. In each subwatershed channelized streams were more common than non-channelized streams. The riparian zones are also lacking native vegetation. Several landowners stopped to tell story about how the streams have changed over the years. One common story was the how much more water flow varied. This was most noted during summer flows. Many area residents commented on how the water ran dry or almost dry now and when they were young the streams had water all summer (and a great amount). There were also many comments on increased development along the streams.

The photos below are representative photos of the land use practices with in each subwatershed. The photos are not designed to single out any one land owner. The practices in these photos were found throughout the watershed. Everyone that lives in the watershed impacts water quality as a collective and are responsible as a collective to be good stewards of the water that the community uses in so many ways.

Christy Creek Subwatershed

Figure 3.15. Photos from Christy Creek Watershed, CC-0.37.

The subwatershed of CC-0.37 is the most developed section of the Christy Creek watershed. The figures above are typical of the watershed. There several areas have exposed soils on the hillsides (figure on the left). The areas along the stream have a narrow row of trees and the hillsides are mostly forested. This is primarily a residential with rental units (figure on the right) watershed with some small patches of livestock. There is some commercial development (commercial rental property).


Figure 3.16. Photos from the Christy Creek Watershed, CC-2.00.

The subwatershed of CC-2.00 has little residential areas. The stream has been channelized through most of the section for agriculture, roads, and development. The streambank is severely eroding in several sections and have been 'reinforced' in several areas to protect the road and residential areas. There are several barren areas. The main stem Christy Creek only has a small strip of trees. The photo on the top right is an example of the channel straightening. The photo on the top right and bottom left show the streambank reinforcements and the strip of trees are exist along most of the main stem. The bottom left shows the exposed areas in the watershed. There are a few small businesses in this watershed (car lot, greenhouse, junk yard)

Figure 3.17. Photos from Christy Creek Watershed, CC-4.33.

The subwatershed of CC 4.33 few little residential areas. However, more land clearing has been occurring, which indicate more development is planned for the area. The two bottom photos represent the land clearing that has occurred. These developments have occurred away from the main stem of Christy Creek. The stream has been channelized through most of the section for agriculture, roads, and development. The instream channel has many sections of solid rock substrate (top right). The valleys are mostly cleared of trees and maintained as residential yards.

Figure 3.18. Photos from Christy Creek Watershed, CC-8.33.

The stream is channelized because it runs along State Route 32 (left). The area is more developed than it first appears. Most of the development is along the tributaries (right). There are several fields with livestock and some small business (green house, store), although it is mostly residential

Figure 3.19. Photos from Old House Watershed, OH-0.11.

This subwatershed is mostly forested with only a few residential areas. The stream has been channelized (left) to make room for development in the narrow valley (right).

Figure 3.20. Photos from Patty's Lick Watershed, PAL-0.10.

Like most of the streams in the Triplett Creek Watershed the Patty's Lick stream has been channelized for development (top left, bottom right and left). The valley is narrow and the hillsides are forested. Even with the forested slopes the streambanks are eroding (top right) and have been reinforced (bottom right). This is a residential watershed only.

Figure 3.21. Photos from Seas Branch Watershed, SB-0.02.

The Seas Branch watershed is a narrow valley. Portions of the hillsides have been de-voided of trees (left). The stream has been channelized against the hillside for residential development and road construction (right).

Dry Creek Subwatershed

Figure 3.22. Photos from Dry Creek Watershed, DC-0.27.

The lower portion of the Dry Creek watershed is the most developed section of the watershed. There are several rental properties. There are a few businesses (vehicle repairs, archery shop, lumber yard). The stream has several bridge crossings (left) and the stream is channelized for road construction and development (right). Detailed descriptions of the Dry Creek watershed are also available in the Dry Creek Watershed Based Plan (2008). The open areas along the streams are either used for hay production or maintain as yards.

Figure 3.23. Photos from Dry Creek Watershed, DC-2.84.

This section of Dry Creek is less development. Development along the main stem is not as close the stream. Along the tributaries the development is adjacent to the stream. Erosion along ditch lines created to protect the roads from development is common (left) barren land is also present from development. Most of the land adjacent to the stream is in fields.

Island Fork Subwatershed

Figure 3.24. Photos from Island Fork Watershed, IF-0.10.

The Island fork watershed has a wide valley that is used for grazing. The hillsides are covered with trees. The cattle are not restricted from the stream (left) and there is very little canopy cover (right).

Morgan Fork Subwatershed


Figure 3.25. Photos from the Morgan Fork Watershed, MF-0.23.

Morgan Fork has a visibly high sediment load compared to Dry Creek. It has been significantly channelized from the construction of 519 and housing developments (left). This watershed contains a mix of residential and commercial (right). The amount of commercial development is much greater than the Dry Creek and it is concentrated along the stream.

Lower North Fork of Triplett Creek

Figure 3.26. Photos from the Big Brushy Watershed, BB-0.23.

The Big Brushy watershed contains many open fields that are used for pastures (top left and right). The pastures are used for cattle. Many of the pastures have open access to the stream (top right). The streams with rocky substrates are common; several sections still have a thin strip of tree lining the stream. However there are several tributaries that have been straighten and channelized (bottom right). Gravel mining, straightening, and development are close to the stream.

Figure 3.27. Photos from Copperas Branch Watershed, CB-0.23.

Copperas Hollow is a residential area. The intermittent stream has been straightened to increase drainage from yards (left). There is an increasing amount of land clearing (right).

Figure 3.28. Photos from Pond Lick Watershed, PL-0.10.

Pond Lick is a large watershed with wide valleys. There is very little development in the watershed. The houses are set back from the creek, but yards and fields are maintained up to the creek. The fields are used for grazing cattle and horses. Even though there is little development the main stream and its tributaries have been straightened (left).

Figure 3.29. Photos from North Fork of Triplett Creek Watershed, NF-1.97.

The lower section of North Fork of Triplett Creek is a diverse watershed. It containers farm land (top left), commercial development (top right, middle left), and pasture land for horses and cattle (middle right, bottom left). The stream has been straightened in many sections for road development and agricultural purposes. Not shown here are the large acres of row crops. The trees have been removed along most of the streams, and many of the livestock and cattle have unlimited access to the stream. Logging is also active in the area.

Upper portion of North Fork of Triplett Creek

Figure 3.30. Photos from Clear Creek Watershed, CR-0.10.

The Clear Creek stream has a rocky substrate (top left). The headwaters of the stream are protected by National Forest (top right) who have developed wetlands (bottom left). There is a golf course within this watershed (bottom left). The housing in this watershed is set back from the streams.

Figure 3.31. Photos from Holly Fork Watershed, HF-0.10.

Holly Fork is a mix of National Forest, agriculture, and housing. There are small herds of livestock (top left) within the watershed. All appear not to have access to the streams. A natural gas line crosses in several locations (top right, bottom left). Most of the trees have been cleared from the stream (bottom left, right). The stream has been straightened and there are several stream crossings (bottom right).

Figure 3.32. Photos from Rock Fork Watershed, RF-0.20.

The Rock Fork Watershed is mainly an agricultural watershed with a wide valley (left). The housing is set back from the stream. There is very little canopy cover and erosion is present (right). Active logging was being conducted during our sampling.





Figure 3.33. Photos from North Fork of Triplett Creek Watershed, NF-9.97.

This watershed is a large valley with forest hillsides and tops. The main stem of North Fork of Triplett Creek is a narrow strip of trees along the riparian zone (top left). Although there is a very rural watershed there are several landuse practices that impact the watershed. The top right photo is a photo of a large junk yard. Other similar smaller areas exist (bottom left). Land is being cleared for development and use. There is some logging in this watershed (bottom right).

Figure 3.34. Photos from North Fork of Triplett Creek Watershed, NF-14.99.

The stream has been straightened in several sections (top left). Erosion is more visual able in the watershed (top right). The watershed has several fields with cattle and some horses (bottom left). There are many open fields that are used for hay production and crops as well (bottom right).

Main Stem of Triplett Creek

Figure 3.35. Photos from Buffalo Branch Watershed, BUB-0.10.

This is a relatively small, narrow valley watershed with a few residents. The stream has been straightened for development (left). There are a few non-bridge crossings. Many of the houses are constructed close to the streams (right).

Figure 3.36. Photos from Hayes Branch Watershed, HB-1.36.

This watershed, like many of the others, has the development concentrated in the valleys. There is also a lot of development on the ridges. The development is both residential and commercial. There is a significant amount of streambank erosion (top left). There has been straightening of the stream for road development (top right, bottom left). Many of the trees have been removed and only a small amount of trees remain along the stream (bottom right).

Figure 3. 37. Photos from Martin Branch Watershed, MB-0.23.

Martin Branch has two residential areas. One is an apartment complex (left) and another is a single dwelling subdivision, both of which are concentrated along the stream. The stream has been straightened for the developments. The residential areas are separated by the Kentucky Division of Forestry and Rodburn Park (a City Park).

Figure 3.38. Photos from the Pig Perry Watershed, PB-0.52.

The Big Perry Watershed has very logging operations and housing. There is a recreational farm with horses adjacent to the stream.   The stream has been straightened for development and road building (top left). The streambanks are eroding (top right, bottom left). Most of the canopy cover has been removed either on both or one side (bottom left). The narrow valley has most of the development concentrated along the stream (bottom right).

Figure 3.39. Photos from Triplett Creek Watershed, TC-0.74.

This is the lowest reaches of the watershed. It is composed of a large flat area that has several farms consisting of cattle, horses, and crop production (left). The community of Farmers is located in this section of the watershed (right).

Figure 3.40. Photos from Triplett Creek Watershed, TC-2.27.

This section of the watershed is a mix of residential, industry and grazing. There are a number of open undeveloped fields (top left). Several of the tributaries have been straighten for drainage and road development (top right). A small industrial park is located in the watershed (bottom left). Several fields, which are not adjacent to the main stem of Triplett Creek, are used for grazing (bottom right).

Figure 3.41. Photos from Triplett Creek Watershed, TC-12.27.

This is one of the more developed sections of the watershed. This area covers much of the Clearfield area. The watershed contains gas stations (top left), residential areas (top right), and many roads and parking lots (bottom right and left).

Figure 3.42. Photos from Triplett Creek Watershed, TC-13.52.

This watershed takes in the west portion of Morehead, KY.   The area includes channelized streams (top left), roads, and commercial development (top right), parking lots (bottom left), and mixed housing and commercial development (bottom right). The development is concentrated along the stream with the hillside remaining mostly forested. This watershed contains the MSU drinking water intake.

Figure 3.43. Photos from Triplett Creek Watershed, TC-14.52.

This watershed is not as developed as TC-13.52, but there is still quite a few roads (top left), commercial property, and housing (top right). The channel has been straighten and stream bank erosion is extensive (bottom left). There are several areas where vegetation has been removed (bottom right).

Figure 3.44. Photos from Triplett Creek Watershed, TC-14.99.

There are several scattered commercial developments (top left). Many areas have been cleared for development (top right). Erosion and stream channelization for roads, development, and bridges are common (bottom left). There are several open fields (bottom right). The fields are a mix of hay production and grazing.

Figure 3.45. Photos from Triplett Creek Watershed, TC-19.52.

Logging is active in this site (top left) and the stream has been channelized (top right).   The photo on the top right is a section of Triplett Creek that has been channelized and paved. Roads have caused the stream to be channelized (bottom left). Most of the development is housing, which tends to be close to the stream (bottom right).


Figure 3.46. Photos from Triplett Creek Watershed, TC-21.80.

Triplett Creek has been straightened for drainage and develop (left). There are residential areas (right). The riparian zone along the stream is kept mowed.

Habitat Assessments

Habitat assessments include riparian zones (the area adjacent to the streambanks) along with instream conditions. The results of each assessment can be found in appendix F. The worst possible score is 0, while the best possible score is 200. For this study, assessments were completed in June 2009 and November/December 2009 in order to observe different flow conditions since flow strongly affects scoring. Results were then averaged for each site (Table 3.26, page136). Habitat quality varies widely throughout the watershed. Riparian zones have been extensively altered. Trees have been removed from one side and, in many cases, both sides of streams. The complete habitat assessments results for each sites parameters can be found in appendix F.

Table 3.26. Average habitat assessment score for each site.

Site ID	Stream Name	Average Score	Rating
Christy Creek Subwatershed			
CC-0.37	Christy Creek	113	Poor
CC-2.00	Christy Creek	137.5	Fair
CC-4.33	Christy Creek	111	Poor
CC-8.11	Christy Creek	132	Fair
OH-0.11	Old House Creek	116.5	Poor
PAL-0.02	Patty's Lick Branch	123.5	Fair
SB-0.02	Sea Branch	122	Fair
Dry Creek Subwatershed			
DC-0.27	Dry Creek	107	Poor
DC-2.38	Dry Creek	104	Poor
Island Fork Subwatershed			
IF-0.05	Island Fork	86.5	Poor
Lower North Fork of Triplett Creek Subwatershed			
BB-0.23	Big Brushy Creek	138.5	Fair
CB-0.38	Copperas Branch	133	Fair
NF-1.61	North Fork Triplett	147.5	Fair
NF-9.77	North Fork Triplett	133.5	Fair
PB-0.42	Perry's Branch	101	Poor
Morgan Fork Subwatershed			
MF-0.23	Morgan Fork	100	Poor
Upper North Fork of Triplett Creek Subwatershed			
CF-0.11	Clearfork	143	Fair
HF-0.09	Holly Fork	100	Poor
PL-0.10	Pond Lick	168	Good
RF-0.15	Rock Fork	136.5	Fair
NF-14.42	North Fork Triplett	90.5	Poor
Triplett Creek Subwatershed			
BUB-0.03	Buffalo Branch	138.5	Fair
EB-0.04	Evan Branch	76.5	Poor
HB-1.36	Hays Branch	99.5	Poor
HUB-0.19	Hungry Branch	92.5	Poor
MB-0.23	Martin Branch	125	Fair
TC-0.37	Triplett Creek	133	Fair
TC-2.27	Triplett Creek	145	Fair
TC-12.27	Triplett Creek	137	Fair
TC-13.52	Triplett Creek	118.5	Fair
TC-14.50	Triplett Creek	124	Fair
TC-14.99	Triplett Creek	106.5	Poor
TC-19.91	Triplett Creek	88.5	Poor
TC-21.80	Triplett Creek	111.5	Poor

The sites with the worst average habitat assessment scores were EB-0.04 and IF-0.05, with a score of 76.5 and 86.5 respectively (Figure 3.48, below). The sites with the best overall average habitat assessment scores were PL-01.10 (168) and NF-1.61 (Figure 3.49, below).

Figure 3.47. Photos of the two worst sites, EB-0.04 (left) and IF-0.05 (right).

The figures above are typical of each site. Neither of the sites have canopy cover and lack native vegetation. Instream habitat diversity is lacking at each site.

Figure 3.48. Photos of the two best sites, NF-1.61 (left) and PL-0.10 (right).

The sites with the highest scores have a variety of instream habitat scores and canopy cover. The riparian zones were not mowed up to the edge of the stream and some native vegetation was present.

Riparian vegetation zones had the lowest average scores. The average score of all the sites for the left bank was 3.6, out of a score 10. The average score of all the site for the right bank was 3.6, out of score 10. Left bank stability, right bank stability, left bank vegetative protection and right bank vegetative protection scored very poorly. The average scores for all the sites were 6.34, 6.38, 6.18, and 6.29, respectively. Every sample site had channel alteration and structure (straightening, dredging, and bridges).

Highest scores would be given to a site that has vegetation cover of 18 meters or more. The vegetation cover is scored even higher if it consists of native plants. The lack of vegetation cover is a large contributor of bank erosion. The average habitat score of the reference reach data (with the same scoring criteria) is 165. Only one sample site (PL-0.10, 168) had an individual habitat assessment score above the reference reach data.

Sediment

Total Suspended Solids (TSS)

Total suspended solids were measured throughout the Triplett Creek Watershed. This method reflects the amount of fine sediment "floating" in water samples. TSS is widely used and can be compared to Western Allegheny reference reach data. The fine particles suspended in the water column that are measured by TSS methods consist of organic and inorganic solids, usually fine sediment and algae. It negatively impacts water quality by reducing sunlight penetration for aquatic plants, which provide oxygen and food for organisms. Settling of suspended solids can also cover creek bottoms, destroying habitat and smothering spawning areas. TSS shows considerable variation from day to day since it is controlled by many factors (e.g., stream flow, rainfall, land use, geology, biological productivity, nutrient levels, etc.).

A firm WQC has not been established for suspended sediment. The narrative WQC for Kentucky regulations under 401 KAR 10:03 that, "total suspended solids shall not be changed to the extent that the indigenous aquatic community is adversely affected." The WQC for Kentucky regulations under 401 KAR 10:03 also states, "Total suspended solids shall not be changed to the extent that the indigenous aquatic community is adversely affected."

Based on the benchmark data from KDOW, 6.5 mg/L is used here as an informal maximum concentration that will not adversely impact aquatic life. The benchmark data is based on April –October normal flow condition. The TSS samples that exceeded 6.5 mg/L between April and October are listed in Table 3.27 (pages 138-240).

Results of TSS Measurements

The results of the TSS are shown below. Table 3.27 (pages 138- 240) show all sites and dates between April and October that exceed the benchmark of 6.5 mg/L. Figures that show all of the TSS concentrations measured for each subwatershed can be found in appendix E. All of the samples included in this table were collected during normal to low flow periods. The low flows in summer and fall would be considered 'normal' for this time of year.

Table 3.27. Summary of TSS (mg/L) for sites that exceed 6.5 mg/L between April and October.

Site Name	Date Sampled	TSS (mg/L)
Christy Creek Subwatershed		
CC-0.37	5/5/2010	35.2
CC-0.37	8/5/2009	25.2
CC-0.37	9/1/2009	24.0
CC-0.37	10/27/2009	136.4
CC-2.0	10/27/2009	11.2
CC-4.33	10/27/2009	15.6
CC-8.11	7/13/2009	8.0
CC-8.11	10/27/2009	31.2
SB-0.02	6/1/2010	8.4
SB-0.02	7/13/2009	34.0
Dry Creek Subwatershed		
DC-0.27	5/5/2010	6.8
Island Fork and Rock Fork Subwatershed		
IF-0.05	7/15/2009	42.4
IF-0.05	9/1/2009	54.8
RF-0.15	7/13/2009	30.4
RF-0.15	7/15/2009	6.8
RF-0.15	7/27/2009	20.8
RF-0.15	8/5/2009	8.0
RF-0.15	9/1/2009	16.0

Table 3.27. Summary of TSS (mg/L) for sites that exceed 6.5 mg/L between April and October (continued).

North Fork of Triplett Creek Subwatershed		
BB-0.23	5/11/2010	19.6
BB-0.23	7/6/2009	2864.0
BB-0.23	7/15/2009	39.2
BB-0.23	8/5/2009	22.0
CB-0.38	7/6/2009	11.6
CB-0.38	7/15/2009	14.8
CB-0.38	8/5/2009	10.0
CB-0.38	10/16/2009	10.8
CF-0.11	5/5/2010	16.8
CF-0.11	7/6/2009	7.2
CF-0.11	7/13/2009	130.4
CF-0.11	10/4/2009	61.6
HF-0.09	9/1/2009	7.2
NF-1.61	5/11/2010	6.8
NF-1.61	5/18/2010	15.6
NF-1.61	7/6/2009	12.8
NF-1.61	7/13/2009	8.8
NF-1.61	7/15/2009	12.4
NF-1.61	7/20/2009	12.8
NF-1.61	9/1/2009	12.4
NF-1.61	10/4/2009	12.4
NF-9.77	5/11/2010	245.2
NF-9.77	7/15/2009	7.6
NF-9.77	8/5/2009	8.4
NF-9.77	10/4/2009	108.4
NF-14.52	7/13/2009	338.4
NF-14.52	7/20/2009	6.8
NF-14.52	5/5/2010	9.2
PL-0.10	4/6/2010	24.8
PL-0.10	7/6/2009	7.6
PL-0.10	7/20/2009	9.2
PL-0.10	8/5/2009	8.8

Table 3.27. Summary of TSS (mg/L) for sites that exceed 6.5 mg/L between April and October (continued).

Lower Triplett Creek		
EB-0.04	5/5/2010	6.8
EB-0.04	5/18/2010	8.8
HUB-0.19	10/14/2009	20.0
Upper Triplett Creek		
BUB-0.03	7/7/2009	2300.0
HB-1.36	6/1/2010	22.4
HB-1.36	7/27/2009	17.2
MB-0.23	7/15/2009	9.6
MB-0.23	9/1/2009	17.2
PB-0.42	5/18/2010	28.8
TC-0.74	5/18/2010	16.4
TC-0.74	7/7/2009	9.2
TC-0.74	7/13/2009	45.6
TC-0.74	7/15/2009	10.0
TC-0.74	8/5/2009	6.8
TC-0.74	9/1/2009	6.8
TC-02.27	5/18/2010	18.0
TC-02.27	8/5/2009	8.8
TC-12.27	5/24/2010	11.6
TC-12.27	7/13/2009	20.0
TC-12.27	10/4/2009	13.2
TC-13.52	7/7/2009	7.6
TC-13.52	7/15/2009	6.8
TC-14.50	7/13/2009	11.2
TC-14.99	7/13/2009	12.0
TC-14.99	10/4/2009	40.4
TC-19.91	7/13/2009	8.4
TC-21.80	5/5/2010	80.4
TC-21.80	7/13/2009	14.4
TC-21.80	8/5/2009	8.8
TC-21.80	10/4/2009	84.0

Analysis of TSS Results

Twenty-six of the thirty-three sites at one point exceeded the benchmark data for TSS. The highest values were in May and October after scattered rain events in the county. The May 5, 2010, samples were collected three days after a major flood event. At this point, the TSS levels would have been much lower than original levels. The peak of TSS (and other pollutants) tend to peak shortly after the beginning of a rain event. Based on visual observations of the flood waters and impacts of the flooding (Figures 3.49, below) the totals were likely much higher than our data. Both photos in figure 3.50 were taken in the Christy Creek Watershed. Several sites exceeded 6.5 mg/L during normal flow conditions between April and October. The water appeared clear when collecting the grab samples, which indicates that the TSS source is algae growth from warm nutrient rich waters.

Figure 3.49. Examples of large wash outs of sediment during heavy rain events. The photo on the left is private drive that crossed a minor tributary of Christy Creek near CC-2.00. The photo on the right is a hillside on HWY 32 near the bridge that crossed Triplett Creek.

Assessment of Bank Erosion

Streambank erosion is recognized worldwide as a leading contributor to sediment loads carried by and deposited in streams. For example, Trimble (1997) found that nearly 2/3 of the total sediment yield in an urbanizing watershed was derived from eroding streambanks. Howard et al. (1998) found that 42% of the sediment load in upper portions of a 147 km^2 watershed in Australia was derived from eroding banks, a figure that increases to 70% in the lower portions of the watershed.

Hundreds of miles of streambanks in the Triplett Creek Watershed are eroding to some degree or another (see Figures 3.50 to 3.54, pages 142 - 146, for examples). In order to estimate the scale of the bank erosion problem, annual bank-derived sediment loads must be calculated using the following equation:

Annual load = bank length x bank height x annual recession rate x bulk density

Data collected in this study and used in this equation include: 1) channel cross-sections measured over a period of months to over a year, 2) Modified Bank Erosion Hazard Index (MBEHI) forms filled out for these measured cross-sections and for other locations in the watershed, and 3) samples of bank material.

Figure 3.50. Example of a streambank with low erosion risk (MBEHI = 10.3).

Figure 3.51. Example of a streambank with moderate erosion risk (MBEHI = 17.8).

Figure 3.52. Example of a streambank with high erosion risk (MBEHI = 21.8).

Figure 3.53. Example of a streambank with extreme erosion risk (MBEHI = 35.0).

Channel cross-sections were chosen to reflect a variety of erosion rates and flow conditions and for easy access. For example, Figure 3.54 (page 146) shows field workers measuring a cross-section with an extreme MBEHI (i.e., an extreme erosion hazard) and high velocity flow near the bank (i.e., high near bank stress). Figure 3.55 (page 147) shows how the channel changed shape over a period of fourteen months.

Figure 3.54. Measurement of channel cross-section between fixed end points (4 ft rebar monument pins).

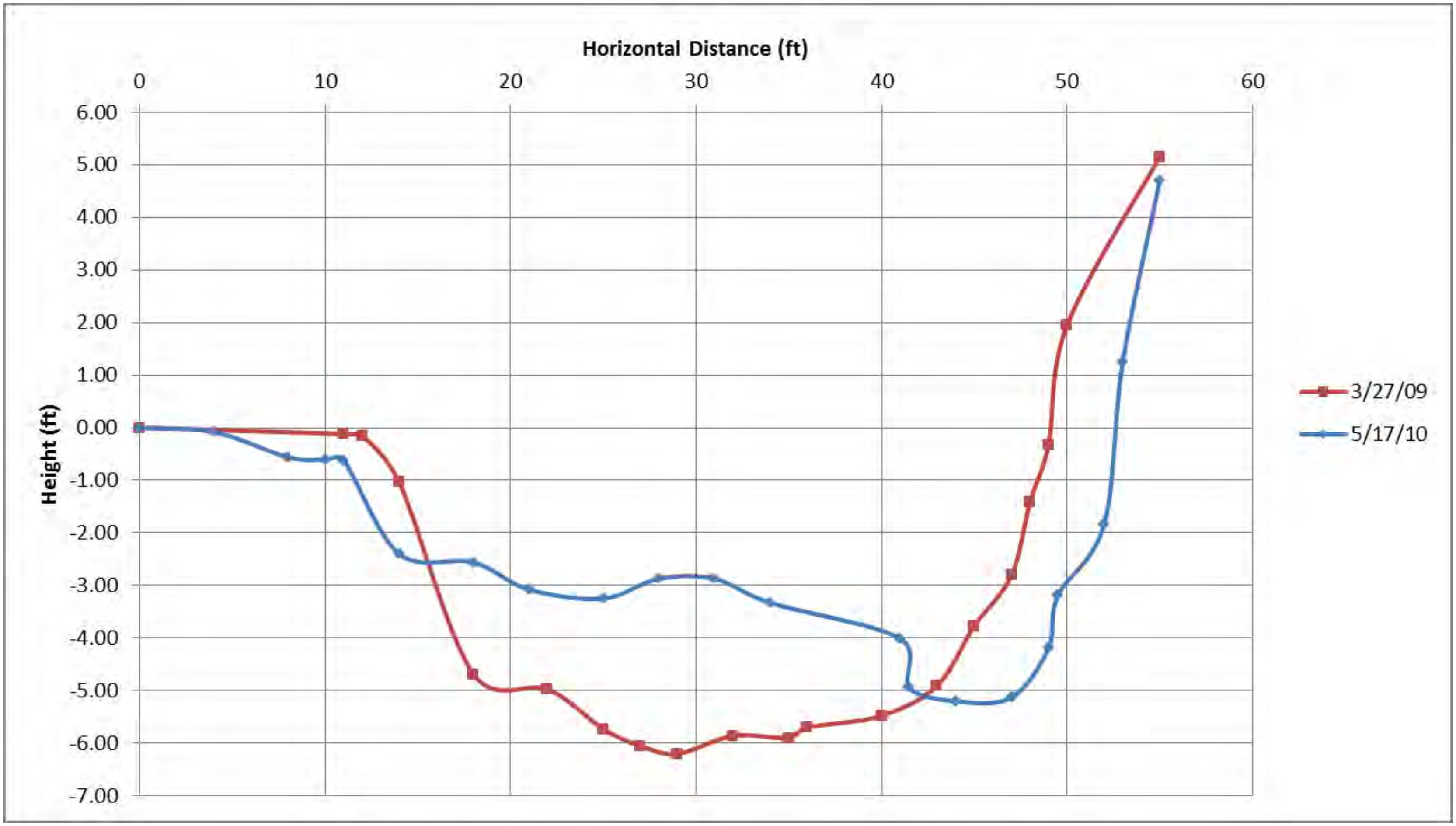

Figure 3.55. Cross-sections measured about one year apart at location shown in Figure 3.55. Note erosion on left and right banks and deposition in the center of the channel.

The average annual loss of streambank (i.e., the average annual bank recession rate) was measured at 0.2 ft intervals over the full height of surveyed banks and averaged. Near bank stress (NBS) was calculated from the same measured cross-sections using Method 5 on the NBS worksheet of Rosgen (2001).

Measured annual average bank recession rates in the Triplett Creek Watershed range from 0.02 ft/yr to 4.34 ft/yr. Rather than simply averaging these rates, however, a regression model incorporating recession rates, NBS and MBEHI was constructed in the manner of Rosgen (2001). Table 3.28 (below) shows average annual bank recession rates used for the STEPL bank erosion module and for other calculations discussed in this section.

Table 3.28. Average annual bank recession ("erosion") rates for each MBEHI ranking.

MBEHI	Range of rates (ft/yr)	Average (ft/yr)
v. low/low	0.82 to 1.00	0.91
moderate	1.01 to 1.35	1.18
high	1.36 to 1.70	1.53
v. high/extreme	1.71 to 2.33	2.02

A total of 29,447 ft (5.6 mi) of streambanks were evaluated for MBEHI in the Triplett Creek Watershed (Figure 3.57, page 151). While this represents a small fraction of the streambanks in the watershed, various sizes of streams and a wide variety of bank erosion severities are represented. To facilitate comparison with results from the STEPL bank erosion module, the six MBEHI categories shown in Figure 3.57 were combined to create the four erosion severity categories used in Table 3.28 (above). Figure 3.58 (page152) shows the percentage of all assessed banks that fall into these four categories.

Sediment Loads from Eroding Banks

The data summarized above were used to constrain input for the Spreadsheet Tool for Estimating Pollutant Loads (STEPL) module for estimating sediment loads due to bank erosion. Total stream miles in each subwatershed and for the entire Triplett Creek Watershed were determined using ArcGIS version 9.3. Erosion severities (MBEHI) along these streambanks were assumed to exist in the same proportions as shown in Figure 3.57 (page 150). Based on this assumption, stream miles in each subwatershed were multiplied by these percentages to obtain total stream miles in each category (Table 3.29, page251). Average heights of eroding banks for each subwatershed were obtained from MBEHI field data sheets (Table 3.30, page 253). In subwatersheds with insufficient field data, average bank heights were assumed to be the same as in similar subwatersheds with better control. Lastly, as required by the STEPL module, bank material type and bulk density were determined by the module based on soil type.

In order to obtain the most realistic load estimate possible, STEPL input summarized above was refined to use the average bulk density (0.05195 tons/cubic foot) and grain size information from our bank material samples (Table 3.31, page 152). In addition, a lower annual bank recession rate was used in areas above 900 ft elevation since these areas are heavily forested and generally undeveloped. This rate (0.42 ft/yr) is the average of our lowest measured rate (0.02 ft/yr) and the lowest rate suggested by our recession rate regression model (0.82 ft/yr).

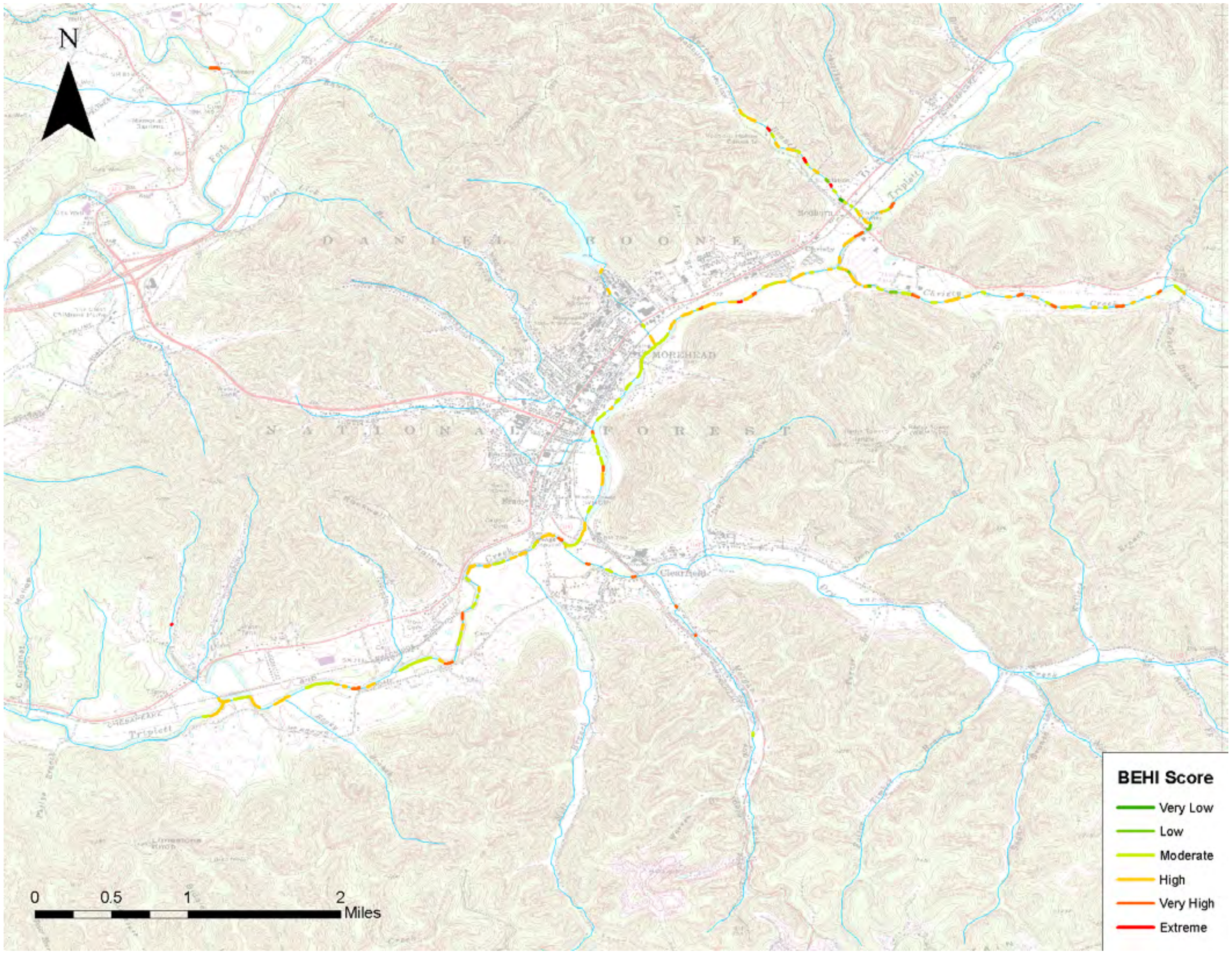

Figure 3.56. Erosion severity (MBEHI) of assessed streambanks near the center of Morehead. An enlarged map can be found in appendix E.

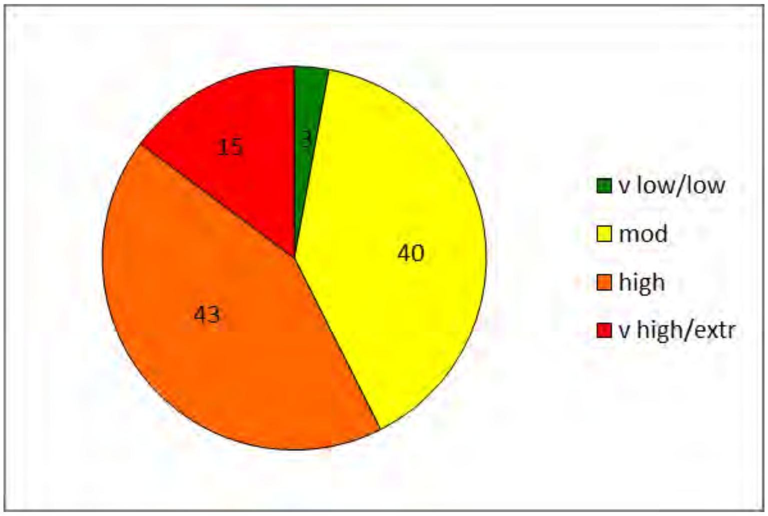

Figure 3.57. Percentage of assessed bank lengths in each MBEHI category.

Table 3.29. Length of streambanks in each MBEHI category by subwatershed and for the entire Triplett Creek Watershed.

Sub watershed	**Stream length (ft)**	**V low/low (ft)**	**Moderate (ft)**	**High (ft)**	**V high/extr (ft)**
TC main	671,174	13,423	288,605	288,605	80,541
upper NFT	484,272	24,214	169,495	217,922	72,641
lower NFT	864,698	43,235	302,644	389,114	129,705
Christy Cr	274,892	19,242	79,719	126,450	49,481
Dry Cr	147,806	7,390	51,732	66,513	22,171
Rock Fk	230,858	11,543	80,800	103,886	34,629
Morgan Fk	28,338	1,417	9,918	12,752	4,251
TC TOTAL	2,702,038	120,465	982,914	1,205,243	393,417

Table 3.30. Average bank heights used for STEPL module and other calculations.

Sub watershed	height (ft)
TC main	9.7
upper NFT	5.8
lower NFT	9.7
Christy Cr	5.8
Dry Cr	5.8
Rock Fk	5.8
Morgan Fk	9.7

Table 3.31. Average percent gravel, sand and mud (silt and clay) from all 42 bank samples collected in this study.

% Gravel	% Sand	% Mud
39.7	52.7	7.6

Comparison of STEPL Module Loads and Loads Based on Field Data

Despite limitations of the STEPL bank erosion module, results for the entire Triplett Creek Watershed agree within about 20% compared to field-based results (compare Tables 3.32 and 3.33, page 153). Therefore, we estimate that sediment loads derived from streambank erosion range from 1.13 to 1.40 million tons/year for the entire Triplett Creek Watershed. We prefer the lower figure since it incorporates more realistic assumptions and all available field data. STEPL and adjusted field based estimates for sediment loads derived from eroding banks match well for larger streams with well-developed floodplains and lower percentages of the subwatershed above 900 feet in elevation. STEPL and adjusted field estimates do not match as well for subwatersheds with a large proportion of area above 900 feet elevation. Without further data from higher elevation, first order streams, this discrepancy cannot be fully explained but it suggests that bank erosion in steep, first-order streams is more severe than estimated. Soil choices for STEPL may also be more appropriate for the types of bank material found in lower elevation streams with well-developed floodplains but less appropriate for higher elevation, rocky soils.

Table 3.32. Sediment loads from bank erosion as calculated by the STEPL module.

Subwatershed	STEPL load (tons/yr) For each subwatershed
TC_main	407,830
Morgan Fork	17,043
Dry Creek	70,826
Christy Creek	119,112
NFT_upper	177,963
Rock Fork	82,848
NFT_lower	524,874
Total	**1,400,497**

Note: The loads are for each subwatershed and not include loads from the upstream watersheds.

Table 3.33. Sediment loads from bank erosion based on best assumptions and all field data.

Subwatershed	Load > 900 ft (tons/yr)	Load < 900 ft (tons/yr)	Subtotals (tons/yr)	% of STEPL estimate
TC_main	23,844	346,881	370,724	91
Morgan Fork	1,188	13,619	14,807	87
Dry Creek	8,097	36,014	44,111	62
Christy Creek	21,724	44,350	66,074	55
NFT_upper	36,454	84,299	120,754	68
Rock Fork	21,022	27,816	48,838	59
NFT_lower	32,840	434,854	467,693	89
Total	145,169	987,833	**1,133,002**	**81**

The STEPL module for bank erosion cannot predict the percentages of total annual sediment loads that consist of gravel, sand and mud (silt and clay). Based on results shown in Table 3.33 (above), we can estimate the amount of gravel, sand and mud that is entering streams in the

Triplett Creek Watershed on an annual basis. Table 3.34 (below) shows these results for the 1.13 million tons/yr estimate for bank-derived sediment load.

Table 3.34. Gravel, sand and mud loads derived from bank erosion.

Subwatershed	Load (tons/yr)	Gravel load (tons/yr)	Sand load (tons/yr)	Mud load (tons/yr)
TC_main	370,724	147,029	195,483	28,212
Morgan Fork	14,807	5,872	7,808	1,127
Dry Creek	44,111	17,494	23,260	3,357
Christy Creek	66,074	26,205	34,841	5,028
NFT_upper	120,754	47,891	63,673	9,189
Rock Fork	48,838	19,369	25,752	3,717
NFT_lower	467,693	185,487	246,615	35,591
Watershed Total	**1,133,002**	**449,348**	**597,432**	**86,221**

Understanding the Scale of the Bank Erosion Problem

Day-to-day processes that re-shape the land tend to go unnoticed. As we live our day-to-day lives, we tend not to notice the day-to-day processes that re-shape the land around us. Humans just don't live long enough to see the cumulative effects of slow processes. People certainly notice the work of streams during floods. When half of the side yard or a road or a bridge simply disappears during a flood, people notice. When the flood is over, people can't help but notice the mud that covers the streets, places of business, yards and living rooms. So it is fairly easy to understand that much of the annual sediment load is moved during floods. But a large percentage of the annual load is moved during more "normal" flow conditions. Even when streams are low or dry, the work continues as freeze/thaw and wet/dry cycles weaken the banks. Then, when flow increases again, the weakened banks are undercut and collapse into the channel where the sediment is carried downstream.

Perhaps more difficult to understand is the sheer size of the annual bank-derived sediment loads summarized in Table 3.34 (above). The following example calculations attempt to put some of these figures in more visual terms.

Example 1: Suppose the load for the entire Triplett Creek Watershed had to be loaded into 25-ton dump trucks and hauled away. In this case,

1,133,002 tons/yr ÷ 25 tons/truck = 45,320 truck loads per year

Put another way, we would have to haul 124 truckloads per day for an entire year to get the job done.

Example 2: Imagine that we took all of these truckloads of sediment and spread it evenly back over the entire Triplett Creek Watershed. The area of the entire watershed is 181 square miles, which is 5,045,990,400 square feet. The load expressed in cubic feet instead of tons is

1,133,002 tons/yr ÷ 0.05195 tons/cubic foot = 21,809,471 cubic feet

Therefore, the thickness of the sediment layer we spread over the watershed would be

21,809,471 cubic feet ÷ 5,045,990,400 square feet x 12 inches/foot = 0.05 inches

Example 3: A layer of sediment five one hundredths of an inch thick, as calculated in Example 2, seems rather insignificant. But suppose we had to pile this sediment onto Kyle Field, the football field on MSU's campus, without letting the pile spread beyond the boundary lines and end lines. Assume we could construct very high walls to confine the pile to the area of the football field. Again, the load expressed in cubic feet is 21,809,471 cubic feet. Since a football field is 160 feet wide and 360 feet long (end line to end line), its area is 57,600 square feet. Therefore, the height of our pile would be

21,809,471 cubic feet ÷ 57,600 square feet = 379 feet

So stacked on a football field, the pile would be slightly taller than the ridge top immediately behind the center of MSU's campus, which is the equivalent of a 24-story building.

Example 4: Lastly, let's suppose we were to dredge Triplett Creek from about 2000 feet upstream of City Park near downtown Morehead, all the way to the KY 519 bridge near Save-a-Lot and the Clearfield post office, a distance of 8,500 feet. For the sake of argument, let's say this trench is also 100 feet wide and 20 feet deep. The volume of our trench would be

8,500 feet x 100 feet x 20 feet = 17,000,000 cubic feet

Sediment derived from erosion of banks upstream of our trench would continue to move downstream and the "trench would eventually refill. The load contributing to refilling would include sediment from Christy Creek load and about half of the main Triplett Creek load. The combined load is 251,436 tons/yr. Expressed in terms of volume,

251,436 tons/yr ÷ 0.05195 tons/cubic foot = 4,839,962 cubic feet per year

If all of the sediment moving through the trench were to settle there, the time required to refill the trench would be

17,000,000 cubic feet ÷ 4,839,962 cubic feet per year = 3.5 years

If half of the sediment flowing through the trench settled there, refilling would take 7 years, while settling of a quarter of the sediment would take 14 years, and so on. The point is that in a relatively few years, the time, effort and enormous cost of dredging would be for naught and we would end up right back where we started. We would be forced to dredge this portion of Triplett Creek repeatedly. The only way around this reality is to stop the sediment at its source.

Autosamplers

Autosamplers are programmable water sampling devices. The can be programmed to collect data after a rain event, time intervals, rise in depth, or increase in discharge. The autosamplers can be extremely helpful in determining load changes in the stream over a long period of time and quick changes (such as storm events) without intensive manual labor. We have successfully used autosampler in several small tributaries in the Licking River Watershed. Therefore, we attempted to use the autosampler on the main stem of Triplett Creek and the North Fork of Triplett. We set the autosamplers up at 7 locations on the main stem of Triplett Creek and the North Fork of Triplett Creek. Unfortunately, we were not able to gather the samples as planned. Figure 3.58 (page 157) is a sample of the type of information that is provided from the autosamplers. These data can be helpful is determine the type of BMPs to implement. From a water quality stand point, from the graph below, the BMP would be design to capture the water runoff from the 30 to 45 mines of the rain event. The green line represents discharge and the red line is TSS.

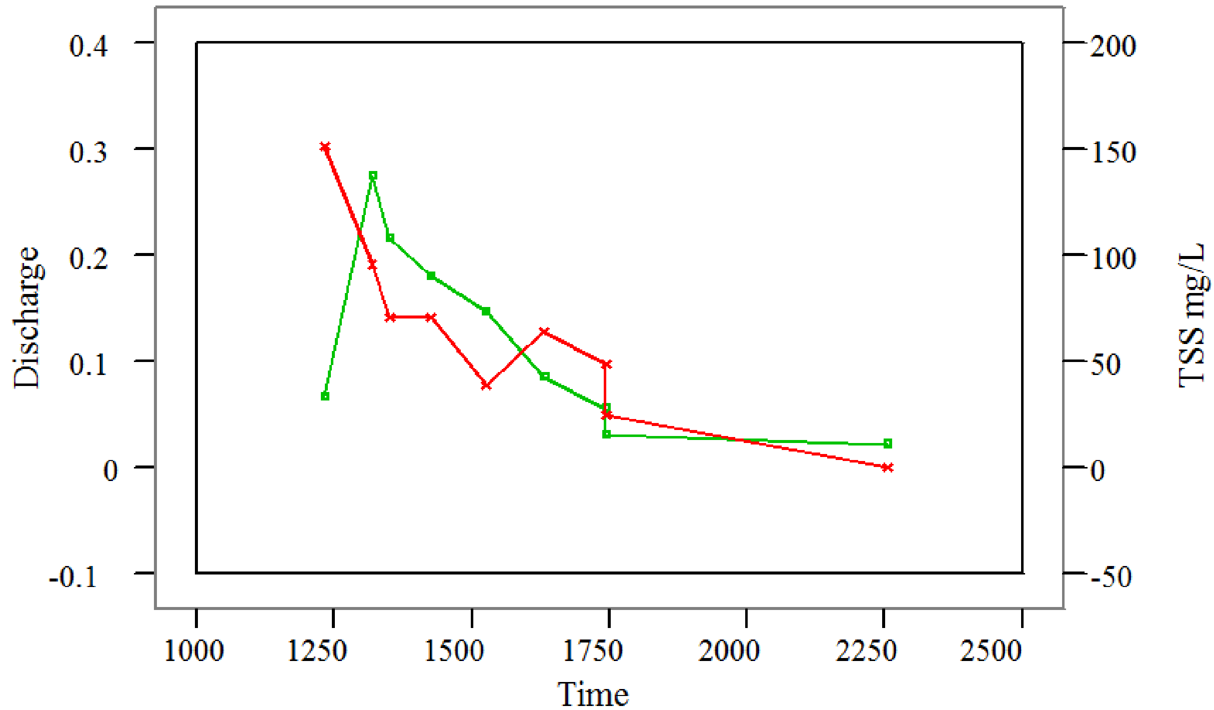

Figure 3.58. An example of results of data collected using an autosampler.

The autosamplers were set out and programmed to sample every 30-minutes after a 1 inch change in water depth. In the fall, winter and summer months, the selected sites did not have the enough water depth increase to activate the sampler. The opposite problem occurred in the spring; there was flooding. The flooding was high enough that the samplers could not be set outside of the flow. Two of the samplers were found on their sides and one was washed downstream.

POLLUTANT LOAD PREDICTION SUMMARY

Impairment Associated with *E. coli*

Bacteriological assessment of the Triplett Creek Watershed is an important component for the development of a WBP. During the summer and fall 2009 collection seasons the Island Fork site (IF- 0.05) exhibited *E. coli* counts well over the KDOW limits. The Island Fork site is in an area of cattle production. Following the May 2010 flooding event, Triplett Creek sites TC- 0.37, TC- 2.27 and TC- 12.27 all had counts far exceeding KDOW limits. The flood event swamped the county's sewage treatment facilities, resulting in a dramatic increase in bacterial counts from collection sites in Morehead and further downstream. The Triplett Creek Watershed continues to exhibit bacterial contamination at levels that impair sections of the watershed for their designated use of primary contact recreation.

Sources and Causes

Load duration curves in Appendix C indicate that *E. coli* impairment occurs during the primary contact recreation season (May to October). Since this also coincides with the dry season, when streams are primarily fed by groundwater, instantaneous loads that dramatically exceed the LDC represent storm events. This implies that fecal contamination traveled to nearby streams in runoff and that the *E. coli* originated from wildlife, livestock or pets. Instantaneous loads that slightly exceed or lie close to the LDC suggest that *E. coli* was carried to Triplett Creek by groundwater, which implies that *E. coli* originated from septic systems or perhaps leaking sewer lines.

Impairment Associated with Sediment

While we may not be able to assess sediment concentrations and loads relative to a firm WQC, KDOW (2008) identifies sedimentation/siltation as a pollutant in the impaired reach. Use of the term sedimentation/siltation implies bedded sediment has been observed and problems such as smothering of spawning beds exist.

Sources and Causes

The sediment measured using SSC methods primarily consists of inorganic clay, silt and sand but also includes well-decomposed organic matter typically found in soils (USEPA, 2006). Sources for this pollution are geological materials (e.g., soil, rock, colluvium, alluvium) and, unlike TSS, are not dependent on nutrient and productivity levels. Impairment by sedimentation/siltation is caused by deposition of clay, silt and sand when water slows down and can no longer keep the sediment in suspension (e.g., at low flows or when water enters pools or eddies).

Based on the field work and visual observations streambank erosion probably represents the largest source for suspended sediment in the Triplett Creek Watershed. The results of habitat assessments and photographic documentation presented in this section indicate that the primary cause of excessive bank erosion is removal of riparian vegetation along with channel alteration. Channel alterations include straightening, moving of the stream, and bridges. Gravel mining and buried pipes with concrete poured over top have also accelerated bank erosion in many places. The unfortunate result is that bank erosion is extremely widespread and is occurring to varying degrees along every stream in the watershed. All streams are entrenched for at least part of their length. Runoff over unimproved roads and bare ground also appears to be a significant source of sediment in the watershed.

Impairment Associated with Selected Physical and Chemical Parameters

Several of the physical and chemical parameters examined in this study address impairments caused by nutrient/eutrophication biological indicators and organic enrichment (sewage) biological indicators as identified in KDOW (2008). Relationships between various parameters are examined in the context of these pollutants.

Investigating Water Quality Relationships

It is impossible to ignore the interrelations between various parameters, habitats, and land use practices on the overall water quality. When impacting one part of the watershed a chain reaction of impacts will occur. With this in mind, correlations were investigated within the Triplett Creek Watershed. Because of all the influencing factors it is difficult to establish a strong correlation when looking at a simple linear correlation because there are multiple factors impacting one parameter. For example, temperature of the water impacts the amount of dissolved oxygen. However, dissolved oxygen is also influenced by excessive nutrients. Conductivity is often associated with elevated bacteria, phosphate, and nitrate; however, no meaningful correlations were found between any of the nutrients and conductivity. A similar approach was used to explore possible relationships between pH, nutrients, conductivity, temperature, and DO but none were significant. Direct relationships were investigated with data from the entire watershed and smaller watersheds.

Poor habitat quality is the number one impact on temperature and DO. Although there are many parameters that can impact DO, only temperature showed a negative relationship to DO levels (Figure 3.59, page 160). Temperate increases are likely the result of tree removal. Another possible source of high water temperature is runoff from pavement since roads exist along most of the waterways. In addition to temperature, low water flow also contributes to excessive DO loss. Low flow can be attributed to the loss of habitat, which reduces the amount of water that is absorbed by the groundwater. Groundwater is slowly released into the streams. The relationship between temperature and DO had the greatest correlation with an r^2 = 0.476 (1 is a perfection correlation). Figure 3.60 (page 161) shows that will temperature increase dissolved oxygen decreases. However, a direct correlation was not found (Figure 3.60, page 160).

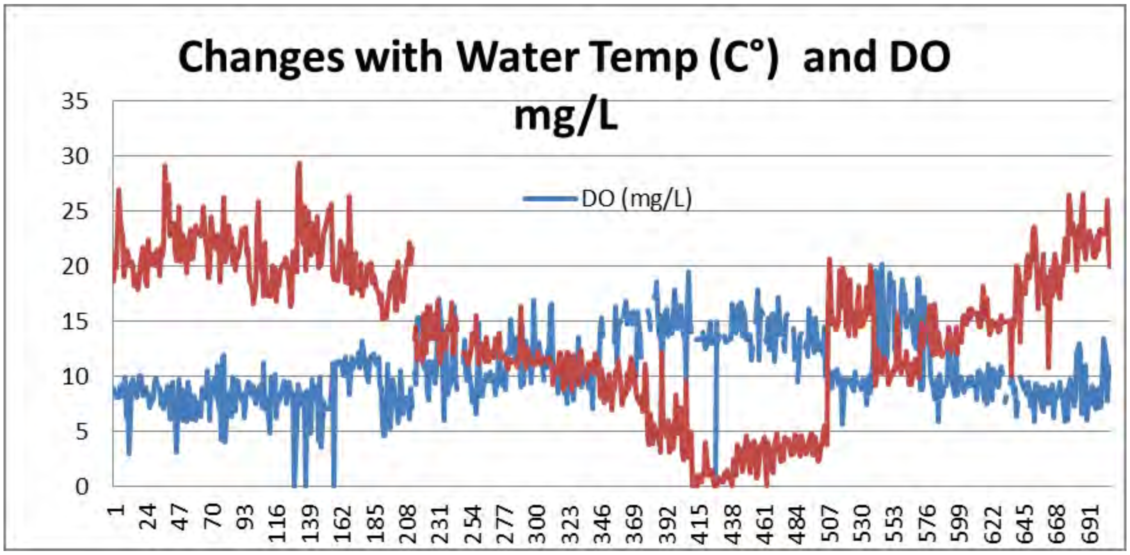

Figure 3.59 Relationship between temperature and dissolved oxygen.

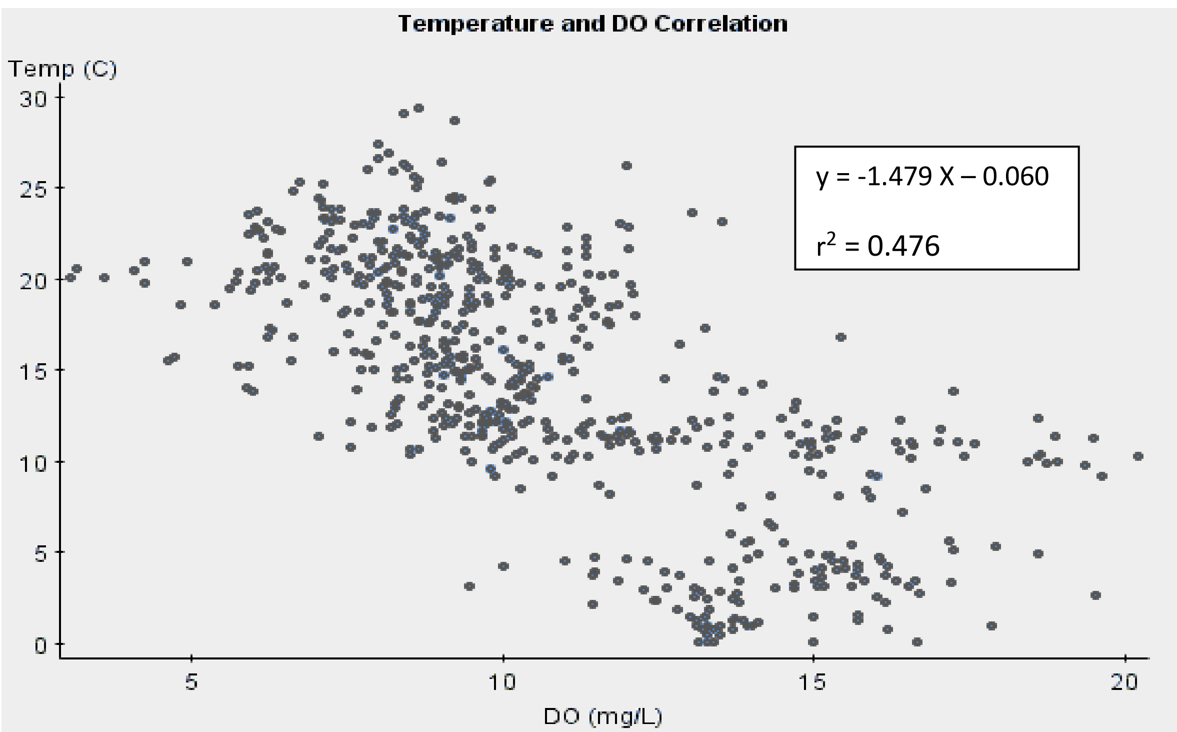

Figure 3.60. Relationship between temperature and dissolved oxygen.

As the stream flows through the watershed, the water quality is impacted by the land use along the stream and its tributaries. As a result, pollutants may increase or decrease in concentration. This depends on the amount of water in the stream (discharge) and the amount of pollutants in the stream. These changes in the waterway can help determine sources of the pollutants.

Biological Indicators of Impairment

Time limitations and budget constraints did not allow us to conduct a detailed examination of biological indicators. However, existing ichthyofaunal (fish) and macroinvertebrate data and limited field observations clearly indicate that sediment, low DO, temperature, pH and habitat loss have had a negative impact on aquatic communities. Species observed show low diversity and a majority of the populations that do exist indicate poor water quality. It is well known that the above impairments negatively impact the diversity and richness of ichthyofaunal and macroinvertebrate communities. Improvements in DO, temperature, pH, and habitat will improve aquatic populations.

OVERALL SUMMARY FOR EACH SAMPLING SITE

Tables 3.35 and 3.36 (pages 162-165) summarize parameter results and implied impairments, for each sampling site in the watershed. Only parameters with targets based on WQC or reference reach averages are included.

Table 3.35. Overall summary of sampling sites not meeting WQC.

Site ID	DO	pH	Alkalinity	Temp.	Unionized Ammonia-N	Bacteria
Christy Creek Subwatershed						
CC-0.37	X	X	X			X
CC-2.00	X	X	X			X
CC-4.33	X	X	X			X
CC-8.11		X	X			X
OH-0.11			X			X
PAL-0.02			X			
SB-0.02			X			
Dry Creek Subwatershed						
DC-0.27		X	X			X
DC-2.84		X	X			X
Rock Fork Subwatershed						
IF-0.05			X			X
Morgan Fork Subwatershed						
MF-0.23		X		X	X	X
Lower North Fork of Triplett Creek Subwatershed						
BB-0.23	X	X			X	X
CB-0.38		X	X			X
CF-0.11	X	X	X		X	X
NF-1.61		X				X
NF-9.77						X
HF-0.09		X	X		X	
Upper North Fork of the Triplett Creek Subwatershed						
NF-14.52		X	X			X
PL-0.10		X	X			X
RF-0.15	X	X	X			X

Table 3.35. Overall summary of sampling sites not meeting WQC (continued).

Site ID	DO	pH	Alkalinity	Temp.	Ammonia-N	Bacteria
Main stem of Triplett Creek Subwatershed						
BUB-0.03	X		X	X		X
EB-0.04			X	X		
HB-1.36		X	X	X		X
HUB-0.19	X	X	X			
MB-0.23	X		X			
PB-0.42	X		X	X		
TC-0.74		X	X		X	X
TC-2.27		X	X			X
TC-12.27		X	X			X
TC-13.52	X		X	X	X	X
TC-14.50			X		X	
TC-14.99		X	X		X	
TC-19.91		X	X	X		
TC-21.80		X	X		X	

Table 3.36. Overall summary parameters without WQC that did not meet benchmark data set by KDOW.

Site ID	Conductivity	TN	TP	SO	Habitat	TSS	MBEHI	Visual Bank erosion
Christy Creek Subwatershed								
CC-0.37	X	X	X	X	X	X	X	X
CC-2.00	X	X	X	X	X	X	X	X
CC-4.33	X	X	X	X	X	X	X	X
CC-8.11	X	X	X	X	X	X		X
OH-0.11		X	X	X	X			
PAL-0.02	X	X	X	X	X			X
SB-0.02		X	X	X	X	X		X
Dry Creek Subwatershed								
DC-0.27	X	X	X	X	X	X	X	X
DC-2.84		X	X	X	X		X	X
Rock Fork Subwatershed								
IF-0.05		X	X	X	X	X		X
Morgan Fork Subwatershed								
MF-0.23	X	X	X	X	X		X	X
Lower North Fork of Triplett Creek Subwatershed								
CB-0.38	X	X	X	X	X	X		X
CF-0.11		X	X	X	X	X		X
BB-0.23	X	X	X	X	X	X		X
NF-1.61	X	X	X	X	X	X	X	X
NF-9.77	X	X	X	X	X	X	X	X
PL-0.10		X	X	X	X			
RF-0.15	X	X	X	X	X	X	X	X
Upper North Fork of Triplett Creek Subwatershed								
HF-0.09	X	X	X	X	X			X
NF-14.52		X	X	X	X	X	X	X

Table 3.36. Overall summary parameters without WQC that did not meet benchmark data set by KDOW (continued).

Site ID	Conductivity	TN	TP	SO	Habitat	TSS	MBEHI	Visual Bank erosion
Main stem of Triplett Creek Subwatershed								
BUB-0.03		X	X	X	X			X
EB-0.04	X	X	X	X	X	X		X
HB-1.36	X	X	X	X	X	X		X
HUB-0.19	X	X	X	X	X			X
MB-0.23		X	X	X	X	X	X	X
PB-0.42		X	X	X	X			X
TC-0.74	X	X	X	X	X	X	X	X
TC-2.27		X	X	X	X	X	X	X
TC-12.27	X	X	X	X	X	X	X	X
TC-13.52	X	X	X	X	X	X	X	X
TC-14.50	X	X	X	X	X	X	X	X
TC-14.99	X	X	X	X	X	X	X	X
TC-19.91	X	X	X	X	X	X	X	X
TC-21.80	X	X	X	X	X	X		

LOAD REDUCTIONS NEEDED

Table 3.37 (pages 167-168) illustrates the load reductions needed to meet minimum benchmarks. Table 3.38 (page 169) contain the load reductions needed to meet *E.coli* standards. The sites selected are at the mouth of the main subwatersheds and the mouth of the entire Triplett Creek Watershed. MAF is used for the calculations. Instantaneous loads are not reported in tables because the field flow data is incomplete. Samplers are not able to measure the lowest flow or the highest flow. Field measurements are included in the master spread sheet (appendix F). In addition, the models and calculation load duration curves are all use proxy watershed data. The concentration of each selected parameter is the average concentration of all the samples collected at the site.

As a reminder, benchmarks and that the load reductions needed to meet water quality standards and criteria are estimates. The purpose of calculating the load reductions are to prioritize the subwatersheds for implementation and future success monitoring will determine if the stream meets its designated uses

Table 3.37. A summary of the needed reductions to meet WQC/benchmarks.

Total Nitrogen						
Site	**MAF**	**TN (mg/L)**	**TN (lb/yr)**	**TN benchmark (lb/yr)**	**Yearly reduction needed (lb/yr)**	**Percent Reduction Needed**
CC-0.37	27.8	2.074	113,515.50	35,576.22	77,939.28	69%
DC-0.27	17.0	2.186	73,164.55	21,755.24	51,409.31	70%
MF-0.23	2.6	2.479	12,689.70	3,327.27	9,362.43	74%
NF-1.61	128.2	1.901	479,812.70	164,060.10	315,752.60	66%
NF-9.77	59.9	1.714	202,133.94	76,655.23	125,478.71	62%
RF-0.15	20.1	2.092	82,786.46	25,722.37	57,064.09	69%
TC-0.74	231.6	2.008	915,595.95	296,383.15	619,212.80	68%
TC-14.50	59.2	2.430	283,223.69	75,759.42	207,464.27	73%
Total Phosphors						
Site	**MAF**	**TP (mg/L)**	**TP (lb/yr)**	**TP benchmark (lb/yr)**	**Yearly reduction needed (lb/yr)**	**Percent Reduction Needed**
CC-0.37	27.8	0.272	14,887.28	1,094.65	13,792.63	93%
DC-0.27	17.0	0.269	9,003.32	669.39	8,333.93	93%
MF-0.23	2.6	0.250	1,279.72	102.38	1,177.34	92%
NF-1.61	128.2	0.256	64,614.44	5,048.00	59,566.44	92%
NF-9.77	59.9	0.268	31,605.54	2,358.62	29,246.92	93%
RF-0.15	20.1	0.258	10,209.80	791.46	9,418.35	92%
TC-0.74	231.6	0.275	125,392.87	9,119.48	116,273.39	93%
TC-14.50	59.2	0.209	24,359.57	2,331.06	22,028.51	90%
Total Suspended Solids (April-October data only)						
Site	**MAF**	**TSS (mg/L)**	**TSS (lb/yr)**	**TSS benchmark (lb/yr)**	**Yearly reduction needed (lb/yr)**	**Percent Reduction Needed**
CC-0.37	27.8	13.812	755,967.22	355,762.16	400,205.06	53%
DC-0.27	17.0	1.743	58,337.51	217,552.40	-159,214.89	NA
MF-0.23	2.6	2.45	12,541.26	33,272.72	-20,731.46	NA
NF-1.61	128.2	6.847	1,728,183.90	1,640,601.04	87,582.86	5%
NF-9.77	59.9	23.412	2,761,003.38	766,552.28	1,994,451.10	72%
RF-0.15	20.1	6.229	246,499.47	257,223.72	-10,724.25	NA
TC-0.74	231.6	7.76	3,538,358.86	2,963,831.52	574,527.34	16%
TC-14.50	59.2	1.973	229,958.99	757,594.24	-527,635.25	NA

Table 3.37. A summary of the needed reductions to meet WQC/benchmarks (continued).

Un-ionized Ammonia-N (UAN)						
Site	**MAF**	**UAN (mg/L)**	**UAN (lb/yr)**	**UAN benchmark (lb/yr)**	**Yearly reduction needed (lb/yr)**	**Percent Reduction Needed**
CC-0.37	27.8	0.002	109.47	2,736.63	-2,627.17	NA
DC-0.27	17.0	0.002	66.94	1,673.48	-1,606.54	NA
MF-0.23	2.6	0.002	10.24	255.94	-245.71	NA
NF-1.61	128.2	0.001	252.40	12,620.01	-12,367.61	NA
NF-9.77	59.9	0.001	117.93	5,896.56	-5,778.62	NA
RF-0.15	20.1	0.001	39.57	1,978.64	-1,939.07	NA
TC-0.74	231.6	0.009	4,103.77	22,798.70	-18,694.94	NA
TC-14.50	59.2	0.007	815.87	5,827.65	-5,011.78	NA
Sulfate						
Site	**MAF**	**Sulfate (mg/L)**	**Sulfate (lb/yr)**	**Sulfate benchmark (lb/yr)**	**Yearly reduction needed (lb/yr)**	**Percent Reduction Needed**
CC-0.37	27.8	30.55	167,2082.15	756,405.08	915,677.07	55%
DC-0.27	17.0	16.11	539,195.26	462,549.87	76,645.38	14%
MF-0.23	2.6	26.95	137,953.82	70,742.92	67,210.89	49%
NF-1.61	128.2	23.19	5,853,159.71	3,488,170.21	2,364,989.50	40%
NF-9.77	59.9	18.23	2,149,884.32	1,629,808.08	520,076.24	24%
RF-0.15	20.1	18.14	717,852.04	546,897.20	170,954.84	24%
TC-0.74	231.6	25.5	11,627,339.04	6,301,561.79	5,325,777.25	46%
TC-14.50	59.2	29.26	3,410,339.61	1,610,761.91	1,799,577.70	53%

Analysis of Results

Un-ionized Ammonia-N parameter did not require a reduction to meet benchmark of 0.05 mg/L. Un-ionized ammonia-N is listed as impairment in this report because it was consistently at or above 0.001 mg/L. Total Phosphorus has the overall greatest amount of reductions needed to meet benchmark data (90% to 93% reductions). Total Nitrogen has the second highest needed reductions (62% to 74%). Sulfate had the next highest needed reductions (14% to 55%). Four of the subwatersheds need reductions to meet benchmark data. NF-9.77 has the highest reduction (72%). The NF-9377 subwatershed was followed by CC-0.37, TC-0.74, and NF-1.61with 53%, 16%, and 5%, respectively.

Table 3.38. *E.coli* load reductions for each subwatershed for a 12-month period, using 240 and 130 *E. coli* benchmarks.

Load Reduction for the 12-Month Period (January 1 - December 31)								
TCW SITE	**MAF**	**Mean *E. coli* (CFU/100 mL)**	***E.coli* CFU/d**	***E. coli* CFU/y**	***240 E. coli* Benchmark (CFU/d)**	***240E. coli* Benchmark (CFU/y)**	**Yearly Reduction (CFU/y)**	**Percent Reduction Needed**
CC-0.37	27.8	199.1	1.3538E+11	4.9415E+13	1.6324E+11	5.9581E+13	-1.0166E+13	NA
DC-0.27	17	175.3	7.2895E+10	2.6607E+13	9.9821E+10	3.6435E+13	-9.8278E+12	NA
MF-0.23	2.6	238.0	1.5139E+10	5.5259E+12	1.5267E+10	5.5724E+12	-4.6436E+10	NA
NF-1.61	128.2	206.7	6.4822E+11	2.366E+14	7.5277E+11	2.7476E+14	-3.8161E+13	NA
NF-9.77	59.9	157.6	2.3089E+11	8.4275E+13	3.5172E+11	1.2838E+14	-4.4103E+13	NA
RF-0.15	20.1	399.5	1.9647E+11	7.1712E+13	1.1802E+11	4.3079E+13	2.8634E+13	39.93%
TC-0.74	231.6	1002.5	5.6805E+12	2.0734E+15	1.3599E+12	4.9637E+14	1.577E+15	76.06%
TC-14.50	59.2	147.0	2.1291E+11	7.7713E+13	3.4761E+11	1.2688E+14	-4.9165E+13	NA
Load Reduction for the 12-Month Period (January 1 - December 31)								
TCW SITE	**MAF**	**Mean *E. coli* (CFU/100 mL)**	***E.coli* CFU/d**	***E. coli* CFU/y**	***130 E. coli* Benchmark (CFU/d)**	***130 E. coli* Benchmark (CFU/y)**	**Yearly Reduction (CFU/y)**	**Percent Reduction Needed**
CC-0.37	27.8	199.1	1.3538E+11	4.9415E+13	8.842E+10	3.2273E+13	1.7142E+13	34.69%
DC-0.27	17	175.3	7.2895E+10	2.6607E+13	5.407E+10	1.9735E+13	6.8714E+12	25.83%
MF-0.23	2.6	238.0	1.5139E+10	5.5259E+12	8269470144	3.0184E+12	2.5076E+12	45.38%
NF-1.61	128.2	206.7	6.4822E+11	2.366E+14	4.0775E+11	1.4883E+14	8.777E+13	37.10%
NF-9.77	59.9	157.6	2.3089E+11	8.4275E+13	1.9052E+11	6.9538E+13	1.4737E+13	17.49%
RF-0.15	20.1	399.5	1.9647E+11	7.1712E+13	6.3929E+10	2.3334E+13	4.8378E+13	67.46%
TC-0.74	231.6	1002.5	5.6805E+12	2.0734E+15	7.3662E+11	2.6887E+14	1.8045E+15	87.03%
TC-14.50	59.2	147.0	2.1291E+11	7.7713E+13	1.8829E+11	6.8726E+13	8.9872E+12	11.56%

PREDICTING POLLUTANT LOADS AND LOAD REDUCTIONS

Model Setup

The EPA's STEPL model was used to estimate annual nitrogen, phosphorous, and sediment loads; and load reductions based on user-selected BMPs for seven subwatersheds in the Triplett Creek Watershed (Figure 3.62, page173). The model is largely based on the NRCS Curve Number runoff model and the Universal Soil Loss Equation (USLE) model – for which parameters are specified by land use type for each subwatershed. STEPL calculates rill and sheet erosion-based sediment loads (and reductions), and has a special sub-module for calculating sediment loads (and reductions) from gullies and impaired streambanks. Moreover, the STEPL model comes with a comprehensive database of BMPs for use in modeling pollutant load reductions by land use type.

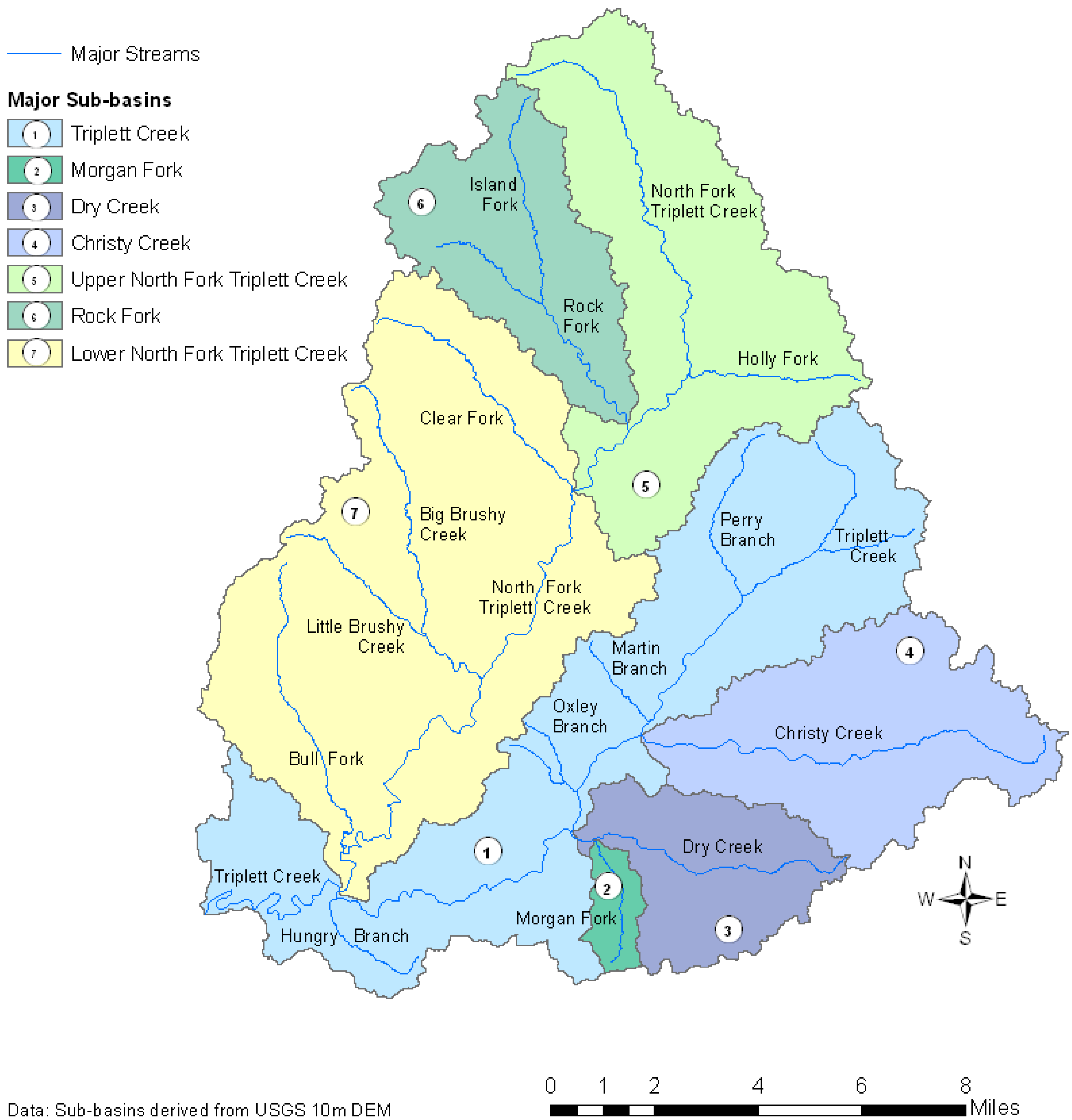

Figure 3.61. Study area - seven subwatersheds of the Triplett Creek Watershed. An enlarged map can be located in appendix E.

STEPL load predictions were made using a variety of input data for each subwatershed including user-supplied information and model default values. Land use composition (cropland, pastureland, forest, and urban) was determined using the 2005 Kentucky land cover change dataset for Rowan County. Information on the numbers and types of agricultural animals in each subwatershed and the corresponding manure application schedules was obtained from the county's agricultural extension office. The Rowan County Public Health Department supplied data on the numbers of septic systems for each road in the watershed. Streambank characteristics (e.g., recession rates, soil texture, length, and average height) for each subwatershed were estimated by watershed scientists on the basis of field data. STEPL model default variables and parameters for Rowan County, Kentucky were used for the remaining input data, including precipitation and soil information. STEPL was used to calculate output nutrient and sediment loads for each subwatershed as a whole, as well as for each of the four separate land use areas (and streambanks) within each subwatershed. STEPL was subsequently used to simulate nutrient and sediment load reductions as a function of user-selected BMPs for each land use type.

Table 3.39 (page 173) highlights key characteristics of each subwatershed including its size, the percent of land under crop, pasture, forest, and urban uses, the numbers and types of agricultural animals, and the numbers of septic systems. More than 70% of each subwatershed is covered by forested land, while no subwatershed has greater than 1% cropland. Four subwatersheds have greater than 10% pastureland, with the Lower North Fork of Triplett Creek Subwatershed reaching 25% coverage. Only two subwatersheds have more than 10% urban area, Morgan Fork (14%) and the main stem of Triplett Creek (11%). The primary agricultural animal found in all subwatersheds is beef cattle, followed by horses. Additionally, over 600 septic systems have been permitted in the main stem of Triplett Creek (TC_main) Subwatershed and the Lower North Fork of Triplett Creek Subwatershed since 1985; Christy Creek, followed by Dry Creek, have the next two highest numbers of permitted systems.

Table 3.39. Key characteristics for each subwatershed in the Triplett Creek Watershed including size, land use composition, number and types of agricultural animals*, and number of septic systems^.

	TC_main	Morgan Fork	Dry Creek	Christy Creek	Upper North Fork Triplett	Rock Fork	Lower North Fork Triplett
Area (acres)	30,310	1,353	7,447	13,960	20,704	10,316	35,094
% Cropland	1	1	0	0	0	0	1
% Pastureland	15	6	8	16	9	11	25
% Forest	73	79	85	78	86	86	66
% Urban	11	14	7	6	5	3	8
# Beef cattle	350	100	400	550	350	250	1000
# Sheep	0	0	0	0	0	0	100
# Horses	100	0	50	50	50	50	100
# Septic Systems	649	13	195	282	140	129	607

*Estimates from the Rowan County Agricultural Extension agent.

^Permitted systems since 1985 (Rowan County Health Department).

Model Results – pollutant loads

Model predicted annual nitrogen, phosphorous, and sediment loads are shown below for each subwatershed in the Triplett Creek Watershed (Table 3.40, page175). Overall, the largest subwatersheds produced the greatest pollutant loads, with sediment comprising the vast majority of the total load in each subwatershed, followed by nitrogen and then phosphorous. In terms total pollutant loads by land use type, Table 3.41 (page177) shows that streambanks, followed by pastureland, generated the largest loads for the Triplett Creek Watershed as a whole.

Table 3.40. STEPL predicted annual nitrogen (N), phosphorous (P), and sediment loads – by subwatershed.

Subwatershed	*N* (lbs/yr)	*P* (lbs/yr)	*Sediment* (lbs/yr)
TC_main#	732,820	267,203	826,750,334
Morgan Fork	30,730	11,310	34,750,464
Dry Creek	109,332	40,079	143,922,766
Christy Creek	193,132	68,823	243,462,531
NFT_upper*	319,651	117,589	361,706,875
Rock Fork	149,560	54,994	169,069,280
NFT_lower^	958,145	345,551	1,066,751,292
TOTAL	**2,493,370**	**905,549**	**2,846,413,543**

#TC_main: main stem of Triplett Creek
*NFT_upper: Upper North Fork Triplett Creek
^NFT_lower: Lower North Fork Triplett Creek

Table 3.41. STEPL predicted annual nitrogen (N), phosphorous (P), and sediment loads for the entire Triplett Creek Watershed – by land use type.

Land Use	*N* (lbs/yr)	*P* (lbs/yr)	*Sediment* (lbs/yr)
Urban	69,524	10,702	3,191,071
Cropland	27,881	7,307	5,537,430
Pastureland	162,869	25,427	26,636,029
Forest	36,634	16,467	10,055,720
Septic	1,253	491	0
Streambank	2,195,210	845,156	2,800,993,294

TOTAL	**2,493,370**	**905,549**	**2,846,413,543**

Figure 3.62 (below) shows that the pollutant load distribution by land use class varied substantially between subwatersheds in accordance with each subwatershed's land use composition. Overall, most of the nitrogen load came from eroding streambanks, followed by pastureland and septic systems. Annual phosphorous loads for each subwatershed were much smaller than corresponding nitrogen loads, however the distribution of phosphorous load by land use classes (Figure 3.63, page176) followed the same pattern as the nitrogen loads (Figure 3.64, page 178). Note that nitrogen includes all forms of nitrogen (TN, NH_4, nitrate, nitrite) Predicted annual sediment loads followed these patterns as well, with most of the sediment load coming from pastureland (Figure 3.64, page178) and, overwhelmingly, streambanks (Figure 3.6, page 179).

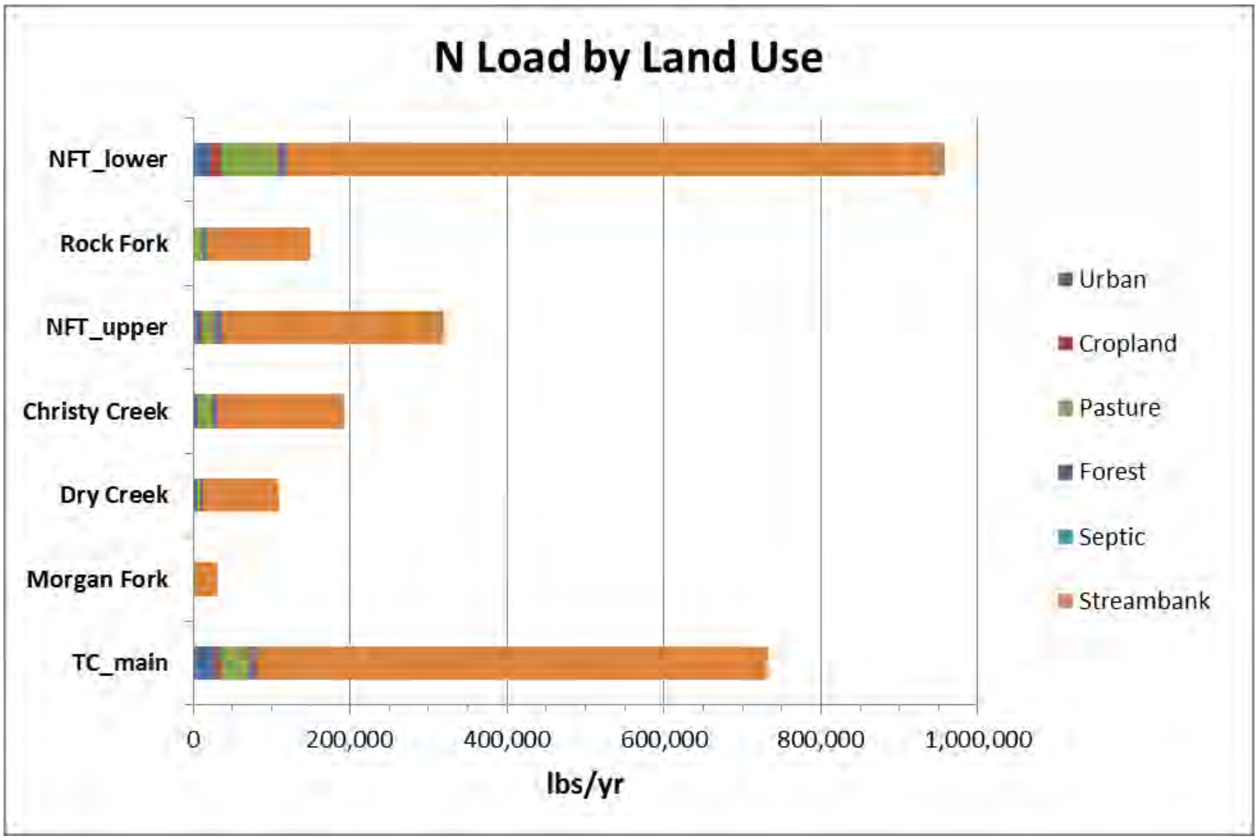

Figure 3.62. STEPL predicted nitrogen (N) load by subwatershed and land use.

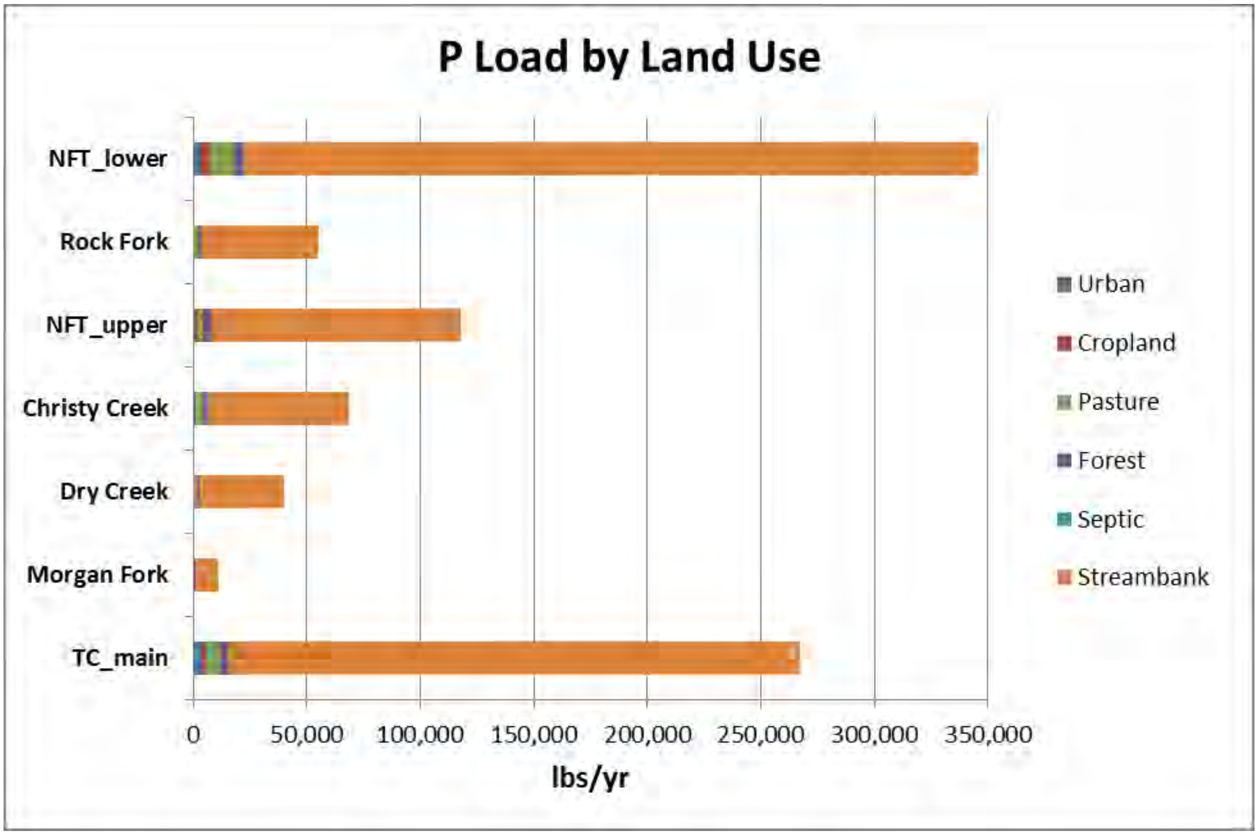

Figure 3.63. STEPL predicted phosphorous (P) load by subwatershed and land use.

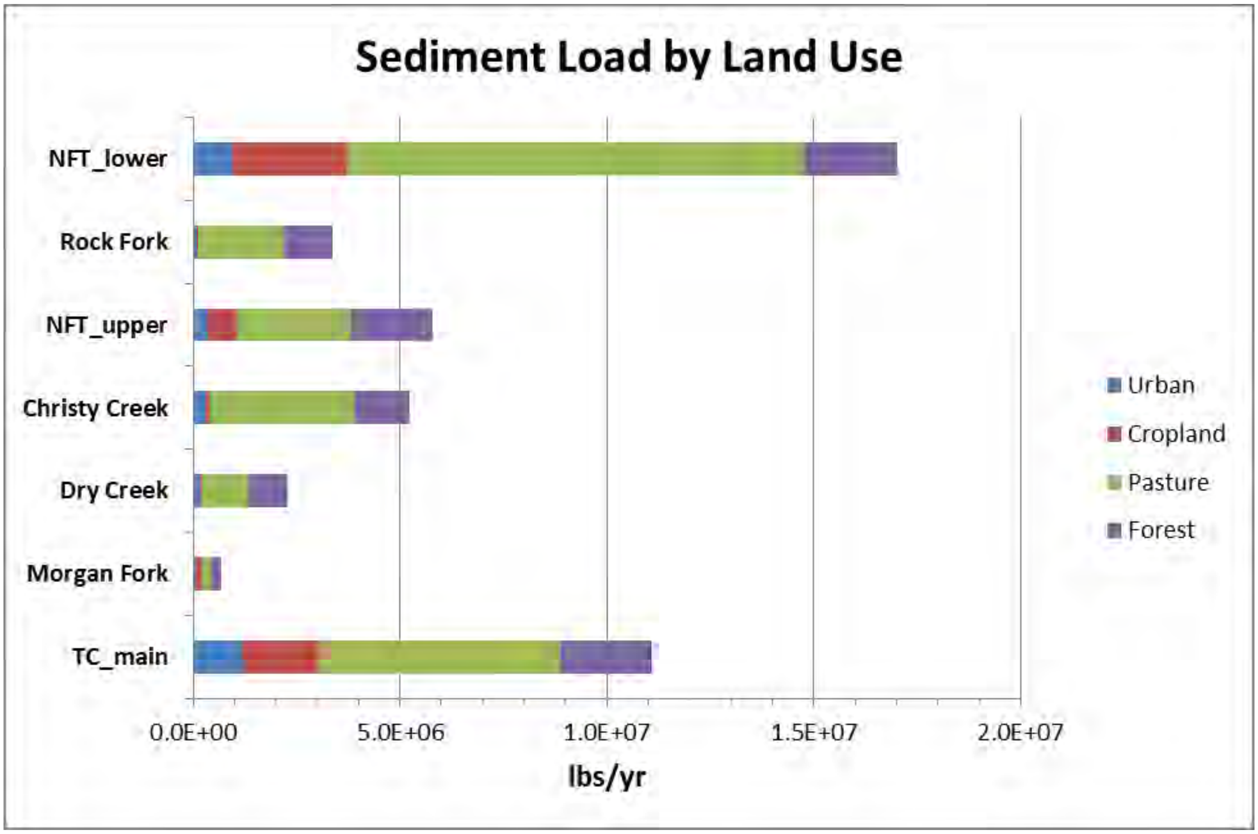

Figure 3.64. STEPL predicted sediment load by subwatershed and land use – except 'streambank' (see Figure 3.66).

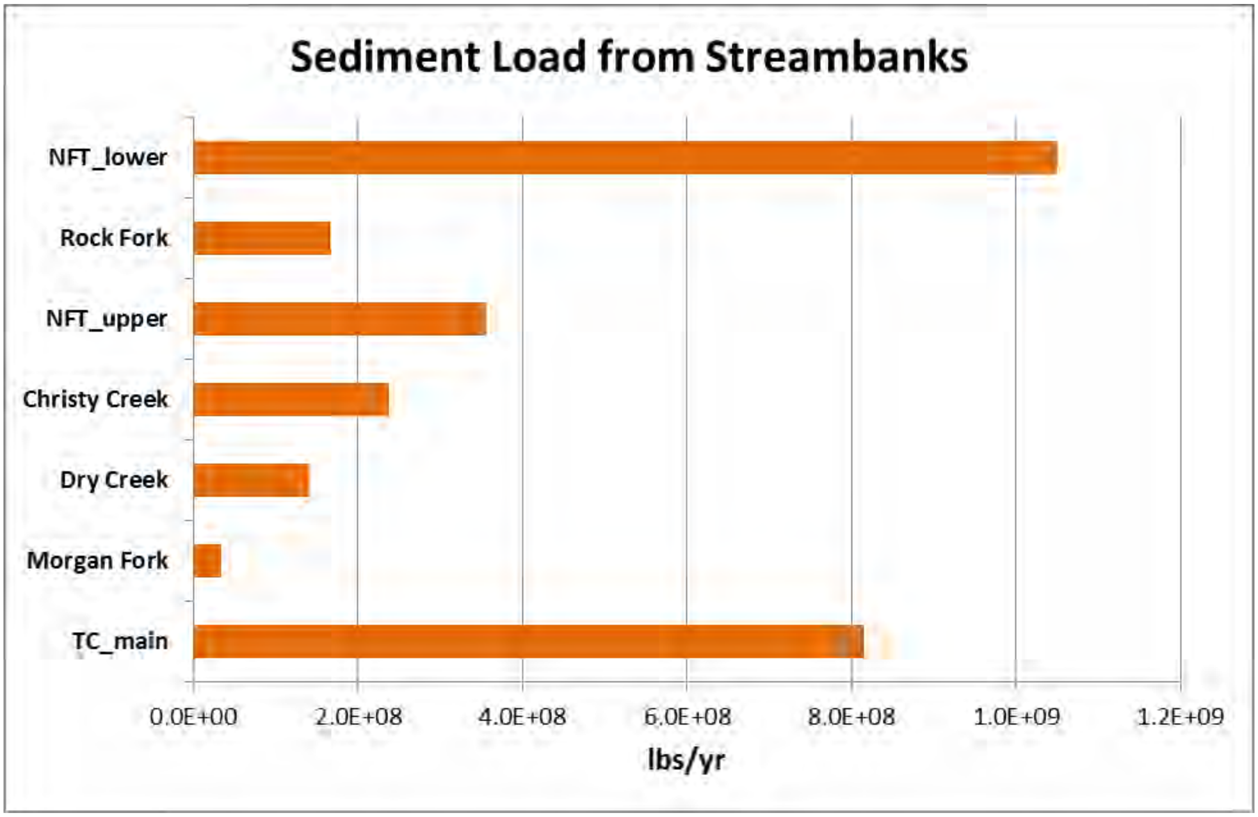

Figure 3.65. STEPL predicted sediment load by subwatershed for the streambank land use.

Model Results – pollutant load reductions

Model predicted nitrogen, phosphorous, and sediment load reductions based on user-selected BMPs are summarized below for each subwatershed in the Triplett Creek Watershed. Eleven different BMPs (appendix G) were selected by the Triplett Creek Watershed science team for pollutant load reduction modeling in STEPL based on local expert knowledge, as well as the probability of actually being able to implement the BMPs in the Triplett Creek Watershed.

Main stem of Triplett Creek (TC_main) Subwatershed

As was the case for every subwatershed, the greatest load reductions in nitrogen, phosphorous, and sediment were seen when the stream channel stabilization BMP was implemented for the two most severely eroded streambank categories in the TC_main subwatershed (Table 3.42, page 181). More specifically, greater than 50% load reductions were predicted for nitrogen, phosphorous, and sediment following this BMP implementation. The next largest post-BMP reductions were seen for nitrogen loads from pastureland (~3.5%), followed by phosphorous loads from pastureland (~1.5%); load reductions following the simulation of all BMPs for cropland and urban areas were less than ~1%. .

Table 3.42. STEPL model predicted loads, and load reductions for user-selected BMPs, for Main Stem of Triplett Creek Subwatershed (sub-basin).

Total sub-basin load w/o BMP			BMP Implementation*		Total sub-basin load w/ BMP			% Load Reduction		
N (lbs/yr)	P (lbs/yr)	Sed (tons/yr)	LULC class	BMP/s	N (lbs/yr)	P (lbs/yr)	Sed (tons/yr)	N (lbs/yr)	P (lbs/yr)	Sed (tons/yr)
732,820	267,203	413,375	***Cropland***	C1: Filter strip	727,696	265,698	412,792	0.70	0.56	0.14
732,820	267,203	413,375	***Cropland***	C2-3: Stream channel stabilization; Streambank fencing	727,176	265,588	412,703	0.77	0.60	0.16
732,820	267,203	413,375	***Cropland***	C1-3: Filter strip; Stream channel stabilization; Streambank fencing	727,355	265,621	412,730	0.75	0.59	0.16
732,820	267,203	413,375	***Pastureland***	P1: Filter strip	707,154	263,283	411,470	3.50	1.47	0.46
732,820	267,203	413,375	***Pastureland***	P2-3: Stream channel stabilization; Streambank fencing	704,818	262,922	411,177	3.82	1.60	0.53
732,820	267,203	413,375	***Pastureland***	P1-3: Filter strip; Stream channel stabilization; Streambank fencing	705,658	263,030	411,264	3.71	1.56	0.51
732,820	267,203	413,375	***Urban***	U1: Infiltration devices	732,820	264,635	412,946	0.00	0.96	0.10
732,820	267,203	413,375	***Urban***	U2: Wetland detention	728,736	265,842	413,021	0.56	0.51	0.09
732,820	267,203	413,375	***Urban***	U3: Vegetated filter strip	724,653	265,803	413,042	1.11	0.52	0.08
732,820	267,203	413,375	***Urban***	U1-3: Infiltration devices; Wetland detention; Vegetated filter strip	726,695	265,717	413,001	0.84	0.56	0.09
732,820	267,203	413,375	***Streambank***	SB: Stream channel stabilization	362,020	124,445	181,625	50.60	53.43	56.06

*Cropland and pastureland BMPs were applied to 100% of these areas, respectively, in the TC_main Subwatershed. Urban BMPs were only applied to the most intensively developed categories utilized by STEPL (commercial, industrial, institutional, transportation, and multi-family housing). The streambank BMP was only applied to streambanks classed in the two most severe bank erosion categories. Default STEPL BMP efficiency values were used in all cases.

Morgan Fork Subwatershed

The largest load reductions in nitrogen, phosphorous, and sediment were seen when the stream channel stabilization BMP was implemented for the two most severely eroded streambank categories in the Morgan Fork Subwatershed (Table 3.43, page 183). More specifically, greater than 50% load reductions were predicted for nitrogen, phosphorous, and sediment following this BMP implementation. The next largest post-BMP reductions were seen for nitrogen loads from pastureland (~2%), followed by phosphorous loads from pastureland and nitrogen loads from cropland (both ~1%); load reductions following the simulation of all other BMPs were less than ~1%.

Table 3.43. STEPL model predicted loads, and load reductions for user-selected BMPs, for the Morgan Fork Subwatershed (sub-basin).

Total sub-basin load w/o BMP			**BMP Implementation***		**Total sub-basin load w/ BMP**			**% Load Reduction**		
N (lbs/yr)	**P (lbs/yr)**	**Sed (tons/yr)**	**LULC class**	**BMP/s**	**N (lbs/yr)**	**P (lbs/yr)**	**Sed (tons/yr)**	**N (lbs/yr)**	**P (lbs/yr)**	**Sed (tons/yr)**
30,730	11,310	17,375	***Cropland***	C1: Filter strip	30,372	11,207	17,326	1.17	0.91	0.28
30,730	11,310	17,375	***Cropland***	C2-3: Stream channel stabilization; Streambank fencing	30,333	11,198	17,318	1.29	1.00	0.33
30,730	11,310	17,375	***Cropland***	C1-3: Filter strip; Stream channel stabilization; Streambank fencing	30,346	11,201	17,321	1.25	0.97	0.31
30,730	11,310	17,375	***Pastureland***	P1: Filter strip	30,137	11,192	17,303	1.93	1.05	0.42
30,730	11,310	17,375	***Pastureland***	P2-3: Stream channel stabilization; Streambank fencing	30,076	11,178	17,291	2.13	1.17	0.48
30,730	11,310	17,375	***Pastureland***	P1-3: Filter strip; Stream channel stabilization; Streambank fencing	30,097	11,182	17,295	2.06	1.13	0.46
30,730	11,310	17,375	***Urban***	U1: Infiltration devices	-	-	-	-	-	-
30,730	11,310	17,375	***Urban***	U2: Wetland detention	-	-	-	-	-	-
30,730	11,310	17,375	***Urban***	U3: Vegetated filter strip	-	-	-	-	-	-
30,730	11,310	17,375	***Urban***	U1-3: Infiltration devices; Wetland detention; Vegetated filter strip	-	-	-	-	-	-
30,730	11,310	17,375	***Streambank***	SB: Stream channel stabilization	13,948	4,849	6,886	54.61	57.12	60.37

*Cropland and pastureland BMPs were applied to 100% of these areas, respectively, in the Morgan Fork Subwatershed. Urban BMPs were not applied in this subwatershed. The streambank BMP was only applied to streambanks classed in the two most severe bank erosion categories. Default STEPL BMP efficiency values were used in all cases.

Dry Creek Subwatershed

Dry Creek Subwatershed

Implementing the stream channel stabilization BMP for the two most severely eroded streambank categories in the Dry Creek Subwatershed resulted in the largest load reductions in nitrogen, phosphorous, and sediment (Table 3.44, page 185). More specifically, greater than 50% load reductions were predicted for nitrogen, phosphorous, and sediment following this BMP implementation. The next largest post-BMP reductions were seen for nitrogen loads from pastureland (~3.5%), followed by phosphorous loads from pastureland and (~1.8%); load reductions following the simulation of all other BMPs were less than ~1%.

Table 3.44. STEPL model predicted loads, and load reductions for user-selected BMPs, for the Dry Creek Subwatershed (sub-basin).

Total sub-basin load w/o BMP			BMP Implementation*		Total sub-basin load w/ BMP			% Load Reduction		
N (lbs/yr)	P (lbs/yr)	Sed (tons/yr)	LULC class	BMP/s	N (lbs/yr)	P (lbs/yr)	Sed (tons/yr)	N (lbs/yr)	P (lbs/yr)	Sed (tons/yr)
109,332	40,079	71,961	***Cropland***	C1: Filter strip	109,248	40,056	71,952	0.08	0.06	0.01
109,332	40,079	71,961	***Cropland***	C2-3: Stream channel stabilization; Streambank fencing	109,240	40,054	71,951	0.08	0.06	0.01
109,332	40,079	71,961	***Cropland***	C1-3: Filter strip; Stream channel stabilization; Streambank fencing	109,243	40,055	71,951	0.08	0.06	0.01
109,332	40,079	71,961	***Pastureland***	P1: Filter strip	105,443	39,401	71,587	3.56	1.69	0.52
109,332	40,079	71,961	***Pastureland***	P2-3: Stream channel stabilization; Streambank fencing	105,067	39,331	71,530	3.90	1.87	0.60
109,332	40,079	71,961	***Pastureland***	P1-3: Filter strip; Stream channel stabilization; Streambank fencing	105,199	39,352	71,547	3.78	1.81	0.58
109,332	40,079	71,961	***Urban***	U1: Infiltration devices	-	-	-	-	-	-
109,332	40,079	71,961	***Urban***	U2: Wetland detention	-	-	-	-	-	-
109,332	40,079	71,961	***Urban***	U3: Vegetated filter strip	-	-	-	-	-	-
109,332	40,079	71,961	***Urban***	U1-3: Infiltration devices; Wetland detention; Vegetated filter strip	-	-	-	-	-	-
109,332	40,079	71,961	***Streambank***	SB: Stream channel stabilization	50,054	17,257	28,374	54.22	56.94	60.57

*Cropland and pastureland BMPs were applied to 100% of these areas, respectively, in the Dry Creek Subwatershed. Urban BMPs were not applied in this subwatershed. The streambank BMP was only applied to streambanks classed in the two most severe bank erosion categories. Default STEPL BMP efficiency values were used in all cases.

Christy Creek Subwatershed

Implementing the stream channel stabilization BMP for the two most severely eroded streambank categories in the Christy Creek Subwatershed resulted in the largest load reductions in nitrogen, phosphorous, and sediment (greater than 50%, Table 3.45, page 187). The next largest post-BMP reductions were seen for nitrogen loads from pastureland (~7%), followed by phosphorous loads from pastureland (~3.5%); load reductions following the simulation of all other BMPs were less than ~1%.

Table 3.45. STEPL model predicted loads, and load reductions for user-selected BMPs, for the Christy Creek Subwatershed (sub-basin).

Total sub-basin load w/o BMP			BMP Implementation*		Total sub-basin load w/ BMP			% Load Reduction		
N (lbs/yr)	P (lbs/yr)	Sed (tons/yr)	LULC class	BMP/s	N (lbs/yr)	P (lbs/yr)	Sed (tons/yr)	N (lbs/yr)	P (lbs/yr)	Sed (tons/yr)
193,132	68,823	121,731	***Cropland***	C1: Filter strip	192,839	68,744	121,702	0.15	0.11	0.02
193,132	68,823	121,731	***Cropland***	C2-3: Stream channel stabilization; Streambank fencing	192,810	68,739	121,698	0.17	0.12	0.03
193,132	68,823	121,731	***Cropland***	C1-3: Filter strip; Stream channel stabilization; Streambank fencing	192,820	68,741	121,699	0.16	0.12	0.03
193,132	68,823	121,731	***Pastureland***	P1: Filter strip	179,966	66,656	120,594	6.82	3.15	0.93
193,132	68,823	121,731	***Pastureland***	P2-3: Stream channel stabilization; Streambank fencing	178,725	66,440	120,419	7.46	3.46	1.08
193,132	68,823	121,731	***Pastureland***	P1-3: Filter strip; Stream channel stabilization; Streambank fencing	179,166	66,505	120,471	7.23	3.37	1.04
193,132	68,823	121,731	***Urban***	U1: Infiltration devices	-	-	-	-	-	-
193,132	68,823	121,731	***Urban***	U2: Wetland detention	-	-	-	-	-	-
193,132	68,823	121,731	***Urban***	U3: Vegetated filter strip	-	-	-	-	-	-
193,132	68,823	121,731	***Urban***	U1-3: Infiltration devices; Wetland detention; Vegetated filter strip	-	-	-	-	-	-
193,132	68,823	121,731	***Streambank***	SB: Stream channel stabilization	87,506	28,157	44,064	54.69	59.09	63.80

*Cropland and pastureland BMPs were applied to 100% of these areas, respectively, in the Christy Creek Subwatershed. Urban BMPs were not applied in this subwatershed. The streambank BMP was only applied to streambanks classed in the two most severe bank erosion categories. Default STEPL BMP efficiency values were used in all cases.

Upper North Fork Triplett Creek (NFT_upper) Subwatershed

The largest load reductions in nitrogen, phosphorous, and sediment were seen when the stream channel stabilization BMP was implemented for the two most severely eroded streambank categories in the Upper North Fork Triplett Creek Subwatershed (greater than 50%, Table 3.46, page 189). The next largest post-BMP reductions were seen for nitrogen loads from pastureland (~3.5%), followed by phosphorous loads from pastureland (~1.5%); load reductions following the simulation of all other BMPs were less than ~1%.

Table 3.46. STEPL model predicted loads, and load reductions for user-selected BMPs, for the Upper North Fork of Triplett Creek (NFT_upper) Subwatershed (sub-basin).

Total sub-basin load w/o BMP			**BMP Implementation***		**Total sub-basin load w/ BMP**			**% Load Reduction**		
N (lbs/yr)	**P (lbs/yr)**	**Sed (tons/yr)**	**LULC class**	**BMP/s**	**N (lbs/yr)**	**P (lbs/yr)**	**Sed (tons/yr)**	**N (lbs/yr)**	**P (lbs/yr)**	**Sed (tons/yr)**
319,651	117,589	180,853	***Cropland***	C1: Filter strip	317,217	116,947	180,628	0.76	0.55	0.12
319,651	117,589	180,853	***Cropland***	C2-3: Stream channel stabilization; Streambank fencing	316,983	116,904	180,593	0.83	0.58	0.14
319,651	117,589	180,853	***Cropland***	C1-3: Filter strip; Stream channel stabilization; Streambank fencing	317,065	116,917	180,603	0.81	0.57	0.14
319,651	117,589	180,853	***Pastureland***	P1: Filter strip	308,451	115,813	179,955	3.50	1.51	0.50
319,651	117,589	180,853	***Pastureland***	P2-3: Stream channel stabilization; Streambank fencing	307,414	115,643	179,817	3.83	1.65	0.57
319,651	117,589	180,853	***Pastureland***	P1-3: Filter strip; Stream channel stabilization; Streambank fencing	307,785	115,694	179,858	3.71	1.61	0.55
319,651	117,589	180,853	***Urban***	U1: Infiltration devices	-	-	-	-	-	-
319,651	117,589	180,853	***Urban***	U2: Wetland detention	-	-	-	-	-	-
319,651	117,589	180,853	***Urban***	U3: Vegetated filter strip	-	-	-	-	-	-
319,651	117,589	180,853	***Urban***	U1-3: Infiltration devices; Wetland detention; Vegetated filter strip	-	-	-	-	-	-
319,651	117,589	180,853	***Streambank***	SB: Stream channel stabilization	144,417	50,124	71,332	54.82	57.37	60.56

*Cropland and pastureland BMPs were applied to 100% of these areas, respectively, in the Upper North Fork Triplett Creek Subwatershed. Urban BMPs were not applied in this subwatershed. The streambank BMP was only applied to streambanks classed in the two most severe bank erosion categories. Default STEPL BMP efficiency values were used in all cases

Rock Fork Subwatershed

The largest load reductions in nitrogen, phosphorous, and sediment were seen when the stream channel stabilization BMP was implemented for the two most severely eroded streambank categories in the Upper North Fork Triplett Creek Subwatershed (greater than 50%, Table 3.47, page 191). The next largest post-BMP reductions were seen for nitrogen loads from pastureland (~5%), followed by phosphorous loads from pastureland (~2.5%); load reductions following the simulation of all other BMPs were less than ~1%.

Table 3.47. STEPL model predicted loads, and load reductions for user-selected BMPs, for the Rock Fork Subwatershed (sub-basin).

Total sub-basin load w/o BMP			BMP Implementation*		Total sub-basin load w/ BMP			% Load Reduction		
N (lbs/yr)	P (lbs/yr)	Sed (tons/yr)	LULC class	BMP/s	N (lbs/yr)	P (lbs/yr)	Sed (tons/yr)	N (lbs/yr)	P (lbs/yr)	Sed (tons/yr)
149,560	54,994	84,535	***Cropland***	C1: Filter strip	149,450	54,964	84,523	0.07	0.05	0.01
149,560	54,994	84,535	***Cropland***	C2-3: Stream channel stabilization; Streambank fencing	149,439	54,962	84,521	0.08	0.06	0.02
149,560	54,994	84,535	***Cropland***	C1-3: Filter strip; Stream channel stabilization; Streambank fencing	149,443	54,963	84,522	0.08	0.06	0.01
149,560	54,994	84,535	***Pastureland***	P1: Filter strip	142,173	53,744	83,862	4.94	2.27	0.80
149,560	54,994	84,535	***Pastureland***	P2-3: Stream channel stabilization; Streambank fencing	141,468	53,617	83,758	5.41	2.50	0.92
149,560	54,994	84,535	***Pastureland***	P1-3: Filter strip; Stream channel stabilization; Streambank fencing	141,717	53,655	83,789	5.24	2.43	0.88
149,560	54,994	84,535	***Urban***	U1: Infiltration devices	-	-	-	-	-	-
149,560	54,994	84,535	***Urban***	U2: Wetland detention	-	-	-	-	-	-
149,560	54,994	84,535	***Urban***	U3: Vegetated filter strip	-	-	-	-	-	-
149,560	54,994	84,535	***Urban***	U1-3: Infiltration devices; Wetland detention; Vegetated filter strip	-	-	-	-	-	-
149,560	54,994	84,535	***Streambank***	SB: Stream channel stabilization	67,982	23,587	33,549	54.55	57.11	60.31

*Cropland and pastureland BMPs were applied to 100% of these areas, respectively, in the Rock Fork Subwatershed. Urban BMPs were not applied in this subwatershed. The streambank BMP was only applied to streambanks classed in the two most severe bank erosion categories. Default STEPL BMP efficiency values were used in all cases.

Lower North Fork Triplett Creek (NFT_lower) Subwatershed

As was the case for every subwatershed, the greatest load reductions in nitrogen, phosphorous, and sediment were seen when the stream channel stabilization BMP was implemented for the two most severely eroded streambank categories in the Lower North Fork Triplett Creek Subwatershed (Table 3.48, page 193). More specifically, greater than 50% load reductions were predicted for nitrogen, phosphorous, and sediment following this BMP implementation. The next largest post-BMP reductions were seen for nitrogen loads from pastureland (~5%), followed by phosphorous loads from pastureland (~2%) and nitrogen loads from cropland (~1%); load reductions following the simulation of all other BMPs were less than ~1%.

Table 3.48. STEPL model predicted loads, and load reductions for user-selected BMPs, for the Lower North Fork of Triplett Creek (NFT_lower) Subwatershed (sub-basin).

Total sub-basin load w/o BMP			**BMP Implementation***		**Total sub-basin load w/ BMP**			**% Load Reduction**		
N (lbs/yr)	***P (lbs/yr)***	***Sed (tons/yr)***	***LULC class***	***BMP/s***	***N (lbs/yr)***	***P (lbs/yr)***	***Sed (tons/yr)***	***N (lbs/yr)***	***P (lbs/yr)***	***Sed (tons/yr)***
958,145	345,551	533,376	**Cropland**	C1: Filter strip	947,476	342,792	532,484	1.11	0.80	0.17
958,145	345,551	533,376	**Cropland**	C2-3: Stream channel stabilization; Streambank fencing	946,478	342,623	532,346	1.22	0.85	0.19
958,145	345,551	533,376	**Cropland**	C1-3: Filter strip; Stream channel stabilization; Streambank fencing	946,833	342,674	532,388	1.18	0.83	0.19
958,145	345,551	533,376	**Pastureland**	P1: Filter strip	908,169	338,030	529,780	5.22	2.18	0.67
958,145	345,551	533,376	**Pastureland**	P2-3: Stream channel stabilization; Streambank fencing	903,651	337,349	529,227	5.69	2.37	0.78
958,145	345,551	533,376	**Pastureland**	P1-3: Filter strip; Stream channel stabilization; Streambank fencing	905,281	337,553	529,393	5.52	2.31	0.75
958,145	345,551	533,376	**Urban**	U1: Infiltration devices	958,145	343,523	533,036	0.00	0.59	0.06
958,145	345,551	533,376	**Urban**	U2: Wetland detention	954,918	344,476	533,096	0.34	0.31	0.05
958,145	345,551	533,376	**Urban**	U3: Vegetated filter strip	951,692	344,445	533,112	0.67	0.32	0.05
958,145	345,551	533,376	***Urban***	U1-3: Infiltration devices; Wetland detention; Vegetated filter strip	953,305	344,158	533,080	0.51	0.40	0.06
958,145	345,551	533,376	***Streambank***	SB: Stream channel stabilization	441,322	146,574	210,361	53.94	57.58	60.56

*Cropland and pastureland BMPs were applied to 100% of these areas, respectively, in the Lower North Fork Triplett Creek Subwatershed. Urban BMPs were only applied to the most intensively developed categories utilized by STEPL (commercial, industrial, institutional, transportation, and multi-family housing). The streambank BMP was only applied to streambanks classed in the two most severe bank erosion categories. Default STEPL BMP efficiency values were used in all cases.

It is very clear that the most effective BMP implementation in all seven subwatersheds involved stabilizing impaired stream channels. This BMP scenario resulted in greater than a 50% reduction, often closer to 60%, in subwatershed nutrient and sediment loads. The next most effective BMP scenario was associated with the pasture land use category, however substantially smaller load reductions were achieved in this case. BMP simulations for all other land use types resulted in negligible load reductions.

Predictive Uncertainty

As is the case with any water quality model, there are a number of assumptions and generalizations associated with the STEPL model structure, and its application in the Triplett Creek Watershed, that may contribute to uncertainty in model predictions. This uncertainty, in turn, may help explain differences between modeled values and field-based load estimates of nitrogen, phosphorous, and sediment. Predictive uncertainty may arise due to the empirical nature of the model's algorithms, which were developed using information from a variety of regions and geographic scales. Moreover, model default values were used in a number of instances due to the lack of specific knowledge for the study area. Other contributions to predictive uncertainty could derive from inaccuracies in the input data used to represent subwatershed conditions, the use of default BMP efficiency values for load reduction predictions, and the inability to calibrate the STEPL model due to data limitations.

We have calculated load using MAF (Tables 3.37, 3.38, and 3.39), instantaneous daily loads (appendix F), and STEPL. All of the data generated from these calculations were taken into consideration when analyzing and prioritizing the subwatersheds. Together the methods provided a very detailed and big picture of the watershed. The MAF and STEPL models are especially helpful and consistent when investigating large watersheds with many sampling sites. If sufficient field data is available post sampling will be compared to the field data in this WBP. However, field data for each site is not always complete. The MAF and STEPL load calculations provide a way to calculate load reductions if data is missing. The STEPL load reductions will be used to estimate load reductions for the BMPIP plans.

PRESENT AND FUTURE STRESSORS ON THE WATERSHED

Increased Development and Impervious Surfaces

Development is likely to increase in the watershed, primarily in the form of single unit housing and apartments. Future development upstream of the current reach of county sewer lines (see Figure 2.6, Section 2 for sewer infrastructure) could lead to more septic systems and potentially higher pathogen loads in the watershed, particularly if the systems are improperly sized or too close to streams. Runoff from lawns could wash fertilizers into nearby streams, which would further increase already high nutrient loads. Runoff laden with other widely used lawn care products (e.g., herbicides and pesticides) could further reduce the diversity of aquatic organisms.

Of course development also increases the percentage of land covered by impervious surfaces. The fact that paved surfaces and rooftops do not allow water to pass through them, i.e., they are impervious, gives rise to a wide range of negative environmental and economic impacts. For example, because impervious surfaces serve as collectors of solid and liquid pollutants (road salt, antifreeze, fertilizers, pet waste) and debris (brake dust, tire rubber, litter, sediment) they are one of the primary contributors to non-point source (NPS) pollution in streams. NPS pollution significantly reduces the quality of water available for human needs (e.g., drinking water) and degrades the integrity of aquatic ecosystem structure and functioning.

In addition to water quality effects, impervious surfaces also impact the quantity and timing of water reaching streams and rivers. Precipitation falling on impervious surfaces reaches the stream channel faster and in greater amounts compared to vegetated surfaces, thereby increasing the risk of flooding and channel erosion and decreasing the amount of groundwater recharge. Other important consequences of paving watersheds include higher steam water temperatures from runoff over warmed asphalt and higher air temperatures due to warmed asphalt and reduced vegetation. Removal of vegetation to build houses, roads, and parking areas reduces shade and evapotranspiration, both of which cool the land surface.

It is generally accepted by watershed and ecosystem management professionals that significant hydro-ecological impairment (e.g. polluted water and increased flooding) occurs once a watershed contains 10% impervious surfaces, and that greater than 25% impervious surface area generally leads to severe levels of impairment. The amount of impervious surfaces in Rowan County is concentrated in the downtown area and the I-64 exit at HWY 32 (Figure 3.67, page 198). The figure below shows these areas between 80 and 98% impervious surfaces.

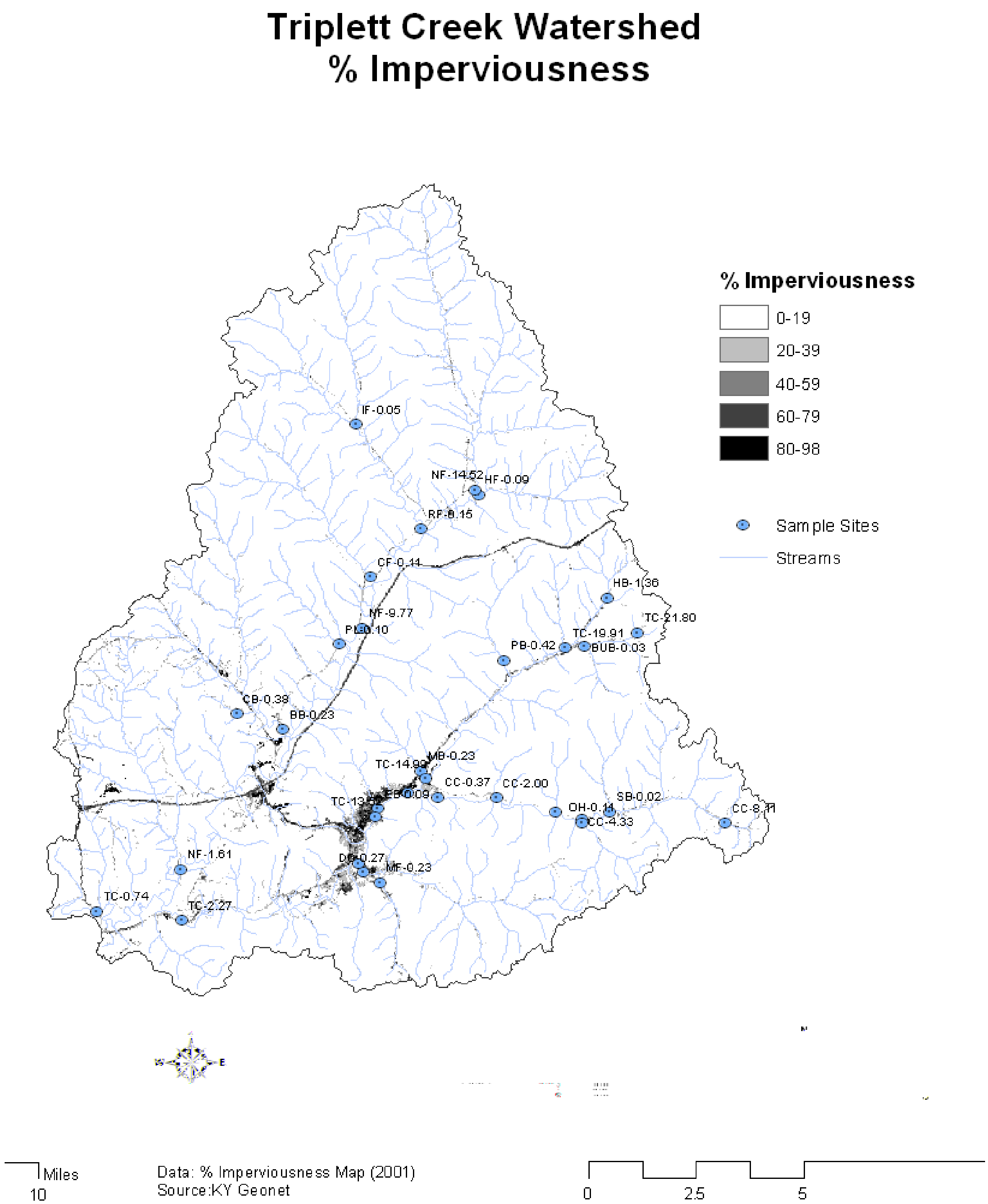

Figure 3.66. Impervious cover in the Triplett Creek Watershed. An enlarged map can be located in appendix E.

Removal of Riparian Zone Vegetation

Removal of riparian zone vegetation is widespread and likely to continue. Some of the problems associated with this activity were alluded to earlier. For example, removal of vegetation from streambanks greatly accelerates erosion, which leads directly to higher SSC and sediment loads. The removal of trees increases evaporation from streams, which can decrease flow. Wholesale removal of willows, sycamores, and river birches decreases transpiration (water "soaked up" by trees) and allows more groundwater to seep into channels, which ironically tends to help streams flow longer during the dry season. This apparent advantage is outweighed by even more problems, however. Once the vegetation is removed, runoff reaches streams faster, which tends to produce more flooding. In addition, the sediment becomes less stable and erodes at a faster rate. Removal of riparian trees also increases water temperature as more sunlight hits the stream, which in turn leads to decreased DO.

Channel Alteration and Gravel Mining

Channel alteration is widespread throughout the watershed. In fact, gravel mining with improper heavy equipment in the streambed appears to be a common practice throughout the entire Triplett Creek Watershed. Several unimproved access roads lead to the Triplett Creek streambed and its tributaries. Some of these roads appear to still be in use, while others are eroded and overgrown.

Channel alteration and gravel mining have and probably will continue to cause a variety of problems in the watershed. Habitat destruction is obvious based on assessments conducted for this study. Complete removal of gravel bars near pools and riffles has eliminated spawning areas. The rapid appearance of "new" gravel due to colluviums and bedrock erosion virtually assures that disruptive gravel mining will continue. All of these practices tend to increase flow velocity and accelerate downcutting and bank erosion. Channel entrenchment is likely to worsen in the future.

Floodplain In-filling

A few relatively small floodplain in-filling projects are in progress within the watershed. All are primarily intended to raise housing construction sites above the 100-year floodplain In the middle and upper parts of the Triplett Creek and North Fork of Triplett Watersheds these projects are less likely to cause problems as they appear to be dispersed and these areas seldom overflows their banks. In the lower, more developed part of the watershed, however, Triplett Creek and the North Fork of Triplett (as well as other tributaries) overflows their banks onto the floodplain, usually due to back-up from Triplett Creek and Licking River flooding. Excessive floodplain in-filling in this part of the watershed could have serious consequences in adjacent upstream and downstream areas that remain unfilled.

Homes and businesses occupying raised land may escape floodwaters but neighbors in the original (lower) floodplain areas will experience worse flooding than before the in-filling projects were completed.

Logging

As a result of the February 2003 ice storm, damaged trees on USFS land are being or will be logged in one of two ways. Approximately 1.3% of the USFS land will be logged commercially, which involves cutting down and removing the damaged tress. Another roughly 2.4% of USFS land will be logged non-commercially, where damaged trees are cut down and left in place to provide wildlife habitat, to add nutrients to soils through decay, etc. Timber harvesting can have lasting impacts on both the quality of the water and the amount of water flowing in watershed streams. Removing trees from hill slopes results in more rain and snowfall reaching the surface and consequently the stream channel. In addition, bare hill slopes are prone to soil erosion by wind and water which in turn increases the amount of sediment and other materials (e.g., leaves, dead wood) entering the stream. Hence, logging may contribute to both degraded water quality as well as increased flooding risk.

Inadequate and Failed Septic Systems

Human waste remains the main source of bacteria and nutrients in our waterways. In the Dry Creek Watershed, up to 75% of the pathogens were human in source. The problem is a combination of many factors, such as improper installation and maintenance, inadequate drain field, and close proximity to waterways. The sewage that enters the waterway poses a human and animal health threat, as well as environmental degradation. As more homes are placed onto the Morehead Utility Plant Board infrastructure, water quality will improve. However, pathogens can live for many years in the soil. Therefore the bacteria level can remain high for several years. In addition, it areas where MUPB infrastructure exist, bacteria levels may still exceed WQS because residents opt out.

Agriculture

Agriculture is a source for both bacteria and nutrient pollutant. Farmers are under more pressure to maximize crop production to cover cost. As this pressures rises, the amount of pollutants are expected to increase as riparian zones are removed, the number of livestock accessing waterways increases, and more crops are planted. These actions can have a negative impact on farmers in the long run. The removal of the riparian zones cause bank erosion – land loses. The Licking River Watershed is a major source of nutrient pollutants in the Gulf of Mexico. Bacteria in the waterways (and other sources) can make livestock sick increasing the cost of treatments. Row crop and lack of vegetation along the waterways increase sediment and nutrient runoff from fields.

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Triplett Creek Best Management Practices Implementation Plan
Section 4

INTRODUCTION

The results of fieldwork conducted for this watershed-based plan and summarized in Section 3 validates KDOW's decision to include portions of Triplett Creek, Rock Fork, Dry Creek, and Christi Creek in the 2010 303(d) list of impaired waterways (KDOW, 2010). Section 3 results also indicate that other reaches of Triplett Creek and its tributaries are impaired by the same pollutants identified by KDOW (2010) and that several physical parameters related to this pollution exceed established Water Quality Criteria (WQC).

In Section 4, targets are set, Best Management Practices (BMPs) are suggested and implementation plan is outlined that will help the community meet our ultimate goal of improving the quality of impaired waterways and protecting high quality waterways within the Triplett Creek Watershed. BMPs are land use practices or construction projects that maintain high quality waterways and improve water quality of impacted streams. Typical BMP includes treatment options (e.g., septic systems), practices to control runoff (e.g., restoration or maintenance of vegetation), operating procedures (e.g., ordinances, agricultural water plans), and public education.

Our top priority in selecting BMPs to improve Triplett Creek and its tributaries was to address impairments identified verbally (and some written) by citizens and public officials, KDOW (2008), and the results of our one-year scientific monitoring program (Sections 2 and 3). From this initial list, we chose the most effective, economic and politically feasible options to present to the public. The deliberation process involved conversations between MSU scientists; local, state and federal officials; an experienced and well-regarded environmental consultant; and widely publicized efforts to solicit feedback from citizens who live in the watershed (e.g., community roundtables). The views of all stakeholders who chose to participate were taken into consideration. Therefore, the BMPs and implementation plan presented below represent our best effort to appeal to as many interest groups as possible yet still adhere to the underlying scientific basis of the watershed-based plan.

GOALS AND OBJECTIVES

Table 4.1 (pages 203-206) summarizes identified problems in the watershed, relates these problems to scientific results presented in Sections 2 and 3, and lists long-term goals that must be met in order to correct or at least decrease the severity of these problems.

Table 4.1 Concerns with water quality in the Triplett Creek Watershed, their potential causes, and long-term goals that must be met to correct the problems.

Concerns	Probable Cause(s)	Supporting Data	Assessment	Long-term Goal
Flooding	Infilling, removal of vegetation, impervious surfaces from roads and development, channelization	Field observation and data	Habitat assessment, and GIS data	· Decrease severity and frequency of flooding.
Trash	Road side litter, illegal disposal, and runoff from yards	Visual assessment and public comments	Visual assessment	· Improve appearance of waterways to encourage a positive attitude towards the resource.
Unsafe swimming and wading conditions	Failed and failing septic systems, domesticated animal waste	KDOW (2010), field data	Measured bacteria counts, DNA fingerprinting of *E. coli*	· Decrease nutrient loads in Triplett Creek Watershed. · Decrease bacteria levels to meet Primary Contact Recreation standards. · Improve water quality so that Triplett Creek Watershed can be safely used as a recreational resource (e.g., fishing, swimming, and canoeing/kayaking).
Sewer odors	Failed and failing septic systems	KDOW (2010), field observations and data	Measured bacteria counts, DNA fingerprinting	· Decrease bacteria levels to meet Primary Contact standards. · Improve water quality so that Triplett Creek

			of *E. coli*	Watershed can be safely used as a recreational resource.

Table 4.1. Concerns with water quality in the Triplett Creek Watershed, their potential causes, and long-term goals that must be met to correct the problems (continued).

Concerns	Probable Cause(s)	Supporting Data	Assessment	Long-term Goal
Land loss from eroding creek banks	Vegetation removal along stream banks, channelization, gravel mining	Visual observations, measured channel cross sections, bank pins	Stream habitat and visual assessment, measured channel cross sections, bank pins	· Decrease severity and frequency of flooding. · Decrease sediment loads in Triplett Creek Watershed. · Decrease nutrient loads in Triplett Creek Watershed. · Improve water quality so that Triplett Creek Watershed can be safely used as a recreational resource.
Decrease in fish populations and diversity	Low dissolved oxygen, loss of habitat and shade cover, gravel mining	McCafferty and Eisenhour (2001)	Previous MSU field research, observations made by fishermen	· Decrease severity and frequency of flooding. · Decrease sediment loads in Triplett Creek Watershed. · Decrease nutrient loads in Triplett Creek Watershed. · Decrease bacteria levels to meet Primary Contact standards. · Improve water quality so that Triplett Creek Watershed can be safely used as a recreational resource.

Table 4.1. Concerns with water quality in the Triplett Creek Watershed, their potential causes, and long-term goals that must be met to correct the problems (continued).

Concerns	Probable Cause(s)	Supporting Data	Assessment	Long-term Goal
Excessive nutrients and algae blooms	Failed and failing septic systems, domesticated animal waste	KDOW (2010), field data	Field measurements, visual observations	• Decrease sediment loads in Triplett Creek Watershed. • Decrease nutrient loads in Triplett Creek Watershed. • Decrease bacteria levels to meet Primary Contact standards. • Improve water quality so that Triplett Creek Watershed can be safely used as a recreational resources.
Loss of native vegetation and ecosystems	Removal of vegetation cover for road, infilling, and housing development	Visual observations, habitat assessments, 2010 KSNPC report	Maps, visual observations	• Decrease severity and frequency of flooding. • Decrease sediment loads in Triplett Creek Watershed. • Decrease nutrient loads in Triplett Creek Watershed. • Decrease bacteria levels to meet Primary Contact standards. • Improve water quality so that Triplett Creek Watershed can be safely used as a recreational resource.

Table 4.1. Concerns with water quality in the Triplett Creek Watershed, their potential causes, and long-term goals that must be met to correct the problems (continued).

Concerns	Probable Cause(s)	Supporting Data	Assessment	Long-term Goal
Excessive sediment inputs	Removal of vegetation cover for road and Housing development, poor land use management, vegetation removal along stream bank, channelization, gravel mining	2008 Integrated Report, field data collection	Field measurements and observations	· Decrease severity and frequency of flooding. · Decrease sediment loads in Triplett Creek Watershed. · Decrease nutrient loads in Triplett Creek Watershed. · Decrease bacteria levels to meet Primary Contact standards. · Improve water quality so that Triplett Creek Watershed can be safely used as a recreational resource.

Each long-term goal outlined in Table 4.1 requires considerable long-term effort, as well as active involvement from all community members. To properly focus these efforts and achieve the desired results, specific objectives must be met. These objectives and their relationship to each goal are summarized in Table 4.2 (pages 207-209).

Table 4.2. Objectives for achieving long-term goals.

Goal	Source/Cause/Pollutant	Indicators	Objectives
Decrease the severity and frequency of flooding	**Removal of native vegetation and riparian zones (banks, riparian zone and wetlands):** the removal of native vegetation reduces the watershed's ability to absorb and store water, which increases runoff; more water enters the streams at a faster rate. **Runoff from disturbed land:** sediment input fills-in creeks causing water to more easily overflow its banks.	Less flooding and flash flooding, habitat assessment, land use, visual assessment	Reduce erosion from runoff associated with vegetation disturbances, impervious areas, and construction Reduce sediment from bank erosion Increase native plants in riparian zones and throughout watershed Restore native wetland areas to absorb water Change in personal behavior/Educate the public Increase previous surfaces
Decrease sediment loads	**Runoff from disturbed land:** sediment input fills-in creeks causing water to more easily overflow its banks. Sediment loads also negatively impact water temperature, nutrient	TSS, MBEHI, visual assessments, water temperature, land cover, habitat	Reduce sediment loss from runoff associated with vegetation disturbances, impervious area, and construction

	concentrations, and aquatic habitat. **Removal of stream bank vegetation:** the removal of vegetation from the bank allows sediment to easily erode.	assessment	Increase stream bank and riparian zone vegetation Stabilize stream banks Restore and/or construct wetlands Change in personal behavior/Educate the public

Notes: TSS = Total Suspended Solids; MBEHI = Bank Erosion Index

Table 4.2. Objectives for achieving long-term goals (continued).

Goal	**Source/Cause/Pollutant**	**Indicators**	**Objectives**
Decrease nutrient loads	**Removal of native vegetation and riparian zones (banks, riparian zone and wetlands):** the removal of native vegetation reduces the watershed's ability to filter water. **Runoff from disturbed land:** nutrient inputs are often attached to sediment	Nutrients concentrations, TSS, land cover, dissolved oxygen, conductivity, MBEHI	Reduce sediment loss from runoff associated with vegetation disturbances, impervious area, and construction Reduce sediment from bank erosion

	particles. **Residential inputs:** urban runoff from paved surfaces, washing cars, lawn fertilizers, and failed septic systems can add nutrients to the streams.		Restore and/or construct wetlands Reduce loads from failed/failing septic systems Change in personal behavior/ Educate the public
Decrease bacteria levels to meet Primary Contact standards	**Residential inputs:** failed septic systems increase bacteria entering the waterways. **Runoff from livestock operations:** bacteria levels increase without proper vegetative buffer zones and creek fencing.	Bacteria, nutrients, visual assessments	Reduce loads from failed/failing septic systems Change in personal behavior/ Educate the public Expand sewer infrastructure

Table 4.2. Objectives for achieving long-term goals (continued).

Goal	Source/Cause/Pollutant	Indicators	Objectives
Improve water quality so that Triplett Creek and its tributes can be safely used as a recreational and drinking water resource	**Residential inputs:** failed septic systems increase bacteria entering waterways; urban runoff from paved surfaces, washing cars, lawn fertilizers, and failed septic systems can add nutrients to the streams. **Runoff from livestock operations:** bacteria levels increase without proper vegetative buffer zones and creek fencing. **Removal of native vegetation and riparian zones (banks, riparian zone and wetlands):** the removal of native vegetation reduces the watershed's ability to filter water. **Runoff from disturbed land:** nutrients are often attached to sediment particles; sediment input fills-in creeks causing water to more easily overflow its banks. Sediment loads also negatively impact water temperature, nutrient concentrations, and aquatic habitat.	Bacteria counts, nutrients, temperature, dissolved oxygen, conductivity, land cover, pH, alkalinity, visual assessment, MBEHI	Reduce bacteria loads from failed/failing septic systems and livestock operations Restore and/or construct native wetland areas to absorb water and filter pollutants Reduce sediment loss from runoff associated with vegetation disturbances and construction Reduce sediment from bank erosion through stabilization and vegetation cover Increase native plants in riparian zones and watershed Change in personal behavior/ Educate the public
Improve appearance of	**Residential inputs:** trash	Visual	Educate the public and increase personal

waterways to encourage a positive attitude towards the resource	from littering and yards	appearance	responsibility

Best Management Practices Needed to Meet our Goals and Objectives
Following the approach outlined in the introduction and taking into consideration the monitoring results, expressed concerns, and goals and objectives outlined in Tables 4.1 and 4.2, MSU scientists and members of the technical team developed a list of BMPs. The technical team agreed to present the following list of BMPs to the public.

1) Enforcement of existing local ordinances and state and federal regulations
2) Improve ordinances that address stormwater issues
3) Increased pervious surfaces
4) Public education
5) Improved riparian buffer zones
6) Stream bank stabilization
7) Repair and replacement of failing or failed septic systems
8) Restore and/or create wetlands
9) Expansion of Morehead Utility Plant Board sewer lines (where feasible)
10) Grazing land management/seeding of barren land
11) Fencing livestock out of streams

Attempts to Receive Feedback on Suggested BMPs
Shortly after development of this list, an attempt was made to present the information to local officials and the general public in order to gain feedback and comments. At the July 2011 watershed meeting, we discussed ways to increase public input. The team was very successful in obtaining public input in the Dry Creek Watershed. This was probably a combination of the high number of renters and smaller watershed. It was decided to run two full page color adds in the Morehead Newspaper (Figure 4.1, page 211). Even if not many responses were received, at least people would hopefully see the efforts and have an idea of what to expect from the final watershed based plan. A survey link was included in the advertisement. This Survey Monkey link was sent to everyone on the Triplett Creek email list and posted on multiple Facebook pages (April Haight, Cave Run Bicycle and Outdoor Center, Licking River Watershed Watch).

Only one forum was hosted since the planning team had experienced poor turnout at the Dry Creek forums (with the exception of the first one) and the Triplett Creek forum (held in October 2010). Other forums that were used to solicit public input regarding BMPs included attending meetings with the Morehead City Council and Rowan County Fiscal Court. Attempts to garner input have resulted in the return of twenty-one survey responses (18 online and three by mail). The explanation of BMPs was simplified on the form to facilitate better understanding by the public. Survey results are summarized in Table 4.3 (page 212).

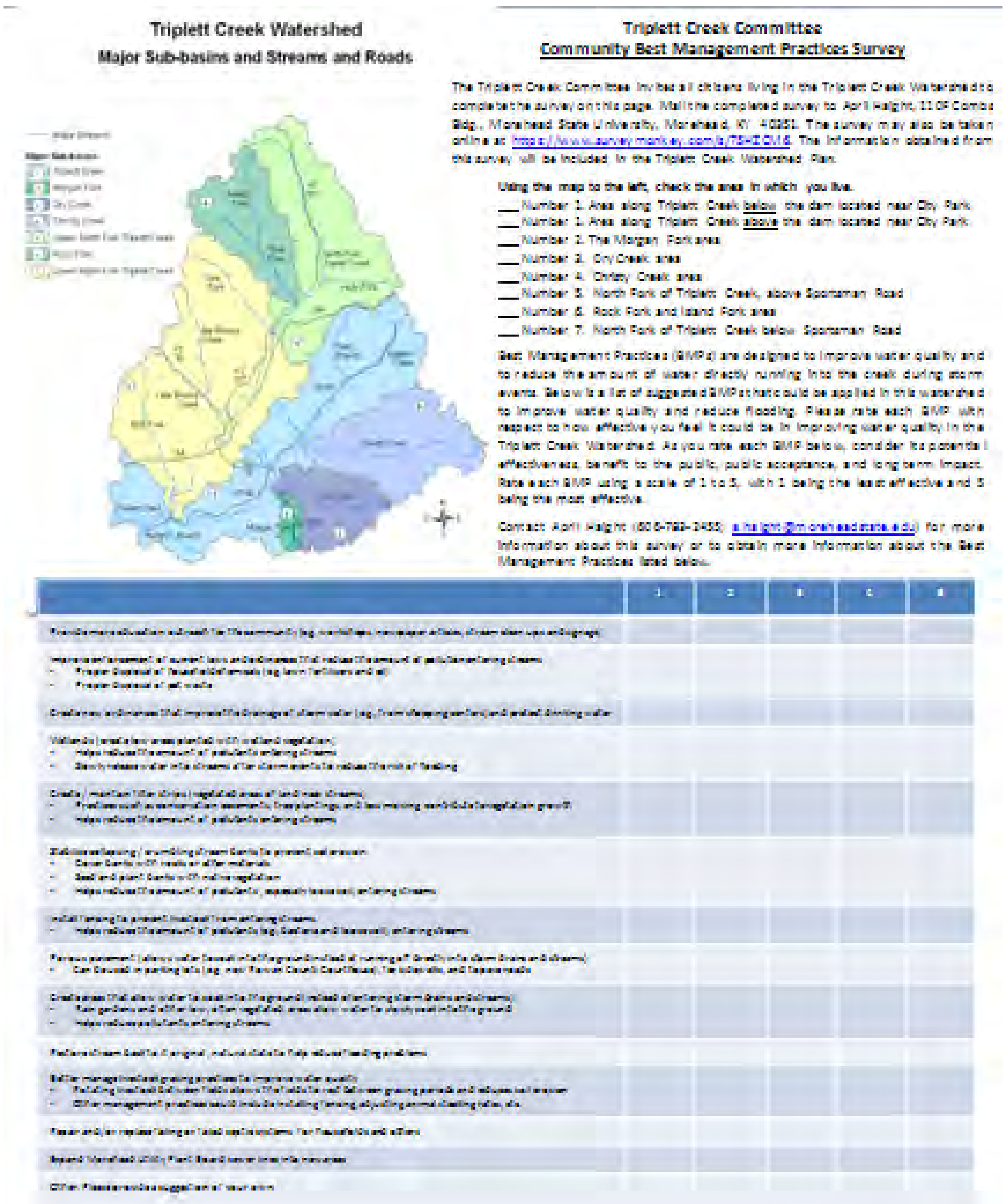

Figure 4.1. An image of the full page advertisement in the Morehead Newspaper. An enlarged copy can be found in appendix E.

Six of the online forms were incomplete, so they were not recorded in the table below. The total score was calculating by adding the number of responses in a category then multiplying by the Likert score. On the Likert scale 1 is the lowest rating and 5 is the highest. For example:

	1	**2**	**3**	**4**	**5**	**Total Score**
Provide more education outreach for the community (e.g. workshops, newspaper articles, stream clean ups and signage)	2 (2x1)	0 (0x2)	4 (4x3)	4 (4x4)	4 (4x5)	50

Table 4.3. Summary of BMPs rating input from community.

	1	**2**	**3**	**4**	**5**	**Total Score**
Stabilize collapsing / crumbling stream banks to prevent soil erosion	0	0	0	6	8	64
Expand Morehead Utility Plant Board sewer lines into new areas	0	3	4	1	7	57
Create new ordinances that improve the drainage of storm water (e.g., from shopping centers) and protect drinking water	0	2	2	4	6	56
Repair and/or replace failing or failed septic systems for households and others	0	1	4	4	5	55
Create areas that allow water to soak into the ground (instead of entering storm drains and streams)	0	1	2	8	3	55
Improve enforcement of current laws and ordinances that reduce the amount of pollution entering streams	0	1	5	3	5	54
Wetlands (create low areas planted with wetland vegetation)	0	2	2	8	2	52
Create / maintain filter strips (vegetated areas of land near streams)	0	2	2	9	1	51
Provide more education outreach for the community (e.g. workshops, newspaper articles, stream clean ups and signage)	2	0	4	4	4	50
Install fencing to prevent livestock from entering streams	0	4	3	5	2	47
Porous pavement (allows water to soak into the ground instead of	2	1	2	8	1	47

running off directly into storm drains and streams)						
Restore stream back to its original, natural state to help reduce flooding problems	0	3	6	2	3	47
Better manage livestock grazing practices to improve water quality	0	3	5	6	0	45

Only one comment was received. The comment was as follows:

> "The main problem is that we filled up the wetlands around Morehead that provided a place for water to be held and released slowly. We need to return "Boone Hollow" area back to a wetland, also along U.S. 60 West and area needs to be created. These are the areas that have an effect on their household. All of these are very important – At present we need to control the flooding issues – once under control we should then work for ideal water quality."

Nine of the participants lived in the Triplett Creek Watershed below the city park. Two participants lived above the city park. One lived in the Morgan Fork Watershed. Three lived in the Dry Creek Watershed. Two lived in the North Fork of the Triplett Creek Watershed above Sportsman Club Road and three lived below. No one from the Rock Fork or Christi Creek Watersheds responded. Keep in mind that not all of the participants that went online completed the survey, but we were not able to remove those from the list of where people lived in the watershed.

WATER QUALITY TARGETS

In order to assess whether goals have been met, it is necessary to relate objectives to target values for water quality parameters that will be monitored after BMP implementation. Target values are set at established WQC if they exist or at average parameter values from benchmark data provided by the KDOW. In the case of sediments derived solely from erosion of geologic materials (i.e., SSC), the Commonwealth of Kentucky has not established a WQC and no benchmark data exist. Therefore, we suggest setting target scores of 10-15 (or better) out of 20 on "embeddedness" and "sediment deposition" on habitat assessment forms to be completed after BMP implementation and a low or better MBEHI (bank erosion index) score. The reasoning is that settling of suspended sediment leads to impairment due to sedimentation/siltation, a pollutant identified in KDOW (2010). The MBEHI will be used as the main indicator since most of the sediment is coming from eroding stream banks. The "embeddedness" and "sediment deposition" scores in the 10-15 range, while not optimal, would indicate improvement. The same approach was used to set target values for habitat and biological assessments. A habitat assessment score of 130 or greater (out of 200) at the sites would indicate improvement. A score of 130 or more can be achieved by implementing the recommended BMPs. The habitat assessment category called "channel alteration" will be practically impossible to address in existing conditions. However, much of the disturbance along the streams is the result of road and bridge building and will hopefully be addressed in policies and practices for future construction. Achieving a score of "good" or higher on the MBEHI will also be the target for stream banks.

Tables 4.4 – 4.9 (pages 214-223) presented below summarize objectives, indicators, target values, the basis and the watersheds associated with each goal. Each table list each subwatershed associated with each indicator. The reason for combining all of the impacted sub-watersheds into one table is to reduce the redundancy of creating 33 tables.

As BMPs are implemented and success monitoring is conducted, it will be important to revisit targets, especially those not based on WQC. Success will ultimately be based upon delisting of impaired waters and protection of waters that meet their designated uses.

Table 4.4. Relationship between objectives and target values with decreased severity and frequency of flooding.

Goal	Objectives	Indicator	Watershed(s)		Target value	Basis
Decrease severity and frequency of flooding	Reduce erosion from runoff associated with vegetation	TSS	BB-0.23	NF-9.77	Below 6.5 mg/L for April – Oct normal flow	Benchmark
			CB-0.38	NF-14.52		
			CC-0.53	SB-0.02		
	disturbances and construction	Habitat assessment	CC-2.00	TC-0.74	130 or higher	Technical team suggestion
			CC-4.33	TC-2.27		
		Visual assessment	CC-8.11	TC-12.27	NA	Technical team suggestion
			CF-0.11	TC-13.52		
			HB-1.36	TC-14.50		
			IF-0.05	TC14.99		
			NF-1.61	TC-19.91		
	Reduce sediment from bank erosion	MBEHI	CC-0.53	NF-14.52	Low to very low	Technical team suggestion
			CC-2.00	RF-0.15		
			CC-4.33	TC-0.74		
			DC-0.27	TC-2.27		
			DC-2.84	TC-12.27		
			MB-0.23	TC-13.52		
			MF-0.23	TC-14.50		

			NF-1.61 TC14.99 NF-9.77 TC-19.91		
		Visual assessment	All sites	NA	Technical team suggestion
		Habitat assessment	All sites	130 or higher, embedded-ness and sediment deposits of sub-optimal or optimal	Technical team suggestion
		TSS	EB-0.04 TC-13.52 HB-1.36 TC-14.50 MB-0.23 TC14.99 TC-0.74 TC-19.91 TC-2.27 TC-21.80 TC-12.27	Below 6.5 mg/L for April – Oct normal flow	Benchmark

Table 4.4. Relationship between objectives and target values with decreased severity and frequency of flooding (continued).

	Increase native plants in riparian zones and throughout watershed	Habitat assessment	All	Bank vegetation score sub-optimal or higher	Technical team suggestion
		Visual assessment		NA	Technical team suggestion
	Restore native wetland area	Visual assessment	All	NA	Technical team suggestion

	Restore riparian zones	Habitat assessment	All	Bank vegetation score sub-optimal or higher	Technical team suggestion
		Visual assessment		NA	Technical team suggestion
	Change in personal behavior/ Educate the public	Visual assessment	All	NA	Technical team suggestion
		Habitat assessment		An overall score above 130	Technical team suggestion

Table 4.5. Relationship between objectives and target values with decreased sediment loads in Triplett Creek Watershed.

Goal	**Objectives**	**Indicator**	**Watershed(s)**		**Target value**	**Basis**
Decrease sediment loads in Triplett Creek Watershed	Reduce sediment loss from runoff associated with vegetation disturbances and construction	TSS	BB-0.23 CB-0.38 CC-0.53 CC-2.00 CC-4.33 CC-8.11 CF-0.11 HB-1.36 IF-0.05 NF-1.61	NF-9.77 NF-14.52 SB-0.02 TC-0.74 TC-2.27 TC-12.27 TC-13.52 TC-14.50 TC14.99 TC-19.91	Below 6.5 mg/L for April – Oct normal flow	Benchmark
		Visual Assessment	All		NA	Technical team suggestion

Table 4.5. Relationship between objectives and target values with decreased sediment loads in Triplett Creek Watershed (continued).

	Increase stream bank and riparian zone vegetation	Habitat assessment	All		Bank vegetation score sub-optimal or higher	Technical team suggestion
		Visual Assessment			Low or very low	Technical team suggestion
		DO	BB-0.23 BUB-0.03 CC-0.53 CC-2.00 CC-4.33 CF-0.11	HUB-0.19 MB-0.23 PB-0.42 RF-0.015 TC-13.52	Greater than 4 mg/L	Water Quality Criteria (WQC)
	Stabilize stream banks	MBEHI	CC-0.53 CC-2.00 CC-4.33 DC-0.27 DC-2.84 MB-0.23 MF-0.23 NF-1.61 NF-9.77	NF-14.52 RF-0.15 TC-0.74 TC-2.27 TC-12.27 TC-13.52 TC-14.50 TC14.99 TC-19.91	Low or very low	Technical team suggestion
		Habitat assessment	All		An overall score above 130	Technical team suggestion

	Restore and/or construct wetlands	Visual assessment	HB-1.36 TC-14.50 TC-0.74 TC14.99 TC-2.27 TC-19.91 TC-12.27 TC-21.80 TC-13.52	NA	Technical team suggestion
	Change in personal behavior / Educate the public	Visual assessment	All	NA	Technical team suggestion

Table 4.6. Relationship between objectives and target values with decreased nutrient loads in Triplett Creek Watershed.

Goal	Objectives	Indicator	Watershed(s)		Target value	Basis
Decrease nutrient loads in Triplett Creek Watershed	Reduce sediment loss from runoff associated with vegetation disturbances and construction	Visual assessment	All		NA	Technical team suggestion
		Total Phosphorus			0.020 mg/L or less	Benchmark
		Total Nitrogen			0.65 mg/L or less	Benchmark
		pH	BB-0.23 BUB-0.03 CC-053 CC-2.00 CC-4.33 CF-.011	MB-0.23 PB-0.42 RF-0.15 TC-13.52	6 to 9 with less than a 1.0 change Over 24-hours	WQC
		DO	BB-0.23 BUB-0.03 CC-0.53 CC-2.00 CC-4.33 CF-0.11	HUB-0.19 MB-0.23 PB-0.42 RF-0.015 TC-13.52	Greater than 4 mg/L	WQC
		Conductivity	BB-0.23 CB-0.38 CC-0.53 CC-2.00 CC-4.33	HF-0.09 PAL-0.02 RF-0.15 TC-0.74 TC-12.27	218 µs/cm max.	Benchmark

			CC-8.11 TC-14.50 DC-0.27 TC-14.99 EB-0.04 TC19.91 HB-1.36 TC-21.80		
	Restore and/or construct wetlands	Visual assessment	All	NA	Technical team suggestion
		Total Phosphorus		0.020 mg/L or less	Benchmark
		Total Nitrogen		0.65 mg/L or less	Benchmark
	Reduce loads from failed/failing septic systems	Bacteria counts	BB-0.23 DC-2.84 BUB-0.03 HB-1.36 CB-0.38 HUB-0.19 CC-2.00 MF-0.23 CC-8.11 TC-14.50 CF-0.11 TC-14.99 DC-0.27 TC19.91	Monthly geometric range of less than 130 cfu/100 mL or 240 CFU/100 mL in no more than 20% of samples	WQC

Table 4.6. Relationship between objectives and target values with decreased nutrient loads in Triplett Creek Watershed (continued).

		Ammonia	All	0.05 mg/L	Benchmark
		Conductivity	BB-0.23 EB-0.04 BUB-0.03 HB-1.36 CB-0.38 HUB-0.19 CC-0.53 TC-14.50 CC-2.00 TC-14.99	218 µs/cm max.	Benchmark

			CC-4.33 TC19.91 CC-8.11 TC-21.80 DC-0.27		
		Sulfate	All	13.8 mg/L	Benchmark
		Total Phosphorus		0.020 mg/L or less	Benchmark
		Total Nitrogen		0.65 mg/L or less	Benchmark
	Change in personal behavior/ Educate the public	Habitat assessment	All	An overall score above 130	Technical team suggestion
		Visual assessment		NA	Technical team suggestion

Table 4.7. Relationship between objectives and target values with decreased bacteria levels to meet Primary Contact standards.

Goal	Objectives	Indicator	Watershed(s)		Target value	Basis
Decrease bacteria levels to meet Primary Contact standards	Reduce loads from failed/failing septic systems	Bacteria counts	BB-0.23 BUB-0.03 CB-0.38 CC-2.00 CC-8.11 CF-0.11 DC-0.27	DC-2.84 HB-1.36 HUB-0.19 MF-0.23 TC-14.50 TC-14.99 TC19.91	Monthly geometric range of less than 130 cfu/100 mL or 240 CFU/100 mL in no more than 20% of samples	WQC
		Unionized Ammonia-N	All		0.05 mg/L	Benchmark
		Sulfate			13.8 mg/L	Benchmark
		Total Phosphorus			0.020 mg/L or less	Benchmark
		Total Nitrogen			0.65 mg/L or less	Benchmark
		Conductivity	BB-0.23 BUB-0.03 CB-0.38 CC-0.53 CC-2.00 CC-4.33 CC-8.11 DC-0.27	EB-0.04 HB-1.36 HUB-0.19 TC-14.50 TC-14.99 TC19.91 TC-21.80	218 µs/cm max.	Benchmark

	Change in personal behavior/ Educate the public	Habitat assessment	All	An overall score above 130	Technical team suggestion
		Visual assessment		NA	Technical team suggestion
	Expand sewer infrastructure	Bacteria counts	BB-0.23 HUB-0.19 BUB-0.03 MF-0.23 CC-2.00 TC-14.50 CC-4.33 TC-14.99 CC-8.11 TC-19.91 HB-1.36 TC-21.80	Monthly geometric range of less than 130 cfu/100 mL or 240 CFU/100 mL in no more than 20% of samples	WQC

Table 4.7. Relationship between objectives and target values with decreased bacteria levels to meet Primary Contact standards (continued).

	Reduce bacteria loads from failed/failing septic systems and livestock operations	Bacteria counts	BB-0.23 NF-9.77 CC-2.00 NF-14.52 CC-8.11 PL-0.10 IF-0.05 RF-0.15 NF-1.61	Monthly geometric range of less than 130 cfu/100 mL or 240 CFU/100 mL in no more than 20% of samples	WQC

Table 4.8. Relationship between objectives and target values with improved water quality so that Triplett Creek Watershed can be safely used as a recreational resource.

Goal	Objectives	Indicator	Watershed(s)	Target value	Basis
Improve water quality so that Triplett Creek Watershed can be safely used as a recreational resource (i.e. fishing, swimming, and canoeing/kayaking)	Reduce bacteria loads from failed/failing septic systems and livestock operations	Bacteria counts	BB-0.23 CC-2.00 CC-8.11 IF-0.05 NF-1.61 NF-9.77 NF-14.52 PL-0.10 RF-0.15	Monthly geometric range of less than 130 cfu/100 mL or 240 CFU/100 mL in no more than 20% of sample	WQC
	Restore and/or construct native wetland areas to absorb water and filter pollutants	Bacteria counts	All	Monthly geometric range of less than 130 cfu/100 mL or 240 CFU/100 mL in no more than 20% of sample	WQC
	Reduce sediment loss from run-off associated with vegetation disturbances and Construction	TSS	CC-0.53 NF-14.52 CC-2.00 RF-0.15 CC-4.33 TC-0.74 DC-0.27 TC-2.27 DC-2.84 TC-12.27 MB-0.23 TC-13.52 MF-0.23 TC-14.50 NF-1.61 TC-14.99 NF-9.77 TC-19.91	Below 6.5 mg/L for April – Oct normal flow	Benchmark

	Reduce sediment from bank erosion through stabilization and vegetation cover	MBEHI	CC-0.53 NF-14.52 CC-2.00 RF-0.15 CC-4.33 TC-0.74 DC-0.27 TC-2.27 DC-2.84 TC-12.27 MB-0.23 TC-13.52 MF-0.23 TC-14.50 NF-1.61 TC-14.99 NF-9.77 TC-19.91	Low or very low	Technical team suggestion
	Increase native plants in riparian zones and watershed	Habitat Assessment	All	An overall score above 130	Technical team suggestion
	Change in personal behavior / Educate the public	Visual Assessment	All	NA	Technical team suggestion

Table 4.9. Relationship between objectives and target values with improved appearance of waterways to encourage a positive attitude towards the resource.

Goal	Objectives	Indicator	Watershed(s)	Target value	Basis
Improve appearance of waterways to encourage a positive attitude towards the resource	Educate the public and increase sense of personal responsibility	Visual Assessment	All	NA	Triplett Creek Committee

ACTION ITEMS

Given the overall goals and objectives of this plan, the selected BMPs and the target values we will use to measure the effectiveness of BMPs (see Table 4.10, pages 222-225), specific steps or actions are required to implement the BMPs. Actions deemed necessary for each sub-basin are related to goals, objectives and specific BMPs in the table below.

Table 4.10. Summary of action items for BMPs for the Triplett Creek Watershed.

Goal	Objective(s)	BMP (in subwatersheds)	Action Items
Decrease severity and frequency of flooding	Reduce sediment loss from run-off associated with vegetation disturbances and construction Reduce sediment from bank erosion Increase native plants in riparian zones and watershed Restore native wetland areas to absorb water	Create and maintain filter strips/riparian zones (all watersheds) Enforce current laws and regulations (all watersheds) Education (all watersheds) Green Infrastructure (all watersheds) Restore stream back to its original , natural state to help reduce flooding problems (all watersheds) Create areas that allow water to soak into the ground (all watersheds)	1. Secure local cost share money to do on-ground BMP demonstration. 2. Obtain funding for landowners and agencies to implement BMPs. 3. Develop a workshop to educate landowners regarding BMP options. 4. Provide monitoring information to local and state agencies. 5. Work with local agencies to provide other educational opportunities for landowners. 6. Apply for grants to construct wetlands. 7. Utilize 319 funds if possible. 8. Work with landowners and DOT.

Table 4.10. Summary of action items for BMPs for the Triplett Creek Watershed (continued).

Goal	Objective(s)	BMP (in sub-watershed)	Action Items
Decrease sediment loads in Triplett Creek Watershed	Reduce sediment loss from runoff associated with vegetation disturbances and construction Increase stream bank and riparian zone vegetation Stabilize stream banks Restore and/or construct wetlands Change in personal behavior / Educate the public	Stabilize collapsing / crumbling stream banks to prevent soil erosion (all watersheds) Create and maintain filter strips/riparian zones (all watersheds) Provide education outreach for the community (all watersheds) Construct wetlands (DC-0.27, NF-1.61, NF-9.77, NF-14.52, TC-0.74, TC-2.27, TC-12.27, TC-13.52, TC-14.50) Create areas that allow water to soak into the ground (all watersheds) Better manage livestock grazing practices to improve water quality (BB-0.23, CC-2.00, CC-8.11, DC-2.38, HF-0.09, NF-9.77, OH-0.11, RF-0.15, IF-0.05, PB-0.42, TC-	1. Secure local cost share money to do on-ground BMP demonstration. 2. Obtain funding for local agencies and landowners to implement BMPs. 3. Develop a workshop to be held to educate landowners regarding BMP options. 4. Provide monitoring information to local and state agencies. 5. Work with local agencies to provide other education opportunities for landowners.

		0.27, TC-2.27, TC-12.27)	

Table 4.10. Summary of action items for BMPs for the Triplett Creek Watershed (continued).

Goal	Objective(s)	BMP (in subwatersheds)	Action Items
Decrease nutrient loads in Triplett Creek Watershed	Reduce sediment loss from runoff associated with vegetation disturbances and construction Restore and/or construct wetlands Reduce loads from failed/failing septic systems Change in personal behavior / Educate the public	Create and maintain filter strips/riparian zones (all watersheds) Provide education outreach for the community (all watersheds) Create areas that allow water to soak into the ground (all watersheds) Green Infrastructure (all watersheds)	1. Work with Rowan County Health Department to provide assistance. 2. Help qualifying homeowners with grant programs to buy/upgrade septic systems. 3. Provide monitoring information to local and state agencies. 4. Work with local agencies to provide other education opportunities for landowners.
Decrease bacteria levels to meet Primary Contact standards	Reduce loads from failed/failing septic systems Change in personal behavior / Educate the public Expand sewer infrastructure	Repair and/or replace failing or failed septic systems for households and others (BB-0.23, BUB-0.03, CB-0.37, CC-2.00, CC-4.33) Expand Morehead Utility Plant Board sewer lines into new areas (DC-2.38, TC-14.99, CC-0.37, CC-2.00, MF-0.23)	1. Secure local cost share money to do on-ground BMP demonstration. 2. Develop a workshop to educate landowners regarding BMP options. 3. Investigate programs to assist landowners with failed/failing septic systems. 4. Work with landowner to develop agreements to implement BMPs. 5. Provide monitoring information to local and state agencies. 6. Work with local agencies to provide

		Better manage livestock grazing practices to improve water quality (BB-0.23, CC-2.00, CC-8.11, DC-2.38, HF-0.09, NF-9.77, OH-0.11, RF-0.15, IF-0.05, PB-0.42, PL-0.10, TC-0.27, TC-2.27, TC-12.27) Create and maintain filter strips/riparian zones (all watersheds) Enforce current laws and regulations (all watersheds)	other education opportunities for landowners. 7. Work with Rowan County Health Department to provide assistance.

Table 4.10. Summary of action items for BMPs for the Triplett Creek Watershed (continued).

Goal	Objective(s)	BMP (in subwatersheds)	Action Items
Improve water quality so that Triplett Creek Watershed can be safely used as a recreational resource (i.e. fishing, swimming, and canoeing/ kayaking)	Reduce bacteria loads from failed/failing septic systems and livestock operations Restore and/or construct native wetland areas to absorb water and filter pollutants Reduce sediment loss from runoff associated with vegetation disturbances and construction Reduce sediment from bank erosion through stabilization and vegetation cover Increase native plants in riparian zones and watershed	Create new ordinances that improve the drainage of stormwater and protect drinking water (all watersheds) Expand Morehead Utility Plant Board sewer lines into new areas (DC-2.38, TC-14.99, CC-0.37, CC-2.00, MF-0.23) Repair and/or replace failing or failed septic systems for households and others Restore stream back to its original, natural state to help reduce flooding problems (all watersheds) Provide more education outreach for the community (all watersheds) Enforce current laws and regulations (all watersheds)	1. Secure local cost share money to do on-the-ground BMP demonstration. 2. Develop a workshop to educate landowners regarding BMP options. 3. Provide monitoring information to local and state agencies. 4. Work with local agencies to provide other education opportunities for landowners.

	Change in personal behavior/ Educate the public		
Improve appearance of waterways to encourage a positive attitude towards the resource	Educate the public and increase personal responsibility	Restore stream back to its original, natural state to help reduce flooding problems (all watersheds) Provide education outreach for the community (all watersheds) Create and maintain filter strips/riparian zones (all watersheds) Enforce current laws and regulations (all watersheds)	1. Develop a workshop to educate landowners regarding BMP options. 2. Work with local agencies to provide education opportunities for landowners. 3. Organize waterway cleanups to connect people to the watershed.

HUMAN RESOURCES AND FUNDING MECHANISMS

Paying for the BMPs is no easy task. Table 4.11 (pages 226-229) is a summary of plans to work toward securing funds for the implementation. Note that all the BMPs for all the sub-basins are combined since the same approach will be used throughout the Triplett Creek Watershed. The funding mechanisms should not be restricted by listings in this table. Other sources may be available and should be utilized. Likewise the technical assistance column should not be limited to what is listed. In order to successfully implement the Triplett Creek Watershed Plan, we must be flexible and work together as a responsible community. Unless otherwise noted, the costs of the BMPs implementation were taken from the Dry Creek Watershed Plan that was approved in June 2010, by the KDOW.

Table 4.11. Human resources and funding mechanisms for implementing the plan.

BMP	Responsible Party	Technical Assistance	Cost	Funding

				Mechanisms
Stabilize collapsing / crumbling stream banks to prevent soil erosion	Landowner: private, business, or public agency	KY Division of Water Engineering firm Sheltowee Environmental Education Coalition UK Agriculture Extension Services NRCS	$25 to $300 per foot depending on the method used	Landowner 319(h) grant In-Lieu Fee Program NRCS and other cost share programs
Expand Morehead Utility Plant Board sewer lines into new areas	Morehead Utility Plant Board Landowner	MUPB Gateway ADD Rowan County Health Department Triplett Creek Watershed Committee KY Division of Water	$15,000 to $25,000 per home	Federal cost share Homeowner Water quality grants Clean Water SRF Funds
Create new ordinances that improve the	City of Morehead	Triplett Creek Watershed Committee	$60,000 to $75,000 (Joe Parson,	319(h) nonpoint source pollution grant and match

drainage of stormwater (e.g., from shopping centers) and protect drinking water	Planning Commission	KY Division of Water 3rd party firm	personal conservation, November, 2011)	from partners

Table 4.11. Human resources and funding mechanisms for implementing the plan (continued).

BMP	Responsible Party	Technical Assistance	Cost	Funding Mechanisms
Repair and/or replace failing or failed septic systems for households and others	Landowner Rowan County Health Department	Rowan County Health Department Triplett Creek Committee	$3,000 to $10,000 per household	Homeowner 319(h) grant East KY PRIDE
Create areas that allow water to soak into the ground (instead of entering storm drains and streams)	Landowner	KY Division of Water Triplett Creek Committee	$0 to $4,000	Landowner 319(h) Corporate partners
Improve enforcement of current laws and ordinances that reduce the amount of pollution entering streams	City of Morehead Rowan County Fiscal Court Rowan County Health Department KY Division of	Rowan County Fiscal Court Rowan County Health Department KY Division of Water KY Transportation	$0 - $60,000	Existing internal funding of agencies (general funds) 319 (h) grant

	Water KY Transportation Cabinet	Cabinet KY Waterways Alliance		
Wetlands (create low areas planted with wetland vegetation)	Landowner	Triplett Creek Committee USFS East KY PRIDE KDFWR National Fish and Wildlife Resources EPA Sheltowee Environmental Education Coalition	$15,000 to $60,000	Landowner National Fish and Wildlife Resources KDFWR cost share programs 319(h) In-Lieu Fee Program

Table 4.11. Human resources and funding mechanisms for implementing the plan (continued).

BMP	Responsible Party	Technical Assistance	Cost	Funding Mechanisms
Create / maintain filter strips (vegetated areas of land near streams)	Landowner	Morehead State University Licking River Watershed Watch KY Division of Water KY Transportation Cabinet KY Waterways Alliance UK Agriculture extension Services NRCS	$0 - $10,000 (vary dependent on the length and width of the zone, as well as techniques used to implement)	Landowner National Fish and Wildlife Resources NRCS cost share In-Lieu Fee Program KDFWR cost share programs 319(h) Grant River Network
Provide more education outreach for the community (e.g. workshops, newspaper articles, stream clean ups and signage)	All citizens	Morehead State University Licking River Watershed Watch	$0 - $100,000	Existing internal funding of agencies Environmental Education Grants

		KY Division of Water UK Agriculture extension Services NRCS KY EXCEL program Sheltowee Environmental Education Coalition		National Fish and Wildlife Resources East KY PRIDE Corporate Foundations 319(h) Grant River Network
Install fencing to prevent livestock from entering streams	Landowner	NRCS UK Agriculture Extension Services KY Division of Water Morehead State University	$15,000 per mile	Landowner KDFWR cost share programs NRCS cost share programs 319(h)

Table 4.11. Human resources and funding mechanisms for implementing the plan (continued).

BMP	**Responsible Party**	**Technical Assistance**	**Cost**	**Funding Mechanisms**
Porous pavement (allows water to soak into the ground instead of running off directly into storm drains and streams)	Landowner	KY Division of Water 3rd party firm Triplett Creek Committee	$2 to $7 per square foot (EPA, September 2010)	Landowner 319(h)
Restore stream back to original , natural state to help reduce flooding problems	Landowner	KY Division of Water 3rd party firm Sheltowee Environmental Education Coalition USFS	$1 to $2 per linear square foot (Jon Walker, personal conservation on February 29, 2012)	Landowner KDFWR cost share programs In-Lieu Fee Program NRCS cost share programs 319(h)
Better manage livestock grazing practices to improve water quality	Landowner	NRCS UK Agriculture Extension Services		Landowner KDFWR cost share programs

		KY Division of Water Morehead State University		In-Lieu Fee Program NRCS cost share programs 319(h)

INDICATORS AND MILESTONES

To assist with the implementation plan it is important to develop indicators and milestones for each BMP (Table 4.12, pages 230-232).

Table 4.12. Measuring progress toward goals and success of action items.

BMP	Indicators to Measure Progress	Milestones			
		Short term	Medium Term	Long Term	Extended
Stabilize collapsing / crumbling stream banks to prevent soil erosion	Installation of a major stream bank stabilization project	Work with watershed partners and landowners to design and implementation strategy	Completion of stream bank stabilization	Completion of stream bank stabilization	Monitoring
Expand Morehead Utility Plant Board sewer lines into new areas	Installation of sewer lines	Discussion of feasibility and current sewer expansion plans	Public forum	Expansions where feasible	Monitoring
Create new ordinances that improve the drainage of stormwater (e.g., from shopping centers) and protect drinking water	Development and approval of new ordinances	Review and develop recommendations for the Planning Commission and the City of Morehead	Hold public meetings	Enforcement of ordinances	
Repair and/or replace failing or failed septic systems for households and others	Homeowners making necessary upgrades to failing	Work with funding agency(s) and county Health	Contact landowners and assist with financial	Contact landowners and assist with	Monitoring

	septic systems	Department to develop a plan	support	financial support	
Create areas that allow water to soak into the ground (instead of entering storm drains and streams)	Installation of swales, rain gardens, and other bioretention techniques	Work with landowners, watershed partners, and schools to construct demonstrations sites	Provide technical information for landowners	Obtain funding and program needs to enforce and revise plan as needed	Obtain funding and program needs to enforce and revise plan as needed

Table 4.12. Measuring progress toward goals and success of action items (continued).

BMP	Indicators to Measure Progress	Milestones			
		Short term	Medium Term	Long Term	Extended
Wetlands (create low areas planted with wetland vegetation)	Construction of wetlands within the watershed	Apply for grant funding	Design and Construction preparations	Complete installation	Monitoring
Create / maintain filter strips (vegetated areas of land near streams)	Increase riparian zones width to a minimum of 18 meters (54 feet) native vegetation buffer along streams	Work with funding agencies, NRCS, and Ag. Extension Officer	Contact key landowners and assist with financial support where appropriate		Monitoring
Provide more education outreach for the community (e.g. workshops, newspaper articles, stream clean ups and signage)	Conduct workshops in the area of land use practices, gravel mining, and agriculture	Develop specific needs for each workshop and agenda	Host workshops within the community	Increase in the number of participants reached and that participant in programs	
Install fencing to prevent livestock from entering streams	Fencing installed	Work with funding agencies, NRCS, and Ag. Extension officer	Contact landowners and assist with financial	Ongoing Support from NRCS and the Ag. Extension officer	Monitoring

			support where appropriate		
Porous pavement (allows water to soak into the ground instead of running off directly into storm drains and streams)	Installation porous pavement (% land use cover)	Work with landowners, watershed partners, and schools to construct demonstrations sites	Provide technical information for landowners		

Table 4.12. Measuring progress toward goals and success of action items (continued).

BMP	**Indicators to Measure Progress**	**Milestones**			
		Short term	**Medium Term**	**Long Term**	**Extended**
Restore stream back to its original, natural state to help reduce flooding problems	Feet of stream restoration	Work with funding agencies, Fish and Wildlife, USFS, NRCS, and Ag. Extension officer	Contact landowners and assist with financial support where appropriate	Obtain funding to complete restoration projects	Monitoring
Better manage livestock grazing practices to improve water quality	Grazing land management plans implemented	Work with Funding agencies, NRCS, and Ag. Extension	Contact landowners and assist with financial	Ongoing Support from NRCS and the Ag. Extension officer	

		officer	support where appropriate		

References

Environmental Protection Agency (September 10, 2009). Pervious Concrete Pavement http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=browse&Rbutton=detail&bmp=137&minmeasure=5

Triplett Creek Watershed Based Plan Post-Monitoring
Section 5

Implementation and Post-monitoring

ORGANIZATION

Successful implementation and monitoring of the BMPs recommended in Section 4 will depend on the continued work of the Triplett Creek Watershed Committee, local government officials, and key partners such as the Kentucky Department of Fish and Wildlife Resources, the Kentucky Division of Water, Morehead State University, the Rowan County Health Department, and the US Forest Service. We will continue to work on increasing citizen involvement and build upon our relationships with organizations such as Licking River Watershed Watch, Sustainable Morehead, and Kentucky Waterways Alliance. We will also look toward MSU students and other organizations for possible volunteer time.

The Triplett Creek Committee will be responsible for implementing the Dry Creek and Triplett Creek Watershed Based Plans. Although the Triplett Creek Watershed Committee includes members from most of the local, state and federal organizations listed above and, of course, concerned citizens, MSU will continue to serve as the lead organization. The implementation and post-monitoring phases of the Dry Creek Watershed Based Plan has been rolled into a USEPA/KDOW 319(h) nonpoint source pollution grant awarded to MSU to develop a WBP for the entire Triplett Creek Watershed. As a result, both Triplett Creek and Dry Creek will be part of the post-monitoring plan. The 319(h) grant will continue through September 30, 2013 and is currently funding the salary for a part-time watershed coordinator. April Haight is currently serving as the coordinator. The watershed coordinator will keep the Triplett Creek Watershed Committee updated on progress through e-mail, website postings and periodic meetings, including public roundtables and presentations to the Rowan County Fiscal Court, Morehead City Council, and other community organizations.

Implementation Team

Core members of the implementation team will include the MSU Watershed Coordinator, the Licking River Basin Coordinator, and the Rowan County Solid Waste and Flood Plain Manager. This core group will be responsible for keeping the larger Triplett Creek Watershed Committee informed regarding ongoing activities and will draw upon community assets as needed to implement the WBP and the associated BMP Implementation Plans.

Technical Team

The same technical team that conducted pre-implementation monitoring and GIS-based mapping/modeling will monitor post-implementation effectiveness of BMPs. As during the pre-monitoring phase, this team will consist of an ecologist (Haight), a geographer (Emrich), a geologist (Reid), and a microbiologist (Gearner) from MSU. The technical team will draw upon the expertise of the Implementation Team, planners, environmental engineering consultants and construction contractors as needed to develop or refine BMP implementation plans.

MONITORING PLAN

The Triplett Creek Watershed Based plan grant can be used to fund the post-monitoring phase of the Dry Creek and Triplett Creek WBPs. However, the post-implementation monitoring will be based on the timing and location of the actual BMP implementations. Post-monitoring cannot begin until the BMPIP are implemented. The timing of the projects may not allow for monitoring. Most likely monitoring will be completed through future funds and continued student research. It is unreasonable to expect that post- monitoring will show immediate improvements in water quality. Therefore, the approach that we will use is that only sampling sites located just upstream and downstream of BMPs will be monitored beginning one year after the completion of the BMP. In addition, they will be monitored for the pollutant(s) the BMP addresses. This is unlikely to allow for a complete year of monitoring, so the monitoring methods will have to be modified and approved by the KDOW. The Dry Creek and Triplett Creek BMPs will be conducted using the approach and methods outlined in the *Triplett Creek Watershed Based Plan* (CFDA Number: 66.460; Control Program #C9994861-08) and it's accompanying Quality Assurance Project Plan (QAPP). These documents are included as appendix B, and were prepared by Geoffrey W. Gearner, PhD; April D. Haight, MS; Christine E. Emrich, PhD and Steven K. Reid, PhD.

EVALUATION PLAN

Approach

The Triplett Creek Watershed Committee will utilize public input, the degree of success in meeting BMP implementation milestones, and post-BMP monitoring to evaluate the effectiveness of the Triplett Creek and Dry Creek WBPs. Specific action items toward BMP implementation and the target values that we hope to achieve using each BMP are outlined in Section 4. Progress on action items will be evaluated at scheduled meetings of the Triplett Creek Watershed Committee. Once BMPs are in place, indicators of their effectiveness will be evaluated at these meetings as well.

Implementation

Success in implementing action items towards BMP implementation in each of the Triplett Creek and Dry Creek sub-basins will be assessed by the Triplett Creek Watershed Committee using score cards. The score cards will be updated every six months for the committee to review and discuss. Table 5.1 (page 235) is an example of a score card for action items associated with a single BMP.

Table 5.1. Example score card for action items associated with a single BMP.

BMP Action Items	No Progress	In Progress	Progress Stalled	Adaptive Strategy	Completed

Outcome Indicators

Post-BMP implementation water quality and geomorphic monitoring data will be compared to target values chosen in Section 4 (Tables 4.4 through Table 4.9) in order to assess whether the objectives are being met. Concentrations and physical parameter values before and after BMP implementation will be compared. In addition, loads calculated using post-implementation concentrations and mean annual flow (MAF) will be used to calculate post-implementation loads. Comparison of these loads with pre-BMP implementation loads and with loads calculated using established water quality criteria (WQC x MAF) will determine whether water quality is improving.

Outreach

Outreach efforts generally take the form of articles in the local newspaper, meetings, community roundtables, presentations, workshops, and field trips. At the end of each activity, when appropriate, evaluation forms will be distributed to participants in order to rate the effectiveness of the event. As discussed under "Adaptive Management" below, we have already found that many of these traditional approaches to outreach are ineffective, not because of the quality of the event but because very few people attend. Outreach will require a more personal approach. Members will seek one on one input from members of the community through conversations (in person, email, phone). In addition, the committee members will attend other community organization meetings, to stay involved and to inform the public when the opportunities arise. In summary, the committee will focus policy windows. An example of a policy window is the current update of the City of Morehead-Rowan County-Lakeview Heights long range plan. The Triplett Creek Committee has been actively involved to incorporate the objectives presented in the Triplett Creek WBP. This is in line with the Adaptive Management approach discussed below.

Adaptive Management

The ultimate, long-term goal of the Triplett Creek Watershed Based Plan is to improve water quality, preferably to the point where the impaired waterways within the watershed can be removed from the KDOW impaired waterways list (i.e., the Integrated Report Volume II). The Triplett Creek Watershed Committee will utilize passive and evolutionary adaptive management strategies as needed. In this strategy we will use the information available to choose best management options, committee meetings and emails to solicit feedback and review new information. To ensure that the committee is showing progress to the community, and to encourage public involvement, we will present updates at the Rowan County Fiscal Court and Morehead City Council meetings. In addition, we will attend other meetings such as Sustainable Morehead, Chamber of Commerce, and Kentuckians for the Commonwealth. If, however, we find that action items are not being completed, that the public is not participating or responding to outreach efforts, or that post-BMP implementation monitoring results indicate that our objectives are not being met, we must adapt.

We have already done this for the development of the Triplett Creek Watershed Based Plan to encourage more public input. We have learned that in order to reach out to the public more effectively, we need to make presentations at meetings of other organizations (e.g. City Council, Sustainable Morehead, etc.). We also used Survey Monkey and a full-page color advertisement as a way to reach more people than we did in the Dry Creek Watershed planning process.

An example of possible adaptation would be, if, in the future we discover that few landowners choose to re-vegetate eroding banks or re-seed barren land, even if we provide the seed, then alternative approaches can be pursued. It has already come to our attention, based on the Pathogen Best Management Practice Implementation Plan for Dry Creek that an alternative approach must be taken to motivate homeowners to participate in a septic system improvement program. We may host a field trip to sites that have implemented good practices versus sites with bad practices. Or, we may convince the city or county to try an inexpensive BMP on public property and compare the results to another public property were the problem is ongoing but unaddressed, and then host a field trip to highlight the effectiveness of the implemented BMP. Even if the field trips themselves were poorly attended, we would still video document the event and post it to YouTube. The YouTube site could then be publicized to the local media, MSU, the city, the county, area schools, and other stakeholder groups.

PRESENTATION OF THE PLAN AND ITS RESULTS

The methods used to share the plan and its results to different constituencies are discussed in the previous two sections. To date, we have geared various presentations to different audiences based on such factors as technical background, position in the community (e.g., citizen, politician, civil servant), and education level. The basic content of each presentation will be the same but the method of delivery and amount of technical language used may be altered. We will utilize local community networks and organizations to share findings about the watershed, as well as news articles, e-mails, the web, and radio. But, as previously discussed, our early experiences indicate that we will have to be much more creative.

Some of the strategies that will be presented to gain public and political support include the following.

- Advertize the fact that the costs of implementing BMPs can be subsidized or shared.
- Investigate the most cost effective way for the audience to engage in positive behavior changes.
- Investigate incentives to encourage positive behavior.
- Piggyback onto an existing projects.
- Educate the target audiences on real and perceived risks of poor water quality.
- Provide simple statistics to show levels of risk in a manner that people can personally relate to.
- Research current community positive behaviors as well as negative behaviors.
- Develop messages that make it socially desirable to protect waterways (e.g., flooding).
- Provide frequent and strategically placed prompts to remind people of desired behavior.
- Identify early adopters in the community and partner with them to spread the word and convince others to adopt the new behavior. They can help develop new social norms that include positive environmental behaviors.
- Show the immediate consequences of both adopting and not adopting the behavior.
- Identify and communicate actual or estimated environmental, social, and economic impacts (e.g., statistics, before- and-after photos) of the opposing behavior and the recommended behavior.
- Provide statistics on the collective impacts of individual actions.

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ADDITIONAL INFORMATION

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