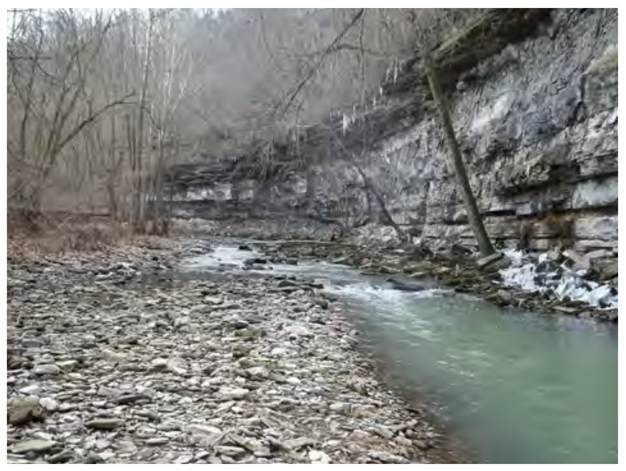
Lower Howards Creek Watershed Management Plan
Winchester, Clark County, Kentucky

January 28, 2014



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LOWER HOWARDS CREEK
WATERSHED MANAGEMENT PLAN

WINCHESTER, CLARK COUNTY, KENTUCKY

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JANUARY 28, 2014 FINAL VERSION

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EXECUTIVE SUMMARY

1. INTRODUCTION

The Lower Howards Creek Watershed Management Plan (LHCWMP) was developed as the Supplemental Environmental Project (SEP), as required by the Environmental Protection Agency (EPA), in the Consent Decree (Civil Action No. 06-1-2KSF, April 10, 2007) with WMU and the City of Winchester. The Consent Decree stipulates that WMU and the City of Winchester must perform a SEP having the objective of securing significant environmental or public health protection and improvements. WMU, the City of Winchester, EPA, and the Kentucky Division of Water (KDOW) agreed that it would be environmentally beneficial to the public to commission a study of the streams in the LHCW and develop the LHCWMP. This project was undertaken in connection with the settlement of a civil enforcement action taken by the United States for violations of the Clean Water Act.

2. LOWER HOWARDS CREEK WATERSHED (LHCW)

Lower Howards Creek Watershed (United States Geological Survey (USGS) Hydrologic Unit Code (HUC) #05100505050) is located in southwestern Clark County. The watershed covers approximately 19.3 square miles, including the southern portion of the City of Winchester and portions of smaller communities including Boonesborough. LHCW is contained within the Palisades Region of the Kentucky River Basin. LHC is a tributary to the Kentucky River, which eventually flows into the Ohio River in Carroll County, Kentucky.

The existing data collection and review indicated that LHCW has a rich and vibrant history with many remnants of old buildings, structures, and fences. The watershed is filled with beautiful scenery and unique geologic formations, providing an ideal area for involving the public with nature. Many people in the community care deeply about LHCW and have developed strong opinions about the future of the area. There are large gaps in the water quality data for the watershed. The monthly monitoring completed as a part of the LHCWMP was used to analyze and identify issues within the LHCW. While this water quality data was not able to be completed in every section of the watershed, it provided an overview where pollutants of concern were identified.

3. MONITORING

The new sampling data collection began with Phase One monitoring. Phase One monitoring allowed for sampling and analysis at a broad scale and helped to make general assessments of the watershed. The assessments resulting from Phase One monitoring aided in the selection of sub-watersheds for a more detailed examination during Phase Two monitoring. Six sites were selected in LHCW along the main channel for Phase One monitoring. Sites were selected for a variety of factors, including location of suspected contaminant discharge, sampling location from previous studies, and location of tributary confluences. Each site was tested for the critical parameters listed in Table 8. Phase One monitoring began in August 2011 and continued through July 2012.

Phase Two monitoring followed Phase One monitoring and involved the selection of sub-watersheds for further monitoring and analysis. Ideally, 12 months of Phase One monitoring would be completed and analyzed prior to Phase Two site selection; however, due to the time constraints set forth within the

Consent Decree four months of Phase One monitoring was completed prior to selection of Phase Two monitoring locations. After four months of Phase One monitoring, the available data was analyzed and an additional four sites were selected for Phase Two monitoring. The four Phase Two sites were located on tributaries to LHC in areas of high pollutant loads in Phase One monitoring or in areas of suspected contaminant discharge based on observation, historical significance and resident testimony. Phase Two monitoring began in December 2011 and will continue through November 2012.

During the analysis of the Phase One sites for Phase Two site selection, it was determined that it would be beneficial to determine the presence or absence of human fecal waste. Elevated levels of Escherichia coli (E. coli) were received at several sites during the period analyzed for Phase Two site selection, but the source of the E. coli was not known. Microbial source tracking (MST) provided a way to identify samples that were indicative of contamination from human fecal waste, using fecal load, age, and source. Five sites were selected for MST. The procedures used were developed by Dr. Gail Brion at the University of Kentucky and applied to numerous local watersheds over the past 18 years with excellent results. The model was developed to evaluate the resulting fecal load, age, and source signals obtained from any single sample provide a metric to estimate how close the analyzed sample is to raw human sewage by issuing a Sanitary Category Value (SCV).

4. ANALYSIS

To evaluate the nature and level of the impairments within LHCW, it was necessary to compare the monitoring results with a set of water quality benchmarks. The water quality benchmarks used for LHCW were a combination of documented legal limits and recommended benchmarks from KDOW. The water quality benchmarks are listed in Table 11. The critical parameters were collected and then compared with these water quality benchmarks to determine exceedances. A summary table for Phase One monitoring is located in APPENDIX G and for Phase Two monitoring in APPENDIX H. Pollutant loads and target loads based on water quality benchmarks were calculated. When pollutant loads exceeded target loads, target reductions were calculated and compared. Four of the six Phase One and two of the four Phase Two monitoring locations required E. coli load reductions. None of the Phase One and two of the four Phase Two monitoring locations required nutrient load reductions; however, large algal blooms were observed during the monitoring period displaying excessive growth at several sites, but elevated levels of nutrients were not found in the water samples. Conductivity was also considered a parameter of concern because all ten sites exceeded water quality benchmarks during at least two of the sampling events. The five sites located highest in the watershed demonstrated habitat impairments.

Samples were analyzed for indicators of fecal load (E. coli, and a non-host specific Bacteroides DNA marker AllBac), fecal source (two human host specific Bacteroides DNA markers, HuBac and qHF183), and fecal age (AC/TC ratio). The results are reported in Section 4.5. The site located in the upstream, developed portions of the watershed, Sites 5, 6, and 10, have the highest SCVs calculated under dry conditions and are of the greatest concern. Site 6 has a fresh and fairly high fecal load entering the stream from the surrounding landscape, but the fecal load appears to be from mixed sources. Site 10 has lesser fecal loads with an older fecal age, but contains a persistent human signal indicating the presence of human sewage inputs into the stream. Site 6 and Site 10 blend together and the result is seen at Site 5. Site 5 has a lower SCV than Site 6, but higher than Site 10. Although it appears that there is another source of fecal load input upstream of Site 5, but downstream of Site 6 and 10 due to increase seen during the wet weather sampling event. Site 4 has a lower SCV than the upstream sites, but a higher proportion of HuBac to sewage and detection of the most specific genetic marker in 100% of the uninhibited samples. The consistent signal of human fecal material is apparent and suggests that the site is receiving human fecal materials, in small, consistent quantities. The human signal at Site 4 appears to be input without the addition of fecal load or significant lowering of fecal age. Consistent with the notion of a leaking or improperly performing septic system, it is hypothesized that small amounts of anaerobically-treated human waste are regularly being input into the creek. The bacteria containing the source tracking markers could persist through treatment that removes a significant portion of the E. coli. The lowest SCV values were seen at Site 2. The consistent human signal input at Site 4 became very dilute and sporadic at Site 2.

5. BEST MANAGEMENT PRACTICES (BMPs)

To direct BMP selection, the project team, with the assistance of stakeholders, established goals and objectives for the LHCW. Based on the existing watershed data, sampling results, stakeholder input, and engineering judgment, the following four goals were prioritized as most important for LHCW:

1. Improve water quality for aquatic life support and safe recreational use;
2. Improve watershed awareness and education in the community;
3. Implement measures to protect the stream & riparian zone during future development; and
4. Improve stormwater management (reduce flooding), especially during large rain events.

Goal selection provided a broad plan of action, but identified priorities that were not strictly measurable or tangible. Objectives were selected to assist in achieving the above identified goals. The project objectives were identified as:

1. Reduce human fecal inputs through SSO elimination and identification of failing septic systems and areas of sewer exfiltration to benchmark levels for bacteria;
2. Reduce fecal inputs from non-human sources to benchmark levels for bacteria;
3. Reduce algal blooms and eutrophication to improve water quality and aesthetic appeal;
4. Expand and/or preserve stream riparian zone to filter runoff and increase habitat;
5. Stabilize stream banks to reduce erosion;
6. Reduce flooding by reducing or slowing stormwater runoff; and
7. Inform the public of the water quality status in LHC.

A large number of the considered BMPs were recommended for implementation. The following list details the BMPs that were recommended for implementation:

A. SSO removal;
B. Make provisions to identify and replace failing or improperly maintained septic systems or straight pipes;
C. Identify and replace failing or improperly maintained septic systems or straight pipes;
D. Provide off stream watering and shade for livestock;
E. Encourage livestock field rotation with limited time in fields with access to streams;
F. Install filter strips to reduce fecal input from runoff;
G. LHC Nature and Heritage Preserve expansion;
H. Implement proper pet waste disposal practices;
I. Install rain gardens and/or streamside wetlands;
J. Provide and inform public of means to dispose of yard waste;
K. Implement water quality requirements for new developments;
L. Conduct tree and vegetation planting along streams;

M. Require a minimum riparian buffer on all new construction projects;
N. Perform stream restoration to repair areas of eroded banks and limited access to floodplain;
O. Develop rain barrel program;
P. Ensure existing stormwater management measures are being properly maintained and all new developments have proper water quantity controls; and
Q. Increase public education of the watershed.

A total of 33 Action Items were selected for implementation associated with these BMPs. The Action Items are listed in Table 38 and discussed in Section 5.3. Watersheds have varied responses to BMP application so it is difficult to predict with certainty the level of success and load reductions that will be achieved. The level of success is often determined by the level of community cooperation and involvement in implementation. Target loads for E. coli, total nitrogen, and total phosphorous may be achieved within seven years of the final date of this report.

6. IMPLEMENTATION

The LHCWMP is a dynamic, public document that is intended to assist in protection and enhancement of water quality within the LHCW in Winchester, Clark County, Kentucky. Since the goals of the LHCWMP align with those of the LHC Nature and Heritage Preserve, and all the water in the watershed will flow through the LHC Nature and Heritage Preserve, the person serving as the LHC Nature and Heritage Preserve Manager will also serve as the LHCWMP Implementation Coordinator. The LHCWMP Implementation Coordinator will pursue BMP installation and construction; assist in securing funding through grants and other sources; ensure the LHCWMP is implemented in a manner consistent with its intent; and provide a main point of contact for volunteers and those interested in specific projects.

The plan will be presented in a public meeting to political leaders, stakeholders, civic and environmental groups, and the general public on October 11, 2012 in accordance with the deadlines outlined in Exhibit D of the Consent Decree. The public meeting will include a review of the plan, steps for implementation, and future monitoring efforts. The locations where the public can review the document will be announced.

The financial requirements for each Action Item vary greatly and may change based on the project scope once implementation begins. A number of potential funding sources have been identified in Section 6.3 to provide the financial assistance required for implementation.

As previously stated, Phase Two monitoring was not complete as of the date of this report. Phase Two monitoring will be completed in November 2012. The Phase Two monitoring results from October and November 2012 will be provided to all plan holders in an addendum prior to January 1, 2013. As a part of the required expenditures for the SEP outlined in the Consent Decree, two additional monitoring activities will be conducted in May 2013 and May 2014. To evaluate the effectiveness of BMP implementation and the progress made toward reaching benchmark concentrations, additional monitoring beyond the above described sampling events would be beneficial. It is suggested that monitoring be completed after three years, seven years, and ten years during spring or early summer. Monitoring should include three monthly sampling events from April to June in 2016, 2020, and 2023. Any sampling sites that show exceedances in the data collected in May 2014 should be included with the monitoring conducted in 2016.

Evaluation of the plan should be conducted following the monitoring activities. The LHCWMP Implementation Coordinator should organize a meeting with watershed stakeholders to discuss the collected results. The effectiveness of the BMPs should be discussed. Alternative approaches should be considered in areas where BMPs are shown to not be feasible and/or effective. The LHCWMP is intended to be a living document, so modifications should be made based on changing conditions. Any modifications should be provided to all plan holders so that updated copies can be maintained by all parties.

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1. INTRODUCTION

1.1. PROJECT OVERVIEW

Winchester Municipal Utilities (WMU) contracted Palmer Engineering to provide consulting services for the development of a Watershed Management Plan (WMP) in Lower Howards Creek Watershed (LHCW) in Winchester, Clark County, Kentucky. The Lower Howards Creek Watershed Management Plan (LHCWMP) was developed as the Supplemental Environmental Project (SEP), as required by the Environmental Protection Agency (EPA) in the Consent Decree (Civil Action No. 06-1-2KSF, April 10, 2007) with WMU and the City of Winchester. The Consent Decree stipulated that WMU and the City of Winchester must perform a SEP having the objective of securing significant environmental or public health protection and improvements. WMU, the City of Winchester, EPA, and the Kentucky Division of Water (KDOW) agreed that it would be environmentally beneficial to the public to commission a study of the streams in the LHCW and develop the LHCWMP. The project was approved by the EPA on March 18, 2011. The completion of the LHCWMP was in accordance with the requirements as set forth by the EPA in Exhibit D of the Consent Decree. This project was undertaken in connection with the settlement of a civil enforcement action taken by the United States for violations of the Clean Water Act.

Preparation of the LHCWMP has been based on EPA's *Handbook for Developing Watershed Plans to Restore and Protect Our Waters* and the State of Kentucky's *Watershed Planning Guidebook for Kentucky Communities.* The objective of the LHCWMP was to meet the requirements of the SEP by providing direction to the community regarding sampling and gathering data; prioritizing projects within the LHCW; and producing a plan for the community that can lead to measureable results to improve water quality, watershed conditions, and enhance future funding opportunities for projects within the watershed. The project team proposed to meet the requirements for 319(h) grant funded projects, as outlined in the *Watershed Planning Guidebook for Kentucky Communities*, to allow for the funding of future projects through the 319(h) grant program as administered by KDOW.

The following is a list of the primary tasks performed by the project team. The tasks are discussed in detail in this plan.

1. Identification of stakeholders in conjunction with state and local officials and civic and environmental groups;
2. Public notification of the creation of the LHCWMP and an invitation to comment or get involved;
3. Public meetings with stakeholders to explain project objectives, enlist support, identify problem areas and potential pollutant sources, and develop indicators and prioritization processes;
4. Collection of existing watershed data including physical and natural features, population and land use, and previous studies and water quality sampling results;
5. Biological assessments of LHC and tributaries;
6. Phase One and Phase Two water quality monitoring and sampling as defined in the State of Kentucky's *Watershed Planning Guidebook for Kentucky Communities*;
7. Identification of pollutant sources through field investigation, water quality testing, and existing available data;
8. Establishment of benchmark concentrations and comparisons for each parameter;
9. Estimation of pollutant loads and target reductions;

10. Identification of Best Management Practices (BMPs) and feasibility analysis of selected measures;
11. Estimation of technical and financial assistance needed to implement identified BMPs;
12. Schedule for implementation of BMPs;
13. Identification of measureable milestones for BMP implementation;
14. Development of monitoring objectives to evaluate the effectiveness in achieving water quality standards;
15. Development of the written LHCWMP to be maintained for public use and benefit; and
16. Presentation of LHCWMP and progress reports with political leaders, stakeholders, civic and environmental groups, and the general public.

The development of the LHCWMP has been funded solely by WMU and the City of Winchester to meet the requirement of the SEP; however, after the finalization of the report, WMU and the City of Winchester shall be indemnified and held harmless to all actions taken by others as it relates to the implementation of the LHCWMP.

1.2. PROJECT TEAM

WMU advertised a request for Statement of Qualifications from consulting engineering firms for the development of the LHCWMP. Through an evaluation of submitted Statement of Qualifications by a selection committee made up of WMU staff and a WMU commissioner, Palmer Engineering was selected for the development of the LHCWMP in accordance with the requirements set forth by the EPA in Exhibit D of the Consent Decree. The project team organization is shown in Figure 1. The tasks and roles for each team member are listed on page 3 of the Quality Assurance Project Plan in APPENDIX F.

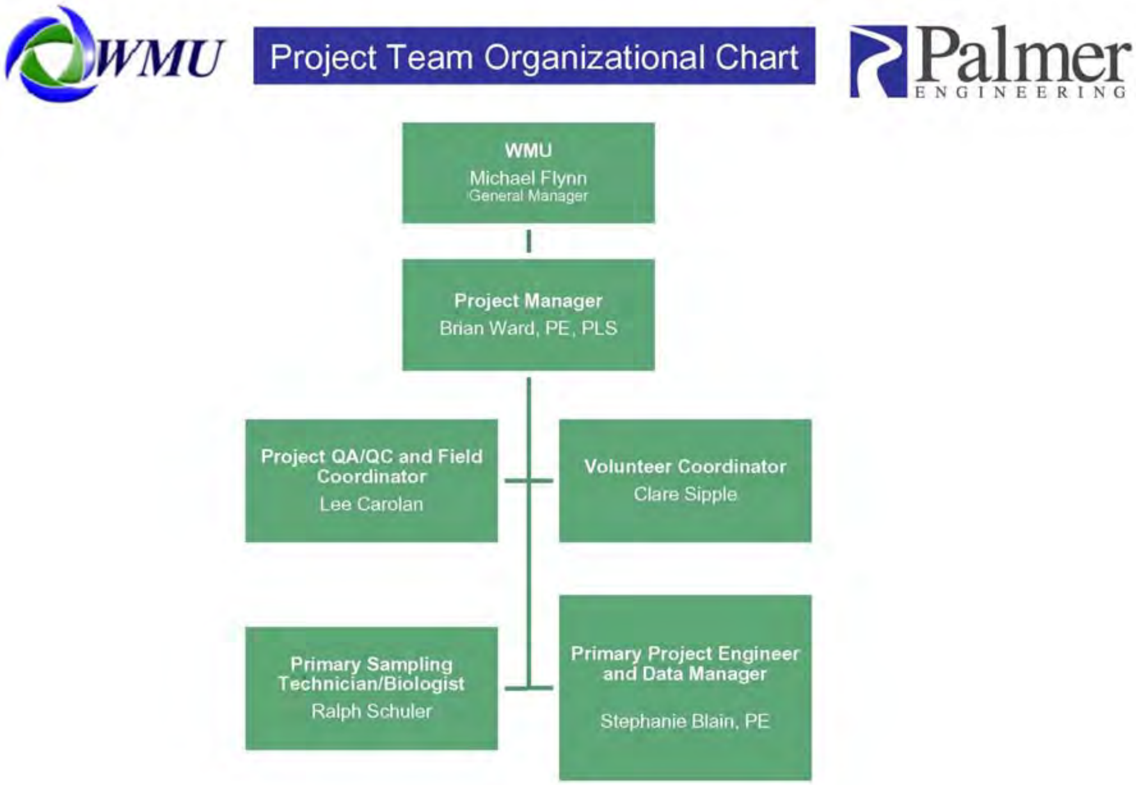


Figure 1. Project Team Organization

1.3. PARTNERS AND STAKEHOLDERS

A vital part of the development of the LHCWMP was the involvement of the partners and stakeholders in the project area. Comments and participation were solicited from City of Winchester and Clark County public officials, Clark County Board of Education, Clark County Health Department, and various civic and environmental groups active within the community. A list of the people and organizations contacted is located in APPENDIX A.

The project team involved interested members of the general public and residents of the watershed through public meetings. Announcements for the meetings were made through mailings, newspaper advertisements, and emails. Three weeks prior to each public meeting, an advertisement was placed in the Winchester Sun informing the public of the upcoming meeting date, location, and agenda. Prior to the first public meeting, five advertisements were placed in the Winchester Sun and letters were sent to all property owners along LHC and tributaries within the watershed to inform them of the development of the LHCWMP and invite them to the first public meeting. Anyone who provided an email or street address was contacted prior to each of the public meetings with the same notice that was included in the advertisement in the newspaper. Prior to sampling site selection, affected property owners were contacted to obtain permission to enter their property to perform habit assessments, biological assessments, and water sampling. The project team coordinated with property owners prior to each sampling event.

A series of three public meetings were held to involve the general public, residents of the watershed, and other interested parties in the development of the plan. Stakeholder Meeting One was held on July 14, 2011 at 6:00 PM at the Clark County Extension Office. The meeting presentation introduced the concept of the WMP; outlined the project scope; and provided a timeline for completion. Attendants of the meeting were given an opportunity to ask questions about the project, signup to assist in the project, and speak with the project team about their concerns. Stakeholder Meeting Two was held on November 29, 2011 at 6:00 PM at the Clark County Extension Office. The meeting presentation discussed the work completed to date, including research of existing data and sampling results; provided an updated project schedule; discussed potential Phase 2 sampling locations; and allowed for project stakeholders to ask questions and express their concerns. Stakeholder Meeting Three was held on May 29, 2012 at 6:00 PM at the Clark County Extension Office. The meeting presentation included a review of the previous two public meetings; discussion of the sampling data collected; identification of possible, goals, objectives, and best management practices; and allowed for stakeholder input. Prior to Stakeholder Meeting Three, a questionnaire was sent out to any party that had expressed interested in the project and provided an email or street address. Approximately 50 questionnaires were sent out prior to the meeting. The questionnaires were also provided to each person who attended Stakeholder Meeting Three. The questionnaires asked for the stakeholders to prioritize goals, objectives, and best management practices for LHCW according to their personal opinions. The project team used these responses to assist in developing the goals, objectives, and best management practices as discussed in Chapter 5 of this report. APPENDIX A includes attendance lists and signup sheets from the stakeholder meetings; copies of the public notices placed in the Winchester Sun prior to the public meetings; and the questionnaire provided at Stakeholder Meeting Three. Table 1 identifies the key partners and stakeholders during the plan development process.

Exhibit D of the Consent Decree requires that the final LHCWMP be distributed and a public presentation on the final plan made by October 13, 2012. A public presentation of the plan will be held on October 11, 2012 at 6:00 PM at the Clark County Extension Office. Copies of the LHCWMP will be distributed to the plan holders prior to or at the public presentation of the final plan. A copy of the public notice placed in the Winchester Sun prior to the meeting is included in APPENDIX A. The attendance list for this meeting will be included in the first addendum to be issued by January 1, 2013.

Table 1. LHCWMP Key Partners and Stakeholders

Name	Organization
Mike Flynn	WMU
Brian Ward	Palmer Engineering
Stephanie Blain	Palmer Engineering
Ralph Schuler	Palmer Engineering
Lee Carolan	Palmer Engineering
Clare Sipple	LHC Nature and Heritage Preserve
Lajuanda Haight-Maybriar	KDOW Non-Point Source Section
Lisa Hicks	KDOW Quality Assurance Officer
Dr. Gail Brion	University of Kentucky
Tricia Coakley	University of Kentucky
Sean Ireland/Dennis Sayre	EPA Region 4
Smith Family Trust	Property Owners/LHCW Resident
James and Earl Gay	Property Owners/LHCW Resident
Henry Branham	Clark County Judge/Executive

2. LOWER HOWARDS CREEK WATERSHED (LHCW)

2.1. WATERSHED OVERVIEW

2.1.1. WATERSHED BASICS

LHCW (United States Geological Survey (USGS) Hydrologic Unit Code (HUC) #05100505050) is located in southwestern Clark County. The watershed covers approximately 19.3 square miles, including the southern portion of the City of Winchester and portions of smaller communities including Boonesborough. LHCW is contained within the Palisades Region of the Kentucky River Basin. LHC is a tributary to the Kentucky River, which eventually flows into the Ohio River in Carroll County, Kentucky. Lexington is located east of the watershed, Mount Sterling to the west, Winchester to the north, and Richmond to the south. The area is characterized by rolling terrain and moderate rates of both groundwater drainage and surface runoff.

2.1.2. BASIS OF SELECTION OF WATERSHED

LHC is listed as impaired in the KDOW 2010 Section 303(d) list from river mile (RM) 2.65 to RM 6.2. The listed impairments are nutrient/eutrophication biological indicators and organic enrichment (sewage) biological indicators. KDOW completed monitoring of LHC in 2004 and the Total Maximum Daily Load (TMDL) is currently under development.

The Kentucky River Basin Management Plan, prepared by the Kentucky Water Resources Research Institute, dated April 2002, identified LHCW as a Framework Mobilization Category II watershed, indicating that it is a watershed targeted for mobilization in the second cycle of the plan. Only three watersheds in the Kentucky River Basin were listed at a higher priority than the LHCW. The watershed contains a reserve drinking water reservoir for the City of Winchester and is part of source water protection zones two and three for Kentucky American's Lexington intake on the Kentucky River.

The WMU Consent Decree outlines 27 sanitary sewer overflows (SSOs) within the WMU sanitary sewer collection system. Four of these SSOs were eliminated with the completion of the Strodes Creek Wastewater Treatment Plant upgrade in 2007, leaving 23 system wide SSOs remaining. Thirteen of these remaining SSOs, 57% of the total, occur in the LHCW, including the two largest remaining SSOs in the WMU sanitary sewer collection system. The compliance projects required in the Consent Decree target the elimination of these SSOs to improve the water quality in LHCW. The SEP, also required by the Consent Decree, has the objective of securing significant environmental or public health protection and improvements. To satisfy the requirement of the SEP and provide the community with a viable plan to protect and restore the watershed, WMU proposed the development of the LHCWMP as the SEP to supplement the SSO elimination efforts occurring within the watershed and further enhance the improvement of water quality within LHCW. Due to historical significance, which will be discussed later in this plan; known presence of impairments; prioritization in the Kentucky River Basin Management Plan; and location and volume of SSOs, the development of the LHCWMP was proposed and approved by the EPA to meet the requirements of the SEP.

2.2. WATER RESOURCES

LHCW contains LHC and many lower order tributaries, including West Fork Lower Howards Creek (West Fork), Dry Fork Lower Howards Creek (Dry Fork), and Deep Branch. The main stem of LHC is approximately 10.3 miles long and drains about 12,360 acres. Figure 2 shows the limits of LHCW. LHCW contains the reserve drinking water reservoir for the City of Winchester and is part of source water protection zones two and three for Kentucky American's Lexington intake to the Kentucky River. Two unnamed tributaries of LHC flow directly into the upstream portion of the reserve drinking water reservoir for the City of Winchester.

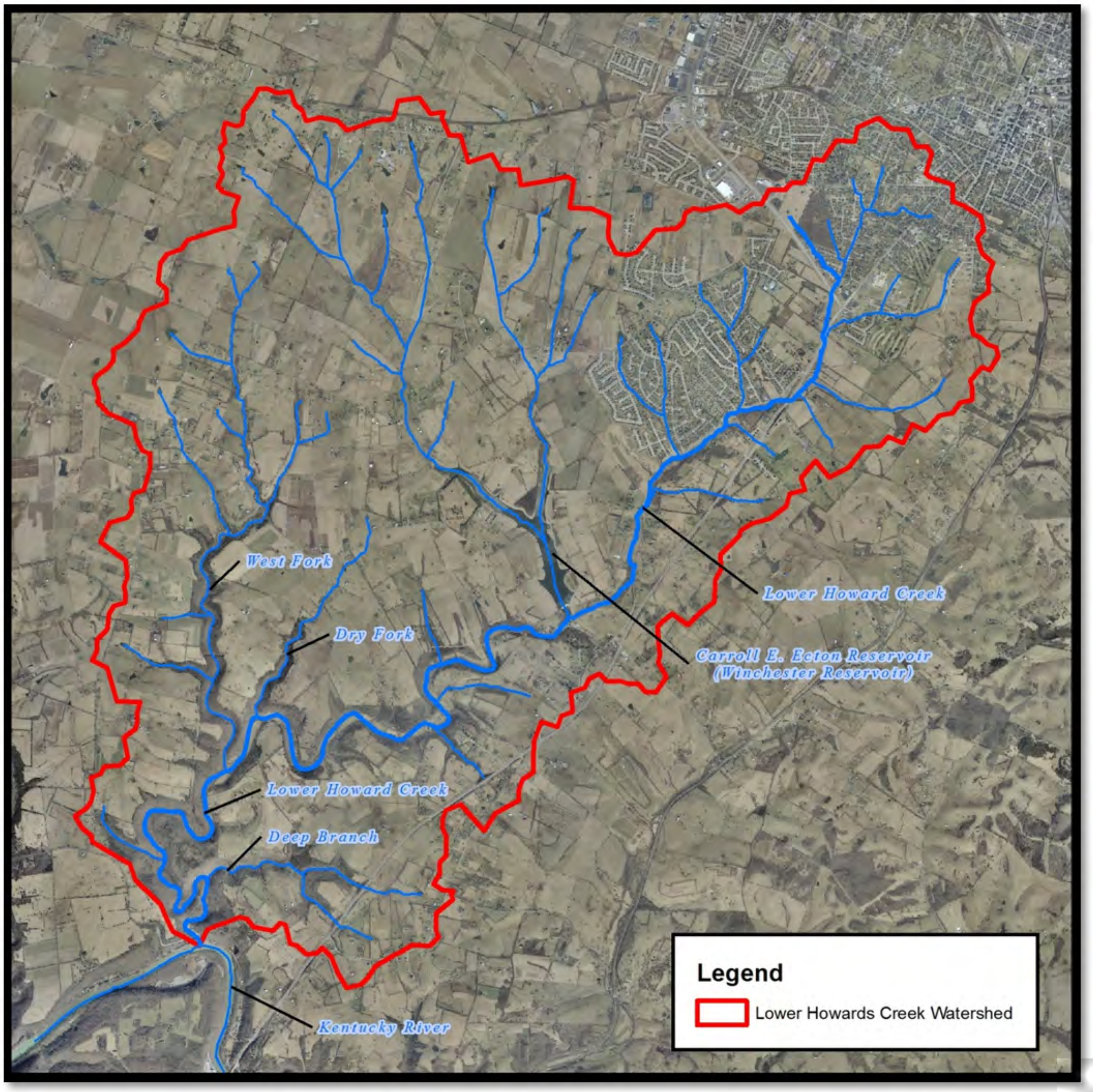


Figure 2. Limits of LHCW

2.2.1. HYDROLOGY

Stream flow in LHC is derived from precipitation runoff and groundwater discharge. Thick layers of easily dissolved limestone underlay the watershed, creating frequent carbonate aquifers. Caves and springs are also common in the region due to groundwater flowing through channels in the limestone. LHCW is prone to flashy storm flows as a result of impervious surfaces associated with the City of Winchester and surrounding residential areas and reduction of floodplain width and riparian buffer.

Clark County does not have a Midwestern Regional Climate Center station. Clark County is partially surrounded by Fayette, Madison, and Bourbon Counties. The precipitation data for the Midwestern Regional Climate Center stations in these counties from 1971 to 2000 is located in Table 2. In the Clark County Soil Survey, the climate is described as temperate and humid with short periods of excessive heat or cold. The rainfall is fairly evenly distributed throughout the year providing favorable growing seasons for grasses and legumes.

Table 2. Precipitation Data

Station ID	County	Annual Precipitation (in)	Annual Snowfall (in)
Richmond State Police	Madison	43.65	5.4
Paris	Bourbon	46.80	1.6
Lexington Bluegrass Airport	Fayette	45.91	15.9

Unites States Geological Survey (USGS) does not have any water gaging stations within LHCW. The closest gauging station is on the Kentucky River at Lock 10 (USGS Site # 03284000), located upstream of the confluence of LHC with the Kentucky River. Flow data was collected at the water quality sampling sites at the time of sampling and will be discussed later in this plan.

2.2.2. GROUNDWATER-SURFACE WATER INTERACTION

The groundwater-surface water interaction has significant impact to LHCW. Due to the underlying limestone, LHCW contains locally integrated karst drainage. KDOW has developed a Groundwater Sensitivity Index to rate the ease and speed with which a contaminant can move into and within a groundwater system. The major factors in determining the sensitivity are recharge to the system, flow rate, and dispersion potential within the system. The index ranges from one (low) to five (high). Figure 3 depicts the index values for Clark County and the surrounding region. LHCW is predominately rated four (purple shading) and five (red shading) with an area of three (green shading) near the confluence, indicating widespread or radial extensive dispersion, conduit or enlarged fissure flow, and convergent recharge.

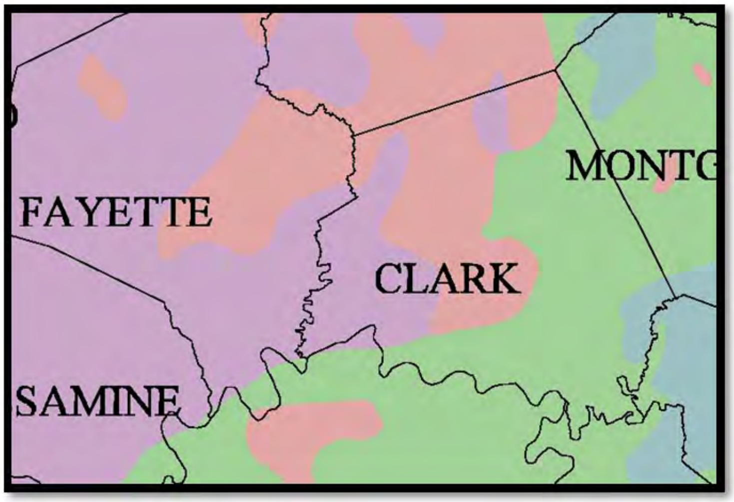


Figure 3. Hydrologic Sensitivity Index Map

The Kentucky Geological Survey has developed Karst Atlas maps of Kentucky that depict groundwater basins, sinkholes prone to flooding and the potential for the development of cover-collapse sinkholes. LHCW is located on the Harrodsburg Quadrangle, and an excerpt of the region is shown in Figure 4. A large groundwater catchment basin is shown in the western portion of the watershed that drains into West Fork. See Section 2.3.1 for more information of the location and identification of karst topography.

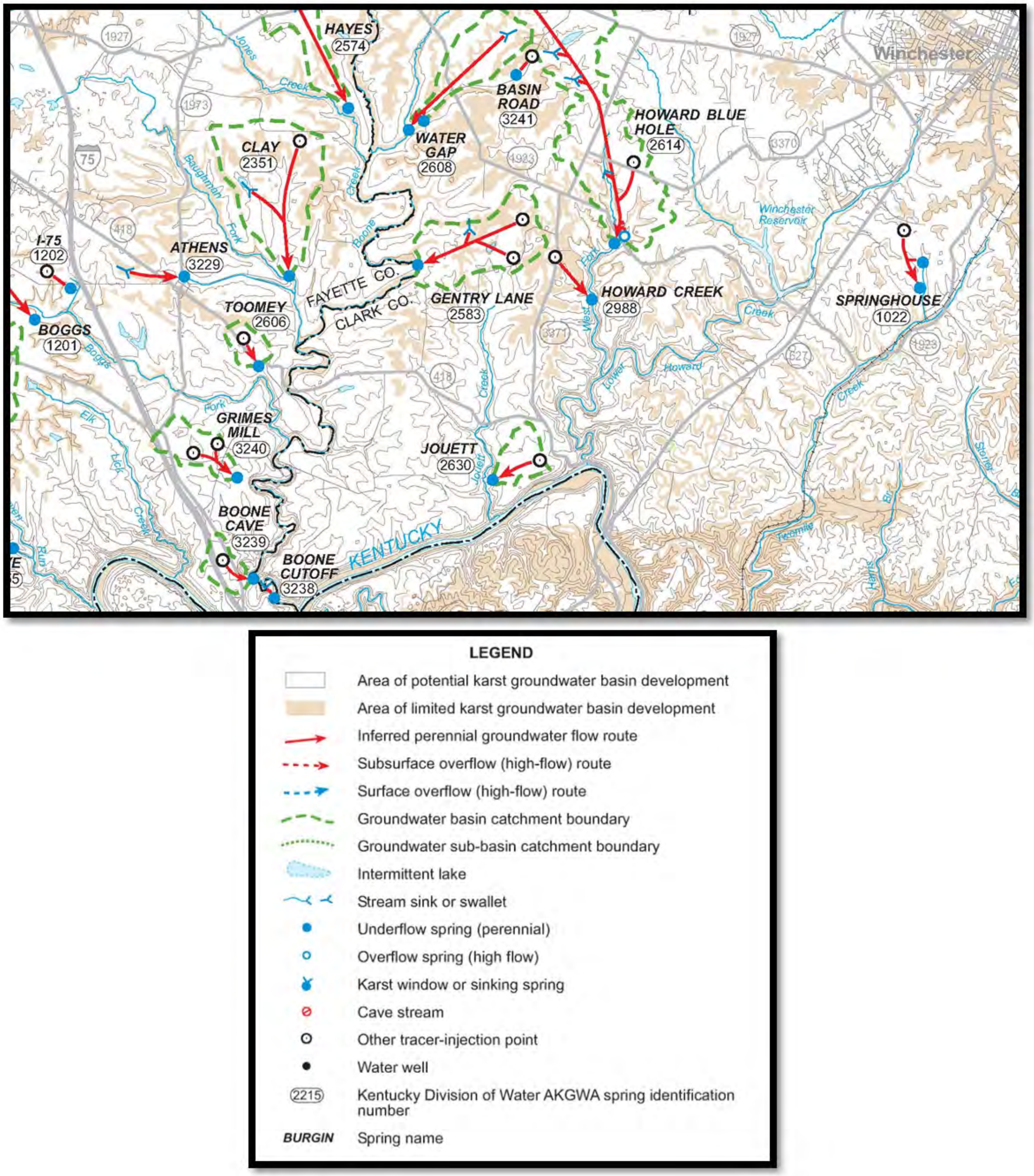


Figure 4. Excerpt from Karst Atlas of Kentucky and Legend

2.2.3. FLOODING

Flooding is a concern in the LHCW, especially in the developed sections. Four previous flood studies were identified for the LHCW. In January 1979, the United States Department of Agriculture (USDA) Soil Conservation Service, now called Natural Resource Conservation Service (NRCS), published a Flood Hazard Study that included the analysis of LHC and tributaries along with two other streams in the Strodes Creek Watershed. The City of Winchester requested the study to accurately define the existing flooding hazard areas and to estimate future flood potential based on anticipated development. During this time Winchester was experiencing rapid urbanization and the City of Winchester desired to assess the situation.

The Federal Emergency Management Agency (FEMA) completed a Flood Insurance Study for Winchester and unincorporated portions of Clark County in 1986. This was not a completely new study, utilizing the hydraulic analysis from the 1979 USDA Flood Study. The study completed by NRCS was reevaluated and Flood Insurance Rate Maps (FIRMs) were produced for the study area. The FIRMs that detail LHCW are 2100560002B, 2102780058B, and 2102780075B. The detailed study did not include the portion of the watershed from the confluence with the Kentucky River to Waterworks Road (RM 6.2).

In September 2003, the United States Army Corps of Engineers (USACE) Louisville District published a Flood Plain Management Service Program Special Study for Winchester, Kentucky. This study examined flooding problems in three primary areas: the Winchester Water Treatment Plant, residential area near LHC (Hampton Manor), and the historic Old Stone Church. The study was conducted at the request of the City of Winchester due to flooding problems experienced at the existing water treatment plant (WTP), located directly adjacent to the Carroll E. Ecton Reservoir on Water Works Road. The model indicated that the risk of flooding at the Old Stone Church was limited, so no alternatives were pursued for this location. It was determined that the primary cause of flooding in Hampton Manor was due to an undersized culvert under the Winchester Bypass (KY 1958). Overbank flooding from LHC and seepage through the underlying soil and rock into the lower levels of the WTP were determined as the cause of flooding at the WTP. The study identified two alternatives to reduce flooding to the WTP and three alternatives to reduce flooding to the residential area. The two alternatives at the WTP included the construction of extensive flood walls and both alternatives were estimated to cost over $4,000,000 (2001 dollars). Neither alternative was constructed due the cost of the modifications representing approximately 25% of the total construction cost of the WTP. The WTP is planned to be replaced in the near future due to capacity limitations. The three alternatives in the residential area ranged from supplementing the culvert with an additional culvert ($135,000 in 2001 dollars) to modifying a bridge and several culverts ($3,009,000 in 2001 dollars). As of September 2012, none of the alternatives have been implemented at the WTP or in the residential area.

Palmer Engineering completed a Flood Study of LHC for WMU in November 2008. The purpose of this study was to determine the 25-year flood elevations along the LHC and one of its tributaries for the construction of a proposed sanitary sewer line. The study was used to select the location and set the manhole rim elevations for the proposed sanitary sewer line to limit opportunities for direct inflow to enter the system. Flood Analysis Maps for the study area that delineate the 25-year and 100-year flood events are located in APPENDIX B. Consistent with the previous studies, there is extensive flooding risk in and adjacent to the developed portions of the watershed, especially in Stoneybrook Neighborhood in the vicinity of Fieldstone Way, Calmes Neighborhood in the vicinity of Calmes Drive, and Hampton Manor in the vicinity of Willowbrook Road. According to residents, Old Boonesboro Road in the vicinity of Fieldstone Way becomes impassable due to a flood event on average twice per year.

2.2.4. WATER WITHDRAWAL AND SUPPLY

KDOW water withdrawal program governs all withdrawals of water greater than 10,000 gallons per day from any surface, spring or groundwater source. WMU has one permitted drinking water withdrawal location from the Carroll E. Ecton Reservoir in LHCW. There is one other known water withdrawal permit within the watershed. The Blackfish Golf and Hunt Club has a commercial permit for surface water withdrawal from LHC at RM 3.7. The withdrawal limits for the Blackfish Golf and Hunt Club vary by month. No water is permitted to be withdrawn from October to February; 25,000 gallons per day is permitted in March; and 320,000 gallons per day is permitted from April to September.

WMU withdraws water to be used for drinking outside of the watershed from the Kentucky River upstream of the confluence of LHC. WMU is currently permitted to withdraw 15 million gallons per day (MGD) from the Kentucky River and 5.3 MGD from the Carroll E. Ecton Reservoir. WMU provides water to most of the residents of the watershed, but Clark County has three community water systems: WMU, East Clark County Water District and Kentucky-American Water. Some residents may also be serviced by the Judy Water Association. Both East Clark County Water District and Kentucky-American Water purchase the water used to serve Clark County from WMU. According to the Bluegrass Area Development District's *Water-Resource Development: A Strategic Plan*, as of 1999, 98% of the residents of Clark County are serviced by public water systems.

The existing WMU WTP has a capacity to treat 6.0 MGD, but is restricted to 5.5 MGD due to the capacity of the distribution mains. The raw water pump runs continuously, drawing 5.3 MGD of raw water from the Kentucky River. Depending on the demand, 3.0 MGD to 5.3 MGD of raw water is treated and distributed to the system. The excess raw water is diverted to the Carroll E. Ecton Reservoir to maintain the level of the reservoir and for storage. The reservoir consistently leaks 1.0 MGD (estimated) due to seepage around the upper impoundment. The reservoir has two impoundments; the upper, which detains a majority of the volume, and the lower, which the main channel of LHC flows into directly. The leakage helps to maintain consistent flow into LHC below the lower impoundment. Additionally, the reservoir may act as a best management practice for pollutant removal and settling, by slowing and detaining flows in LHC. However, it may also add pollutants to the stream during high flows or if not properly maintained. The pumping of water from the Kentucky River adds a potential for pollutant containments from outside of watershed to be introduced at the reservoir.

The reservoir is also used for recreational activities by the Clark County Fish and Game Club, such as fishing and other outdoor activities. Only non-gasoline powered boats (paddle, row, or boats with electric troll motors) are permitted for use in the reservoir. Raw water for treatment is only pumped directly to the reservoir during periods of maintenance of the intake facilities at the WTP (typically one to three months during the winter). During this time, the water flows from the reservoir through a gravity line to be treated at the WTP for distribution. It is expected that the existing WTP will have to be replaced in the near future due to age of the infrastructure, capacity of the existing facility, and continued growth in the Winchester area. There are preliminary plans to replace the existing WTP with a new facility adjacent to the new Lower Howards Creek Wastewater Treatment Plant (WWTP), also located within the watershed. The projected demand for water in the greater Winchester area in 2020 is 12 MGD. When the new WTP is constructed, pumping from the Kentucky River to the reservoir may no longer occur. Due to the leakage occurring, this would likely cause issues in maintaining the level of water in the reservoir for recreational activities. The amount of flow in LHC below the impoundment would also be affected because the stream would not be receiving the 1.0 MGD to 2.0 MGD of excess water that had previously been pumped to the reservoir.

2.2.5. EXISTING WATERSHED MANAGEMENT ACTIVITIES

No formal comprehensive watershed plan is currently in place for LHCW. Although the Commonwealth of Kentucky, City of Winchester, Clark County, and LHC Nature and Heritage Preserve have some existing watershed management activities in place in LHCW through regulations and planning documents.

2.2.5.1. REGULATIONS AND ORDINANCES

As of September 2012, the City of Winchester and Clark County were in the process of revising the Subdivision Regulations and creating the Infrastructure Manual. The new Infrastructure Manual will specify requirements for street construction, stormwater drainage, and erosion and sediment control implementation. Previously these sections had been addressed within the Subdivision Regulations, but the new Infrastructure Manual will allow for a document dedicated to these improvements. The following regulations and ordinances have been approved (or are planned to be approved in the near future) and must be followed within the City of Winchester and/or Clark County as noted:

Illicit Discharge Ordinance – Code of Ordinances Article 11 Section 25 - 28 (City of Winchester): *"Whatever is dangerous to human health, whatever renders the ground, water, air, or food a hazard or an injury to human health, and the following specific acts, conditions and things are, each and all of them, declared nuisances and are prohibited and made unlawful."*

Floodplain Regulation – Subdivision Regulations Article VII Section 740.D (City of Winchester and Clark County): *"Development shall be prohibited in areas designated as within the one-hundred year flood plain on the Flood Hazard Maps produced by the Federal Emergency Management Agency (FEMA). Land subject to flooding or otherwise uninhabitable shall not be platted for residential use or for any other use which may increase the danger of health, life, property or aggravate erosion or flood hazards…Fill may be used in flood danger areas to render lots habitable if such fill does not inhibit flow of the waters and thereby unduly increase flood heights in other areas and meets the approval of the Kentucky Division of Water and the Planning Commission."*

Stormwater Drainage – Draft Infrastructure Manual Stormwater Section A (City of Winchester and Clark County): *"A subdivision plat shall not be considered for preliminary approval until the subdivider shall submit to the Planning Commission a written report by a professional engineer as to the ability of existing water course channels, storm sewers, culverts, and other improvements pertaining to drainage or flood control, within the subdivision, to handle the additional run-off for the storms noted below which would be generated by the planned future development of the land within the area according to long range planning. There shall be no increase in the rate of run-off as a result of new construction. Additional information shall be submitted to adequately indicate that provision has been made for disposal of surface water without any damage to the developed or undeveloped land downstream or below the proposed subdivision. This report shall also include: 1. Estimate of the quantity (cubic feet) of storm water entering the subdivision naturally from area outside the subdivision on each inlet. 2. Calculation of stormwater runoff water quality treatment standard...3. Standards for protection of high quality water...4. Peak flow rates (cfs) at each pick-up point (inlet). 5. The preliminary plan shall record the location, size, and grades of all stormwater features and include...design calculations...6. The basic standard for design of drainage systems for subdivisions will be to keep run-off characteristics after development at the same level as existed prior to development. No excess stormwater runoff is permitted to occur."*

Construction Erosion and Sediment Control Regulation – Subdivision Regulations Article VIII Section 860 (City of Winchester and Clark County): *"In the event that any developer shall intend to make changes in the contour of any land proposed to be subdivided, developed or changed in use by grading, excavating or the removal or destruction of the natural topsoil, trees, or other vegetation covering, the owner of said land or his agent shall submit to the Planning Commission for approval a plan for erosion protection and sedimentation control (EPSC). Under no conditions shall topsoil or other construction products be allowed to wash from the site under development onto adjacent roadways or public or private property. The procedures for EPSC measures are further described in the Infrastructure Manual."*

The Post-Construction Stormwater Runoff Requirements for the City of Winchester - Ordinance 14-2011 Section 2 (City of Winchester): *"The City of Winchester established this ordinance in order to establish a set of water quality and quantity policies applicable to all surface waters to provide reasonable guidance for the regulation of stormwater runoff in all public and private developments for the purpose of protecting local water resources from degradation and to protect and maintain the native vegetation in riparian stream and wetland areas. This ordinance seeks to meet the purposes through the following objectives: 1. To protect the general health, safety, and welfare of the citizens, property owners, and businesses in the City of Winchester; 2. To protect and enhance the municipal storm sewer system (MS4), community waters and waters of the Commonwealth by inhibiting the deterioration of water resources resulting from development; 3. To maintain after development, as nearly as possible, the predevelopment runoff characteristics, and to reduce stream channel erosion, pollution, siltation and sedimentation, and local flooding; and 4. To provide long-term responsibility for and maintenance of stormwater BMPs."*

The full regulations and ordinances for each of the above sections can be found on the City of Winchester's website (http://www.winchesterky.com). As summarized above and detailed in the full regulations and ordinances, all new developments in the City of Winchester (over 0.25 acres or part of a larger common plan of development) and Clark County (over 1.0 acres or part of a larger common plan of development) are required to follow requirements for stormwater runoff and erosion and sediment control for new developments. These regulations and ordinances are aimed at minimizing impacts to the streams and existing surrounding areas during and after construction of a new development. Flooding is an issue within LHCW due to limited regulations being in place at the time of development. Proper stormwater management quality control devices were not installed in areas of the watershed, especially the residential developments along Old Boonesboro Road, resulting in severe flooding during storm events. All new projects in the City of Winchester and Clark County must go through the Winchester/Clark County Planning Commission approval; however, the Subdivision Regulations and Infrastructure Manual do not clearly identify how enforcement will be addressed in areas outside the City of Winchester limits. Areas within the City of Winchester limits are overseen and inspected by the City Engineering Technician. In a meeting with Clark County Judge/Executive, Henry Branham, on May 18, 2012, it was discussed that the leadership in Clark County recognizes the need for watershed protection and is considering implementing measures to promote preserving and improving water quantity. Leadership in Clark County is also aware of the potential for problems in the county where construction projects, especially single family homes, are not required to go through the Winchester/Clark County Planning Commission approval process.

The draft Infrastructure Manual implements requirements for new developments that not only address storm water quantity control through assessing the existing stormwater entering the new development from adjacent areas, analyzing peak flow rates, and limiting stormwater runoff to existing levels, but also stormwater quality control through the calculation of the stormwater runoff water quality treatment standard. The first flush of stormwater runoff often carries heavy loads of pollutants from impervious areas such as streets and parking areas. The pollutant laden runoff from these impervious areas can negatively impact receiving streams by altering the water chemistry and water quality. The goal of the stormwater runoff quality treatment standard is to establish the water quality volume metric and provide treatment for this volume. The water quality volume is defined as the amount of stormwater runoff from any given storm that should be captured and treated to remove a majority of the stormwater pollutants on an average annual basis. The regulation requires that the calculated water quality volume "be treated in combination or alone, by management measures that are designed, built and maintained to treat, filter, flocculate, infiltrate, screen, evapotranspire and reuse stormwater runoff, or otherwise manage the stormwater runoff quality."

2.2.5.2. STORMWATER QUALITY MANAGEMENT PLAN

The City of Winchester has been designated as a Phase II Municipal Separate Storm Sewer System (MS4) community and has developed a Stormwater Quality Management Plan (SWQMP) in accordance with EPA regulations. The MS4 program was established by the EPA to improve the nation’s waterways by reducing the quantity of pollutants that stormwater picks up and carries into storm sewer systems during storm events. KDOW requires each MS4 to develop a stormwater quality management program designed to reduce the discharge of pollutants to the maximum extent possible. The stormwater quality management program is formalized in the SWQMP. The SWQMP addresses the six minimum control measures (MCMs): (1) public education and outreach; (2) public involvement/participation; (3) illicit discharge detection and elimination; (4) construction site stormwater runoff control; (5) post-construction stormwater management in new development and redevelopment; and (6) pollution prevention/good housekeeping for municipal operations. The City of Winchester is required to implement ordinances, conduct public education and outreach, complete record keeping, and perform inspections to meet the requirements of the MCMs; however, the MS4 boundary is the City limits so the oversight is not required to extend into other areas of Clark County. The changes to the Subdivision Regulations and creation of the Infrastructure Manual will be completed to maintain compliance with the Phase II MS4 permit, but these regulations extend throughout all of Clark County. However, as of September 2012, there is not an inspection and maintenance procedure in place outside of the City of Winchester. The City of Winchester has also passed two additional ordinances, Ordinance 5-2011, relating to erosion prevention and sediment control requirements, and Ordinance 14-2011, relating to post construction stormwater runoff requirements. These ordinances are only applicable within the City limits and define submittal requirements, approval procedures, inspection timing and procedures, and maintenance requirements. The City of Winchester is currently working with CDP Engineers (Lexington, KY) and under guidance from the Stormwater Advisory Committee to meet the six MCMs.

2.2.5.3. WINCHESTER MUNICIPAL UTILITIES FACILITIES PLAN

The *Winchester Municipal Utilities Facilities Plan*, dated November 2009, was prepared in accordance with regulation 401 KAR 5:006 and approved by KDOW in August 2010. Prepared by Palmer Engineering, Hazen and Sawyer, and CDP Engineers, the purpose of the plan was to analyze the need and the alternatives for the collection and treatment of wastewater for the City of Winchester and portions of Clark County, including LHCW. The primary intent of the plan was to address the wastewater needs for the WMU Service Area and comply with the requirements established in the EPA Consent Decree to eliminate the known SSOs.

The plan provided analysis and comparison of several different alternatives for sewer service based on cost-effectiveness, environmental soundness, and the ability to implement. Four alternatives where presented for the LHCW: 1. Construct an intermediate transfer pump station and transport the flow to the existing Strodes Creek WWTP, requiring expansion of the recently upgraded plant; 2. Construct an intermediate transfer pump station and transport the flow to a new WWTP; 3. Take no action; 4. Construct an intermediate transfer pump station and transport to the Strodes Creek Basin by partially utilizing existing sanitary sewer infrastructure. The selected alternative, Alternative 2, involved constructing a new gravity wastewater collection system in LHCW, an intermediate transfer pump station and force main, and a new WWTP. Construction of this alternative is currently underway and will be substantially completed by January 2013. WMU expects this construction will eliminate 13 of the SSOs identified in the Consent Decree. Four additional SSOs identified in the Consent Decree were previously eliminated by WMU.

2.2.5.4. LOWER HOWARDS CREEK MANAGEMENT PLAN

The *Lower Howards Creek Management Plan* was prepared by Parsons Brinckerhoff, Ned Crankshaw, and Cultural Resource Analysts for Clark County Fiscal Court, Clark County – Winchester Heritage Commission, and the Friends of LHC in October 2005. This plan provided an overview of the LHC area from the confluence with the Kentucky River to just prior to Old Stone Church Road, which includes the LHC Nature and Heritage Preserve and lands directly to the north along LHC and its tributaries, namely Deep Branch, Dry Fork, and West Fork. Components of the plan included an inventory of the vegetation, cultural, and geologic resources; analysis of these resources; recommendations for future action; and recommendations for organizational management to ensure this area of LHC is protected for future generations. Much of the information and analysis outlined in the *Lower Howards Creek Management Plan* will be referenced in this report.

The plan outlines several areas within the LHC Nature and Heritage Preserve for preservation, rehabilitation, restoration, and reconstruction. An action plan was developed to systematically implement the plan's recommendations. The action plan included:

1. Develop a shared vision for the management entity;
2. Develop a Watershed Management Plan for LHC;
3. Acquire and protect critical lands;
4. Extend resource documentation;
5. Focus on interpretation and intensive intervention in cultural resources in the areas having the greatest ability to depict themes;
6. Conduct archeological studies;
7. Stabilize resources in danger of loss;
8. Establish relationship with other heritage-based venues; and
9. Design and implement visitor interpretive facilities.

The development of the LHCWMP fulfills the second item of the action plan outlined in the *Lower Howards Creek Management Plan* and supplements the remaining action items through raising awareness of LHC on the community level. The LHC Nature and Heritage Preserve is actively pursuing acquiring additional land. A trail was opened for public use (from dawn until dusk) in the spring of 2012.

2.2.5.5. KENTUCKY AGRICULTURE WATER QUALITY PLANS

In 1994, the Kentucky General Assembly passed the Kentucky Agriculture Water Quality Act to protect surface and groundwater resources from pollution as a result of agriculture and silviculture (forestry) activities. The Kentucky Agriculture Water Quality Act requires development of a Kentucky Agriculture Water Quality Plan by all landowners with 10 or more acres that are being used for agriculture or silviculture. The development, implementation, and revision of the Kentucky Agriculture Water Quality Plan for each property is the sole responsibility of the landowner according to the KDOW website. The Kentucky Agriculture Water Quality Plan should address BMPs dealing with silviculture, pesticides and fertilizers, farmstead, crops, livestock, and streams and other waters. The Kentucky Division of Conservation reported that as of February 19, 2010 there were 250 Kentucky Agriculture Water Quality Plans in Clark County. A website, Kentucky Agriculture Water Quality Act Planning Tool (http://www.bae.uky.edu/awqpt), has been developed by the University of Kentucky Cooperative Extension to assist landowners in BMP selection and implementation.

2.2.6. REGULATORY STATUS OF WATERWAY

The EPA water quality standards regulation necessitates that Kentucky must specify appropriate water uses to be achieved and protected for each of the water bodies. Warm water aquatic habitat, fish consumption, primary contact recreation, and secondary contact recreation are the designated uses for LHC. Warm water aquatic habitat is defined as waters that provide suitable habitat for aquatic organisms and fish, excluding cold water species. Fish consumption is defined as consumption of fish or other aquatic organisms by humans. Primary contact recreation is defined as the ability for humans to swim or wade without risk to their health. Secondary contact recreation is defined as the ability for humans to canoe or boat with only occasional contact with the water without risk to their health. From the confluence with the Kentucky River to RM 2.65, LHC is designated as an Exceptional Water and Outstanding State Resource Water due to the location in the LHC Nature and Heritage Preserve.

The 303(d) List of Waters identifies impaired streams and lakes within Kentucky. Each water body is listed as impaired for one or more pollutants if the pollutant levels do not allow the water body to meet one or more of the water quality standards. KDOW personnel, volunteer networks, and other local, state, and federal agencies identify impaired waters through assessment and monitoring programs. The 2010 Kentucky 303(d) List identifies LHC from RM 2.65 to 6.2 as impaired due to unknown causes, nutrient/ eutrophication biological indicators, and organic enrichment (sewage) biological indicators. Warm water aquatic habitat is listed as the non-supported impaired use. The report states that the monitoring was completed in 2004 by KDOW and that nutrient and organic enrichment TMDLs will be developed when nutrient targets are established. The impaired section of LHC is identified in Figure 5. None of the tributaries to LHC are currently listed as impaired.

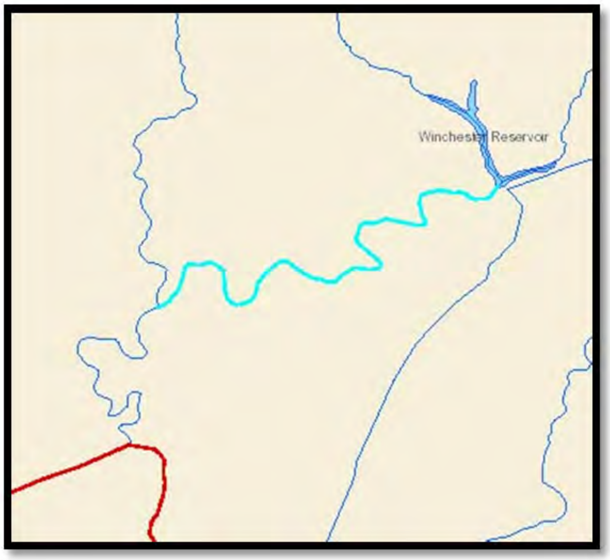


Figure 5. Impaired Section of LHC

2.2.7. EXISTING WATER CHEMISTRY AND BIOLOGY DATA

To assist in evaluation of the watershed, data was gathered from all existing known sources including educational papers, scientific studies, non-profit organizations, government agencies, and volunteer sources. The following sections summarize the information on water and biological data relative to this plan. A map identifying the locations where the previous data was collected is located in APPENDIX C. A full discussion of the rare and exotic/invasive plant and animals species identified in previous studies is located in Section 2.5.

2.2.7.1. DANIEL WALKER MASTER'S THESIS

Mr. Daniel Walker conducted his master's thesis, entitled *Chemical Properties of Lower Howards Creek during a Drought and the Species Present*, undated, in LHCW on the LHC Nature and Heritage Preserve. A point of interest in his study was to determine if Deep Branch, also known as Old Branch, was contributing water with higher concentrations of pollutants, specifically during a time of drought. Three sites were sampled for this study: one 1,600 meters upstream of the Deep Branch confluent (DW Site 1); one 15 meters upstream on Deep Branch from the LHC confluent (DW Site 2); and one 30 meters downstream of the Deep Branch confluent (DW Site 3). Each site was sampled three times with two weeks between sampling events. Temperature, pH, and dissolved oxygen were collected at the time of sampling. Water samples were taken to evaluate the phosphate and nitrate concentrations and identify the most probable number (MPN) of coliforms present in the water source, total coliform number, and fecal coliform number. The water quality results are displayed in Table 3. The abbreviation TNT indicated that the colonies were too numerous to count as valid.

Table 3. Water Quality Results from Daniel Walker's Master's Thesis

Date	Upstream (DW SITE 1)	Deep Branch (DW SITE 2)	Downstream (DW SITE 3)
	Nitrate (mg/L)		
5/21/2007	1.8	2.4	1.8
6/4/2007	1.7	2.4	1.3
6/18/2007	1.6	1.3	1.3
	Phosphate (mg/L)		
5/21/2007	0.44	0.91	0.56
6/4/2007	0.5	1.35	0.6
6/18/2007	0.56	1.54	0.61
	Coliform (MPN/100 mL)		
5/21/2007	46	49	33
6/4/2007	920	>2,400	350
6/18/2007	>2,400	>2,400	1,600
	Total Coliform (#/5 mL)		
5/21/2007	63	252	158
6/4/2007	116	TNT	97
6/18/2007	179	TNT	175
	Fecal Coliform (#/5 mL)		
5/21/2007	4	2	5
6/4/2007	10	110	7
6/18/2007	218	TNT	198

In the discussion of the results, Mr. Walker noted that the phosphorous rose as the drought progressed and the nitrate dropped. Mr. Walker theorized that the loss of plants contributed to the increase in the phosphate levels as the drought progressed. Both the nitrate and phosphate levels where elevated in Deep Branch when compared to LHC. He suggested that the nitrate levels in Deep Branch were higher than LHC due to increase of agricultural impacts upstream and the drop in nitrate concentration through the sampling period coincides with a reduction in runoff to wash pollutants into the stream. The pH of the stream indicated that the water was slightly basic, but it was noted that this was consistent with the region due to the limestone subsurface. The coliform data was mostly higher in Deep Branch than the main channel of LHC. Mr. Walker noted, coliform concentrations were higher upstream of Deep Branch. He summarized that the since the coliform concentrations were higher upstream of Deep Branch than downstream, Deep Branch was not having an adverse effect on LHC. Mr. Walker did not consider the effect of the water flow on these concentrations or the potential for dilution from additional runoff between the site upstream of Deep Branch and the site downstream of Deep Branch. Based on the map provided in the document, the upstream site was approximately one mile (1600 meters) upstream of the Deep Branch confluent. The results of the report are inconclusive because drainage area and flow were not considered.

2.2.7.2. KENTUCKY RIVER WATERSHED WATCH VOLUNTEER DATA

The Kentucky River Watershed Watch (KRWW) trains volunteers interested in water quality. The volunteers are trained on how to take a qualified water sample that is then analyzed by a professional laboratory. Volunteers may also be trained to perform biological and habitat assessment. There are currently five sites monitored by volunteers in the LHCW, all of which are close to historically sampled sites by KDOW. Two of the sites are upstream and downstream of a suspected illicit discharge directly downstream of the Carroll E. Ecton Reservoir. Testing for two pesticides, triazines and 2,4-D by immunoassay, was conducted at the two sampling locations directly upstream and downstream of the suspected illicit discharge in May 2011. The levels of both pesticides were below the water quality standards for drinking water supply. Several of the sampling events showed elevated levels of E. coli with values in excess of 2420 colonies per 100 milliliter (mL) both above and below the suspected discharge. The complete available sampling data from 2010 and 2011 is located in APPENDIX C.

2.2.7.3. KDOW SAMPLING DATA

Through an open records request, sampling data previously collected by KDOW was obtained. The data was collected at various intervals from 1998 to 2009. Data from previous macroinvertebrate, diatoms, fish, habitat, and water chemistry sampling was obtained and reviewed. A majority of the data was collected in 2003 and early 2004 at the time the portion of LHC from RM 2.65 to RM 6.2 was monitored for TMDL development. Sampling site locations can be found in APPENDIX C.

One diatoms sample was previously collected in 1998 at DOW04022005 which is located approximately 0.2 kilometers below Old Stone Church Road bridge. The results of the sample are listed in Table 4. Three habitat assessments, one in 2001 and two in 2003, were conducted at three different sites by KDOW. In 2001, a habitat assessment was performed at DOW0402207 which is located approximately 0.4 miles above the Kentucky River confluence within the LHC Nature and Heritage Preserve. The habitat assessment resulted in a Rapid Bioassessment Protocol (RBP) score of 145, qualifying as a good rating for wadeable streams in accordance with KDOW Standard Operating Procedure (SOP) 03024 (DOWSOP030240). In 2003, two habitat assessments were conducted at DOW04022011, located below the Fish and Game Club back road bridge at RM 6.8, and at DOW04022012, located at an unpaved driveway off KY 627 at RM 9.1. The RBP scores were 124 and 76, respectively. Both scores are rated as poor for headwater streams with drainage areas of less than 5 square miles by DOWSOP03024.

Table 4. KDOW Diatom Sampling Results

Diatom Bioassessment Index Metric	Value	Diatom Bioassessment Index Metric	Value
Taxa Richness	33	Diversity	0.639
Total Number of Individuals	500	Percent Sensitive Individuals	8.2
Generic Richness	18	Pollution Tolerance Index	1.582
Cymbella Group Richness	1	% Dominant Taxon	48
Division Richness	1	%Cymbella/Achnanthes Complex	2.4
Fragillaria Group Index	2	%Navicula+Nitschia+Surirella	91.4

Since 2001, KDOW has assessed the water chemistry at five sites on LHC and one site on West Fork. Most of the sampling occurred at four sites on LHC, namely DOW04022011, DOW04022012, DOW0402218, DOW04022019, and the one site on West Fork, DOW04022014, from April 2003 through February 2004. Each of these five sites was sampled each month during this time period. The dissolved oxygen, pH, specific conductivity, ammonia-nitrogen, chloride, nitrate, organic carbon, phosphorus, sulfate, total suspended solids, temperature, and discharge where recorded at each sampling event. Some months the orthophosphorus and percent saturation of dissolved oxygen were also recorded. Alkalinity and hardness were assessed at DOW04022018. The hardness at this site ranged from 188 mg/L to 231 mg/L. The alkalinity ranged from 121 mg/L to 182 mg/L, exceeding the 20 mg/L requirement for warm water aquatic habitat.

The dissolved oxygen exceeded 5.0 mg/L in all samples except for one instance at DOW04022012 where the value fell to 4.73 mg/L in October 2003. The pH readings tended to be slightly basic, but all fell within normal limits of six to nine. The specific conductivity ranged from 189.4 micromhos/cm to 832.2 micromhos/cm. The highest levels of specific conductivity were observed at DOW0402212 exceeding 505 micromhos/cm in all sampling events except for two. Ammonia-nitrogen exceeded 0.05 mg/L only two times at DOW04022012 and six times at DOW04022019. The maximum chloride reading was 93.3 mg/L at DOW04022012, falling well below the drinking water standard of less than 250 mg/L specified in the Kentucky Surface Water Standards (401 KAR 10:031). Nitrates were consistently above 2.0 mg/L at DOW04022014 and in three of the 12 samples at DOW04022018. Organic carbon was consistently below 4.0 mg/L, but spiked to 7.04 mg/L at DOW04022012 in June 2003. Total phosphorus was above 0.25 mg/L at DOW04022014 during every sampling event, with only minor sporadic exceedances at the other sampling locations. Sulfate concentrations did not exceed 55 mg/L with a majority of the samples containing less than 30 mg/L. It appears that the samples collected in June 2003 were following some sort of disturbance, possible a large rain event due to the high total suspended solids concentration at every site. The concentrations during this sampling event were over 10 times greater than the average value at all sites except DOW04022014, which is the site located the highest in the watershed. Total suspended solids were also high in the December 2003 sampling event at three of the five sites. The water temperature never exceeded 31.7 °C, the maximum limit specified in the Kentucky Surface Water Standards (401 KAR 10:031).

The review of the monthly sampling results from these five locations precipitated the following observations:

- Nutrient loading may be a concern on West Fork due to high concentrations of nitrates and total phosphorus at DOW04022014;

- Phosphorus loading may be a concern on LHC in the LHC Nature and Heritage Preserve above the confluence of Deep Branch due to sampling results at DOW04022018;
- The largest values of ammonia-nitrogen were observed at DOW0402219 above the Waterworks Road bridge, but below the lower impoundment of the Carroll E. Ecton Reservoir;
- Specific conductivity is the largest concern at DOW04022012, the site located the farthest upstream along the main channel of LHC; and
- Most of the sampling results from DOW04022011 were within limits specified in the Kentucky Surface Water Standards (401 KAR 10:031).

In addition to this monthly sampling, DOW04022007 was sampled in 2001 and 2009, and DOW04022018 was sampled in 2009. Several additional chemical tests were completed at these samplings. The values appeared to be within acceptable limits. A summary of the results from these three sampling events are located in APPENDIX C.

2.2.8. GEOMORPHOLOGY

Geomorphology is defined as the study of landforms, starting with their origin through the processes that continue to shape them. Landforms are modified by a combination of surface processes and geologic processes. Surface processes are comprised of the actions of water, wind, ice, fire, and living organisms which are strongly mediated by climate. Geologic processes include the processes such as the uplift of mountain ranges and the growth of volcanoes. Landforms transform in response to the balance of additive processes, such as uplift and deposition, and subtractive processes, such as subsidence and erosion.

LHC is located in a region of the Kentucky River Valley known as the Palisades, stretching from Clays Ferry in Madison County to Frankfort in Franklin County. In this region, the Kentucky River cuts a deep gorge with walls rising as high as 400 feet. The Palisades are categorized by a series of steep, scenic gorges and limestone outcroppings. The region is a part of the Interior Low Plateaus geomorphic province. In *Ecological Subregions of the United States*, McNab and Avers explain, “Platform deposition of continental sediments into a shallow inland sea was followed by uplifting to form a level-bedded plateau, which has been shaped by differential erosion to form a moderately dissected surface.” Equal amounts of irregular plains and open hills comprise 90 percent of the landforms in the region, with a small area of smooth plains.

2.3. NATURAL FEATURES

2.3.1. GEOLOGY

Geology is the study of Earth's crust and the processes by which it changes. Clark County is part of the Bluegrass physiographical region. The Bluegrass Region is divided into three subregions: Inner Bluegrass, Hills of the Bluegrass, and the Outer Bluegrass. LHCW is in both the Inner Bluegrass Region and Outer Bluegrass Region, mostly residing in the Inner Bluegrass Region. Figure 6, from Kentucky Geological Survey, depicts the physiographical regions for the State of Kentucky. The Inner Bluegrass Region has typical karst topography, such as sinkhole-dominated areas, while the Outer Bluegrass Region is moderately dissected by surface streams. The Inner Bluegrass is characterized by gently rolling hills which originated from the weathering of thick-bedded Ordovician limestone that has been pushed up along the crest of the Cincinnati Arch. The Inner Bluegrass is also known for fertile soils due to the phosphate minerals in the Ordovician limestone, which are natural fertilizers. The Inner Bluegrass is underlain by Middle Ordovician Lexington Limestone and is lithologically distinct from the rest of the Interior Plateau. The Outer Bluegrass is characterized by deeper valleys with little flat land due to the interbedded Ordovician limestone and shale. The underlying rock in the Outer Bluegrass is more easily eroded than the limestone found in the Inner Bluegrass. The Outer Bluegrass is mostly underlain by Upper Ordovician limestone and shale. The limestone in LHCW is mostly of the Lexington Limestone Group and the High Bridge Group. A geological map of Clark County, Figure 7, and a karst area map of Clark County developed by the Kentucky Geological Survey is located in Figure 8, both on page 21.

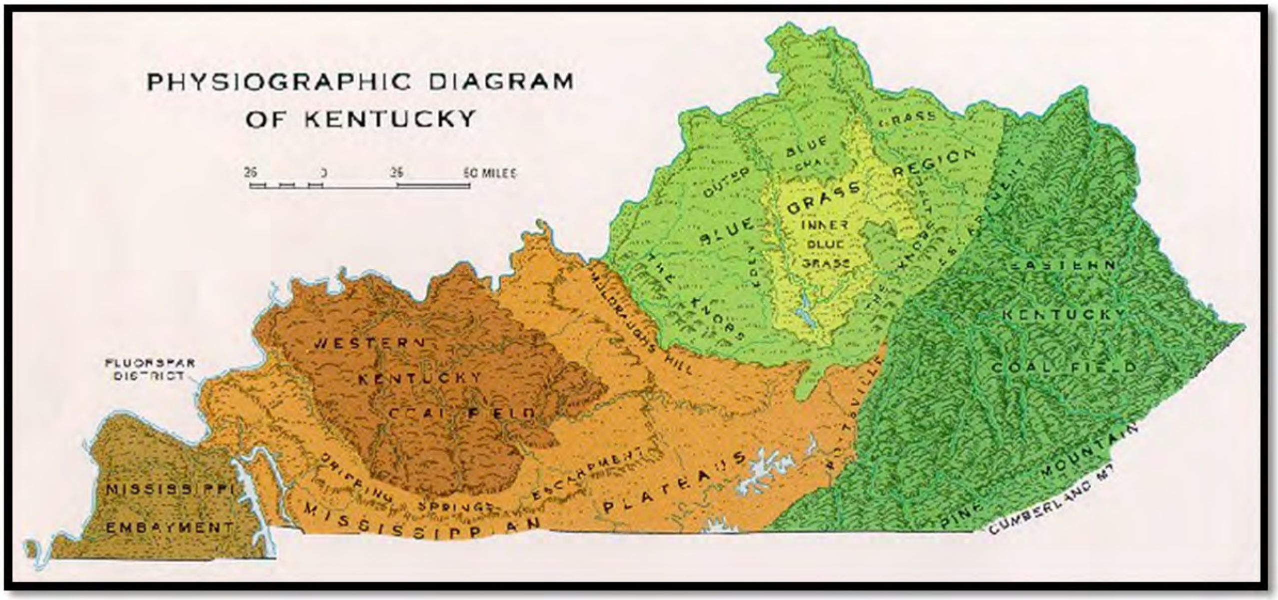


Figure 6. Physiographic Diagram of Kentucky

2.3.2. TOPOGRAPHY

The topography in LHCW ranges from rolling to hilly. The most noticeable feature is the entrenched valley of the Kentucky River. The elevations range from less than 600 feet above mean sea level at the confluence with the Kentucky River to almost 1000 feet above mean sea level in northern areas of the watershed. LHCW is located on the Winchester (K44) and Ford (K43) 7.5-minute topographic quadrangle maps. Figure 9 contains a portion of these maps in the vicinity of LHCW. According to the

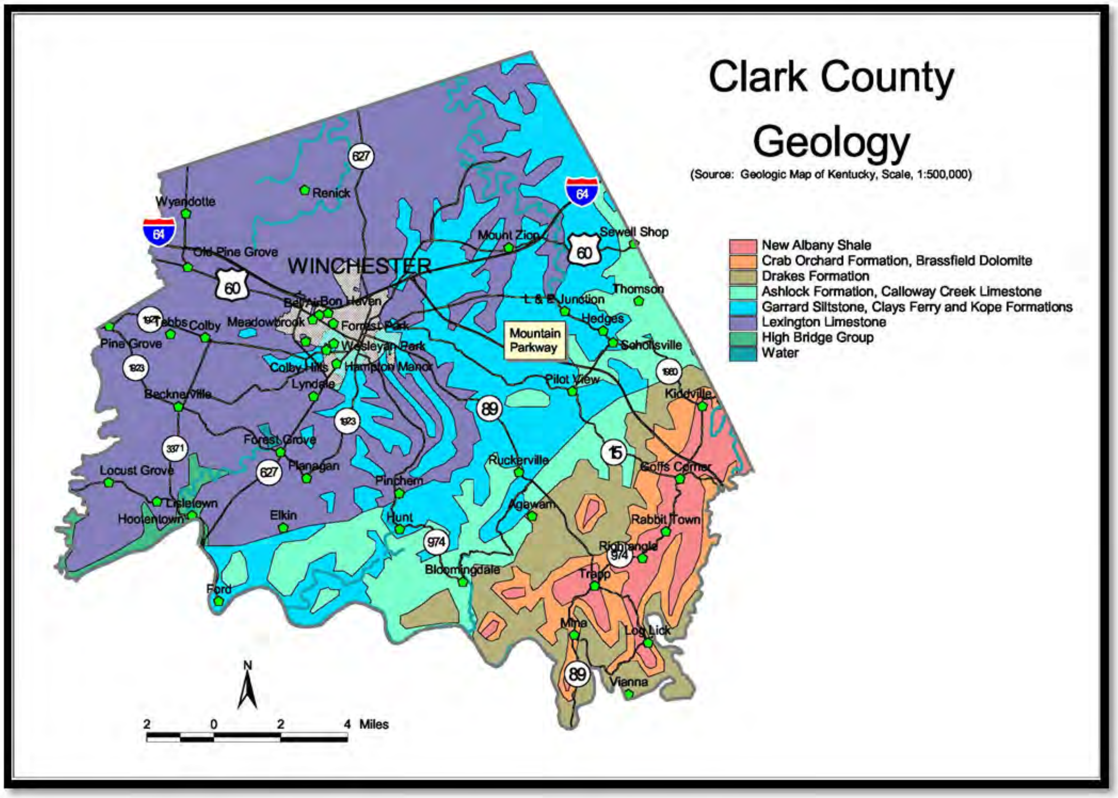


Figure 7. Clark County Geology (Not to Scale)

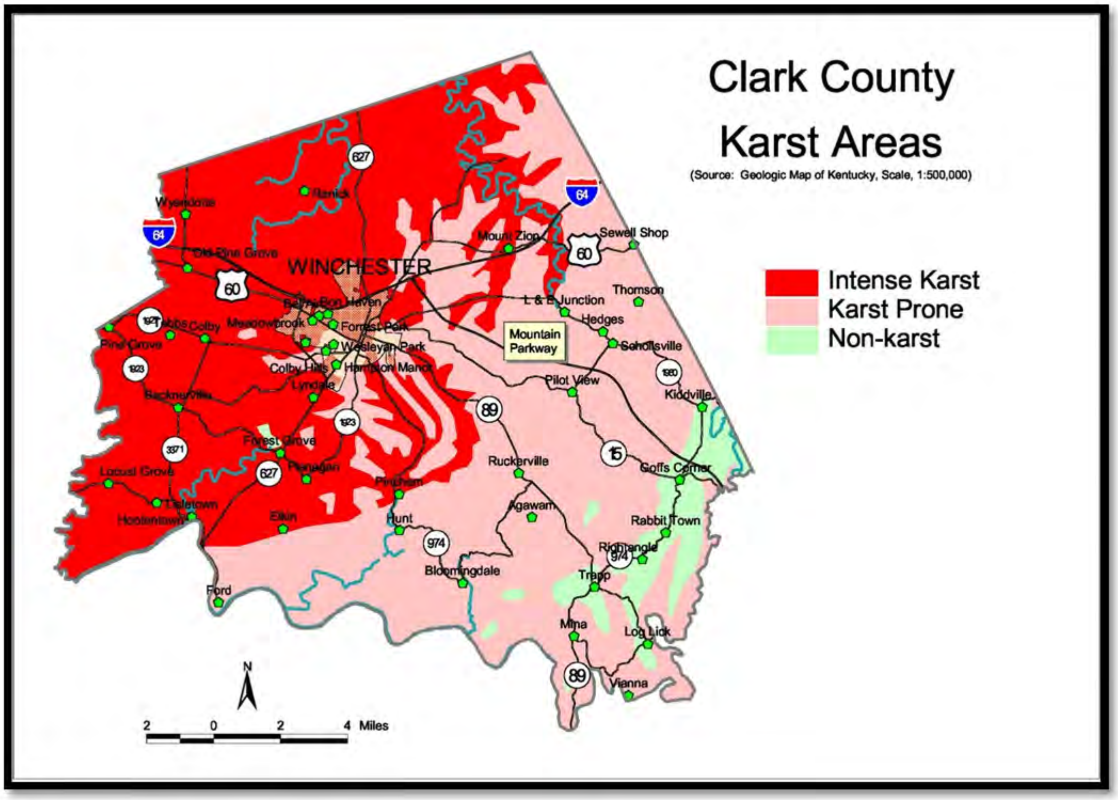


Figure 8. Karst Map of Clark County (Not to scale)

Clark County Soil Survey (USDA 1989), topography is irregular and has several slight depressions. In addition, the area has some steep slopes around sinkholes that may lead to subterranean caverns. The difference in elevation between the ridge tops and the bottoms of the drainage ways averages over 50 feet.

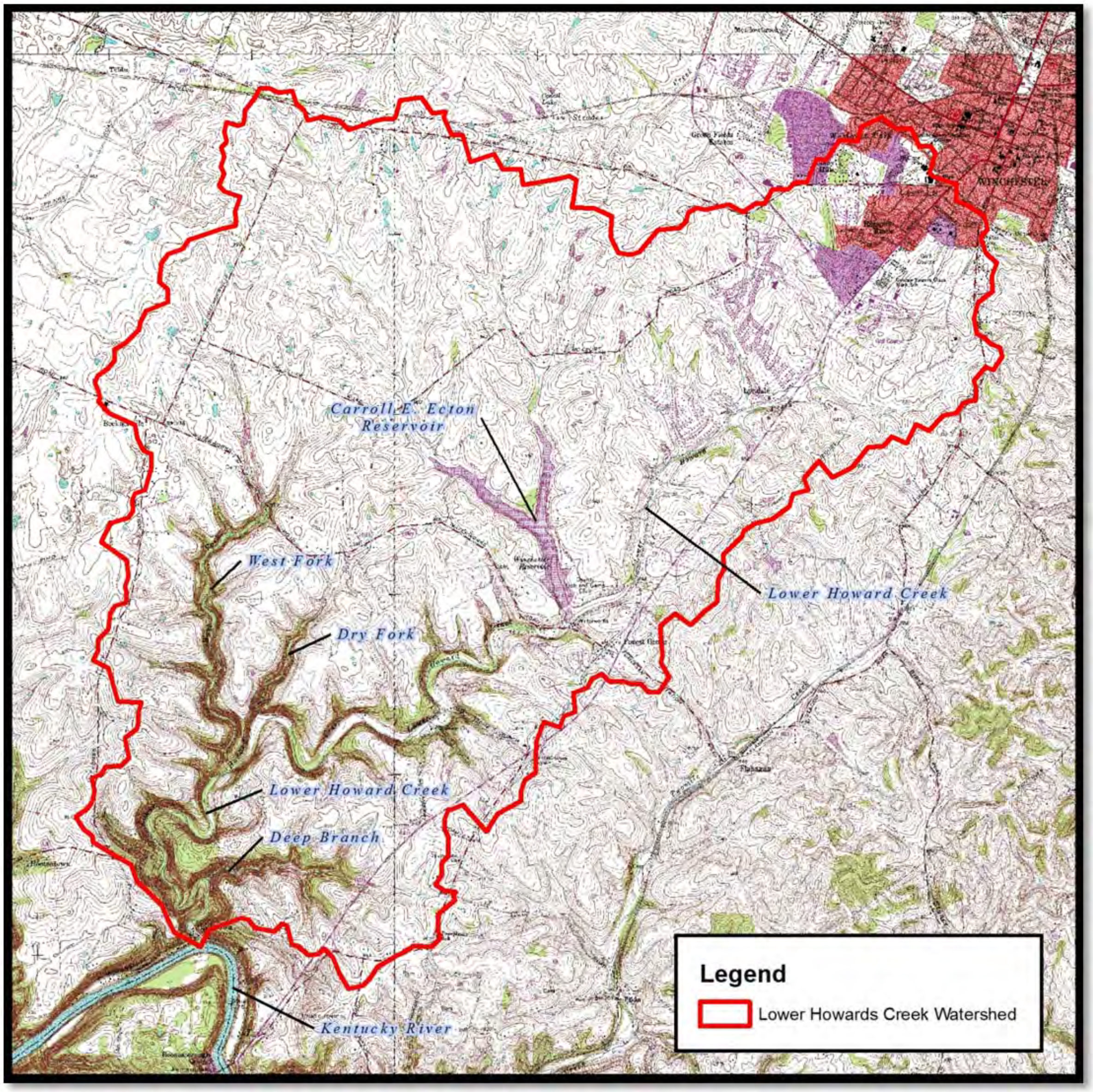


Figure 9. Topographic Map of LHCW

2.3.3. SOILS

According to the Clark County soils information provided through GIS data by the Natural Resources Conservation Service (NRCS), the soils in LHCW are predominately silt and clay loam with varying slopes ranging from 2 percent to 20 percent and part of hydrologic group C. Most of the soils are highly erodible, not hydric, and moderately well to well drained. The following soil classifications are located

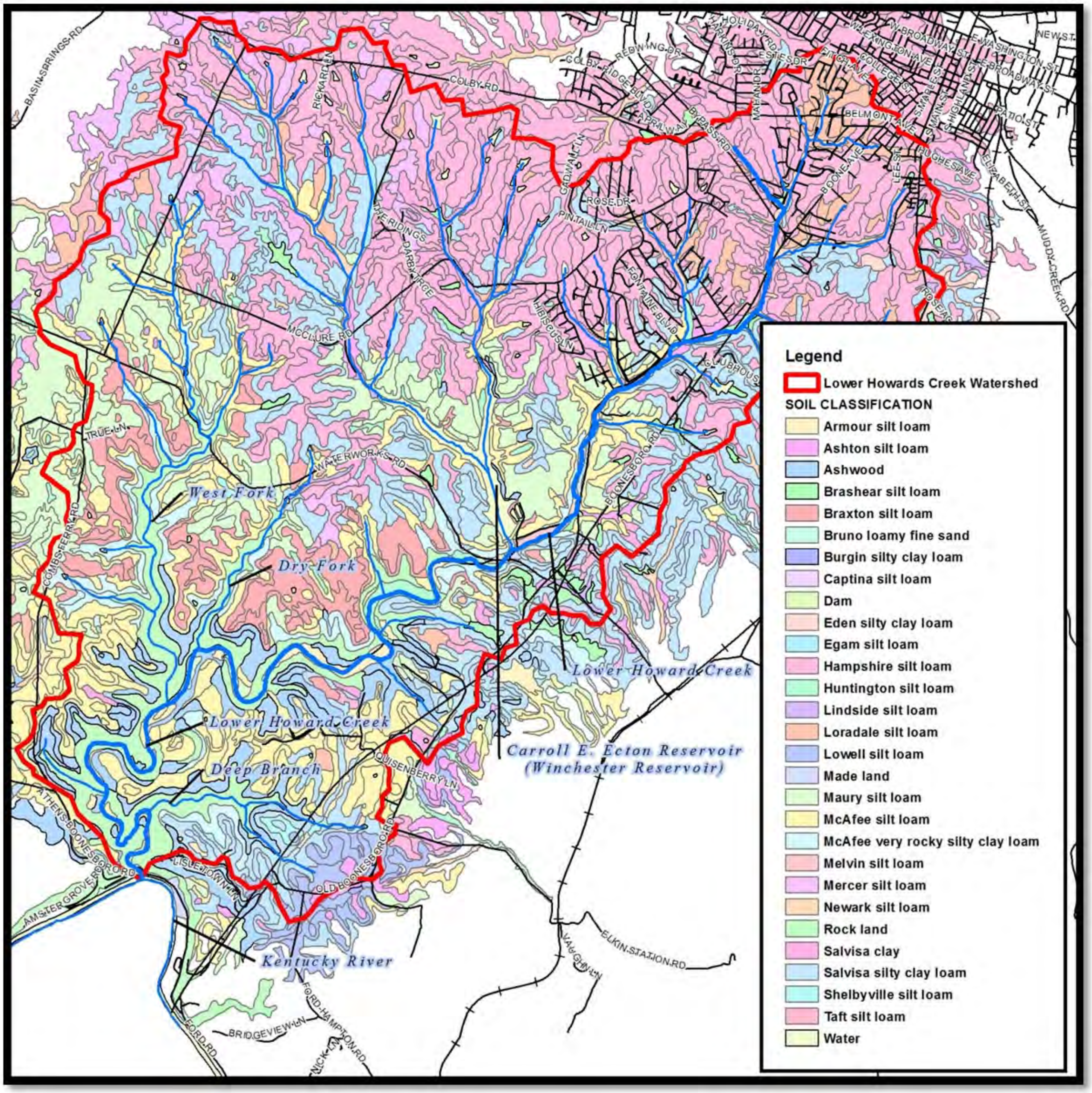
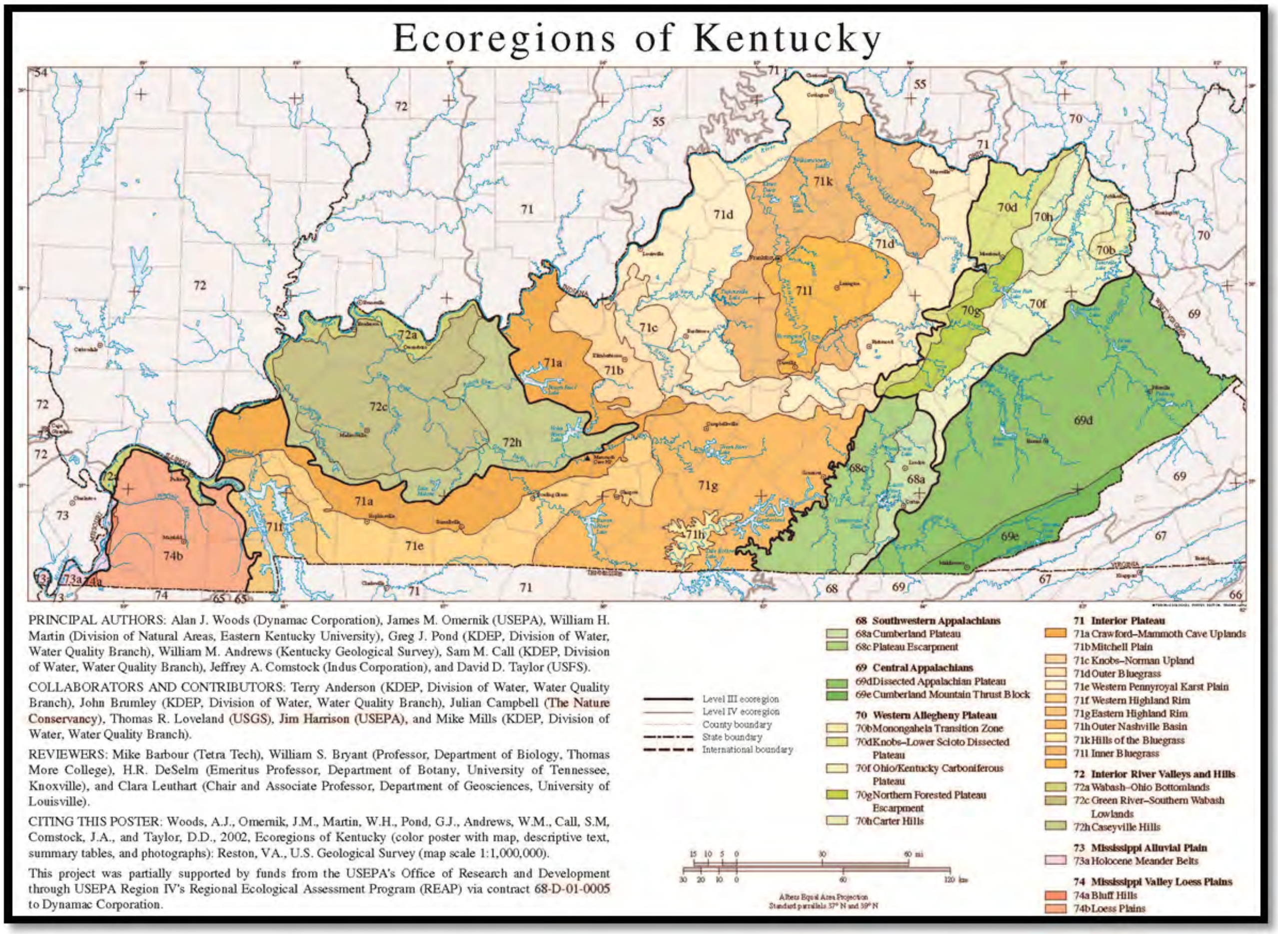


Figure 10. Soil Classification Map of LHCW

within LHCW: Armour silt loam; Ashton silt loam; Ashwood; Brashear silt loam; Braxton silt loam; Bruno loamy fine sand; Burgin silty clay loam; Captina silt loam; Eden silty clay loam; Egam silt loam; Hampshire silt loam; Huntington silt loam; Lindside silt loam; Loradale silt loam; Lowell silt loam; Maury silt loam; McAfee silt loam and very rocky silty clay loam; Melvin silt loam; Mercer silt loam; Newark silt loam; Salvisa clay and silty clay loam; Shelbyville silt loam; and Taft silt loam. Figure 10 depicts the location of the soil classifications within LHCW. The soil classifications with the largest presence in the watershed are Maury silt loam, Hampshire silt loam, McAfee silt loam, and Salvisa silty clay loam. Maury silt loam is typically deep, well-drained soil of the uplands underlain by limestone and bound on broad ridgetops in undulating areas. Hampshire silt loam is typically deep, well-drained to moderately well-drained soil of the uplands developed in residuum from limestone and found on ridgetops in undulating areas. McAfee silt loam is typically moderately deep, well-drained soil of the uplands formed in residuum from limestone. Salvisa silty clay loam is typically moderately deep well-drained soil of the uplands formed in residuum from limestone and found on the crest of ridges and on gentle side slopes. These four classifications, as well as much of the watershed, are designated as prime farmland or farmland of statewide importance.

2.3.4. ECOREGIONS

Ecoregions in Kentucky have been designated by the EPA and denote areas of general similarity in the type, quality, and quantity of environmental resources. Ecoregions differentiate sections of the environment by its possible response to disturbance by recognizing the spatial differences in the capacities and potentials of the ecosystem. The United States had been broken up into a set of four levels of delineation, with level one being the coarsest and level four being the finest. There are seven level three ecoregions, and twenty five level four ecoregions in Kentucky. Ecological and biological diversity in Kentucky strongly correlates with regional physiographic characteristics, geology, land use, and soil properties according to the EPA.



PRINCIPAL AUTHORS: Alan J. Woods (Dynamac Corporation), James M. Omernik (USEPA), William H. Martin (Division of Natural Areas, Eastern Kentucky University), Greg J. Pond (KDEP, Division of Water, Water Quality Branch), William M. Andrews (Kentucky Geological Survey), Sam M. Call (KDEP, Division of Water, Water Quality Branch), Jeffrey A. Comstock (Indus Corporation), and David D. Taylor (USFS).

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

This project was partially supported by funds from the USEPA's Office of Research and Development through USEPA Region IV's Regional Ecological Assessment Program (REAP) via contract 68-D-01-0005 to Dynamac Corporation.

Figure 11. Ecoregions of Kentucky (Not to Scale)

LHCW is located in the Interior Plateau ecoregion at the level three designation and the Inner Bluegrass and Outer Bluegrass ecoregions at the level four designation. Figure 11 depicts the ecoregion boundaries for the Commonwealth of Kentucky. The Interior Plateau ecoregion is made up of extensive plains interrupted by dissected uplands, knobs, a few deeply incised streams and large areas of karst. The Outer Bluegrass, similar to the physiographic region, is characterized by rolling to hilly topography containing sinkholes, springs, entrenched rivers, and intermittent and perennial streams. Currently pastureland and cropland is widespread with pockets of wooded areas. However, savanna woodlands were found on most uplands at the time of settlement. At the time of settlement, white oak stands occurred and cane grew along the streams. The streams often have moderate to high gradients with cobble, boulder, or bedrock substrates. The Outer Bluegrass has a greater stream density than the Inner Bluegrass and concentration of suspended sediments and nutrients may be high. The Inner Bluegrass is characterized by level to rolling topography containing extensive karst, intermittent streams, and expanding urban areas. The open woodlands, savanna, and swamp forests existing at the time of settlement have been replaced by agriculture and urbanized areas containing residential, commercial, and industrial uses. The streams have moderate to low gradients with cobble or bedrock substrates. Figure 12 shows the dividing line of the Inner Bluegrass and the Outer Bluegrass in the LHCW.

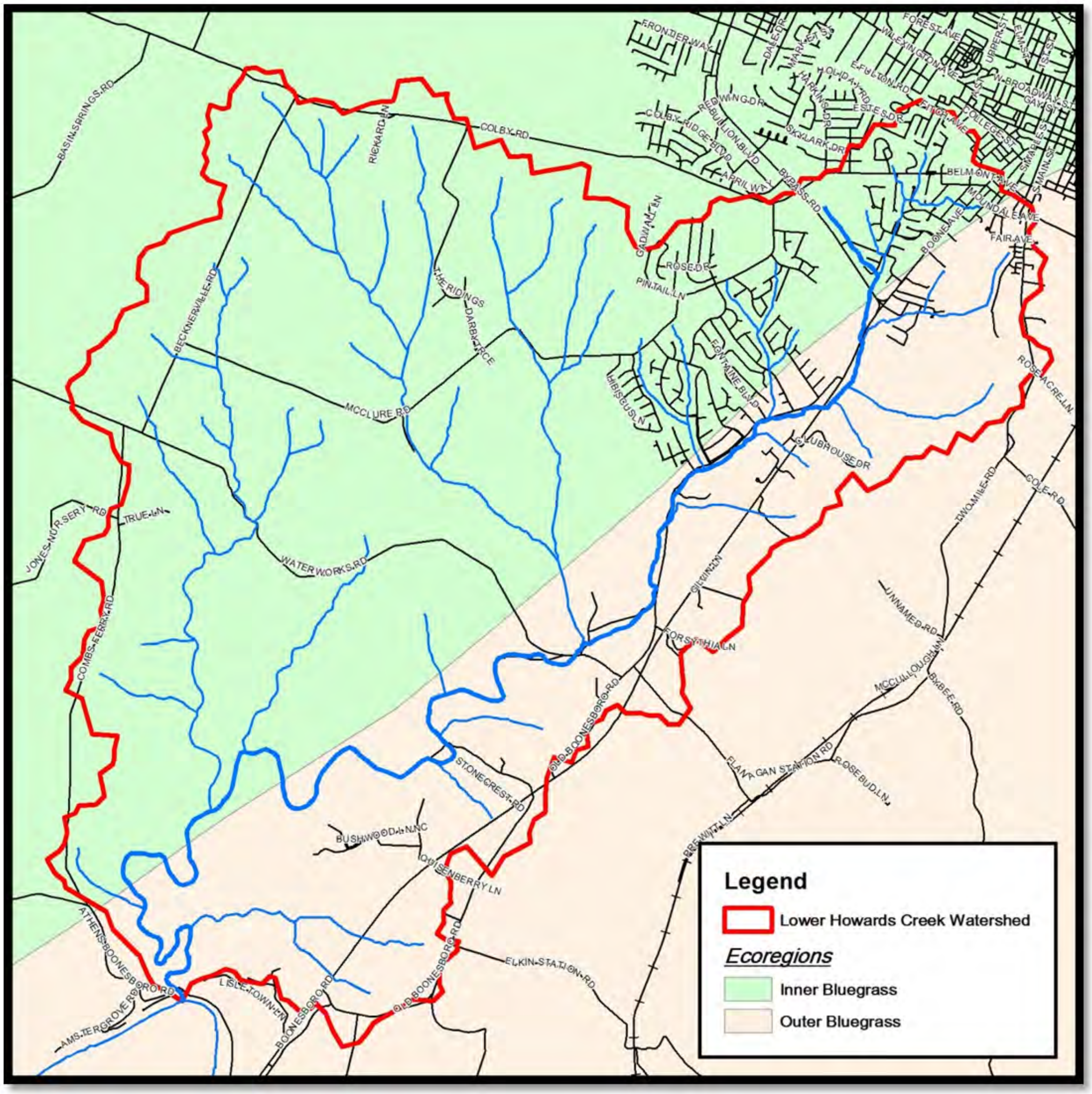

Figure 12. Ecoregion Map of LHCW

2.4. RIPARIAN/STREAMSIDE VEGETATION

The vegetation from the confluence with the Kentucky River to Old Stone Church Road was extensively mapped in 2003 and 2004 for the *Lower Howards Creek Corridor Management Plan* (Parsons Brinckerhoff and Crankshaw, 2005). The vegetative cover was classified into pasture, fence row, grazed woodland, early successional woodland, and mid-successional woodland based on a historical and structural categorization. Figure 2 from the *Lower Howards Creek Corridor Management Plan* has been included in APPENDIX D depicting the classified areas. Several noteworthy vegetation areas were identified within the study area for the *Lower Howards Creek Corridor Management Plan*, including moist woods in sinkholes on the ridgetop above the John and Rachel Martin house; cedar glades on south -facing rocky slopes and on rocky flats on ridge spurs and uplands; sycamore woodlands in rocky alluvial deposits along the creek edge and in lands between creek channels; open bottom woods with predominant boxelder; open bottomland woods with mixed tree species; pawpaw patches; cane stands; and open mesic woods free of cedar and bush honeysuckle. The plan indicated that these areas should be protected and considered areas of interest for future visitors. Based on visual observation by the project team, the previous assessment appears to be accurate. No development and little change have occurred in this portion of the watershed since the assessment was completed. Figure 13 is a picture taken of the vegetation on the LHC Nature and Heritage Preserve in August 2010.

Figure 13. LHC Nature and Heritage Preserve

Upstream of this area, the vegetation is dominated by pasture and agricultural lands, fence row vegetation, and manicured residential lawns. Fence row vegetation is defined as a mix of forb, shrub, and tree species. Areas from the Old Stone Church to Waterworks Road have pockets of early successional and mid-successional woodlands, dominated by a mix of deciduous species that vary depending on slope orientation and soil moisture. Natural riparian vegetation is limited or nonexistent in areas north of the Waterworks Road. Natural riparian vegetation is important because it provides shade to the stream, filters nutrients, traps sediments, provides wildlife habitat, and reduces stream erosion. An area of concern along the main channel is located directly north of the new high school and spans from 2070 Old Boonesboro Road to 3140 Old Boonesboro Road. In this area LHC has little natural riparian zone vegetation and manicured lawns to the top of the stream banks. The stream banks are steep with a shallow root depth, resulting in unstable, erodible banks. This area is also prone to flooding problems. Figure 14 depicts the condition of the stream in this area in January 2012. Similar areas extend along many of the tributaries to LHC through the northern residential sections of the watershed.

Figure 14. Area North of New High School Property

2.5. RARE AND EXOTIC/INVASIVE PLANTS AND ANIMALS

There are three existing noteworthy publications concerning the rare and exotic/invasive plants and animals within the LHCW, all conducted within the LHC Nature and Heritage Preserve. The existence of rare and uncommon plants in this area is attributed to the inaccessibility of parts of the LHC Nature and Heritage Preserve, which hinders grazing and other disturbances in this area.

Ronald Cicerello, in *Biological Inventory of Lower Howard's Creek Heritage Park and State Nature Preserve*, along with six others who comprised of aquatic, vertebrate, and invertebrate zoologist and botanist completed a biological inventory of the 244 acre (the size at the time of study) LHC Nature and Heritage Preserve. The report provides: 1. species lists for the respective biotic groups surveyed; 2. rare and endangered species locations; 3. invasive exotic species locations; 4. a characterization of the ecological communities; and 5. management recommendations.

A report to Kentucky State Nature Preserves Commission (KSNPC), entitled *Biological Survey for Venable Acquisition*, was conducted in 2004 and 2005 by botanist Dr. William B. Crankshaw. The Venable Acquisition is a 47 acre tract of land west of LHC that includes the mouth of West Fork. This report provides a detailed list of approximately 880 plants located on this tract of land.

Ryan Evans and Jonathan Hart, in *Evaluation of the Fishes, Freshwater Snails, and Associated Parameters of Lower Howard's Creek at Deep Branch, Lower Howard's Creek State Nature Preserve*, provide a detailed list of the aquatic snail and fish fauna in LHC with comparisons to previous studies and the changes in fauna that have occurred. During two site visits, 344 individuals representing 24 species of fish were observed in LHC in the vicinity of Deep Branch, resulting in a Kentucky Index of Biotic Integrity (IBI) rating of excellent. Four species of snails were observed during the study. The small size of LHCW limits the potential for diversity in freshwater snail community, which is closely tied to watershed drainage area.

The Cicerello et al. and KSNPC report both mention the presence of rare plant species such as running buffalo clover (*Trifolium stoloniferum*); white walnut or butternut (*Juglans cinerea*); giant or nodding rattlesnake root (*Prenanthes crepindinea*); and water stitchwort (*Stellaria* or *Arenaria frontinalis*). Cicerello et al. (2003) reported one additional rare plant, Missouri arrowhead (*Viburnum molle*). Both reports expressed concerns over the same exotic/invasive species, namely bush honeysuckle (*Lonicera maackii*). Bush honeysuckle was identified with much importance due to its widespread presence. Other exotic/invasive plant species of concern were garlic mustard (*Alliaria petiolata*); Euonymus species, such as climbing euonymus (*E. fortune*); tree-of-heaven (*Ailanthus altissima*); multiflora rose (*Rosa multiflora*); and privet (*Ligustrum vulgare*). The LHC Nature and Heritage Preserve has implemented some exotic/invasive species plant management practices through the removal of these species when found. In areas where bush honeysuckle has been removed the native plant community has responded well. Reducing the spread or introduction of exotic/invasive plants is of major concern for the KSNPC and LHC Nature and Heritage Preserve. In 1938, Joe Kendall Neel performed a biological survey of the entire LHCW where honeysuckle was not identified. Cicerello reported bush honeysuckle, Japanese honeysuckle, and multiflora rose have become well established in the 65 years since the Neel study was completed.

The list of rare and exotic animals was not as extensive as the list of rare and exotic plants. In 2001, Cicerello captured three gray bats (*Myotis grisescens*) and one evening bat (*Nycticeius humeralis*). In 2010, Jackson Environmental noted the presence of five bat species, including the gray bat, utilizing abandoned limestone mines along the Kentucky River approximately 0.25 miles from the confluence of LHC. Cicerello (2003) and Evans and Hart (2009) examined the fish fauna in LHC and found that the fish fauna is comprised of taxa widely or regionally distributed and common in Kentucky. One notable fish collected from LHC was the river chub (*Nocomis micropogon*), a fish common in the upper Kentucky River basin but only as far downstream as the Red River. LHC is a considerable distance downstream of the Red River, making the presence of the river chub unusual. The Asian clam (*Corbicula fluminea*), which is widespread throughout Kentucky, was the only exotic animal noted in the studies to date.

Other biological studies from the area include a study by Jodi Stacy, a masters' student from Eastern Kentucky University, on salamanders within the LHC Nature and Heritage Preserve and a 1938 master's thesis from University of Kentucky by Joe Kendall Neel. The Jodi Stacy study, *An Evaluation of Artificial Cover Objects in Monitoring Plethodontid Salamanders in Central Kentucky*, August 2006, aimed to evaluate the effectiveness of artificial cover object searches to detect terrestrial salamanders. One of the selected testing sites was on the LHC Nature and Heritage Preserve, which showed an abundance of terrestrial salamanders when compared with other sites not located within a preservation area. Joe Neel completed a biological and physiological survey of the LHC watershed. His study included biological lists and/or physical descriptions for algae, plant, insects, fishes, amphibians, reptiles, birds, and mammals. The report notes the importance of the reservoir and pumping station, located at the current location of the WTP, which provides consistent flow in LHC and habitat for several terrestrial and aquatic species.

2.6. HUMAN INFLUENCES AND IMPACTS

2.6.1. HISTORICAL CONTEXT AND CULTURAL RESOURCES

According to the *Cultural Resource Survey of the Lower Howards Creek Area* (2005), Kentucky's central Bluegrass Region was first settled by Euro-Americans in the 1770s. Through the Native American warfare and settlement of the pioneers, a unique economy was developed based on a symbiotic relationship between agriculture and manufacturing. The topography of the region provided the settlers with many excellent mill sites. The settlers took advantage of this and built many water-powered mills to process corn and wheat in the 1780s and 1790s. The first mill was built in the LHCW in the mid-1780s and was followed by approximately five more by the start of the War in 1812. By the early 1900s, most of these mills were no longer standing and the banks of LHC now had "a dozen big water mills and several factories" as reported in the *Clark County Chronicles* (Anonymous 1923). As technology advanced in the 1900s, the water mills were taken out of service in favor of steam powered mills. As railroads were constructed, the Kentucky River was used less as the transportation link to more western regions. Eventually all that remained along LHC was agricultural lands.

A cultural resource survey was completed by Cultural Resource Analysts, Inc. in 2001 at the request of the Clark County Fiscal Court. The primary objective of the survey was to observe visible historical features within the LHC Nature and Heritage Preserve. Sites of note in this report included the Homer Martin Homestead and Quarry; Thompson Ridge Settlement; Molly Allen Farm; Martin's Mill; Robert Martin House and Quarry; Richard Arnold House and Quarry; John Martin Homestead; and Martin's Mill Dam and Millrace. Dry stone fences were also found throughout the study area. The Homer Martin Homestead and Quarry is located just upstream of the confluence with the Kentucky River. Today the house exists as a double-cell dry stone foundation with external end chimneys. The Thompson Ridge Settlement is a group of multiple homesteads that exists today only as dry stone foundations due to deterioration of the superstructures. The Molly Allen Farm is located at the entrance to the LHC Nature and Heritage Preserve on the present road to the mouth of LHC. The Molly Allen house is a 1.5-story, double-pen, eave-oriented, single-pile frame house. The Martin's Mill represents one of the numerous industrial buildings which lined the lower section of LHC. Today Martin's Mill exists as a stone shell with some of the stonework fallen in on the basement. The Robert Martin House and Quarry includes at least two structures, both with dry stone foundations. The Richard Arnold House and Quarry includes a large quarry area on the hillside located above the ruins of a stone foundation and chimney base enclosed by a dry stone fence. The John Martin Homestead is an impressive complex of historic features including the main dwelling, multiple outbuildings, and family cemetery with gravestones still intact. The John Martin House is an important example of Kentucky's stone building tradition and is listed on the National Register of Historic Places. The Martin's Mill Dam and Millrace have been mostly washed away except for the abutments of the dam on both the east and west sides and the cut stone gate to the millrace. The locations of these historical and cultural resources are located in a map in APPENDIX D.

A cultural resource survey was completed by Cultural Resource Analysts, Inc. in 2005 as a part of the *Lower Howards Creek Corridor Management Plan*. The survey was conducted along LHC and included areas of West Fork, Dry Fork, and Deep Branch outside the LHC Nature and Heritage Preserve property. The Taylor House is a stone house with a wood frame addition located on LHC across from the confluence with Dry Fork. Since 1979 the Taylor House has been listed on the National Register of

Historic Places. The Distillery Complex is located just north of the LHC Nature and Heritage Preserve property on the east bank of LHC. The distillery was most likely in operation by the 1850s. The Factory Bottom Complex is made up of a number of structures, a mill, and a cemetery and is located on LHC east of the Taylor House. The survey also identified an additional four mill complexes, three structures, and two springhouses within the study area. The locations of these historical and cultural resources are located on Figure 2 of the above referenced report in APPENDIX D. Dry stone fences are also found throughout LHCW in varying stages of decay.

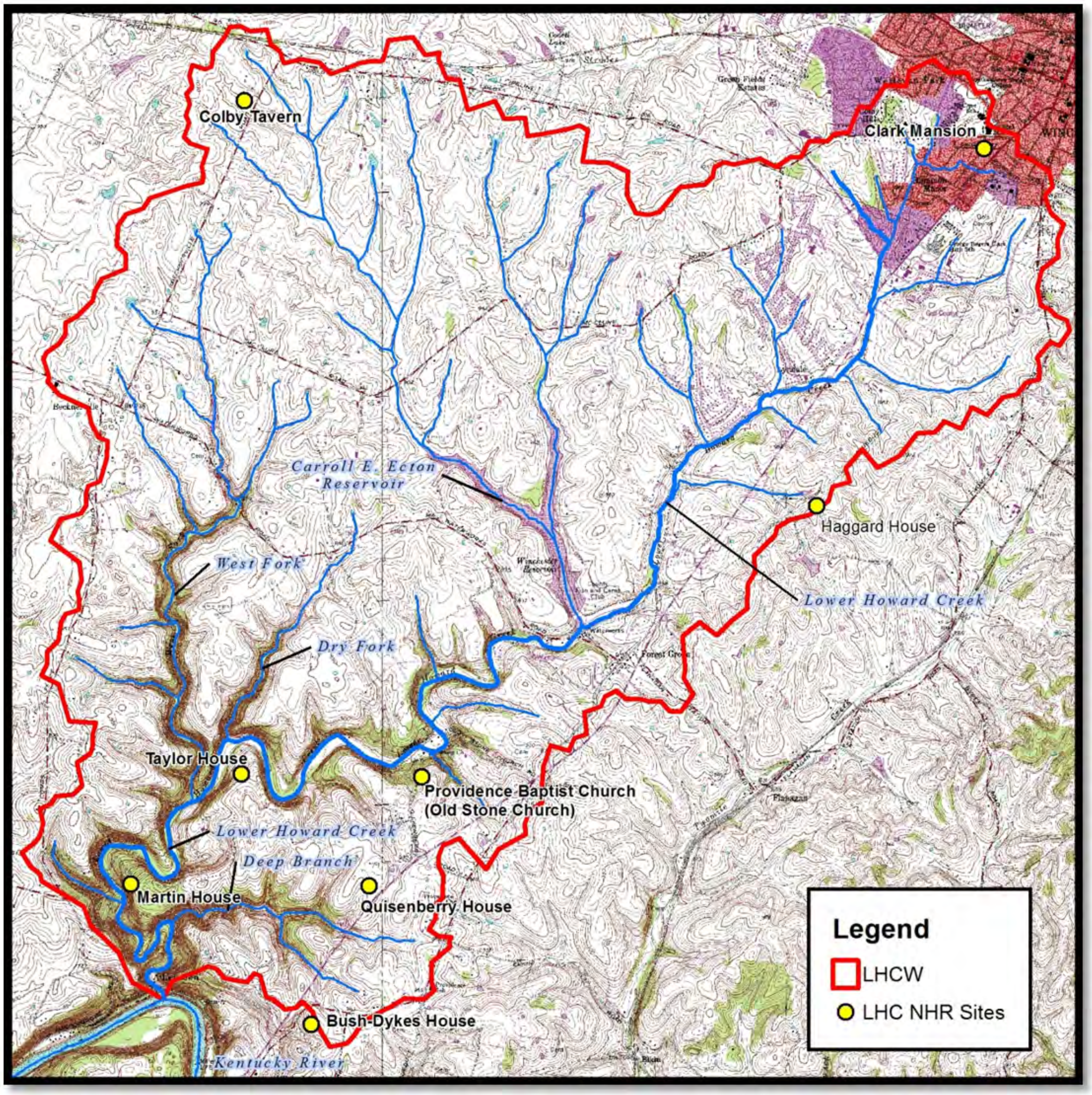

Figure 15. NHR Sites in LHCW

Several cultural historic resources and archeological investigations were completed by Palmer Engineering and Brockington and Associates for WMU during 2009 and 2010. Palmer Engineering identified multiple cultural historic sites during the cultural historic resource investigations. One identified site, the Bush-Dykes House, located at the corner of Old Boonesboro Road and KY 627, is listed on the National Register of Historic Places. Brockington and Associates suggests that the area of investigation has a moderate to high probability of identifying additional prehistoric and historic sites. Due to the rich history of LHCW, there are many cultural historic and archeological resources worth protecting for future generations to enjoy and study. Figure 15 depicts the sites listed on the National Register of Historic Places within the LHCW as provided by the agency. According to this data, eight sites within LHCW are listed on the National Register of Historic Places. The Kentucky Heritage Council has 187 sites listed within LHCW. Of the 187 historical sites, 114 of them are located within the limits of the City of Winchester. As shown by the large number of state and federal historically significant sites, LHCW has a rich history.

As a part of the *Lower Howards Creek Corridor Management Plan*, the study area, which included the LHC Nature and Heritage Preserve and areas of West Fork, Dry Fork, and Deep Branch, was separated into 20 landscape districts. Each landscape district contains smaller units of landscape and distinct point features. The grouping and sequencing clarifies connections between the features and spaces and helps to tell the story of the landscape's natural and cultural history. The landscape districts are linked together by association with historic activities, geographic location, or other shared characteristics. APPENDIX D contains Figure 6 from the *Lower Howards Creek Corridor Management Plan* which names and locates each of the landscape districts. Many of the districts are based around the historical and cultural artifacts found within the area.

2.6.2. POPULATION INFORMATION

In the November 2009 the WMU Regional Facilities Plan, population was projected to year 2028 for each drainage basin in the Planning Area. Since that time, the U.S. Census has released updated population data for Clark County and Winchester; population projections from the Kentucky State Data Center (http://ksdc.louisville.edu) have also been updated. According to the Kentucky State Data Center in 2009, Clark County's population was expected to increase 8.64% between 2000 and 2010; however, U.S. Census data indicated that the county's population only grew 7.45% during that time. The City of Winchester was projected to lose 2.22% of its population between 2000 and 2010; however, the City grew by 9.8%. Future projections indicate that Clark County's population is not expected to exceed 40,000 and may start to decrease by 2050. Table II.6 from the 2009 WMU Regional Facilities Plan has been revised in Table 5 to reflect updated data.

Table 5. Updated Population Data

	1990 Census	2000 Census	2010 Census	2020 Projection	2030 Projection
Clark County	29,496	33,144	35,613	37,985	39,423
% change		12.36%	7.45%	6.66%	3.79%
Winchester	15,799	16,724	18,368	Not available	Not available
% change		5.85%	9.8%	Unknown	Unknown

Given that the population of the City of Winchester dramatically increased beyond projections, county population will most likely not increase as expected in the 2009 WMU Regional Facilities Plan; however, population growth of the Lower Howards Creek Drainage Basin is still expected to increase at a greater rate than the rest of the basins. Lower Howards Creek Sub-Basins A and B, as defined in the 2009 WMU Regional Facilities Plan, are located in all or portions of Census Tracts 201.01 (Block Group 1), 201.03 (Block Groups 1 and 2), 201.04 (Block Groups 5 and 6), and 205 (Block Group 1). According to WMU in 2008, 3,300 water meters were located in LHC Sub-Basins A and B. The U.S. Census approximated there were 2.65 people per home; therefore, 8,745 people were estimated to live in LHC Sub-Basins A and B in

2008. In the 2009 WMU Regional Facilities Plan, population was expected to increase 10% between 2008 and 2018; however, since both city and county populations are expected to slow, this figure has been revised to 8.5%. Between 2018 and 2028, population is expected to grow 6%. The estimated and projected populations for LHC Sub-Basins A and B are listed in Table 6.

Table 6. Population for LHC Sub-Basins A and B

	2008 Estimate	2010 Estimate	2018 Projection	2028 Projection	Total Change (2008 to 2028)
LHC Sub-Basins A and B	8,745	8,920	9,488	10,057	1,312
% change		8.5%		6.0%	

2.6.3. WATER USE

The sources of water for the WMU WTP are the Carroll E. Ecton Reservoir and the Kentucky River, Pool 10. WMU, in conjunction with Kentucky American Water, Judy Water Association and East Clark County Water District (which purchases water from WMU), supplies drinking water to the majority of the county's population. WMU is currently permitted to withdraw 15 MGD from the Kentucky River. The raw water intake pump station has an ultimate capacity of 15 MGD and should serve the growing community in the future. Currently the raw water intake pump station has two 5.3 MGD pumps; however, the WTP capacity is limited by the raw water line from the Kentucky River to the WTP. The 18-inch concrete raw water line has a capacity of approximately 5.5 MGD. The WTP has a maximum treatment capacity of 6.0 MGD. On peak consumption days, the full capacity of water transported to the WTP will be treated and used. The ability of available treated water to meet expanding needs is a critical problem facing Winchester and Clark County. The projected demand for water in the greater Winchester area is expected to increase with the growing population projections. There are also several large industrial water users within the service area that increase the water demand.

To meet the growing water needs of the community, WMU is planning for the design and construction of a new WTP on the same property as the LHC Wastewater Treatment Plant (WWTP). The new WTP will be directly adjacent to the WWTP and is planned to have the capacity to treat 6.0 MGD to 9.0 MGD. Design is tentatively scheduled to begin in January 2013, followed by construction in April 2014.

2.6.4. LAND USE

Primary land uses in LHCW include agricultural, commercial, low-density residential, and high-density residential. Outside the City limits, Clark County is developed at a low density, with a majority of the land serving agricultural functions. As of 2012, the City of Winchester had 5,717 acres within its city limits, a 27 percent increase from 1997. As the county seat and primary growth area in Clark County, Winchester is the only incorporated city within Clark County. Most of the City, as well as some areas immediately surrounding the city boundaries, are developed. Single-family and multi-family residential zoned areas make up the largest land use category, totaling approximately 2,959 acres within the city limits. Commercial usage is most likely found around the Central Business District, Bypass Road, Lexington Avenue, and the western Interstate 64 interchange. The majority of industrial land uses are found north of Interstate 64 outside LHCW. Figure 16 is a map of the land uses in Clark County in the vicinity of LHCW.

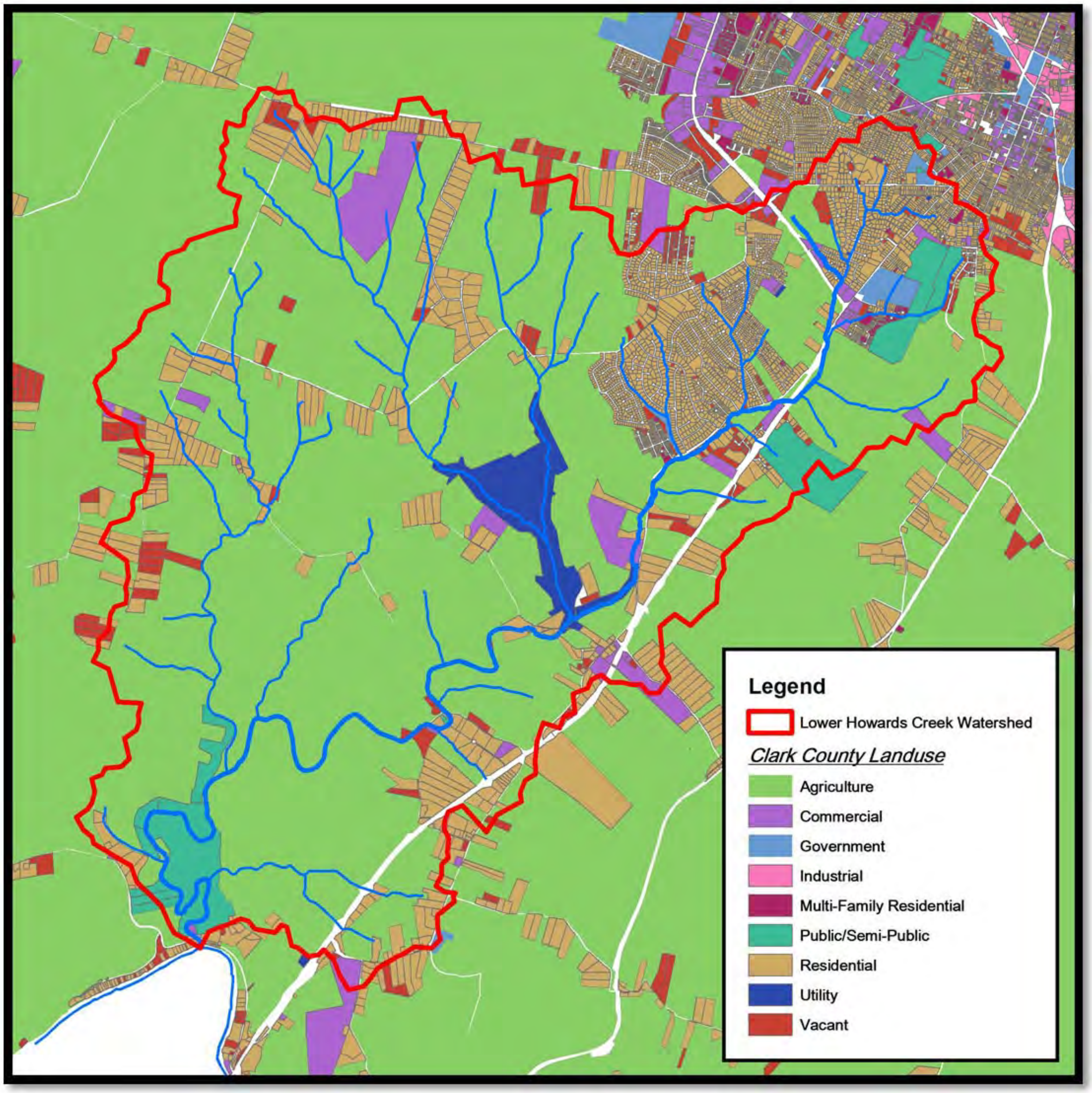

Figure 16. Clark County Land Use Map

Population growth in the LHCW, particularly between Boonesboro Road and McClure Road and west of Bypass Road, has occurred at a greater intensity than any other area in the county over the past 30 years. The growth has resulted in the conversion of land uses and shown the need for improvements to the wastewater and water facilities. Some of the necessitated improvements are being completed as a part of the construction of the Lower Howards Creek Influent Pump Station and WWTP project. The construction is expected to be substantially completed in January 2013 and will include the installation of new gravity interceptors in the vicinity of the main channel of LHC from the intersection of KY 627 and Bypass Road to the location of the Influent Pump Station just north of the existing WTP adjacent to the Carroll E. Ecton Reservoir. As discussed in Section 2.6.3, there are long range plans for construction of a new WTP on the same site as the LHC WWTP.

There are also public/semi-public recreational areas and facilities within LHCW. The LHC Nature and Heritage Preserve is approximately 228 acres of land that was dedicated on January 22, 2001 by the

Kentucky State Nature Preserves Commission and the Clark County Fiscal Court. The Lower Howards Creek Nature and Heritage Preserve is open to the public through guided hikes led by the Preserve Manager or members of the Friends of Lower Howards Creek. A trail was opened to unguided public use in April 2012. In addition, the Carroll E. Ecton Reservoir provides hunting and fishing opportunities for the local community through the Clark County Fish and Game Club. Only non-gasoline powered boats (paddle, row, or boats with electric troll motors) are permitted for use in the reservoir. Based on GIS mapping, 72% of the land within LHCW is agricultural, 17% residential, 4% commercial, and 3% public/semi-public. The remaining land uses are 2% or less of the total area within the watershed.

The Winchester-Clark County Planning Commission adopted the Winchester/Clark County 2012 Comprehensive Plan Update on January 3, 2012. The plan is intended to provide a comprehensive policy framework that can be used to manage and direct future developments in Winchester and Clark County. The 2012 Comprehensive Plan indicates two urban planning area boundaries: the Urban Planning Boundary and the Long Range Planning Area. The plan indicates that the land within these boundaries exceeds the urban land anticipated to be needed by Clark County for the twenty year planning horizon and should prevent zoning changes that are in conflict with the report. In rural areas, the plan promotes concentrating major development to reduce the cost of providing necessary services and enabling the remaining portions of the county to maintain the existing rural or agricultural character. The future land use planning maps and service boundaries are located in APPENDIX E.

2.6.5. LAND DISTURBANCES

Land disturbance within LHCW mainly results from new development and replacement of failing infrastructure. At the time of assessment of LHCW, several large construction projects -- the new Clark County high school, gravity trunk sewer, WWTP, force main and influent pump station -- were occurring. A new high school for Clark County is being constructed between LHC and KY 627 (Boonesboro Road) at 160 Patton Lane. It is unknown if the construction of the new high school will lead to additional future development in this area. Based on the population and census data, development of the LHCW is expected to occur at a higher rate than the rest of Clark County. So land disturbance from new construction is expected to continue as a concern. All new developments must comply with Subdivision Regulations Article VIII Section 860 and the Infrastructure Manual in relation to erosion and sediment control measures. Sites over one acre or part of a larger plan of development also must follow Kentucky Pollutant Discharge Elimination System KYR10 permit. Areas within the limits of the City of Winchester, must also comply with the MS4 permit requirements.

As a part of the Consent Decree and to eliminate known SSOs, a new gravity trunk sewer, influent pump station, force main, and WWTP are under construction to replace failing infrastructure while also meeting the needs of future growth. The gravity trunk sewer extends from the intersection of KY 627 and KY 1958 (Bypass Road) to the location of the new influent pump station adjacent to the existing WTP. The force main extends from the new influent pump station to the new LHC WWTP located at 7055 Boonesboro Road. The LHC WWTP discharge line extends from the plant site to the discharge location in the Kentucky River, Pool 9, just upstream of the confluence of LHC with the Kentucky River. These projects are creating a significant amount of disturbance in the watershed, in many cases, in close proximity to the stream. However, the land disturbance impacts will be temporary. Construction is expected to be substantially complete on all portions of this project by January 2013. This construction will allow for improved water quality by the removal of SSOs and exfiltrating sewers.

2.6.6. OTHER WATER DISTURBANCES

Other disturbances to the stream besides land disturbance include livestock grazing, residential lawn and garden maintenance, and stormwater runoff or a combination of these items. Livestock have direct access to portions of LHC and its tributaries from the upstream boundary of the LHC Nature and Heritage Preserve to Waterworks Road. Impacts occur in areas where livestock have direct access to the stream due to bank trampling and direct input of pollutants through fecal matter. In areas where there is no direct access, runoff from pasture lands flows into LHC and its tributaries. Stormwater runoff from the pastures may contain pollutants from the fecal matter or contaminants from fertilizers or pesticides used to maintain the pastures. The pollutants and contaminants in stormwater runoff are of an even larger concern in areas with limited riparian vegetation because there is little opportunity for the pollutants and contaminants to be removed prior to entering the stream. To help try to eliminate direct access to the stream by livestock, fences have been installed in some locations. The fences were originally installed at no cost to the owner, but after installation the owner is responsible for maintenance and repairs. Due to the high flows, flooding potential, and areas of limited floodplain access, fence maintenance and repair is a major concern for property owners. The fences that have been installed show evidence of damage due to high flows and/or large debris. Figure 17 depicts damage to an existing fence installed across a tributary (West Fork) upstream of the confluence with LHC.

Figure 17. Fence Damage on Tributary to LHC

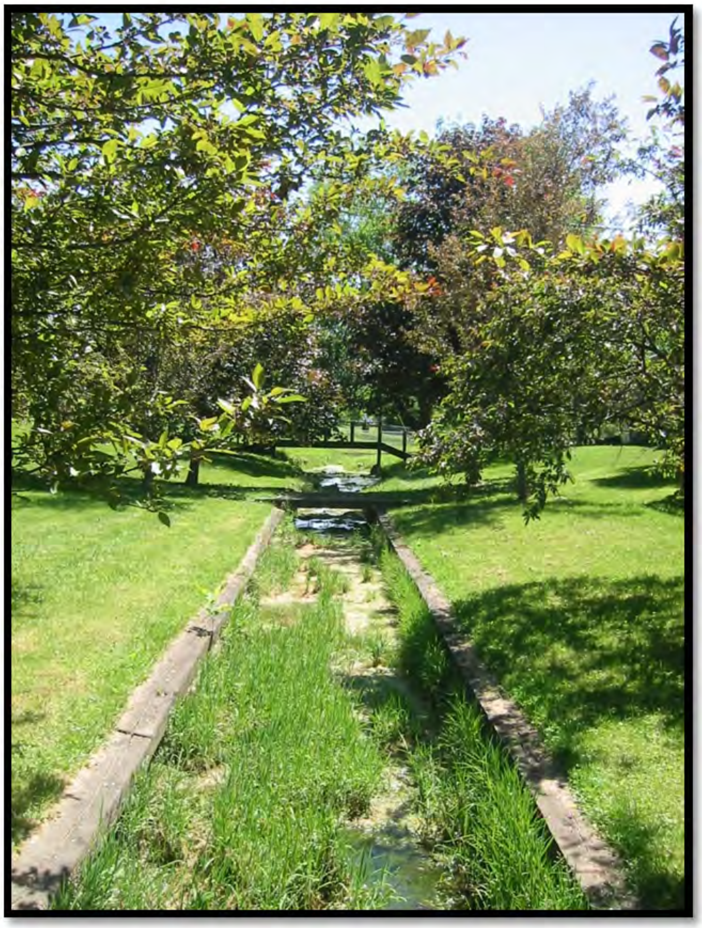

Figure 18. Residential Area in Hampton Manor

Since a large portion of the upper section of the watershed is residential area, the fertilizers and pesticides used by property owners to maintain their lawns, flowers, and vegetable gardens can cause impacts to the stream. Many owners in the watershed take pride in the property and use chemicals to maintain pervious areas for weeds and pests. While these chemicals may be useful when applied in moderation and according to proper procedures; excess and improper usage can lead to polluted stormwater runoff entering LHC. Property owners may also feel that the unkempt appearance of a natural riparian buffer is aesthetically unappealing. This has led to the removal of the riparian buffer through much of the residential area. A natural riparian buffer has been replaced with short, manicured grass. The absence of the riparian buffer only increases the impact of the excess fertilizer and pesticides within the stormwater runoff due to reduced opportunity for slowing the velocity of the water and infiltration. Infiltration will naturally remove some of the pollutants that cause impacts to streams. Residents have indicated that some property owners are dumping their grass and yard clippings into LHC or its tributaries behind their homes. The dumping of grass and yard clippings can restrict the flow in the stream channel causing stagnant water in the stream channel. Grass and yard clippings can also be detrimental to the stream when they break down because they may cause an increase in nutrient loading, decrease in oxygen, and the eventual death of aquatic organisms. Some property owners used wood or stone retaining walls to stabilize the banks and limit erosion. These retaining walls can lead to increased water velocity during storm events, decreased access to the floodplain, and limit aquatic habitat. Figure 18 depicts the typical stream conditions in the upper portion of the watershed in residential areas. This particular photograph was taken in Hampton Manor neighborhood in May 2008. Algae growth appears to be a major concern, especially in the upper portions of the watershed. Residents report excessive presence of algal blooms during most of the growing season. The residents indicated that often the algae dissipate only after a storm event, returning within a number of days.

2.6.7. POINT SOURCE DISCHARGES

An open records request from KDOW, completed in February 2012, indicated 57 active Kentucky Pollutant Discharge Elimination System (KPDES) permits in Clark County and four active KPDES permits in the Lower Howards Creek Watershed. Three of the four active permits within the watershed where General Permits for Stormwater Discharges Associated with Construction Activities (KYR10) for the construction on the new gravity trunk sanitary sewer, new Clark County high school, and the new

WWTP, which included the construction of the influent pump station and force main. The remaining KPDES permit within the watershed is associated with the existing WTP adjacent to the Carroll E. Ecton Reservoir (KPDES Permit No. KYG640043). No known violations have occurred.

2.6.8. HAZARDOUS MATERIALS

The discharge of hazardous material to LHCW is prohibited by the City of Winchester, Clark County, and the State of Kentucky. An illicit discharge ordinance (Code of Ordinances, Article 11, Section 25 - 28) has been enacted by the City of Winchester to protect residences from substances dangerous to human health that may contaminate the water. As of February 2012, the City of Winchester had no reported instances of illicit discharge. However, it is possible that illicit discharges have taken place but were not reported.

In 2009, Palmer Engineering prepared a Phase I Environmental Site Assessment at the request of WMU for the proposed construction of sanitary sewer improvements in LHCW, including approximately four miles of gravity sewer, three miles of force main pipeline, and the 38-acre site for the construction of the new WWTP and WTP. The corridor included a one-mile radius around the proposed project locations. The main objective of the report was to identify the presence or likely presence, use, or release of hazardous substances or petroleum products as defined in AST Practice E 1527-05 as a recognized environmental condition (REC) within the study corridor. The report recognized the Marathon gas station and the Boonesboro Animal Clinic located near the intersection of Bypass Road and US 627/Boonesboro Road as RECs or historical recognized environmental conditions (HRECs). Beech Springs Farmers Market and an unnamed spring where dumping has occurred located between Old Boonesboro Road and US 627/Boonesboro Road have also been identified as RECs. The report recommends that disturbance of these areas should be avoided.

2.7. DEMOGRAPHIC AND SOCIAL ISSUES

The demographics of LHCW help to provide an indication of how the watershed will develop and where the most impact can be made. As previously discussed in Section 2.6.2, the population for Clark County increased by 7.45% and the population for the City of Winchester increased by 9.8% between the 2000 and 2010 census. The population increased slightly more than the overall state of Kentucky, which increased by 7.4%. The population in the LHCW is expected to increase at a greater rate than the rest of the watersheds within the City of Winchester and Clark County. An 8.5% increase is projected from 2008 to 2018 and a 6.0% increase is projected from 2018 to 2028 in LHCW. Table 7, on page 38, contains a summary of the US Census Bureau data available for the City of Winchester, Clark County, and Kentucky from the State and County QuickFacts website. The census data indicates that Clark County has a lower percentage of the population with a Bachelor's degree than the average for Kentucky; however, Clark County has a higher median household income and per capita yearly income than the average for Kentucky.

Farming is a large and vital part of LHCW. According to the 2007 Census of Agriculture published by the United States Department of Agriculture, there are 907 farms in Clark County totaling 149,201 acres. The average farm size is 164 acres and the average market value of products sold was $35,694 per farm. Livestock sales made up 76% of the market value of the products sold. The National Agricultural Statistics Service estimates that 44,500 cattle were expected in Clark County in 2011, indicating almost 25% more cattle than humans in the county. It is important to consider the potential impact that future projects within the watershed will have on the farms and the way they conduct their operations during the water quality assessments.

Table 7. Census Data Summary

	Winchester	*Clark County*	*Kentucky*
Population	18,368	35,613	4,369,356
Average Household Size	2.35	2.42	2.48
High School Graduates	76.5%	81.4%	81.0%
Bachelor's Degree or Higher	14.0%	17.7%	20.3%
Median Household Income	$38,104	$46,575	$41,576
Per Capita Yearly Income	$19,028	$23,966	$22,515
Persons Below Poverty Line	20.7%	16.0%	17.7%
Home Ownership Rate	49.2%	65.2%	69.9%

Many of the people in Clark County and LHCW seem to be unaware or uninformed about water quality issues. For example, at the public meetings citizens reported observing their neighbors dumping grass and yard clippings into the stream and/or storm sewer. Visual evidence of the dumping of grass and yard clipping was observed within the residential section of the watershed. Property owners may not be aware that this is harmful to the stream or continue to do so because of learned behaviors. Outreach efforts have recently begun in an effort to inform the public on water quality issues. The City of Winchester has begun to conduct more public outreach regarding water quality in accordance with the MS4 permit requirements. The Strodes Creek Conservatory is also active in the community and has developed a Watershed Management Plan for Hancock Creek.

2.8. FIELD OBSERVATIONS

A visual assessment of LHC was completed by Ralph Schuler and Stephanie Blain on December 13 and 14, 2011. This visual assessment was completed by walking the majority of LHC from the Kentucky River to its headwaters near the Hampton Manor neighborhood in Winchester. Prior to the visual assessment, letters were sent to property owners to obtain permission to enter their property for the assessment. Some of the property owners did not grant permission or were nonresponsive, so these properties could not be directly assessed. In several locations where LHC could not be directly assessed, the stream could be observed from an adjacent property, providing the project team with a thorough visual assessment of the entire length of the main channel of LHC. The purpose of this assessment was to observe and photograph the creek channel; note areas of interest, such as severe bank erosion; characterize stream bed substrate and areas of high bed load; locate tributary confluences; and identify potential impacts to the stream water quality and degradation.

LHC can be characterized as flowing through three distinct areas; palisade zone, transition zone, and urban zone. The palisade zone is approximately 4 river miles, the transition zone is approximately 2.5 river miles, and the urban zone is approximately 4.0 river miles. Each of the areas will be described in more detail in the sections below.

2.8.1. PALISADE ZONE

The palisade zone begins at the confluence of LHC with the Kentucky River and extends upstream for approximately 4 miles to the northern edge of Blackfish Golf and Hunt Club property. This zone is characterized as being mostly forested with high rock bluffs with some areas of access to pasture and agricultural lands. Due to the beauty, unique geology, and historical significance in the area, the LHC Nature and Heritage Preserve, part of the Kentucky State Nature Preserves Commission, owns a large portion within this zone. According to their website, the purpose of the LHC Nature and Heritage Preserve is to "provide nature education, to preserve endangered species, and to preserve and interpret an important chapter in the history of Clark County and the Bluegrass Region of Kentucky." Figure 19 depicts a portion of LHC on the LHC Nature and Heritage Preserve with a high rock bluff on one side. The palisade zone also contains three major tributaries locally known as Deep Branch, West Fork, and Dry Fork.

Figure 19. Palisade Zone

The stream bed consists primarily of gravel, cobble, and boulders with some areas of exposed bedrock. The substrate transitions multiple times throughout the reach from gravel and cobble to bedrock. The stream banks are mostly stable and well vegetated except in areas of rock bluffs or where cattle or other livestock have access and on a few outside bends where high flows are causing erosion. There are a couple of notable areas of unstable banks on the LHC Nature and Heritage Preserve; one being in the bend behind the restaurant Hall's on the River (RM 0.15), and the other in the vicinity of Sample Site 1 (RM 0.4). In this reach, LHC contains many large bends and meanders, nearly doubling the horizontal distance in stream length. Wood with removed bark was found on the LHC Nature and Heritage Preserve property indicating the possible presence of beavers. Numerous rock walls, Martin's Mill, and the John and Rachel Martin house were observed along the LHC corridor. A modern metal suspension pedestrian bridge is located just south of the John and Rachel Martin house.

The vegetation community in this zone has been well documented by the LHC Nature and Heritage Preserve (Cicerello et al. 2003) and by William Crankshaw in 2004. The LHC Nature and Heritage Preserve has also instituted an invasive plant eradication program, so the presence of exotics like Bush Honeysuckle (*Lonicera maacki*) has been greatly reduced. Once leaving the LHC Nature and Heritage

Preserve, the plant community in this zone, under private ownership, changes from forested to forested and pasture and there is also an increased presence of Bush Honeysuckle (*Lonicera maacki*) and other invasive plant species. There are some areas where cattle have access to the creek and there was evidence of bank trampling and erosion in these areas.

Just prior to the start of the transition zone a section of LHC appears to have been diverted. A very long pool has formed and the channel splits with a majority of the flow directed at a 90 degree angle from the pool. This channel has unstable, unvegetated banks typical of streams that have been modified. Figure 20 is taken from the large pool looking downstream toward the altered channel. After speaking with longtime residents of the area, it was discovered that a low water crossing made of stone used for tractor access was previously constructed in this area. The low water crossing created the large pool that was often used for recreational swimming during the summer months. It is unknown if the altered channel was constructed or created by the erosive forces of the stream. The low water crossing is no longer in use, but evidence of it was observed directly downstream of the altered channel. It is also in this area that Blackfish Golf and Hunt Club has a permit to withdrawal water as noted in Section 2.2.4.

Figure 20. Channel Alteration

2.8.2. TRANSITION ZONE

The transition zone is designated from northern property line on the Blackfish Golf and Hunt Club to Waterworks Road. In this zone, LHC changes from rocky bluffs to more maintained, developed conditions. The transition is characterized as being predominantly agricultural in the form of pasture lands with some forested areas. The vegetation community is consistent with this type of land use. In areas where pastures are the dominant land use, trees and shrubs are located primarily along LHC and in fence rows, with large areas of open grasses for livestock roaming. Figure 21 shows a section of LHC in the transition zone. One area that appeared to have a small amount of illegal trash dumping was located on a hillside. Most of the trash was well away from LHC, but it appeared that some of the debris was making its way to the creek during high flow events.

The stream bed in this area consists primarily of gravel, cobble, and boulders with some areas of exposed bedrock. As in the palisades zone, the substrate transitions multiple times throughout the reach from gravel and cobble to bedrock. Stream banks in this area were relatively stable with some areas of erosion where cattle or other livestock have access to the stream. The riparian zone is limited in areas due to pastures and agricultural land uses. In this zone LHC begins to straighten, even though there are some large bends present. The overall stream length is approximately 1.5 times the horizontal distance. The tributaries are small first order headwater streams. Man-made stream obstructions in the form of culvert road crossings are present in the transition zone. The road crossings are made of multiple steel or concrete culverts laid side by side and covered with concrete and/or asphalt. These crossings alter LHC natural flow by slowing the velocity, increasing localized sediment, raising the water level on the upstream side, and scouring portions of the streambed on the downstream side.

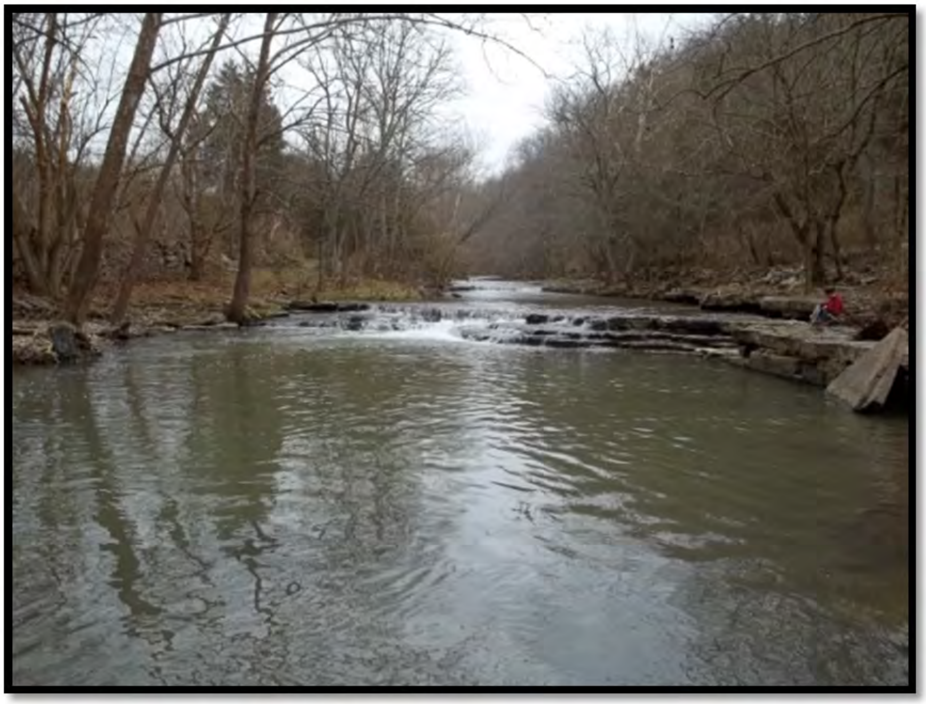

Figure 21. Transition Zone

2.8.3. URBAN ZONE

The urban zone is designated from Waterworks Road to LHC headwaters located in the City of Winchester and outlying developed areas of Clark County. This zone is characterized as being predominantly residential with a few scattered agricultural areas, mainly in the lower end of the zone near Waterworks Road, and commercial uses, in the upper portion of the reach within the limits of the City of Winchester. The vegetation community along LHC in the urban zone is a mix of forest, shrub, pasture, and manicured residential lawns. Tributaries in the area are small first order headwater streams and two large springs of which one is of historical significance, Indian Spring. Of the eight main tributaries in the area, four of them flow through densely populated residential areas. In this area there are a number of SSOs that either flow directly into LHC or into one of its tributaries. These SSOs will be eliminated by WMU in accordance with the Consent Decree. The natural flow of LHC is frequently disrupted by the large number of driveway and roadway culverts in the channel. The stream banks in the area show areas of erosion due to high flow events. The stream substrate in this zone consists primarily of gravel, cobble, and boulder with areas of thick silt. The overall channel is relatively straight with sinuosity barely increasing its overall length from the horizontal distance. Areas appear to have been straightened in the past. The algae growth in the stream also appeared to be significantly higher in this zone than in the transition and palisades zones. Figure 22 is a picture taken in the urban zone showing a section of the stream with steep, unvegetated banks.

The existing WTP and Carroll E. Ecton Reservoir are located at the downstream end of this zone. Two tributaries were dammed to create the reservoir. LHC receives water from this reservoir from overflows and through numerous leaks via karst features around and possibly under the dam. Below the main dam is an additional smaller reservoir, the lower impoundment, which LHC enters before continuing downstream. The lower impoundment acts as a settling basin for the water flowing in LHC. At the present time there are several large construction projects occurring in this portion of the watershed; a new influent pump station, a new county high school and gravity sewer line installation and replacement. The new influent pump station construction is adjacent to the existing WTP off Waterworks Road. The high school construction is located between LHC and KY 627 (Boonesboro Road) just below to the area of the watershed that has been fully developed. The gravity sewer installation and replacement is located directly adjacent to LHC from site of the new Influent Pump Station to the location of the existing Snowfall Pump Station at the intersection of KY 627 and KY 1958 (Bypass Road). The sediment load in LHC in the vicinity of these projects was a fine texture, silty, and found in higher than normal volumes due to the amount of construction occurring and the large volume of rain received in fall 2011. This is expected to be a temporary issue and to improve upon construction completion.

Figure 22. Urban Zone

2.9. CONCLUSIONS FROM EXISTING DATA

The existing data collection and review indicates that LHCW has a rich and vibrant history with many remnants of old buildings, structures, and fences. The watershed is filled with beautiful scenery and unique geologic formations, providing an ideal area for involving the public with nature. Many people in the community care deeply about LHCW and have developed strong opinions about the future of the area.

The LHC Nature and Heritage Preserve has been the most widely studied portion of the watershed. Several studies completed by graduate students have been completed in this section of the watershed. Information and mapping of the vegetation, geologic formations, and cultural historic resources have been detailed in the *Lower Howards Creek Management Plan* prepared by Parsons Brinckerhoff, Ned Crankshaw, and Cultural Resource Analysts, Inc. However, this plan did not include water quality monitoring. KDOW completed some water quality monitoring within the watershed, mostly in 2003 and early 2004. Very limited water quality data has been recently collected through the Kentucky River Watershed Watch program.

Flooding is a known issue in LHCW. A flood study was completed in 2009 by Palmer Engineering for the portion of LHC upstream of Waterworks Road (RM 6.2). Areas downstream of Waterworks Road also experience flooding which can sometimes be severe due to the limited floodplain in the palisades region. The stream flow can quickly change during a storm event resulting in rapidly rising water which creates access problems for residents.

Upon review of existing data, there are large gaps in the water quality data for the watershed. No one conclusive study has been conducted to evaluate water quality in LHCW. The monitoring completed as a part of the LHCWMP enabled data collected once a month for a year to be used to analyze and identify issues. While this water quality data was not able to be completed in every section of the watershed, it provided a cohesive overview where pollutants of concern can be identified. The water quality data collected as a part of the LHCWMP provided baseline data, but also identified additional areas for future study. These areas will be discussed in detail in Section 3 of this report.

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3. MONITORING

3.1. MONITORING OVERVIEW

An integral part of the development of the LHCWMP is the review of existing monitoring data and collection of new sampling data. As discussed in Section 2.2.7, there are three main known existing sources of monitoring data within LHCW. The previous monitoring data was completed by KDOW, volunteers through KRWW, and a graduate student from Eastern Kentucky University. The previous monitoring data has been mostly collected in the southern portion of the watershed, downstream of Waterworks Road. The previous data collection site locations are shown on the map in APPENDIX C.

The data from KDOW was collected at various intervals from 1998 to 2009, with a majority of the data being collected in 2003 and early 2004. Dissolved oxygen, pH, specific conductivity, ammonia-nitrogen, chloride, nitrate, organic carbon, phosphorus, sulfate, total suspended solids, temperature, and discharge where recorded at monthly sampling events at five sites. Orthophosphorus and percent saturation of dissolved oxygen were also recorded in some instances, but no bacteria concentrations were assessed. Limited macroinvertebrate, diatoms, fish, habitat, and additional water chemistry data had also been collected by KDOW. A full review of this data is found in Section 2.2.7.3. Since most of this data was collected over eight years ago, it is difficult to know if watershed conditions have changed.

The KRWW is a group of volunteers interested in water quality who collect data throughout the Kentucky River watershed. Available data collected by KRWW from 2010 and 2011 at five sites within the watershed is located in APPENDIX C. Several of the sampling events showed elevated levels of E. coli with values in excess of 2420 colonies per 100 mL. The total recoverable phosphorous and conductivity also appeared elevated during some sampling events. Since the data has been collected by volunteers, it has not been consistently collected and is difficult to verify that proper quality assurance and quality control procedures were followed.

A graduate student from Eastern Kentucky University, Daniel Walker, conducted his master's thesis, entitled *Chemical Properties of Lower Howards Creek during a Drought and the Species Present*. The study involved the collection of nitrate, phosphate, and bacteria at three locations in the LHC Nature and Heritage Preserve from May 17, 2007 to June 27, 2007. Each site was sampled every two weeks for a total of three samples per location. The results indicated elevated levels of nitrates at the sample site on Deep Branch and elevated levels of bacteria at all three sites. A full discussion of the results is located in Section 2.2.7.1. The data collected was completed in a very short timeframe and under drought conditions, so it is difficult to accurately draw conclusions from this information.

The review of the existing monitoring data showed inconsistencies and large gaps within the data. The additional monitoring, as a part of this report, was intended to be a representative sample of the watershed that allows for analysis, identification of potential issues, and recommendation of solutions and areas for preservation. In compliance with the *Watershed Planning Guidebook for Kentucky Communities* and requirements for Kentucky 319-funded watershed plan projects, monitoring was under taken in a system of two phases. The collection of the new sampling data was taken throughout the watershed and will be discussed in detail in Section 3.3 and Section 3.4 of this report. In addition to the requirements outlined, Microbial Source Tracking (MST) was also performed and will be discussed in detail in Section 3.5 of this report.

3.2. MONITORING PARAMETERS

The *Watershed Planning Guidebook for Kentucky Communities* specifies parameters that must be collected for WMP development to be in compliance with 319(h) grant funded projects. These parameters were also identified as critical parameters because they are directly related to the objectives of this study. The critical parameters, sampling frequencies, and related standard operating procedures are listed in Table 8. The critical parameters can be broken down into seven main groups -- bacteria, nutrients, sediment, flow, field data, habitat, and biology. To assist in monitoring evaluation, photographs were taken at a minimum of two times per location over the course of all the sampling events. Monitoring locations were identified in World Geodetic System (WGS 84) coordinates using a handheld GPS unit.

Table 8. Monitoring Parameters

Group	**Parameter**	**Monthly**	**5X/30 days May or June**	**1X/year**	**Every Time**	**Standard Operating Procedure (SOP)**
Bacteria	E. coli (*Escherichia coli*)	X	X			DOWSOP03015
Nutrient	NO3/NO2 (Nitrate / Nitrite)	X				DOWSOP03015
	NH3-N (Ammonia – Nitrogen)	X				DOWSOP03015
	TKN (Total Kjeldahl Nitrogen)	X				DOWSOP03015
	TP (Total Phosphorus)	X				DOWSOP03015
	OP (Orthophosphate)	X				DOWSOP03015
	BOD5 (Biochemical Oxygen Demand)	X				DOWSOP03015
Sediment	TSS (Total Suspended Solids)	X				DOWSOP03015
	Turbidity (actual or estimated)	X				DOWSOP03014/ DOWSOP0315
Flow	Stream Discharge				X	DOWSOP03019
Field Data	pH				X	DOWSOP03014
	DO (Dissolved Oxygen)				X	DOWSOP03014
	Specific Conductivity				X	DOWSOP03014
	% Saturation (Percent of DO)				X	DOWSOP03014
	Temperature				X	DOWSOP03014
Habitat	Habitat Assessment (KDOW Method)			X		DOWSOP03024
Biology	Biological Assessment (KDOW Method)			X		DOWSOP03003 / DOWSOP03005

Figure 23. Water Sampling

Critical parameters were tested in accordance with *Quality Assurance Project Plan (QAPP) for the Lower Howards Creek Watershed Management Plan* prepared by Palmer Engineering dated September 26, 2011 and approved by KDOW October 14, 2011. This plan is located in APPENDIX F. Samples and field data at the time of sampling were collected by Palmer Engineering employees with limited assistance of volunteers. Bacteria, nutrient, and sediment parameters were analyzed and processed at Fouser Environmental Services, a commercial laboratory specializing in the testing of wastewater and drinking water; environmental assessments; microbiological; and whole effluent toxicity. The chain of custody form used is located in APPENDIX F. Habitat and biology data was collected by Palmer Engineering employees with limited assistance of volunteers. Figure 23 is a photograph of water collection taken during a sampling event.

MST was incorporated as a part of the development of the LHCWMP to establish a systematic approach to water quality and data analysis that identifies hot spots of human fecal wastes within LHC. The procedures developed by Dr. Gail Brion at the University of Kentucky were used to identify samples that were indicative of contamination with human fecal waste, using fecal load, age, and source. Samples were collected by Palmer Engineering employees with limited assistance of volunteers in accordance with Quality *Assurance Project Plan for the Lower Howards Creek Watershed Management Plan*. Samples were processed at the University of Kentucky Environmental Research and Training Laboratories in accordance with *A Plan for Identifying Hot-Spots of Human Fecal Pollution by Analysis of Fecal Load, Source, and Age in Water Quality Samples from Lower Howards Creek Watershed Quality Assurance Project Plan* by Dr. Gail Brion approved by KDOW on May 3, 2012 and located in APPENDIX F.

3.2.1. BACTERIA

Bacteria are microscopic organisms that cannot be seen with the naked eye. Bacteria are found everywhere and most are harmless to humans; some even assist in keeping human's bodies functioning properly. The critical parameter E. coli is a type of bacteria in the fecal coliform group. Fecal coliform are only found in fecal waste of humans and other warm-blooded animals. E. coli is a gram-negative rod-shaped bacterium that is commonly found in the lower intestine of warm-blooded organisms. Most strains are harmless to humans. Determining the number of E. coli colony forming units (cfu) found in a water sample of a given size serves as an indicator to whether pathogens are possibly present. Pathogens are defined as bacteria, viruses, and parasites that cause disease and illness. The pathogens of primary concern in water with temperatures of less than 30 degrees Celsius include Bacteroides species; salmonella; shigella; aeromonas; enamoeba histolytica; and the O157:H7 strain of E. coli. The higher the level of E. coli, the more likely the water contains pathogens. E. coli was measured using the method SM 9223 B and reported in Most Probable Number (MPN) or CFU per 100 ml. The minimum detection limit was 1 MPN/100 ml.

To assist in developing best management practices for pollutant load reductions, MST sampling and analysis was incorporated into the project in addition to determining the amount of E. coli at select sampling sites. In areas where high levels of E. coli were found, it was impossible to determine whether the bacteria was being introduced into the stream through human or animal sources without additional testing. The process of MST used for the LHCW was developed by Dr. Gail Brion of the University of Kentucky and included analyzing the fecal load, age, and source. The fecal load, age, and source provided metrics to estimate how close the analyzed sample was to human sewage. If high levels of E. coli were found in areas where low or no human indicators were present, the source was likely not human. Fecal load was measured using Colilert media by IDEXX to determine the MPN of E. coli bacteria per 100 mL. Fecal age was measured by determining the ratio of atypical (AC) colonies to total coliform (TC) bacteria using membrane filtration and mEndo media. A low AC/TC ratio, typically less than five, indicated fresh fecal material in the water. A higher AC/TC ratio, typically greater than 20, indicated older fecal material in the water. Lower AC/TC ratios are often indicative of human sources because fresh fecal material is introduced into the water through sanitary sewer overflows, failing sewer lines or septic systems, and straight pipes. Fecal material from animal sources is mostly washed into streams from overland flow, resulting in older fecal material. Fresh fecal matter from animal sources is occasionally found when animals defecate in the stream or when a concentrated animal feed operation is in proximity to the stream. However, the freshest, most consistent fecal signal in a watershed has been documented in past studies to originate from sewage. Fecal source was measured by quantifying two types of fecal genetic markers for Bacteroides known as AllBac and HuBac. The AllBac marker is not specific to one type of fecal source and was correlated with the E. coli fecal load concentration. The HuBac marker is associated with human fecal materials. The contribution of feces attributable to human sources was determined by comparing the values obtained from the HuBac marker concentrations with those obtained from a raw influent sewage sample. When levels of HuBac are high, a confirmatory marker (qHF183) was applied as a quality control measure. This confirmatory marker is less sensitive than the HuBac, but more specific for the detection of only human fecal materials.

3.2.2. NUTRIENTS

Nutrients are natural elements in soil, water, and organisms that are essential for plant and animal growth, maintenance, and reproduction. Excess nutrients are usually the result of pollution from land use activities and can be detrimental to streams. Stormwater runoff, decomposition of organic matter, discharges from wastewater systems, failing septic systems, excess use of fertilizers, and waste products from farm animals and domestic pets are common sources of nutrients. High concentrations of nutrients within a water body promote excessive growth of algae, causing bacteria to breakdown the decomposing algae and depleting the water of available oxygen. The depletion of oxygen can lead to the death of other organisms such as fish. This process is called eutrophication. Excess algae can cause unpleasant conditions, odors, and poor habitat.

Nitrogen and phosphorus are the two primary nutrients. Nitrogen and phosphorus are found in fertilizers applied to farm land and residential lawns and gardens and are essential for plant growth. Nitrogen and phosphorus can be measured in several forms. The critical parameters for phosphorus are total phosphorus (TP) and orthophosphate (OP). Orthophosphate is the portion of the total phosphorus that is soluble in water and available to organisms for growth. Total phosphorus and orthophosphate were measured using the method SM 4500-P E and reported in milligrams (mg) per liter (L). The minimum detection limit for this method was 0.033 mg/L. The critical parameters for nitrogen are total kjeldahl nitrogen (TKN), nitrate-nitrogen, nitrite-nitrogen, and ammonia nitrogen. Total kjeldahl nitrogen represents the portion of total nitrogen that is unavailable for growth or bound up in organic form. Elevated nitrogen and phosphorus levels may indicate the presence of a pollution source. Total kjeldahl nitrogen was measured using the method SM 4500-NH3 C and reported in milligrams per liter. The minimum detection limit was 0.1 mg/L. Nitrate-nitrogen and nitrite-nitrogen were measured using the method EPA 300.0 and reported in milligrams per liter. The minimum detection limit was 0.1 mg/L. Ammonia nitrogen was measured using the method EPA 350.1 and reported in milligrams per liter. The minimum detection limit was 0.05 mg/L.

Biochemical Oxygen Demand (BOD) is the measure of the amount of oxygen consumed by microorganisms as organic matter is decomposed in a water body. The amount of dissolved oxygen in a water body is directly affected by the level of BOD; the higher the BOD, the less the amount of dissolved oxygen available to organisms. BOD can be affected by temperature, pH, presence of certain microorganisms, and type of organic and inorganic material in the water. Higher levels of BOD can indicate the presence of a source of pollution. BOD5 is the critical parameter that is measured after a five day incubation period. BOD5 was measured using the method SM 5210 B and reported in milligrams per liter. The minimum detection limit was 3 mg/L.

3.2.3. FLOW

Flow is determined by measuring stream discharge. Stream discharge is the volume of water that passes through a stream in one second. Stream discharge is calculated using measurements of stream width, depth, and velocity. To obtain an accurate estimate of the stream discharge, a nylon measuring tape was stretched and secured across the stream channel during each sampling event. The total width of the channel was recorded. The channel was divided into a minimum of four sections for channels over four feet in width. In the center of each section, the depth of the water was measured using a folding ruler and the velocity of the water was measuring using a Flow Watch meter. In areas where the depth of water was less than 2.5 feet the average velocity is measured at approximately 60% of the total depth. If the depth of water was greater than 2.5

Figure 24. Flow Measurement

feet the velocity was measured at 20% of the total depth and 80% of the total depth and then averaged together. The width, depth and velocity of each section were multiplied to obtain flow for that section of the stream. The flow values for each section were added together to provide the total stream discharge at the time of sampling. The form used to record this data is located in APPENDIX F. This procedure was important because water depth and velocity are not consistent across the channel, so only measuring the velocity and depth in one location would not provide very accurate information. Figure 24 is a photograph taken during flow measurement, depicting the nylon tape being stretched across the channel.

3.2.4. SEDIMENTS

Total suspended solids concentrations and turbidity are critical parameters used to measure the amount of solid material suspended in the water. High levels of total suspended solids and turbidity will often cause the water to appear muddy or cloudy. Suspended materials allow for less light to be able to reach plants at deeper depths in the water body. Suspended materials often carry other pollutants such as metals and bacteria. Turbidity is the cloudiness or haziness of a fluid caused by suspended solids and measures the amount of light scattered. The total suspended solids test measures the actual weight of material in a given volume of water. High total suspended solids concentrations and turbidity values can be an indicator of a source of sediment. Turbidity was measured using the method EPA 180.1 and reported in nephelometric turbidity units (NTUs). Total suspended solids were measured using the method SM 2540 D and reported in milligrams per liter. The minimum detection limit was 2 mg/L.

3.2.5. FIELD DATA

Field data was collected at each sample site in conjunction with the water sample collection and flow measurements. Field data was collected using the YSI Professional Plus Water Quality Instrument and included measuring dissolved oxygen (DO), percent saturation of dissolved oxygen, potential Hydrogen (pH), conductivity, and water temperature. The field data was recorded on the form included in APPENDIX F. Figure 25 depicts collection of the field data using the YSI Professional Plus.

Figure 25. Field Data Collection

Water temperature quantitatively assigns a value to the notion of hot and cold. Aquatic organisms can be greatly affected by the water temperature. The optimal water temperature can vary greatly by the species, but variations above or below a normal range can impact organisms' processes. Temperatures will vary during the day, especially near the water surface or in shallow waters. Aquatic organisms adjust to temperature changes by moving to other areas in the water body according to their desired temperature. Extended periods of temperature variation can cause stress and death of organisms. Water temperature can be changed by the removal of trees and other vegetation that normally provides shade; dam construction or other impoundments; industrial or urban stormwater discharges; and groundwater flows. Water temperature was measured in degrees Celsius.

Dissolved oxygen (DO) is the amount of oxygen that is present in the water. Most aquatic organisms get the oxygen they need to survive from the DO in the water. Water is oxygenated by diffusion from the surrounding air, aeration through rapid movement, and as a waste product of photosynthesis. Colder water typically has higher levels of DO. Dissolved oxygen can be affected by high levels of bacteria which consume oxygen as organic matter decays. Dissolved oxygen was measured using a polarographic sensor and reported in milligrams per liter. Percent saturation of DO was the amount of oxygen dissolved in the water sample compared to the maximum amount possible at the same temperature. If the percent saturation of DO is equal to 100%, the water is said to be saturated. Water can become supersaturated with oxygen when percent saturation of DO exceeds 100%. According to the YSI Professional Plus manufacturer's information, typically percent saturation of DO exceeds 100% due to the production of pure oxygen by photosynthetically-active organisms or non-ideal equilibrium of dissolved oxygen between the water and air above it. Percent saturation of DO was measured using a polarographic senor and reported as a percentage.

Potential Hydrogen (pH) is a measure of the concentration of hydrogen ions in a water sample and indicates whether a sample is acidic or basic. Potential Hydrogen values are unit less and range from zero to 14, with pure water measuring seven. Water samples with a pH below seven are considered acidic. Water samples with a pH above seven are considered basic. Most organisms are more successful in a pH range of 6.5 to 8. Potential hydrogen values outside of this range can lessen diversity due to reductions in reproduction and stress on organisms. Very acidic solutions can change the solubility of material, causing harmful metals or other compounds to be leached into water in previously insoluble compounds. Water in the central Kentucky region tends to be slightly basic due to the underlying limestone. As the limestone dissolves, hydroxide ions are released into the water increasing the pH. The pH can also be affected by the pH of rainfall. Acid rain can lower the pH of a stream. The pH was measured with a glass combination electrode senor.

The measure of a material's ability to conduct electricity is known as conductivity. According to the EPA, conductivity can indicate the presence of inorganic dissolved solids such as chloride, nitrate, sulfate, and phosphate anions or sodium, magnesium, calcium, iron, and aluminum cations. Pure water has a very low conductivity. Water temperature also effects conductivity; typically the warmer the water, the higher the conductivity. Conductivity can also be affected by the geology of the region in which stream is located. Areas where the stream flows through limestone and clay soils tend to have high conductivity. Discharges into streams may also change the conductivity. Discharge from a failing septic system would raise the conductivity due to the presence of chloride, phosphate, and nitrate. Specific conductivity was measured because it normalizes the reading to 25 degrees Celsius. Specific conductivity was measured in microsiemens per centimeter (µS/cm) using a four electrode cell sensor.

3.2.6. HABITAT

Stream habitat is vital for successful plant and animal communities within waterways. Stream habitat is the areas where plants and animals live, including on, under, and between rocks; in or on plant and woody debris; and in mud or sand. Stream habitat is not limited to the area within the channel banks, but also includes the riparian zone. If a variety of habitats are available within the stream corridor, there is more opportunity for multiple plant and animal species to thrive. Assessing the habitat can help in determining the health of the stream. Stream habitat assessment looks at particular features within a section of stream and analyzes how those features function. Habitat assessments were performed using the Rapid Bioassessment Protocols (RBPs) developed by KDOW. Two sets of RBPs have been established, one for high gradient stream and one for low gradient streams. High-gradient streams are defined as streams with velocities greater than 0.5 feet per second (ft/s) that exhibit rapid changes in stream gradient and a high frequency of riffle habitat. Low-gradient streams are defined as streams with velocities less than 0.5 ft/s and often lacking rifle habitat. All the sample site locations for the LHCWMP were classified as high-gradient. The RBPs for high-gradient streams include the assessment of ten major parameters: epifaunal substrate and available cover; embeddedness; velocity and depth regime; sediment deposition; channel flow status; channel alteration; frequency of riffles; bank stability; vegetation protection; and riparian vegetative zone width. KDOW has established specific criteria for the time of year habitat assessment should be completed based on stream size and drainage area. Streams are classified as headwater or wadeable based on these factors. Headwater streams have a surface drainage area less than five square miles and wadeable streams have a surface drainage area of more than five square miles. The Standard Operating Procedure (SOP) developed by KDOW, DOWSOP03024, specifies that habitat assessment for wadeable streams should be conducted from June 1st until September 30th and headwater streams from March 1st until May 31st. The habitat assessments for the wadeable streams sampled for LHCWMP were assessed in August 2011. The habitat assessments for the headwater streams sampled for LHCWMP were assessed in March and April 2012. The RBP assessment form used is located in APPENDIX F.

3.2.7. BIOLOGY

Biological assessments can also help determine the health of a watershed. Different organisms can tolerate varying levels of pollution in the water. If organisms with a very low pollution tolerance are found it is an indicator of good water quality. A large portion of the organisms living in streams are benthic macroinvertebrates. These organisms live close to or on the bottom of the stream, do not have backbones, and can be seen with the naked eye. Benthic macroinvertebrates may be immature forms of organism that live on land once full grown. Benthic macroinvertebrates serve important roles in the stream system, providing food for larger organisms, eating algae and bacteria, and breaking down decaying material and debris. *Watershed Planning Guidebook for Kentucky Communities* indicates that benthic macroinvertebrates are good indicators of the health of a watershed "because they:

- live in the water for all or most of their lives
- stay in areas suitable for their survival
- are easy to collect
- tolerate different amounts and types of pollution
- are easy to identify in a laboratory
- often live for more than one year
- do not move very far in the stream
- are exposed to all conditions and pollution in the stream."

The Macroinvertebrate Biotic Index (MBI) is used to classify the water based on benthic macroinvertebrates that are found within a stream reach. KDOW uses seven core metrics in the MBI computation: Taxa Richness (G-TR); Ephemeroptera, Plecoptera, Trichoptera Richness (EPT); Modified Hilsenhoff Biotic Index (mHBI); Modified Percent EPT Abundance (m%EPT); Percent Ephemeroptera (%EPHEM); Percent Chironomidae + Oligochaeta (%Chir+%Olig); and Percent Primary Clingers (%Clingers). Table 9 lists these metrics and defines their function and response to disturbance.

Table 9. Metrics to Develop an MBI for Water Quality Analysis and Responses to Disturbances

Metric	Function	Response to Disturbance
G-TR	Refers to total number of taxa present	Negative
EPT	Number of taxa within these pollution-sensitive insect orders	Negative
mHBI	Assesses impacts other than organic enrichment	Positive
m%EPT	Measures relative abundance of pollution-sensitive organisms	Negative
%EPHEM	Measures impacts in response to metals and high conductivity	Negative
%Chir+%Olig	Measures relative abundance of pollution tolerant organisms	Positive
%Clingers	Habitat metric for organisms that need hard silt-free substrate	Negative

Similar to the habitat assessment, KDOW stipulates specific times of the year when benthic macroinvertebrate should be collected to obtain accurate, comparable results for wadeable and headwater streams. Benthic macroinvertebrate collection for wadeable streams should be conducted from June 1st until September 30th and headwater streams from March 1st until May 31st.

3.3. PHASE ONE MONITORING

The new sampling data collection for the LHCWMP began with Phase One monitoring. Phase One monitoring allowed for sampling and analysis at a broad scale and helped to make general assessments of the watershed. The assessments resulting from Phase One monitoring aided in the selection of sub-watersheds for a more detailed examination during Phase Two monitoring. Six sites were selected in LHCW along the main channel for Phase One monitoring. Sites were selected for a variety of factors, including location of suspected contaminant discharge, sampling location from previous studies, and location of tributary confluences. The Phase One monitoring sites are identified as Site 1 through Site 6 on the map in Figure 27 on the next page and will be discussed in detail below.

Site 1 is located on the LHC Nature and Heritage Preserve. Site 1 is located approximately 660 linear feet downstream of the confluence with the tributary locally known as Deep Branch and 2,200 linear feet upstream of the confluence with the Kentucky River. Site 1 is in the vicinity of three historical sampling locations: DOW04022007, KRWW 941 (K211), and Site 3 of in the 2007 Walker study (DW3). The site is accessible from a trail on the LHC Nature and Heritage Preserve beginning at the Hall's on the River Restaurant parking lot. Site 1 is located within the

Figure 26. Site 1 Facing Upstream

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FIGURE 27
LOWER HOWARDS CREEK WATERSHED
MONITORING LOCATIONS

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section of LHC classified as Exceptional Waters and Outstanding State Resource Water by KDOW due to its location within the LHC Nature and Heritage Preserve. Site 1 is characterized by a mostly cobble substrate, with limited access to the floodplain on the right bank. The right bank is also very unstable with evidence of bank erosion, lacking vegetative cover and sufficient root depth along the face of the bank. Figure 26, on page 53, is taken at Site 1 looking upstream towards Deep Branch depicting the problematic right bank. Other areas on the LHC Nature and Historic Preserve have limited floodplain access due to the geology of the area. In some areas, one bank is a vertical rock wall which does not allow for access to the floodplain. Due to the protection provided by the KSNPC the riparian zone is expansive with no nearby development or human disturbances. The LHC Nature and Heritage Preserve has a program dedicated to control of invasive plant species. Little to no invasive plant species were observed during site visits and sampling events.

Site 2 is located on a privately owned agricultural property, primarily used for cattle grazing. Site 2 is located at approximately RM 2.65 and 200 linear feet downstream of the confluence with the tributary locally known as West Fork. Site 2 is located where LHC shifts from being classified as an Exceptional Water and Outstanding State Resource Water to 303(d) listed for impairment due to unknown causes, nutrient/eutrophication biological indicators, and organic enrichment (sewage) biological indicators. No existing sampling locations have been located in the vicinity of Site 2. Access to Site 2 is across private agricultural property with no gravel or paved road for approximately one mile, causing difficulties when trying to reach the site under wet conditions. To respect the property owner and limit damage to the fields, a vehicle was not taken to Site 2 during wet conditions. The only way to access the site during wet conditions was by foot, adding a significant amount of travel time to the sampling events. If the monthly sampling events were completed during wet conditions, samples at Site 2 had to be taken at a later day to ensure all collected samples met the required hold times. Site 2 is characterized by a cobble and boulder substrate, with access to the floodplain on both sides of the channel. Cattle have access to this portion of LHC at various times of the year. The property owner rotates the cattle through several fields, so access is only when the cattle are in the field adjacent to the stream. The riparian zone extends on the right and left banks, with no nearby development or human disturbances. The riparian zone appears to be natural and undisturbed except by the cattle. Similar to areas of the LHC Nature and Heritage Preserve, portions of this property outside of the immediate vicinity of Site 2 have limited access to the floodplain due to the natural geology of the region. Invasive species, such as bush honeysuckle, were identified within the riparian

Figure 28. Site 2 Facing Downstream

zone. A few limited areas of unstable banks are located near Site 2. The area of most instability is located on West Fork, just above the confluence with LHC. Cattle often cross the stream in this area to reach another portion of the field causing bank trampling and erosion. Figure 28, on page 57, is taken at Site 2 looking downstream.

Figure 29. Site 3 Facing Downstream

Site 3 is located in a rural area directly upstream of the culvert under Old Stone Church Road. The historic Old Stone Church is located in close proximity to the sampling location and was in the area of study for the 2003 USACE Louisville District Flood Plain Management Service Program Special Study for Winchester, Kentucky. The area was found to have minimal flooding risk to the Old Stone Church. Site 3 is located at approximately RM 5.0 and is within the section of LHC designated as impaired and 303(d) listed. Site 3 is in the vicinity of two historical sampling locations. KRWW 942 (K212) is located at approximately the same location as Site 3. DOW04022005 is located approximately 1,800 linear feet downstream of Site 3. Site 3 is easily accessible from Old Stone Church Road. Figure 29 depicts Site 3 looking downstream towards Old Stone Church Road. Site 3 has a mostly bedrock substrate with gravel and cobbles in the riffle complexes. The property owners indicated that large gravel loads often deposit in the vicinity of the culvert under Old Stone Church Road. Gravel deposits have occasionally been mechanically removed in the past by the property owner. The stream has access to the floodplain on both sides, but has limited riparian zone. The riparian zone is only limited for a small stretch, approximately 200 linear feet, in the immediate vicinity of the sampling location. On the left, the riparian zone is limited due to Old Stone Church Road and a private drive. On the right, the riparian zone is limited due to a residence and the surrounding maintained yard. Outside of this area, the riparian zone is mostly undisturbed and not limited due to human influences. Invasive species, such as bush honeysuckle, were identified within the riparian zone.

Site 4 is located on private property in a rural area of the watershed. Site 4 is approximately 200 linear feet downstream of the Waterworks Road bridge and 350 linear feet below the lower impoundment area of the Carroll E. Ecton Reservoir. The flow at Site 4 is directly influenced by leakage of the reservoir. Site 4 is in the immediate vicinity of three historical sampling locations: KRWW 3006, KRWW 3007, and DOW04022019. The two KRWW sites are located in close proximity due to the suspected presence of a straight pipe or failing septic system. Site 4 is located at approximately RM 6.2 where the stream transitions from being designated as impaired and 303(d) listed to a high quality water. Waters in Kentucky default to being designated as high quality if they are not designated as an outstanding national/state resource, exceptional water, or impaired. Site 4 has a bedrock substrate with no access to the floodplain. It appears that the water has incised a channel into the bedrock which holds the base flow. The banks on either side are steep and partially made up of weathered bedrock as shown in Figure 30. Even with the high velocity flows created by no access to the floodplain, the banks appear stable due to the composition. The riparian zone is limited on the right bank due to a residence and surrounding yard. The WTP is located on the left bank approximately 400 linear feet upstream, directly adjacent to the Carroll E. Ecton Reservoir. The riparian zone on the right bank is undisturbed at the sampling location, but becomes limited approximately 100 linear feet upstream due to the WTP and equipment. Invasive species, such as bush honeysuckle and garlic mustard (Alliaria petiolata), were identified within the riparian zone.

Figure 30. Site 4 Facing Upstream

Site 5 is located 200 linear feet downstream of the Patton Lane low water crossing at approximately RM 7.5. Site 5 was originally located just upstream of the low water crossing at Patton Lane. The first three months of sampling data was collected at this location. In November 2011, the sampling location had to be moved downstream due to debris blockage of the low water crossing, creating a large area of stagnant water in the sampling location. The location was moved to

Figure 31. Site 5 Facing Upstream

allow for the water samples to be collected in an area of flowing water. Figure 31 was taken from Site 5 facing upstream towards the low water crossing at Patton Lane. Site 5 is located on an undeveloped portion of the property were the new Clark County high school is currently being constructed. A new gravity trunk sewer, which is being installed as a part of the LHC WWTP, was also under construction directly adjacent to the left bank during the time sampling was conducted for this report. No historic sampling locations are in the vicinity of Site 5. At Site 5, the watershed begins to transition from rural, mostly agricultural land to more urban, residential areas. Site 5 has a gravel and cobble substrate with limited access to the floodplain and limited riparian zone on the right bank. Old Boonesboro Road runs parallel with the stream along the right bank, causing high velocity flows during storm events in some areas due to steep, high banks. The right bank approximately 100 linear feet downstream of Site 5 is very steep and within 10 feet of the edge of pavement of Old Boonesboro Road. It appears that an attempt to stabilize this area was made using quick setting concrete on the bank. The bank is shown in the background of Figure 33 on page 61 of this report. The stream has access to the floodplain on the left bank, but due to the recent construction of the new gravity sanitary sewer the riparian zone was disturbed and much of the natural vegetation was removed. No future construction or development is planned for this area, so the native vegetation should return over the coming years. A large amount of excessive algae growth was observed in the stream during sampling in February, March, and April 2012.

Site 6 is located approximately 200 linear feet upstream of the culvert under the Winchester Bypass (KY 1958) in an urban, residential area at approximately RM 9.4. Site 6 is located higher in the watershed than any of the historic sampling locations. Site 6 is located in the Hampton Manor neighborhood and the left bank is adjacent to a church. The stream has access to the floodplain, but no riparian zone on the right bank and limited riparian zone on the left bank as shown in Figure 32. Site 6 is typical of the stream in the urban, residential portions of the watershed. Manicured lawns extend to the edge of water in many locations. Similar to Site 5, excessive algae growth was observed in the stream during sampling in February, March, and April 2012. The substrate is mostly made up of gravel and cobble. The stream banks in the vicinity of Site 6 are vegetated and stable. Residents in the area reported that they have seen neighbors disposing of yard waste by dumping into the stream. Evidence of grass clippings in the stream was observed during sampling events.

Figure 32. Site 6 Facing Upstream

The Phase One sites were sampled on a monthly basis beginning in August 2011 and continuing through July 2012 for the parameters listed in Table 8. The Phase One monitoring results are located in

APPENDIX G and will be discussed in detail in Section 4.1. During the 12 months of sampling, the project team aimed to collect two wet weather samples and two dry weather samples. Wet weather, as defined in the *Watershed Planning Guidebook for Kentucky Communities*, is a "seven-day antecedent dry period (in which no more than 0.1 inch of precipitation occurs) followed by visible run-off conditions, such as sheet flow on impervious surfaces and visible surface flow in ephemeral channels." Dry weather, as defined in the *Watershed Planning Guidebook for Kentucky Communities*, is a "seven-day dry period, in which no more than 0.1 inch of precipitation occurs. Only one wet weather sample was able to be collected (December 2011) due to the required dry period prior to sampling, very dry conditions in 2012, laboratory availability, and scheduling conflicts. Wet weather sampling at Site 2 could not be conducted due to difficulties accessing the site and required sample hold times. Dry weather samples were collected in October 2011, April 2012, and June 2012. In addition to the monthly E. coli sampling, five E. coli samples were collected within a 30 day period in May 2012. This additional sampling is required during May or June by the *Watershed Planning Guidebook for Kentucky Communities* to ensure a sufficient number of samples were obtained during primary contact recreation season.

Samples were only collected when there was visible flow between the pools of the stream; however, samples at Site 5 and Site 6 were collected from pooled water during some sampling events due to an insufficient amount of flow between pools. This data was not used in load calculations. There were also instances where there was visible, but immeasurable flow at Site 5 and Site 6 due to the excessive algae growth and limitations of the Flow Watch meter. In these instances, the flow was approximated at 0.1 cubic foot per second. The sampling events where there was no or immeasurable flow are identified in the data located in APPENDIX G. Biological and habitat assessments were completed at Sites 1, 2, 3, and 4 in August 2011 and at Site 6 in March 2012. The habitat assessment at Site 5 was completed in April 2012, but the biological assessment could not be performed due to the presence of the algae previously noted. The algae was completely covering the substrate, making it impossible to identify the location of riffle complexes. Figure 33 shows the condition of the stream at Site 5 on April 4, 2012. During the sampling event on May 8, 2012, the presence of algae at both Site 5 and Site 6 was greatly reduced from the previous sampling events. The algae remained at lower levels through the sampling event on May 17, 2012.

Figure 33. Site 5 Facing Downstream

According to Temperature and Precipation Rankings from the National Oceanic and Atmospheric Adminstration (NOAA), 2011 was the wettest year on record in the Bluegrass Division (Kentucky Climate Division 3). NOAA reports that the region received 64.09 inches of precipitation in 2011. The twentith century annual average precipitation for the region is 45.34 inches. For the portion of 2011 when monitoring was completed from August through December, the region received 24.37 inches of rain, exceeding the average rainfall for this time of year by eight inches. From January 2012 through April 2012, the region received 12.25 inches of precipitation, over 3.5 inches less rainfall than the average year. The amount of rainfall preceding each sampling event is located in Table 10 on page 67. The region also experienced the warmest winter on record, averaging 42.85°F (6.03°C) from December 2011 through March 2012. The twentith century average temperature from December through March is 36.76°F (2.66°C). The average temperature from August 2011 through April 2012 was 52.01°F (11.12°C), qualifying as the third warmest for these months since 1895. William Crankshaw, a volunteer at the LHC Nature and Heritage Preserve and biologist specializing in vegetation, has kept records of wild flowering blooming dates on the LHC Nature and Heritage Preserve for the past several years. He indicated that the from his records, the plants were blooming approximately three weeks ahead of normal due to the mild winter and continued warm weather. This appeared to be consistent with national reports. The LHC Nature and Heritage Preserve March Newsletter reported that the blue flowers in the creek valley typically peak the second week of April, but this year peaked the fourth week of March.

3.4. PHASE TWO MONITORING

Phase Two monitoring followed Phase One monitoring and involved the selection of sub-watersheds for further monitoring and analysis. Ideally, 12 months of Phase One monitoring would be completed and analyzed prior to Phase Two site selection; however, due to the time constraints set forth within the Consent Decree only four months of Phase One monitoring was completed prior to selection of Phase Two monitoring locations. In November 2011, the available monitoring data was analyzed and an additional four sites were selected for Phase Two monitoring. The four Phase Two sites were located on tributaries to LHC in areas of high pollutant loads in Phase One monitoring or in areas of suspected contaminant discharge based on observation, historical significance and resident testimony. The Phase Two sites are identified as Site 7 through Site 10 on the map in Figure 27 and will be discussed in detail below.

Figure 34. Site 7 Facing Upstream

Site 7 is located on the LHC Nature and Heritage Preserve on the tributary locally known as Deep Branch. The confluence of Deep

Branch into LHC is located approximately 660 linear feet upstream of Site 1 and 2860 linear feet upstream of the confluence with the Kentucky River. Site 7 is located approximately 50 linear feet upstream of the confluence of Deep Branch into LHC and in the vicinity of Site 2 of in the 2007 Walker study. Site 7 is located downstream of a large waterfall, receiving water from an agricultural property not a part of the LHC Nature and Heritage Preserve. It was believed that the agricultural property allows cattle access to Deep Branch. Due to the presence of the livestock and elevated bacteria levels in the 2007 Walker study, Site 7 was selected as a Phase Two monitoring location although elevated pollutant levels were not detected at Site 1 during the time period analyzed. Figure 34 is taken from Site 7 facing upstream towards the waterfall. Site 7 is characterized by a gravel and cobble substrate with a steep bedrock right bank. There is no access to the floodplain on the right bank, but ample room on the left bank. Due to the protection provided by the LHC Nature and Heritage Preserve, the riparian zone is expansive with no nearby development or human disturbances on the property. As previously mentioned, the agricultural property upstream of the LHC Nature and Heritage Preserve may present some disturbance due to livestock and fertilizer application. The LHC Nature and Heritage Preserve has a program dedicated to the control of invasive plant species. Little to no invasive plant species were observed during site visits and sampling events. Evidence of garlic mustard removal was observed in April 2012.

Site 8 is located on the same private agricultural property as Site 2 on the tributary locally known as West Fork. The confluence of West Fork with LHC is located at approximately RM 2.65. Site 2 is located approximately 200 feet downstream of the confluence. Site 8 is located approximately 500 feet upstream West Fork from the confluence with LHC. A fence has been installed approximately 50 feet downstream of the sampling location across the stream to limit livestock access to the stream. The fence also runs parallel with the stream banks. The fence across the stream channel appears to have been damaged by high flows or debris in the stream, allowing for partial access for livestock. Figure 35 is taken from Site 8 facing downstream towards the damaged fence. Elevated pollutant levels were seen at Site 2 during the time period analyzed. Site 8 was selected to try to determine if the pollutants were contributed from West Fork or other upstream areas and to determine the effectiveness of attempting to remove the livestock from this portion of the tributary. Similar to Site 2, access to Site 8 is across agricultural fields with no gravel or paved road for approximately one mile, causing difficulties when trying to reach the site during wet conditions. To respect the property owner and limit damage to the fields, a vehicle was not taken to Site 8 during wet

Figure 35. Site 8 Facing Downstream

conditions. The only way to access the site during wet conditions was by foot, adding a significant amount of travel time to the sampling events. For the monthly sampling events completed during wet conditions, sampling at Site 8 had to be completed at a later day to ensure all collected samples met the required hold times. Site 8 has a mostly bedrock substrate with cobble and boulders overlaying. There is limited access to the floodplain with steep slopes on both sides of the channel in most areas in the vicinity of the sampling location. The right bank directly upstream on Site 8 is vertical with barren soil, being particularly susceptible to erosive forces. The riparian zone extends on the right and left banks, with no nearby development or human disturbances. The riparian zone is mostly forested with little area suitable for grazing. No evidence of cattle in the stream channel was observed in the vicinity of the sampling location within the portion enclosed by the fence. As previously discussed with Site 2, an area approximately 250 linear feet downstream of Site 8 on West Fork is unstable due to bank trampling from cattle crossing the stream. This location appears to be the main crossing to the adjacent field with little to no disturbance upstream.

Site 9 is located on an unnamed tributary to LHC in a residential neighborhood near the intersection of Old Boonesboro Road and Fontaine Boulevard. Site 9 is located 150 linear feet upstream from the confluence with LHC and approximately 100 linear feet upstream of the centerline of Old Boonesboro Road. The confluence on the unnamed tributary is at approximately RM 8.2 on LHC. Figure 36 was taken from Site 9 facing upstream. Area residents reported high levels of algae growth and unpleasant smelling, stagnant water in the unnamed tributary, especially during the summer. The unnamed tributary flows through multiple residential properties. Property owners reported seeing other residents dump yard waste into the stream channel. Property owners also reported prior instances of stream straightening and dredging, and they expressed the desire to straighten and dredge the stream again. Site 9 was selected to better assess the possible sources of the residents' complaints and help identify potential remediation techniques. The substrate is mostly made up of gravel and cobbles. The stream appears to have good access to the floodplain, but little natural riparian zone. In most areas, manicured lawns extend to the edges of the bank giving pollutants in the runoff little time to settle out and runoff little time to infiltrate. Evidence of dumped yard waste was observed within the stream channel. High levels of algae growth were also observed, especially in March and April 2012. The algae appeared to be impeding the flow and covering the riffle structure, causing few areas of varying water

Figure 36. Site 9 Facing Upstream

speeds and depths. The algae growth was not as excessive as at Site 5 and Site 6. There was no water in the stream during several sampling events, so no samples were able to be collected at those times.

Site 10 is located on an unnamed tributary to LHC in the right of way of Boonesboro Road (KY 627). The unnamed tributary's confluence with LHC is at approximately RM 9.0. Site 10 is located 150 linear feet upstream from the confluence with LHC and 50 linear feet below a bridge for a driveway. Site 9 is located approximately 550 linear feet upstream of the historical sampling location DOW04022012, although the historical sampling site is located on the main channel of LHC. Site 10 is located downstream of some agricultural properties, an area of commercial development, and an area of residential development with both single-family and multi-family units. Site 10 is downstream of the highest volume SSO within the watershed associated with Snowfall Pump Station. Snowfall Pump Station is located on the main channel of LHC, so Site 10 is not affected by overflow directly from the pump station. However, the manhole immediately upstream of Snowfall Pump Station is located 400 linear feet upstream the unnamed tributary from Site 10. Per WMU, this manhole often overflows when Snowfall Pump Station overflows. WMU does not track the overflow of this manhole separate from the Snowfall Pump Station. This SSO will be removed when Snowfall Pump Station is decommissioned as a part of the startup of the LHC WWTP, which is scheduled to occur prior to January 31, 2013. Site 10 was selected to help assess the pollutant load from the mixed uses upstream and determine the effect of the SSO removal. The substrate is made up of silt, gravel, and cobbles. The banks are vertical and high, limiting access to the floodplain. Portions of the banks lack vegetative cover and are susceptible to erosive forces. It appears that the stream may have been modified in the area of Site 10 to follow the road right of way. The riparian zone width varies, but is more natural than in the other urban sites. The vegetation is allowed to grow with limited cutting. Portions of the right of way are well vegetated and appear to have less maintenance for visual appeal. Figure 37 was taken at Site 10 looking downstream towards the confluence with LHC. Some algae growth was observed in the stream channel, but the growth was much less than at Sites 5, 6, and 9. Site 10 is located downstream of an area where there are agricultural, residential, and commercial land uses. An agricultural property where sheep are raised is located directly adjacent to Site 10.

Figure 37. Site 10 Facing Downstream

The Phase Two sites were sampled on a monthly basis beginning December 2011 and will continue through November 2012 for the parameters listed in Table 8. The sampling will continue beyond the date of this report and be included as an addendum once completed. This report must be compiled prior to completion of the 12 months of sampling to meet the requirements of the EPA as set forth in the Consent Decree. The Phase Two monitoring results as of the date of this report are located in APPENDIX H and will be discussed in Section 4.4.

During the 12 months of sampling, the project team aimed to collect two wet weather samples and two dry weather samples. Wet weather, as defined in the *Watershed Planning Guidebook for Kentucky Communities*, is a "seven-day antecedent dry period (in which no more than 0.1 inch of precipitation occurs) followed by visible run-off conditions, such as sheet flow on impervious surfaces and visible surface flow in ephemeral channels." Dry weather, as defined in the *Watershed Planning Guidebook for Kentucky Communities*, is a "seven-day dry period, in which no more than 0.1 inch of precipitation occurs. Wet weather samples were collected in December 2011 and are planned for October or November 2012. Similar to Site 2, wet weather sampling at Site 8 could not be conducted due to difficulties accessing the site and required sample hold times. Dry weather samples were collected in February 2012 and June 2012. In addition to the monthly E. coli sampling, five E. coli samples were collected within a 30 day period in May 2012. This additional sampling is required during May or June by the *Watershed Planning Guidebook for Kentucky Communities* to ensure a sufficient number of samples were obtained during primary contact recreation season.

Samples were only collected when there was visible flow between the pools of the stream; however, sometimes the flow was visible, but immeasurable because of the limitations of the Flow Watch meter. In these instances, a flow of 0.1 cubic foot per second was utilized for loading calculations. Biological and habitat assessments were completed at Sites 7, 8, and 10 in April 2012 and at Site 9 in March 2012. A full biological assessment was not completed at Site 10 due to limited riffle habitat at the sampling location. A 0.5 square meter benthic macroinvertebrate sample was taken at Site 10 opposed to the typical 1.0 square meter sample.

According to Temperature and Precipation Rankings from the National Oceanic and Atmospheric Adminstration (NOAA), December 2011 through March 2012 was the warmest winter on record in the Bluegrass Division (Kentucky Climate Division 3). Temperatures in the region averaged 42.85°F (6.03°C) from December 2011 through March 2012. The twentith century average temperature from December through March is 36.76°F (2.66°C). From January 2012 through April 2012, the region recieved 12.25 inches of precipitation, over 3.5 inches less rainfall than the average year. The amount of rainfall preceding each sampling event is located in Table 10 on page 67.

3.5. MICROBIAL SOURCE TRACKING

During the analysis of the Phase One sites for Phase Two site selection, it was determined that it would be beneficial to determine the presence or absence of human fecal waste. Elevated levels of E. coli were received at several sites during the period analyzed for Phase Two site selection, but the source of the E. coli was not known. Microbial source tracking provided a way to identify samples that were indicative of contamination from human fecal waste, using fecal load, age, and source. The procedures used were developed by Dr. Gail Brion at the University of Kentucky and applied to numerous local watersheds over the past 18 years with excellent results. The model developed to evaluate the resulting fecal load, age, and source signals obtained from any single sample provide a metric to estimate how close the analyzed sample is to raw human sewage by issuing a Sanitary Category Value (SCV). SCVs are between 0 and 3.00 for each location and observation. In the *Final Report and Executive Summary to Palmer Engineering on Water Quality Study on Lower Howards Creek*, Dr. Gail Brion describes, “The SCV calculated by the model was compromised of values between zero to one for each of the three indicator classes [fecal load, age, and source] selected…Low SCVs (<1.0) are related to conditions associated with cleaner surface waters (low fecal load, little detectable human signal, and old fecal age). High SCVs (>1.5) are associated with higher values of fecal load, a greater detectable value for human specific qPCR markers, and a lower fecal age." Midpoint values (0.5) for each indicator class act as a threshold of concern. Historic results of influent wastewater flow at the Town Branch WWTP in Lexington, Kentucky were used for comparison. After SCVs were assigned, they were used to assist in ranking water quality at the sites relative to each other and influent wastewater at the WWTP. Details of the tests conducted are located in Section 3.2.1. The results of the MST and report prepared by Dr. Gail Brion of the University of Kentucky are located in APPENDIX I and will be discussed in Section 4.5. MST was not in the original scope of sampling nor was it required by the *Watershed Planning Guidebook for Kentucky Communities*. However, these results provide a more complete picture of the fecal sources impacting the watershed.

Sites were selected for MST in February 2012. Sampling results from August 2011 through January 2012 were analyzed for Phase One sites and from December 2011 and January 2012 for Phase Two sites. Due to budget constraints only five sites were able to be included in the MST. Sites 2, 4, 5, 6 and 10 were selected to receive additional testing and analysis due to elevated levels of E. coli noted from previous sampling events. The sites selected provided two rural sites (Sites 2 and 4), two urban sites (Sites 6 and 10), and one site located close to the transition from rural to urban (Site 5).

Table 10. Rainfall Preceding Sampling

Date	Sampling Event	Rain in Last 48 Hours (in)	Rain in Last 5 days (in)	Rain in Last 7 days(In)	Rain During Sampling (in)	WMP Sample Type
8/26/2011	1	0.37	0.47	0.47	0.00	Routine
9/8/2011	2	0.70	3.07	3.07	0.00	Routine
10/6/2011	3	0.00	0.00	Trace	0.00	Dry
11/1/2011	4	0.02	0.44	1.25	0.00	Routine
12/15/2011	5	0.00	0.00	0.00	0.37	Wet
1/16/2012	6	0.04	1.15	1.15	0.00	Routine
2/23/2012	7	0.00	0.06	0.12	Trace	Dry
3/21/2012	8	0.00	0.85	1.45	0.00	Routine/MST Dry
4/4/2012	MST-A	0.00	0.15	0.15	0.00	MST Dry
4/11/2012	9	0.00	0.00	0.45	0.00	Dry/MST Dry
4/27/2012	MST-B	0.05	0.20	0.68	0.00	MST Dry
5/3/2012	10	0.00	0.40	0.62	0.00	Routine/MST Dry
5/8/2012	10A	0.12	1.00	1.25	0.15	Routine/MST
5/10/2012	10B	0.15	0.27	1.15	0.00	Routine/MST Dry
5/15/2012	10C	1.55	2.00	2.27	0.00	Routine
5/17/2012	10D	0.00	2.00	2.00	0.00	Routine
6/27/2012*	11	0.00	0.00	0.00	0.00	Dry
7/24/2012*	12	Trace	0.05	0.80	0.00	Routine
8/23/2012*	13	0.05	0.05	0.05	0.00	Dry
8/28/2012*	MST-C	0.50	0.50	0.55	Trace	MST Wet
9/04/2012*	14	0.94	0.94	1.44	0.00	Routine

*Data from Kentucky Mesonet (http://www.kymesonet.org)

MST included sampling six times during dry weather on March 21, 2012, April 4, 2012, April 11, 2012, April 27, 2012, May 3, 2012, and May 8, 2012. Dry weather was defined as receiving less than 0.5 inches of rain in the past 24 hours and less than 1.0 inches of rain in the past five days. Wet weather sampling was conducted on August 28, 2012 immediately following a 0.5 inch rain event. Wet weather was defined as receiving more than 0.5 inches of rain during a storm event with visible flow in ephemeral channels. The amount of rainfall preceding each sampling event is listed in Table 10. Rainfall information was recorded from the USGS gaging station on the Kentucky River at Lock 10 (Site #03284000) for sampling events from August 2011 through May 2012. Due to website unavailability and the gage not recording precipitation data, rainfall information from June 2012 through September 2012 was recorded from the Clark County station on the Kentucky Mesonet website. MST samples were initially screened by determining the amount of E. coli and the AC/TC ratio. The samples taken on March 21, 2012, April 4, 2012, and April 11, 2012 did not meet internal quality control standards for the AC/TC tests due to problems with the media supplied by an external vendor. The results from these AC/TC tests are not included in this report. The amount of E. coli present and fecal source results (HuBac and qHF183) in these samples were still used in the analysis because these analyses were not compromised and met all quality control standards. SCVs could not be assigned to these samples due to the absence of a valid AC/TC result. Only four sampling events were planned to be included in the MST analysis, but due to the quality control issues with the first three samples AC/TC analyses, an additional three samples were taken to replace these initial samples so that complete data on fecal load (E. coli), fecal age (AC/TC), and fecal source (relative HuBac) could be used in the model to calculate SCVs for each site.

4. ANALYSIS

4.1. ANALYSIS OVERVIEW

To evaluate the nature and level of the impairments within LHCW, it was necessary to compare the monitoring results with a set of water quality benchmarks. The water quality benchmarks used for LHCW are a combination of documented legal limits and recommended benchmarks from KDOW.

The legal limits for surface water standards are published in 401 KAR 10:301. As stated in 401 KAR 10:031, this "regulation establishes water quality standards that consist of designated uses of the surface waters of the commonwealth and the associated water quality criteria necessary to protect those uses." The parameters listed for warm water aquatic habitat and primary contact recreation waters were used as benchmarks for comparison. The regulation lists specific numeric parameters for E. coli, pH, dissolved oxygen, and temperature. These values are listed in Table 11. No specific values are listed in 401 KAR 10:031 for specific conductivity, flow, and total suspended solids, but it is indicated that levels "shall not be changed to the extent that the indigenous aquatic community is adversely affected." The regulation also specifies that "where eutrophication problems exist, nitrogen, phosphorous, carbon, and contributing trace element discharges shall be limited in accordance with: 1. the scope of the problem; 2. the geography of the affected area; and 3. relative contributions from existing and proposed sources."

KDOW provided nutrient benchmarks for LHCW in the document *Benchmark Recommendations for Nutrient Parameters*, dated September 29, 2011. The benchmarks provided were "estimates of typical in-stream concentrations below which it is unlikely that nutrients are a cause of observed impairments." Several factors were used to develop these recommendations, including regional and watershed specific nutrient expectations, indicators of nutrient enrichment found in the watershed, and regional scale patterns in biological effects. The document indicated that nutrient concentrations vary widely within the Bluegrass bioregion, so the published Bluegrass draft guidelines may not be applicable in LHCW. According to KDOW, higher levels of nutrients can still support good quality aquatic communities in streams in the Inner Bluegrass with good in-stream habitat and intact riparian zones. The document provided final benchmark recommendations for total phosphorous, TKN, nitrate-nitrite-nitrogen, and total nitrogen specific to LHCW as listed in Table 11.

KDOW provided benchmark recommendations for non-nutrient parameters for LHCW in the document *Benchmark Recommendations for Non-Nutrient Parameters*, dated September 29, 2011. As recommended, the 75th percentile of the combined Bluegrass bioregion was the reference used for non-nutrient parameters with no numeric standards. Since LHCW is part of more than one ecoregion, the Inner Bluegrass, Outer Bluegrass, and Hills of the Bluegrass were combined to estimate the regional expectations. The total suspended solids and turbidity benchmark was only applicable under normal flow conditions occurring from April to October. Not enough information was available for a high flow or winter benchmark recommendation. The document provided recommendations for ammonia-nitrogen, specific conductivity, total suspended solids, and turbidity as listed in Table 11. The document advised that "benchmarks for data screening and prioritization may be lower than those listed to be used ultimately as targets for reduction in the watershed plan, since reference conditions may be well below reductions necessary to restore uses."

Table 11. Project Water Quality Benchmarks

Parameter	Min Limit	Max Limit	Notes	Source
E. Coli	---	240 colonies/100 ml	Shall not exceed 130 colonies/100 ml as a geometric mean based on not less than five samples taken in 30 days	401 KAR 10:031
Nitrate-Nitrite-N	---	2.0 mg/L		LHC Nutrient Benchmarks
Ammonia-Nitrogen	---	0.05 mg/L		LHC Non-nutrient Standards
TKN	---	0.50 mg/L		LHC Nutrient Benchmarks
Total Phosphorous (TP)	---	0.25 mg/L		LHC Nutrient Benchmarks
OP	---	---	No specific legal or local standard	
Total Nitrogen (TN)	---	2.5 mg/L		LHC Nutrient Benchmarks
BOD	---	10.0 mg/L	No specific legal or local standard	
TSS	---	10		LHC Non-Nutrient Standards
Stream Discharge	---	---	No overall specific stream discharge requirements; varies based on drainage area size and characteristics	
Turbidity	---	8.7		LHC Non-Nutrient Standards
pH	6.0	9.0	Cannot vary more than 1.0 units over a 24 hour period	401 KAR 10:031
DO	5.0 mg/L*	---	Instantaneous minimum shall not be less than 4.0 mg/L	401 KAR 10:031
Conductivity	---	505 (µS/cm)		LHC Non-Nutrient Standards
% Saturation	---	---	No specific legal or local standard	
Temperature	---	31.7 C (89 F)		401 KAR 10:031
Habitat Assessment (RBP Scoring)	130 (wadeable) 156 (headwater)	---	Habitat rating of good	DOWSOP03024
Biological Assessment (MBI Scoring)	61 (wadeable) 49 (headwater)	---	Biological classification of good or excellent	Kentucky Macroinvertebrate Bioassessment Index

*Outstanding State Resource Waters have a standard of 5.0mg/L instantaneous and 6.0 mg/L as 24-hour average

The habitat assessment benchmark was specified as receiving a "good" rating as listed in *Methods for Assessing Habitat in Wadeable Waters* (DOWSOP03024), dated March 2011. The habitat parameters were assessed and cumulative score designated as "good", "fair", or "poor" according to the ratings as shown in Table 12. The biological assessment benchmark was specified as receiving an "excellent" or "good" rating as listed in *The Kentucky Macroinvertebrate Bioassessment Index*, dated September 2003. Similar to the habitat parameters, the biological parameters were assessed and the cumulative score designated as "excellent", "good", "fair", "poor", or "very poor" according to the ratings as shown in Table 13.

Table 12. Habitat Ratings

Rating	Headwater (<5.0 sq. miles)	Wadeable (>5.0 sq. miles)
Good	≥ 156	≥ 130
Fair	142-155	114-129
Poor	≤ 141	≤ 113

Table 13. Biological Ratings

Rating	Headwater (<5.0 sq. miles)	Wadeable (>5.0 sq. miles)
Excellent	≥ 58	≥ 70
Good	51-57	61-69
Fair	39-50	41-60
Poor	19-38	21-40
Very Poor	0-18	0-20

No specific legal limit or local standard was available for orthophosphate, stream discharge, percent saturation, or BOD. There are no existing stream gaging sites within LHCW, so there was no available comparison for the flow information collected. Since 10 mg/L is a common KPDES permit limit for BOD, this value was selected to evaluate the BOD levels within LHCW.

4.2. PHASE ONE ANALYSIS

4.2.1. COMPARISON TO WATER QUALITY BENCHMARKS

Phase One monitoring began in August 2011 and continued through July 2012 at Sites 1 through 6. The critical parameters identified in Table 8 where collected and then compared with the project water quality benchmarks in Table 11. APPENDIX G contains a summary table for monitoring results at each site. Parameters that exceeded water quality benchmarks are highlighted red. All critical parameters had at least one occurrence of exceeding water quality benchmarks. E. coli and conductivity exceeded water quality standards at least twice during the monitoring period at every site. No sites exceeded the water quality benchmarks for BOD or turbidity more than once. Table 14 shows the number of sampling events that exceeded the water quality benchmarks for each site. The first number represents the number of events exceeding water quality benchmarks and the second number represents the total number of sampling events (exceedances/number of samples). A total of twelve full sampling events were completed, but the total number varies in some instances due to additional E. coli collection requirements, MST sampling, dry or no flow conditions, and limited equipment malfunction. Total suspended solids and turbidity were sampled at each of the twelve monthly sampling events, but the benchmarks are only valid for comparison from April through October. The project team determined that exceeding the water quality benchmark more than once (a possible anomaly) indicated a potential issue. The shading in Table 14 indicates that the critical parameter exceeded the project water quality benchmark at least twice at the indicated site.

Table 14. Phase One Number of Events Exceeding Water Quality Benchmarks

Site #	E. coli	Nitrate-Nitrite-N	NH3-N	TKN	TN	TP	BOD	TSS	Turbidity	Conductivity	DO
1	2/16	3/12	1/12	0/12	3/12	2/12	0/12	1/7	0/7	3/16	1/16
2	5/19	4/12	0/12	0/12	3/12	2/12	0/12	1/7	0/7	2/16	0/16
3	2/16	0/12	0/12	1/12	1/12	2/12	0/12	1/7	1/7	2/15	0/15
4	9/19	0/12	6/12	3/12	1/12	2/12	1/12	2/7	1/7	2/17	1/17
5	8/17	1/10	4/10	1/10	1/10	2/10	0/10	1/5	1/5	11/16	5/16
6	11/17	0/10	2/10	1/10	0/10	1/10	1/10	1/5	0/5	15/16	2/16

Large algae blooms were observed during the monitoring period displaying excessive growth, especially at Site 5 and Site 6, but elevated levels of nutrients were not found in the water samples. Evidence of increased algae growth was seen throughout the watershed, even extending down to the LHC Nature and Heritage Preserve in April and May 2012. Most of the occurrences where the nutrient water quality benchmarks were exceeded took place from August 2011 through January 2012 prior to the appearance of the large algae blooms. The DO levels were affected by the algae blooms. Dissolved oxygen was greater than 14 mg/L at Site 5 and Site 6 from February to April 2012. As the algae died off near the beginning of May 2012, the DO levels dropped. During the five sampling events in May 2012, the DO at Site 5 was less than 5.0 mg/L four times. The decrease in DO appears to correspond with an increase in bacteria. E. coli exceeded water quality standards in four of the five samples from Site 5 and in all five samples from Site 6 during May 2012.

Five E. coli samples were taken within 30 days to assess the presence of bacteria during primary contact recreation season in accordance with the requirements set forth in *Watershed Planning Guidebook for Kentucky Communities*. The arithmetic and geometric means for the five E. coli samples taken in May 2012 are listed in Table 15. Sites 4, 5, and 6 exceed the geometric mean benchmark of 130 MPN/100 mL for five samples in a 30 day period.

Table 15. Phase One E. coli Primary Contact Recreation Season Mean Values

Site #	Arithmetic Mean (MPN/100 mL)	Geometric Mean (MPN/100 mL)
1	117	90
2	177	93
3	152	99
4	687	417
5	2205	717
6	2092	1812

During the sampling event on May 3, 2012, E. coli samples were collected for MST and E. coli analysis only. The samples were taken at the same time, but were not split. The samples were processed by two separate laboratories. Both laboratories provided E. coli values for Sites 2, 4, 5, and 6. Some of the results did not correspond, especially at Site 5. One laboratory reported an E. coli value of 100 MPN/100 mL, where a 1:100 dilution was used. The other laboratory reported a value of 8,664 MPN/100 mL, where a 1:10 dilution was used. Both laboratories verified that quality control measures were followed. The project team hypothesizes that sampling occurred during a clumping event where bacteria levels varied greater through the sample and the 1:100 sample was over diluted. The sampling occurred at the time the large algae blooms were detaching and beginning to decay. The clumping event may have occurred due to capture by extracellular materials produced by the algae. Four of the six times MST samples were collected, E. coli was also tested at a separate laboratory. All other results correlated within acceptable limits. For the purpose of assessment, the higher E. coli values are reported in the sampling results and were used for analysis and calculations.

To ensure quality control in the laboratory testing, blank and duplicate samples were collected and analyzed in accordance with the *Quality Assurance Project Plan for the Lower Howards Creek Watershed Management Plan*. One blank and one duplicate sample were collected and analyzed every quarter. During the additional E. coli sampling conducted in May 2012, one blind duplicate sample was collected and analyzed. As previously discussed, an additional quality control check for the E. coli testing was provided by the MST sampling results. All quality control testing results were within acceptable tolerances except for the one instance discussed above. The quality control for Phase One and Phase Two was combined and the results are located in APPENDIX G.

Habitat was assessed at Sites 1 through 6 and compared with benchmarks listed in Table 12. Three of the six sites scored below a "good" rating in accordance with *Methods for Assessing Habitat in Wadeable Waters* (DOWSOP03024), dated March 2011. Table 16 identifies the scoring value for each habitat parameter. The orange shading represents a "poor" rating (numeric value from zero to five). The blue shading represents a "marginal" rating (numeric value from six to 10). The green shading represents a "suboptimal" rating (numeric value from 11 to 15). The purple shading represents an "optimal" rating (numeric value from 16 to 20). Epifaunal substrate/cover, embeddedness, frequency of riffles/bends, and riparian zone vegetation width were the habitat parameters of the greatest concern at these locations.

Table 16. Phase One Habitat Assessment

Site #	Habitat Parameters											Rating	Stream Category
	Epifaunal Substrate / Cover	Embeddedness	Velocity/ Depth Regime	Sediment Deposition	Channel Flow Status	Channel Alteration	Frequency of Riffles / Bends	Bank Stability	Vegetation Protection	Riparian Vegetation Zone Width	Final Score		
1	15	15	16	9	11	19	16	12	13	20	146	Good	Wade
2	16	16	16	11	12	18	14	20	18	20	161	Good	Wade
3	10	11	10	12	16	16	10	17	17	12	131	Good	Wade
4	7	5	11	15	8	11	10	12	8	12	99	Poor	Wade
5	5	1	6	7	12	10	2	8	10	4	65	Poor	Head
6	5	2	10	16	18	12	8	17	13	3	104	Poor	Head

Formal habitat assessment through RBP was only performed at the monitoring locations. To provide an indication of the quality of habitat for stream reaches not monitored, a GIS assessment of riparian vegetation and tree canopy was performed using notes and photographs from the visual assessment completed in December 2012 and aerial imagery. As shown in Figure 38, the riparian zone vegetation was classified as acceptable or limited. Riparian vegetation zones of less than 25 feet on each side of the stream (50 feet total width) were designated as limited. Only intermittent and perennial streams were assessed. According to this analysis, approximately 59 percent of the intermittent and perennial streams in LHCW have limited riparian zone vegetation. Areas with tree canopy and riparian vegetation tend to have higher quality habitat. Based on the riparian vegetation zone analysis, it is estimated that 55 to 65 percent of LHCW would not meet habitat rating benchmarks.

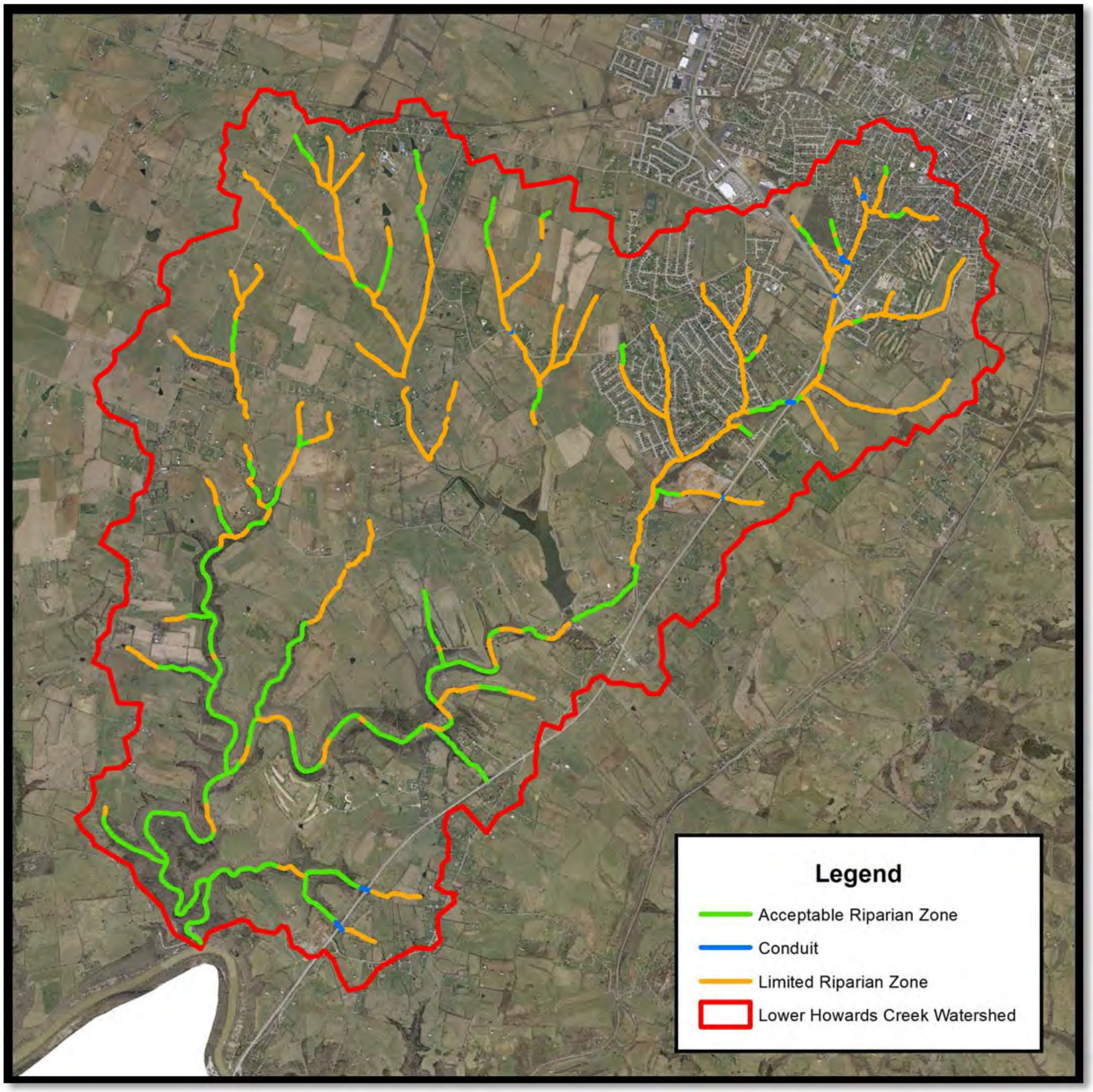

Figure 38. Riparian Zone Evaluation

The benthic macroinvertebrates were assessed and compared with the benchmarks listed in Table 13. As previously mentioned, Site 5 could not be assessed due to the algal growth covering the substrate at the time of assessment. Two of the five sites, Site 4 and Site 6, assessed did not meet biological benchmarks receiving a "poor" rating in accordance with *The Kentucky Macroinvertebrate Bioassessment Index*, dated September 2003. Samples from Site 4 and Site 6 had limited species diversity. Table 17 displays the MBI calculation values for each monitoring location. The %Ephem matrix is only applicable to headwater streams, so the value was not assessed at Sites 1 through 4. Biological assessments were not conducted outside of the monitoring locations.

Table 17. Phase One Biological Assessment

Site #	MBI Calculation Matrices							MBI Score	Stream Rating	Stream Category
	G-TR	G-EPT	mHBI	m%EPT	%Ephem	%C+O	%ClingP			
1	25	10	4.58	45.6	N/A	8	71	70	Excellent	Wadeable
2	18	7	4.36	36	N/A	1	77	66	Good	Wadeable
3	22	8	4.52	35.8	N/A	5	72	66	Good	Wadeable
4	19	4	6.20	12.5	N/A	39	17	35	Poor	Wadeable
5	Did not sample due to dense algal growth on stream substrate									Headwater
6	7	0	6.81	0	0	0	3	23	Poor	Headwater

During sample collection in August 2011, a sheen was observed on the water surface at Site 5. An additional water sample was collected and analyzed for total petroleum hydrocarbons using test method SW-9071B. The test resulted in a value below the minimum detection limit of 0.002 percent, so it was concluded that the sheen did not result from petroleum pollutants. A similar sheen was not observed again at Site 5.

4.2.2. POLLUTANT LOAD PREDICTION

Pollutant load predictions in LHCW were based on the concentration of the pollutant and the stream flow. The concentrations of the pollutants were utilized from the sampling results discussed in Section 4.2.1. Based on the requirements outlined in the *Watershed Planning Guidebook for Kentucky Communities*, pollutant loads were calculated for total nitrogen, total phosphorous, total suspended solids, and E. coli. Conductivity was noted to exceed water quality benchmarks, but pollutant loads were not calculated. Since there were no water gaging stations within the watershed, discharge was estimated using the flow measurements taken at the

Figure 39. Gravel Deposit at Site 1 Facing Upstream

sampling events. Flow data was not able to be collected at the sampling events in August and September 2011, so the mean annual flow was used for load calculations as outlined in *Estimating Mean Annual Flow of Rural Streams in Kentucky*. Table 18 lists the mean annual stream flow and information used to perform the calculation at each of the sites. The mean annual stream flow was only used for load calculations in August and September 2011 when no flow data was able to be collected at the time of sampling. The discharge recorded at each sampling event is recorded in the tables in APPENDIX G. No historical flow information was available due to the absence of a USGS gaging station, so there was no basis for separating flows in low, moderate, and high events. Although Site 1 is downstream of Site 2 the discharge at Site 2 was often greater than Site 1. The project team speculates that this is due to subsurface flow at Site 1. At Site 1 the visible flow channel narrows and a large gravel deposit is present as shown in Figure 39 on page 75. The watershed is also known to have karst features which could also be contributing to the reduction in flow. The flow at Site 1 was especially reduced in comparison with Site 2 during low flow events.

Table 18. Mean Annual Stream Flow

Site	Area (Sq. Miles)	Latitude	Mean Annual Stream Flow (cfs)
1	19.2	37.92253	24.4
2	17.3	37.93344	22.0
3	11.4	37.93928	14.4
4	10.4	37.94654	13.1
5	4.1	37.96087	5.1
6	0.8	37.97869	1.0

Pollutant load predictions and target load reductions for E. coli were derived from the following formula:

$$\underset{\text{(CFU/yr)}}{\text{E. coli Loading}} = \underset{\text{(CFU/100mL)}}{\text{Concentration}} \times \underset{\text{(cfs)}}{\text{Discharge}} \times \underset{\text{(Annual Load Conversion)}}{8{,}907{,}973{,}920}$$

For E. coli loading calculations, the above formula was applied to the data from each sampling event. All sampling events were then averaged using the arithmetic mean to obtain an average annual load. Two samples at Site 4 and one sample at Site 6 had readings of greater than 2420 MPN/100mL because the sample was not diluted prior to processing. It was impossible to estimate the actual value, so 2420 MPN/100mL was used for the load calculations. Although a portion of LHC is on the 303(d) list for impaired streams, no TMDLs have been provided by KDOW. The benchmark of 240 CFU/100 mL was used to calculate the target loads. Based on these calculations, the E. coli loading and target reductions are shown in Table 19. The reduction to achieve the target loading was calculated by subtracting the E. coli loading from the E. coli target loading. The percent reduction target was calculated by dividing the required value for the reduction to achieve the target loading by the E. coli loading present expressed as a percentage. E. coli loadings in the lower potions of the watershed at Sites 1 and 3 are below the E. coli target loadings. E. coli loadings at Sites 2, 4, 5, and 6 exceed E. coli target loading. The high E. coli concentrations found in the upper portions of the watershed do not appear to negatively impact the lower reaches. Sites 2, 4, 5, and 6 were heavily influenced by the sampling data collected on August 28, 2012 immediately following a 0.5 inch rain event. The E. coli concentrations during this sampling event were significantly higher than any other sampling event. This indicates particular concern for E. coli loading during wet weather events. Considering the Phase One sampling data, E. coli is a critical parameter of concern in the upper, developed portions of LHCW, particularly at Sites 4, 5, and 6, but also at Site 2.

Table 19. Phase One E. coli Loading and Target Reductions

Site #	E. Coli Loading (Trillion CFU/yr)	E. Coli Target (Trillion CFU/yr)	Reduction to Achieve Target (Trillion CFU/yr)	Percent Reduction Target
1	14.5	40.2	N/A	N/A
2	78.6	37.4	41.2	52%
3	14.2	19.2	N/A	N/A
4	691.3	22.5	668.8	97%
5	441.0	6.6	434.4	99%
6	29.3	1.5	27.8	95%

Pollutant load predictions and target load reductions for total nitrogen, total phosphorous, and total suspended solids were derived from the following formula:

$$\underset{\text{(lbs/yr)}}{\text{Nutrient/TSS Loading}} = \underset{\text{(mg/L)}}{\text{Concentration}} \times \underset{\text{(cfs)}}{\text{Discharge}} \times \underset{\text{(Annual Load Conversion)}}{1968.80}$$

For total nitrogen and total phosphorous, the above formula was used for each sampling event and then all the values were averaged together to obtain an average annual load. For total suspended solids, the above formula was applied to samples collected in August through October and April through July and then all the values were averaged together to obtain an average annual load. Total suspended solids results from November to March were excluded in accordance with the recommendations from KDOW in *Benchmark Recommendations for Nutrient Parameters*. Some sampling results for total nitrogen, total phosphorous, and total suspended solids were reported to be below the detection limit. Since an exact value could not be assigned to these results, the value of the detection limit was utilized in the load calculations. Although a portion of LHC is on the 303(d) list for impaired streams, no TMDLs have been approved by KDOW. The water quality benchmark concentrations in Table 11 were used for target load calculations, which were: 0.25 mg/L for total phosphorous; 2.5 mg/L for total nitrogen; and 8.7 mg/L for total suspended solids. Based on these calculations, the calculated and target loadings for total nitrogen and phosphorous are shown in Table 20 and for total suspended solids in Table 21.

Table 20. Phase One TN and TP Loadings and Target Loadings

Site #	TN Loading (lbs/yr)	TN Target Loading (lbs/yr)	TP Loading (lbs/yr)	TP Target Loading (lbs/yr)
1	82,588	104,195	9,840	10,419
2	78,790	95,844	7,407	9,584
3	25,540	48,350	3,813	4,835
4	24,251	45,524	3,829*	4,552
5	8,155	14,668	1,465	1,467
6	2,180	4,571	169	457

*TP Loading (lbs/yr) with October 2011 sample was 15,761

Table 21. Phase One TSS Loadings and Target Loadings

Site #	TSS Loading (lbs/yr)	TSS Target Loading (lbs/yr)
1	97,804	239,744
2	111,184	260,050
3	42,487*	148,152
4	70,434**	132,950
5	10,326	51,386
6	2,822	9,188

*TSS Loading (lbs/yr) with the October 2011 sample was 184,471

**TSS Loading (lbs/yr) with the October 2011 sample was 563,665

Total nitrogen loadings were below target loadings at each site. Total phosphorous loadings were below target loadings at all sites except Site 4. The total phosphorous loading is significantly impacted by the October 2011 sample. The samples in October 2011 were collected at the time of disturbance in the lower impoundment at the reservoir. The disturbance ended a few hours after the sampling occurred. If this result is removed, the total phosphorous annual loading was 3,829 pounds per year, falling well within the benchmark annual loading. The project teams feels that the annual load without the October 2011 data is a better representation of the actual conditions at Site 4 and was used for analysis.

As previously noted, extensive algae growth was seen beginning in February 2012 indicating nutrient loads were present. It is suspected that the nutrient input was being immediately consumed by the algal blooms, causing low nutrient readings in the sampling results. Due to the presence of the algal blooms, nitrogen and phosphorous are critical parameters of concern within LHCW.

Total suspended solids loadings were below target loadings at each site except Site 3 and Site 4. As previously discussed, the samples in October 2011 were collected at the time of disturbance in the lower impoundment at the reservoir. The disturbance ended a few hours after the sampling occurred. If this result is removed, the total suspended solids annual loading would be 42,487 pounds per year at Site 3 and 70,432 pounds per year at Site 4. This adjusted loadings fall within the target loadings. The project teams feels that the annual loads without the October 2011 data is a better representation of the actual conditions at Site 3 and Site 4 and was used for analysis. Total suspended solids does not appear to be a critical parameter of concern within LHCW and no further analysis will be performed in this report.

Conductivity is often used to estimate the total ion concentration of surface water and as an alternative measure of dissolved solids. Conductivity can vary as a function of flow. As flow decreases, the concentration of total dissolved solids may also increase, in turn increasing conductivity. Since limited flow data was available, load calculations for conductivity could not be separated into low, moderate, and high flow events because there was no basis for comparison. Elevated conductivity can result from a number of factors, including the geology of the area, failing sewage systems, industrial discharges, fertilization, chemical application, and land disturbance. It is believed that elevated levels of conductivity occur within LHCW due to a combination of the limestone geology and clay soils of the region, and bacteria and nutrient contamination. Due to the limited flow information and suspected causes of contamination, loading for conductivity was not calculated. The practices applicable to reduction in E. coli and nutrient loadings will also address reductions in conductivity loading. Conductivity will not be analyzed separately from E. coli and nutrients in the remainder of this report.

4.2.3. ANALYSIS OF RESULTS

4.2.3.1. E. COLI ANALYSIS

SITE 1

Site 1 had the least significant E. coli impairments. The E. coli load at Site 1 was 64% lower than the target load for the monitoring period. The 30 day geometric average during primary contact recreation season was 31% below the 130 MPN/100 mL requirement. The E. coli concentrations appear to be reduced from those collected in the Daniel Walker Study in 2007. This change was attributed to a change in agricultural practices upstream on Deep Branch and will be discussed in further detail in relation to Site 7. Due to the existing preservation and protection provided by the LHC Nature and Heritage Preserve at Site 1, there should be no sources of input for E. coli except for fecal matter from wildlife such as birds, deer, and other small mammals other than transport from upstream areas. The suspected E. coli sources in order of anticipated greatest contribution are: 1. upstream livestock fecal matter washoff; 2. upstream direct input from livestock in the stream; 3. fecal matter from wildlife; and 4. upstream human fecal inputs. The two occurrences where E. coli surpassed the water quality benchmark of 240 MPN/100 ML occurred when over two inches of rain had been received in the five days prior to sampling. These exceedances were likely caused from upstream inputs. No additional best management practices (BMPs) will be evaluated to address E. coli impairment at Site 1 in this report.

SITE 2

E. coli impairments at Site 2 were of less significance than Sites 4, 5, and 6. Five results exceeded water quality benchmarks, with the largest exceedance in August 2012 during the wet weather MST sampling. The second highest exceedance occurred in September 2011. This sampling event was following a rain event where over three inches of rain was received in the previous five days. The owner of Site 2 raises cattle and rotates them through various fields on his property. One field has direct access to LHC at Site 2. The cattle were in this field at the time of the elevated results in September 2011. One other field has access to a tributary locally known as Dry Fork which flows into LHC prior to Site 2. The cattle have not been rotated back to the field with direct access to LHC since fall 2011, but have had access to Dry Fork at various times throughout the sampling period. The E. coli load at Site 2 was 52% higher than the target load for the monitoring period, but was significantly impacted by August 2012 sampling event. The 30 day geometric average during primary contact recreation season was 28% below the 130 MPN/100 mL requirement. The property owner indicated that the cattle would typically be rotated into the field with access to LHC on a more regular basis then has occurred during the monitoring period. The cattle are normally in this field during each rotation approximately seven to 10 days. He stated that seven to 10 days was the minimum amount of time for the cattle to eat the grass in the field. It is estimated that E. coli loads would increase with a more consistent presence of cattle in the field with access to LHC, but the level of increased impairment is unknown. Site 2 is located at the downstream end of the portion of LHC included on the 303(d) list of impaired waters. One of the cited impairments is organic enrichment (sewage) biological indicators; however, no previous bacteria concentrations or loadings are available at this location. As will be discussed in further detail in Section 4.5, the MST results showed Site 2 had the lowest SCV for any site analyzed (below 0.5 on all dry days). The most specific human source marker, qHF183, was seen at detectable levels in three out of the six uninhibited MST samples, but only at a quantifiable level in one sample. The suspected E. coli sources in order of anticipated greatest contribution are: 1. livestock fecal matter washoff; 2. failing septic systems from upstream inputs; 3. direct input from livestock in the stream; and 4. fecal matter from wildlife. This site was selected for MST to assist with bacteria source identification. Due to the fecal age detected in the MST results, runoff containing fecal matter was suspected as the largest contributor to E. coli loadings. Some human source is also impacting the site, but it is sporadic and dilute. The human source is likely from the failing septic system in the vicinity of Site 4 (to be discussed with Site 4). It is expected that some livestock inputs are occurring between Site 2 and Site 3 because an increase in pollutant yield is seen (4.54 trillion CFU per year per square mile of drainage area at Site 2 and 1.2 trillion CFU per year per square mile of drainage area at Site 3). BMPs will be evaluated later in this report to address E. coli impairments from livestock and protect water quality as it flows into the LHC Nature and Heritage Preserve.

SITE 3

Site 3 had E. coli impairments of less significance than Sites 2, 4, 5, and 6. Two results exceeded water quality benchmarks, with the largest exceedance in September 2011 after receiving three inches of rain in the previous five days. Similar to Site 1, the two occurrences where E. coli surpassed the water quality benchmark of 240 MPN/100 ML were when over two inches of rain had been received in the five days prior to sampling. The owner of Site 3 raises cattle on the property, but there is no evidence that the cattle have access to the creek. The E. coli load at Site 3 was 26% lower than the target load for the monitoring period. The 30 day geometric average during primary contact recreation season was 23% below the 130 MPN/100 mL requirement. Site 3 is located in the portion of LHC included on the 303(d) list of impaired waters. One of the cited impairments is organic enrichment (sewage) biological indicators; however, E. coli loading was within benchmark recommendations for primary contact recreation waters. The suspected E. coli sources in order of anticipated greatest contribution are: 1. livestock fecal matter washoff; 2. failing septic system; 3. Washout from lower impoundment (to be discussed in the Site 4 E. coli analysis); and 4. fecal matter from wildlife. No additional best management practices (BMPs) will be evaluated to address E. coli impairment at Site 3 in this report.

SITE 4

Site 4 experienced E. coli concentrations that exceeded water quality benchmarks in nine of the 19 samples collected during the monitoring period. The largest E. coli loading occurred in August 2012 during the wet weather MST sampling event. The second largest E. coli loading occurred in September 2011 when the concentration exceeded 2,420 MPN/100 mL. Previous sampling by KRWW volunteers had indicated multiple samples in excess of 2,420 MPN/100 mL. A straight pipe or failing septic system was suspected approximately 50 feet upstream of Site 4 by KRWW volunteers prior to sampling for the LHCWMP. Visible drainage can be observed on most days flowing from the weathered rock along the right bank. An older residence is located along the right bank within 100 feet of the stream channel. There is no sanitary sewer service in this area. E. coli concentrations were within water quality standards from November 2011 through April 2012. Elevated levels were reported for four of the five samples during May 2012; however all of these concentrations except for one were below 550 MPN/100 mL. The MST results showed that the most specific human source marker, qHF183, was seen at a detectable level in all uninhibited samples, and was at a quantifiable level in four of the six samples. However, the SCV did not exceed 0.55 in the three dry samples due to relatively low E. coli concentration and old fecal age. The human signal appears to be input in this location without the addition of fecal load or significant lowering of fecal age. This data is consistent with the previous hypothesis of a failing septic system where it seems that small amounts of anaerobically-treated human waste is steadily being input into the creek at this location without adding fecal loading. Dr. Gail Brion suggests that “since the bacteria for the genetic markers are present in quantities more than 1000 times higher than E. coli in fecal material, the bacteria containing the source tracking markers could persist through treatment that removes a significant portion of E. coli. Hence the appearance of source marker signals without a significant increase in E. coli loadings." Since E. coli is only an indicator of the presence of fecal material, low concentrations do not exclude the site from fecal issues when human source signals are consistently obtained. The full MST results will be presented in Section 4.5.

Site 4 is directly below the lower impoundment of the reservoir. In October 2011, the lower impoundment was drained and excessive sediment was removed and disposed of by WMU. Since the drop in E. coli concentrations corresponds with the cleaning of the lower impoundment, it is hypothesized that E. coli concentration may have increased in the lower impoundment prior to cleaning due to ponded water at higher temperatures and excess available nutrients. During high turbulent flows these E. coli were introduced into LHC. This hypothesis is consistent with KRWW data collected during July 2011 where samples collected below the lower impoundment but upstream of the suspected straight pipe or failing septic system were higher than those collected downstream of the suspected straight pipe or failing septic system.

The 30 day geometric average during primary contact recreation season was approximately 3.2 times greater than the 130 MPN/100 mL requirement. The E. coli loading has a target reduction of 97% to meet water quality benchmarks, which was greatly influenced by the wet weather event in August 2012. Site 4 is located at the upstream end of the portion of LHC included on the 303(d) list of impaired waters. The suspected E. coli sources in order of anticipated greatest contribution are: 1. failing septic system; 2. lower impoundment washout during high flow event; and 3. fecal matter from wildlife. There are no livestock between the lower impoundment and Site 4. BMPs will be evaluated later in this report to address E. coli impairments at Site 4.

SITE 5

E. coli concentrations at Site 5 exceeded water quality benchmarks in eight of the 17 samples collected during the monitoring period. The largest E. coli loading was reported during the wet weather MST sampling event in August 2012. The second largest E. coli concentration was reported in the sample collected May 3, 2012. As previously discussed, two E. coli samples were collected at the same time and processed by different laboratories. One laboratory reported an E. coli value of 100 MPN/100 mL, where a 1:100 dilution was used. The other laboratory reported a value of 8,664 MPN/100 mL, where a 1:10 dilution was used. Both laboratories verified that quality control measures were followed. The project team hypothesizes that sampling occurred during a clumping event where bacteria levels varied greatly through the sample and that the 1:100 sample was over diluted. The sampling occurred at the time the large algae blooms were detaching and beginning to decay. The clumping event may have been due to capture by extracellular materials produced by the algae. The stream also had minimal flow during this sampling event. The E. coli loads were all below the 240 MPN/100 mL water quality benchmark when the large algae blooms were present. As the algae detached and decayed the E. coli levels increased. It is suspected that the E. coli levels may have increased due to rising water temperatures and an abundant food source; however an additional source could have been input. The high E. coli levels were accompanied by low DO and high BOD. As will be discussed in Section 4.5 of this report, the AC/TC ratio was the lowest reported value of the samples collected during a dry event, indicating the youngest bacteria age. The SCV was 2.04 during this sampling event, but the fecal source markers were inhibited on this day. The SCV was calculated using the average HuBac value from the non-inhibited, dry samples. The human signal was only above the quantifiable limit during the wet weather event, indicating that human sources may not be a main concern during dry weather.

Table 22. SSOs in LHCW During Monitoring Period

Date	Location	Estimated Overflow Quantity (gallons)	Cause
8/8/2011	Snowfall Lift St	4,560	Mechanical failure
9/26/2011	Snowfall Lift St	328,320	Heavy rainfall
10/19/2011	Snowfall Lift St	355,680	Heavy rainfall
10/27/2011	Snowfall Lift St	456,000	Heavy rainfall
11/16/2011	Snowfall Lift St	419,520	Heavy rainfall
11/16/2011	11 Lynnway Dr / MH 8-2	280,140	Heavy rainfall
11/22/2011	Mockingbird Valley Rd / MH 14-51	48,720	Heavy rainfall
11/22/2011	27 Bonnie Brook Ln / MH 14-76A	48,720	Heavy rainfall
11/22/2011	Snowfall Lift St	456,000	Heavy rainfall
11/22/2011	11 Lynnway Dr / MH 8-2	304,500	Heavy rainfall
11/28/2011	Mockingbird Valley Rd / MH 14-51	267,960	Heavy rainfall
11/28/2011	27 Bonnie Brook Ln / MH 14-76A	267,960	Heavy rainfall
11/28/2011	Snowfall Lift St	565,440	Heavy rainfall
11/28/2011	11 Lynnway Dr / MH 8-2	377,580	Heavy rainfall
12/6/2011	Snowfall Lift St	419,520	Heavy rainfall
12/6/2011	11 Lynnway Dr / MH 8-2	79,170	Heavy rainfall
12/28/2011	Snowfall Lift St	91,200	Heavy rainfall / mechanical failure
1/24/2012	Snowfall Lift St	437,760	Heavy rainfall
1/24/2012	Mockingbird Valley Rd / MH 14-51	85,260	Heavy rainfall
1/24/2012	11 Lynnway Dr / MH 8-2	85,260	Heavy rainfall
1/24/2012	27 Bonnie Brook Ln / MH 14-76A	85,260	Heavy rainfall
5/16/2012	MH 14-145	20,160	Line blockage

The 30 day geometric average during primary contact recreation season was approximately 5.5 times greater than the 130 MPN/100 mL requirement, but this value was heavily influenced by the large concentration on May 3, 2012. The E. coli loading has a target reduction of 99% to meet water quality benchmarks, which was heavily influenced by the wet weather event in August 2012. Site 5 is 1,200 feet downstream of Stoneybrook Pump Station. A known SSO occurs at a manhole at 11 Lynnway Drive, approximately 200 feet away from Stoneybrook Pump Station. This manhole has a constructed overflow due to insufficient capacity at Stoneybrook Pump Station. There were five reported SSOs at this location during the monitoring period, four of which occurred in less than 20 days in November and early December 2011. The closest sampling event to a reported SSOs was nine days after the overflow in early December 2011. It is unknown if the direct effect of the SSO was seen in the sampling data. A list of the SSOs that have occurred in LHCW during the monitoring period is located in Table 22 on page 82. It is expected that the August 2012 MST wet weather sampling event was affected by human sewage. The SCV was 2.20 and the highest level of qHF183 in any sample during the course of the monitoring was detected. No SSOs were reported on this day, but it is thought that the E. coli loading was predominantly from exfiltrating sewers. Site 5 is downstream of an approximately 35 year old gravity sewer and force main connected to the Stoneybrook Pump Station. Due to the depth of pump station, it is likely that wastewater only backs up in the aged gravity sewer during wet weather events. The gravity sewer has been visually inspected using CCTV and no apparent cracks in the pipe were observed, but it is hypothesized that a significant amount of exfiltration occurs from the joints in the pipe when under pressure. The pipe is only under pressure during wet weather events when the pump station fills with water. This hypothesis is consistent with the MST sampling results, were human signal markers were much more pronounced during the wet weather event. Stoneybrook Pump Station, the existing gravity sewer, and the existing force main are being eliminated with the construction of the LHC WWTP and related projects. It is expected that the SSO at 11 Lynnway Drive will be eliminated by the infrastructure improvements due to the additional capacity provided by the upgraded system. The suspected E. coli sources in order of anticipated greatest contribution are: 1. leaks/exfiltration in the sanitary sewer system; 2. SSOs; 3. fecal matter from domestic pets; and 4. fecal matter from wildlife. BMPs will be evaluated later in this report to address E. coli impairments at Site 5.

SITE 6

E. coli impairments at Site 6 were the most consistent of the Phase One sampling locations. E. coli concentrations at Site 6 exceeded water quality standards in 11 of the 17 samples. The highest E. coli loading was observed at the wet weather sampling event in August 2012. The second largest concentrations occurred during the wet weather sampling event in December 2011 and at the time the algae was decaying in May 2012. The E. coli concentrations almost doubled at each of the sampling events from May 3, 2012 through May 10, 2012. During this time the large algae blooms were detaching and decaying. Similar to Site 5, it is suspected that the E. coli levels may have increased due to rising water temperatures and an abundant food source; however, an additional source could have been input. The high E. coli levels were accompanied by low DO and high BOD. A rain event exceeding two inches was received prior to the next sampling event on May 15, 2012 when the E. coli concentration was reduced to the previous level on May 3, 2012. This insinuated that bacteria growth may have been the cause due to the fact that E. coli concentrations normally increase during wet weather due to increased runoff.

Site 6 is approximately 1500 linear feet downstream of two known SSOs on Mockingbird Valley Road and Bonnie Brook Lane. Three SSOs were reported at each location during the monitoring period as shown in Table 22 on page 82. The closest sampling event to a reported SSOs was nine days after the overflow in December 2011. It is not known if the direct effect of the SSO was seen in the sampling data; however, Site 5 and Site 6 are the only Phase One sites that reported high E. coli concentrations for the December 2011 sampling event and both were downstream of reported SSOs. The Consent Decree requires that the SSOs upstream of Site 6 be eliminated by 2022, but WMU expects that they will be removed due to additional capacity downstream with the construction of the LHC WWTP and related projects. Preliminary plans are in place to replace the main gravity sewer line that flows directly adjacent to LHC upstream of Site 6 as a part of the Hampton Manor Sanitary Sewer Improvements Project. This line is the oldest portion of the sanitary sewer system in this area. Currently this project does not have funding. An additional SSO was reported at a manhole approximately 4,200 linear feet upstream due to a line blockage on May 17, 2012. Samples were collected at Site 6 during the time the SSO was occurring, but E. coli concentrations were only slightly higher than the concentrations reported on May 15, 2012. WMU reported 20,160 gallons of overflow during the 24 hour period the SSO occurred. Based on the flow data collected at Site 6 at the sampling event, approximately 97,000 gallons of total water passed through the channel at Site 6 during the same 24 hour period. The MST results indicated that there was a fresh and fairly high fecal load entering the creek from the surrounding landscape. The load appears to be from mixed sources because the qHF183 was only above the detectable limit on two occasions (only one of the six dry days), although both were quantifiable. The highest SCV (2.45) was reported during the wet weather sampling event; however, the value was significantly impacted by increased fecal load and decreased fecal age. The concentration of the HuBac source markers did not show a marked increase from previous sampling events, indicating that the increased fecal load may not be caused by human sources. The qHF183 source marker during the wet weather event was similar to the level detected in the only other quantifiable sample. It is expected that Site 6 may still have been somewhat impacted by exfiltrating sewers due to the age of the infrastructure and insufficient capacity during the MST wet weather sampling event. Due to the elevation of pump station, excessive exfiltration likely only occurs when the line is under pressure during wet weather events. With the planned sewer infrastructure projects in the watershed, this problem will be eliminated.

The 30 day geometric average during primary contact recreation season was approximately 14 times greater than the 130 MPN/100 mL requirement. The E. coli loading has a target reduction of 95% to meet water quality benchmarks. The suspected E. coli sources in order of anticipated greatest contribution are: 1. SSOs; 2. fecal matter from domestic pets; 3. leaks/exfiltration in the sanitary sewer system; and 4. fecal matter from wildlife. BMPs will be evaluated later in this report to address E. coli impairments at Site 6.

4.2.3.2. NUTRIENT ANALYSIS

Total nitrogen and total phosphorous loadings were below target loadings at each site (when the October 2011 results are excluded from Site 4 due to the disturbance). Based solely on the load calculations, no reductions would be required. However, due to the algae growth observed, nutrients are a concern within LHCW. The algae growth may have been higher than normal due to the warm winter and wet conditions experienced in December and January.

The results collected during this monitoring period appear to be fairly consistent with the sampling data collected by KDOW in 2003 and 2004. DOW04022018, located at RM 1.2 on the LHC Nature and Heritage Preserve, was the only site along the main channel of LHC were nitrates exceeded 2.0 mg/L (occurred in three of 11 samples). However, the average annual total nitrogen load (149,876 lbs/year) during the KDOW monitoring period was still less than the benchmark load (164,407 lbs/year) based on the flow data collected at the time of sampling. This total nitrogen loading was only based on nitrates and TKN concentrations because nitrite information was not included in the sampling data. The phosphorous loading was also below benchmark loadings during the KDOW monitoring period, although the benchmark concentrations were exceeded on three occasions. Sampling events were no flow data was collected were excluded from the calculations. A site was not located in proximity to DOW04022018 for this study because the nutrient KDOW sampling data was not provided at the time of sampling site selection. Total nitrogen loads cannot be calculated for the other KDOW sites for comparison because TKN values were not obtained except for one sample. The only site were phosphorous loading exceeded benchmarks loadings during the KDOW monitoring period was DOW04022011 (located at RM 6.8, below the Fish and Game Club back road bridge). A site was not located in proximity to DOW04022011 for this study because the nutrient KDOW sampling data was not provided at the time of sampling site selection.

SITE 1

Sampling results indicate that nitrates are the largest nutrient concern at Site 1. Nitrates exceeded water quality benchmarks in three of the 12 samples, which resulted in causing total nitrogen to exceed water quality benchmarks as well. Only two elevated levels of total phosphorous were reported. Total nitrogen and total phosphorous loads were below target loads for the monitoring period. No non-natural nutrient sources are suspected on the LHC Nature and Heritage Preserve, but are thought to be introduced into LHC through agricultural uses upstream on the tributaries. Some algae growth was observed near the beginning of May, but the growth did not completely cover the substrate or impede flow. The algae growth had died back significantly by the sampling event on May 17, 2012. The suspected nutrient sources in order of anticipated greatest contribution are: 1. fertilizer from upstream areas; 2. decaying vegetation; and 3. fecal matter. BMPs will be evaluated later in this report to address nutrient sources upstream of Site 1.

SITE 2

Similar to Site 1, nitrates are the largest nutrient concern at Site 2. Nitrates exceeded water quality benchmarks in four of the 12 samples, which resulted in total nitrogen exceedances in three instances.
Total phosphorous also exceeded water quality benchmarks in two samples. A meeting was held with the property owner of Site 2 on May 24, 2012 to discuss the sampling results and potential BMPs. He indicated that he did not fertilize his fields with nitrogen or phosphorous products. He only uses boron supplements in recommended quantities to yield increased alfalfa production. Based on this information, nitrogen and phosphorous loads are suspected from upstream agricultural uses along West Fork and Dry Fork. Site 3, the next upstream monitoring location, has no exceedance for nitrates and two low exceedances for phosphorous, so nutrient input from upstream along the main channel is not anticipated as a major concern. The elevated nitrate levels occurred from November 2011 through March 2012. It is suspected that this trend occurs primarily because streamside plants, crops, and bacteria typically do not grow during the winter months and are not utilizing the available nitrates. Fertilizer is often applied in the fall to prepare for spring planting. The application of fertilizer is supplemented with decaying plants, providing additional nutrient sources to the stream. Site 2 is located approximately 4,100 linear feet downstream of the Blackfish Golf and Hunt Club. The fertilizers applied to the golf course could be an additional source of nutrients, but the Blackfish Golf and Hunt Club has a nutrient management plan. Total nitrogen and total phosphorous loads were below target loads for the monitoring period. Algae growth was observed at Site 2 in April and early May 2012 particularly in the portion of the channel with slower moving water where the algae completely covered the substrate. The suspected nutrient sources in order of anticipated greatest contribution are: 1. fertilizer and nutrient inputs from West Fork (to be discussed with Site 8); 2. fertilizer and nutrient input from Dry Fork; 3. decaying plant matter; and 4. fecal matter. Due to the nitrate exceedances and algae growth, BMPs will be evaluated later in this report to address nutrient sources upstream of Site 2.

SITE 3

At Site 3, total phosphorous exceeded water quality benchmarks in two of the 12 samples, one of which was associated with the disturbance at the lower impoundment. One nitrogen exceedances was observed in the sampling results in July 2012 when the largest concentration of TKN was observed. Total nitrogen and total phosphorous loads were below target loads for the monitoring period. Algae growth was observed at Site 3 in April and early May 2012 particularly in the portion of the channel with slower moving water where the algae completely covered the substrate. Site 3 is located adjacent to an agricultural property, but it is not known if the property owners fertilize their fields. The property is used to raise cattle, so it is unlikely that heavy doses of nitrogen or phosphorous products are applied. Fecal matter is not a suspected source because the E. coli concentrations were within benchmark concentrations. The suspected nutrient sources in order of anticipated greatest contribution are: 1. fertilizer and nutrient inputs; 2. decaying plant matter; 3. failing septic system; and 4. input from the lower impoundment. Due to the observed algae growth, BMPs will be evaluated later in this report to address nutrient sources upstream of Site 3.

SITE 4

Two of the 12 samples exceeded total phosphorous water quality benchmarks at Site 4. One of the phosphorous exceedances, as well as the only instance when total nitrogen surpassed water quality standards, occurred during the October 2011 sampling event when there was a disturbance of the lower impoundment. As previously discussed, this was a temporary disturbance and ended a few hours after sampling occurred. Ammonia-nitrogen exceeded benchmark concentrations in six of the 12 samples. Three of the ammonia-nitrogen exceedances corresponded with high E. coli loads, indicating a possible fecal source. Ammonia-nitrogen can be the most common form of nitrogen found in fecal matter. Site 4 is also directly downstream of the lower impoundment of the Carroll E. Ecton reservoir. Upstream portions of LHC flow into the reservoir and are temporarily detained. It is thought that this detention time may provide a measure of water quality treatment, allowing for settling and pollutant removal. While the lower impoundment may provide a measure of water quality when properly maintained, it may also provide a potential pollutant source if not. The lower impoundment is not shaded and probably contains warmer water temperatures than the rest of the stream. Algae are more likely to be found in areas of ponded water, and the decay of algae could also lead to increased ammonia-nitrogen concentrations. As previously noted, the lower impoundment was cleaned in October 2011.

Algae growth was observed at Site 4 in early May 2012 attached to the bottom of the channel. Algae growth was limited due to the high water velocity and bedrock channel. The low flow channel at Site 4 is incised into bedrock, making it difficult for algae to attach. Total nitrogen and total phosphorous loads were below target loads for the monitoring period if the October 2011 data is excluded. A possible nutrient source is the suspected failing septic system located just upstream of Site 4 which is located downstream of the reservoir. The suspected nutrient sources in order of anticipated greatest contribution are: 1. failing septic system; and 2. input from the lower impoundment. Due to ammonia-nitrogen exceedances and suspected failing septic system, BMPs will be evaluated later in this report to address nutrient sources upstream of Site 4.

SITE 5

Although Site 5 did not exceed nutrient target loads for the monitoring period, the large algal blooms signify a nutrient concern. Ammonia-nitrogen exceeded water quality benchmarks in four of the ten samples. Ammonia-nitrogen is a common form of nitrogen found in fecal matter, but is also associated with decaying organic matter. Ammonia-nitrogen is no longer commonly found in commercial fertilizers except in diammonium phosphate (DAP), which is used in the fall when grass seed is planted to assist in root system development. The only exceedance of total nitrogen and the largest exceedance of ammonia-nitrogen occurred in January 2012, prior to most of the algae growth which was first detected in February 2012. The algae growth was so dense that flow was impeded and the substrate of the channel was completely covered. It is hypothesized that high nutrient levels were not found while the algae was present because as soon as the nutrients were input they were consumed by the algae.

Algae growth is facilitated by the presence of both nitrogen and phosphorous. Based on the higher levels of nitrogen in January and February, it is hypothesized that phosphorous is the limiting nutrient. Phosphorous is commonly the limiting agent in algae. As previously stated, Site 5 is located downstream of a primarily residential area where property owners have indicated that yard waste is often dumped into the tributaries of LHC. The suspected nutrient sources in order of anticipated greatest contribution are: 1. fertilizer and decaying organic matter; 2. SSOs; 3. leaking/exfiltrating sewer system; and 4. domestic pet fecal matter. Due to the observed algae growth, BMPs will be evaluated later in this report to address nutrient sources at and upstream of Site 5.

SITE 6
Similar to Site 5, Site 6 did not exceed target loads for the monitoring period, but large algal blooms were present. The algae growth was so dense that flow was impeded and the substrate of the channel was completed covered. It is hypothesized that high nutrient levels were not found while the algae was present because the nutrients were immediately consumed by the algae. The property owner at Site 6 indicated that algae are typically present most of the time during warm weather. Higher flows during storm events often cause the algae to detach and wash downstream. Although no total nitrogen exceedances were found, total nitrogen levels peaked in January 2012 prior to appearance of the algae blooms in February 2012. Based on the higher levels of total nitrogen in January and February and the very low levels of phosphorous, it is hypothesized that phosphorous is the limiting nutrient. As previously stated, Site 6 is located downstream of a primarily residential area where property owners have indicated that yard waste is often dumped into LHC. The suspected nutrient sources in order of anticipated greatest contribution are: 1. fertilizer and decaying organic matter; 2. SSOs; 3. domestic pet fecal matter; and 4. leaking/exfiltrating sewer system. Due to the observed algae growth, BMPs will be evaluated later in this report to address nutrient sources at and upstream of Site 6.

4.2.3.3. HABITAT ANALYSIS

Sites 1, 2, and 3 satisfied project benchmarks by receiving a RBP rating of "good" in accordance with *Methods for Assessing Habitat in Wadeable Waters*. At Site 1, the largest concerns were sediment deposition and the unstable right bank. Although these issues did not cause Site 1 to fall below project benchmarks, BMPs will be evaluated later in this report to address them due to the presence in the LHC Nature and Heritage Preserve. Site 1 is located along the trail open to the public and BMPs in this area could be used to not only enhance habitat and water quality, but serve as an educational opportunity for those visiting the LHC Nature and Heritage Preserve. Site 2 received the highest RBP habitat assessment rating of the Phase One sites. Although there are some unstable banks in the vicinity of Site 2 because of occasional cattle accessing the stream, they do not appear to be causing major habitat concerns. The access appears to be limited to a couple of areas. The riparian zone begins to be limited or lacking in some areas near Site 3, but overall there are no major habitat concerns. No additional habitat specific BMPs will be evaluated for Site 2 or Site 3.

Habitat impairments at Sites 4, 5, and 6 are primarily due to channel alteration and narrow or lacking riparian vegetation. All three sites did not meet project benchmarks and received a RBP rating of "poor" in accordance with *Methods for Assessing Habitat in Wadeable Waters*. At Site 4, the largest concerns are embeddedness, vegetation protection, and epifaunal substrate/cover. These issues are likely due to the incised low flow bedrock channel and consistent high velocity flows due to the location directly downstream of the lower reservoir impoundment. The absence of a natural frequency of riffles and bends and the way the stream follows the road corridor indicates that channel alteration has likely occurred at Site 5. The riparian zone at Site 5 is also limited due to the presence of Old Boonesboro Road and the recent adjacent installation of the new gravity trunk sewer. Site 6 has limited riparian vegetation width due to yard maintenance along the stream edge. Channel alteration likely has occurred at Site 6 due to the absence of a natural frequency of riffles and bends. BMPs will be evaluated later in this report to address habitat impairments at Sites 4, 5, and 6.

As previously discussed, based on a visual and GIS assessment, riparian vegetation and tree canopy is lacking along 59 percent of the intermittent and perennial streams in LHCW. A majority of the areas lacking riparian vegetation and tree canopy are located in the upper, more developed portions of the watershed and along tributaries. Watershed wide BMPs will be evaluated later in this report to address limited riparian vegetation and tree canopy.

4.3. PHASE ONE PRIORITIZATION

As previously stated, due to the required submittal dates set forth in the Consent Decree a preliminary analysis of the Phase One data was conducted after four months of sampling in November 2011. The available parameter concentrations and pollutant loads were evaluated by the project team. Input was solicited from project stakeholders at the public meeting held on November 29, 2012 and the KDOW Non-Point Source Project Coordinator. The parameter concentrations and pollutant loads calculated during the preliminary analysis have not been detailed in this report because more complete results are now available as presented and analyzed in Section 4.2. The results available at the time of Phase Two selection were from August 2011 to November 2011 as listed in APPENDIX G.

As of November 2011, one sampling event at Site 1 had exceeded benchmark concentrations in each of the following parameters: total phosphorous, total nitrogen, nitrate-nitrogen, E. coli, and conductivity. Considering the designated status of Outstanding State Resource Water and Exceptional Water at Site 1, the project team gave high priority to further investigating pollutant sources from tributaries on the LHC Nature and Heritage Preserve. The project team reviewed the results collected as a part of the study completed by Daniel Walker in 2007 on the tributary locally known as Deep Branch. These results showed bacteria and phosphorous levels that greatly exceeded project water quality benchmarks. The nitrogen levels were also elevated in comparison to nitrogen levels reported in the downstream sampling location in the main channel of LHC. Upstream of the LHC Nature and Heritage Preserve property, Deep Branch crosses an agricultural property used to raise cattle. Due to the sampling results presented by Mr. Walker, the presence of the agricultural property, and the desire to ensure water quality on the LHC Nature and Heritage Preserve, Site 7 was selected for Phase Two monitoring on Deep Branch approximately 50 linear feet upstream from the confluence with LHC.

At Site 2, one sampling event had exceeded benchmark concentrations in conductivity, total phosphorous, nitrate-nitrogen, and total nitrogen as of November 2011. Two samples had exceeded benchmark concentrations for E. coli concentration. As previously stated, Site 2 is the approximate location where LHC transitions from being on the 303(d) list of impaired waters to an Outstanding State Resource Water and Exceptional Water. The confluence of a tributary locally known as West Fork is located approximately 200 linear feet upstream from Site 2. West Fork is the largest tributary within the section of LHC designated as impaired. A grant had previously been used to install a fence along the stream banks and across the channel to limit livestock access. The fence across the stream channel appeared to have been damaged by high flows or debris in the stream, allowing for partial access for livestock. With the elevated bacteria concentrations at Site 2, the project team wanted to determine the level of contribution of E. coli from West Fork and the effectiveness of the fence, so Site 8 was selected for Phase Two monitoring. Site 8 was also selected to assess if the nutrient pollutants were contributed from West Fork or other upstream areas. Site 8 was located approximately 500 linear feet upstream West Fork from the confluence with LHC inside the livestock exclusion fence.

Water quality benchmarks at Site 5 were exceeded multiple times in the following parameters: total phosphorous, ammonia-nitrogen, E. coli, and conductivity. As previously stated, Site 5 is located where LHCW shifts from rural, agricultural lands to more developed, residential areas. To try to identify the possible sources of pollutant contamination, the two largest tributaries upstream were selected for Phase Two monitoring. Site 9, located near the intersection of Old Boonesboro Road and Fontaine

Boulevard at approximately RM 8.2, was selected due to the size of the contributing drainage area (more consistent flow) and because of residents' reports of prior channel alteration and dumping of yard waste into the channel. Site 10, located in the right of way of Boonesboro Road (KY 627) at approximately RM 9.0, was selected based on the mixed upstream uses (residential, commercial, and agricultural), and position downstream of a documented SSO. The SSO will be removed by January 31, 2013, so follow up sampling will allow the project team to assess the effect of SSO removal. Both Site 9 and Site 10 are located downstream of Site 5.

Other locations were considered for Phase Two monitoring, including: the tributary locally known as Dry Fork located within the section of LHC designated as impaired; tributaries upstream of Site 6; tributaries upstream of Site 5 through the Stoneybrook and Calmes residential areas; and tributaries upstream of Carroll E. Ecton Reservoir. Dry Fork was not selected because the tributary does not have continuous flow, limiting the number of samples that could be collected. Access to Dry Fork was also difficult and would require additional travel time increasing the difficulty in meeting the specified sample hold times. Although elevated conductivity, E. coli, and ammonia-nitrogen levels were found at Site 6, upstream tributaries were not selected for Phase Two monitoring due to the small contribution area and concern about the amount of time during the year when flow would be present. Similar to areas upstream of Site 6, tributaries upstream of Site 5 through the Stoneybrook and Calmes residential areas were not selected for Phase Two monitoring due to the small contribution area and concern about the amount of time during the year when flow would be present. The two largest tributaries upstream of Site 5 and downstream of Site 6 were selected as Site 9 and Site 10 for Phase Two monitoring. Two tributaries carrying flow from substantial drainage areas empty into the upstream ends of the Carroll E. Ecton Reservoir. These tributaries did not get prioritized highly due to the presence of the reservoir downstream. The reservoir is suspected to provide a measure of water quality improvement for these tributaries before they enter the main channel of LHC by allowing for settling and pollutant removal, especially with the filtration provided by the sub-surface leakage around the dam. The two tributaries upstream of the reservoir were the highest priority locations not selected for Phase Two monitoring. If additional sampling is conducted in the future, it is recommended that these tributaries be highly considered due to the area of contribution.

4.4. PHASE TWO ANALYSIS

4.4.1. COMPARISON TO WATER QUALITY BENCHMARKS

After four months of Phase One monitoring and analysis, Phase Two sites, Sites 7 through 10, were monitored beginning in December 2011. Phase Two monitoring will continue through November 2012. The critical parameters identified in Table 8 were collected and then compared with water quality benchmarks in Table 11. APPENDIX H contains a summary table for monitoring results at each site through September 2012. Parameters that exceed water quality benchmarks are highlighted in red. Turbidity, total suspended solids, and BOD had no occurrences of exceeding water quality benchmarks at Phase Two monitoring locations. E. coli and conductivity exceeded water quality standards at least four times during the monitoring period at three of the four sites. Table 23 shows the number of sampling events that exceeded the water quality benchmarks by site. The first number represents the number of events exceeding water quality benchmarks and the second number represents the total number of sampling events (exceedances/number of samples). A total of ten full sampling events were completed, but the total number of samples varies in some instances due to additional E. coli collection requirements, MST sampling, instances of no water flow, and limited equipment malfunction. Total suspended solids and turbidity were sampled at each of the ten monthly sampling events, but the benchmarks are only valid for comparison from April to October. The project team designated that exceeding the water quality benchmark two or more times indicated a potential issue. The shading in Table 23 indicates that the critical parameter exceeded the project water quality benchmark at least twice at the indicated site.

Table 23. Phase Two Number of Events Exceeding Water Quality Benchmarks

Site #	E. coli	Nitrate-Nitrite-N	NH3-N	TKN	TN	TP	BOD	TSS	Turbidity	Conductivity	DO
7	1/13	3/8	0/8	0/8	1/8	8/8	0/8	0/4	0/4	11/13	5/13
8	6/14	8/10	0/10	1/10	9/10	9/10	0/10	0/6	0/6	4/14	0/14
9	4/10	0/6	0/6	0/6	0/6	0/6	0/6	0/2	0/2	10/11	0/11
10	10/16	0/9	2/9	0/9	0/9	1/9	0/9	0/5	0/5	12/15	0/15

Similar to Phase One, large algal blooms were observed during the monitoring period displaying excessive growth at Sites 9 and 10, but elevated levels of nutrients were not found in the water samples. Little to no algae was observed at Site 7 or Site 8; however, total phosphorous exceedances were observed at both sites, and total nitrogen exceedances were observed at Site 8. Algal blooms were present at Site 10, but never completely covered the substrate. Site 9 had the greatest amount of algae growth of the Phase Two monitoring locations, but did not display as dense growth as seen at Site 5 or Site 6. At the May 3, 2012 sampling event, Site 9 was completely dry at the sampling location as shown in Figure 40. Limited algal blooms were present at the May 8, 2012 sampling event when the tributary once again had flow. The DO levels were affected by the algae blooms at Site 9, measuring over 16 mg/L from February 2012 until the stream was dry in May 2012. Once flow returned, the DO was lower and E. coli levels were higher.

Figure 40. Dry Conditions at Site 9

Five E. coli samples were taken within 30 days to assess the presence of bacteria during primary contact recreation season in accordance with the requirements set forth in *Watershed Planning Guidebook for Kentucky Communities*. Only four samples were collected at Site 9 due to the absence of water at the May 3, 2012 sampling event. The arithmetic and geometric means for the five E. coli samples taken in May 2012 are listed in Table 24. Sites 8, 9, and 10 exceed the geometric benchmark of 130 MPN/100 mL for five samples in a 30 day period during primary contact recreation season.

Table 24. Phase Two E. coli Primary Contact Recreation Season Mean Values

Site #	Arithmetic Mean (MPN/100 mL)	Geometric Mean (MPN/100 mL)
7	130	78
8	410	309
9	595	424
10	1082	504

To ensure quality control in the laboratory testing, blank and duplicate samples were collected and analyzed in accordance with the *Quality Assurance Project Plan for the Lower Howards Creek Watershed Management Plan*. One blank and one duplicate sample were collected and analyzed every quarter. During the additional E. coli sampling conducted in May 2012, one blind duplicate sample was collected and analyzed. As previously discussed, an additional quality control check for the E. coli testing was provided by the preliminary MST sampling results. All quality control testing results were within acceptable tolerances except for one instance at Site 5 which is discussed in Section 4.2.1. The quality control testing for Phase One and Phase Two was combined and the results are located in APPENDIX G.

Table 25. Phase Two Habitat Assessment

Site #	Habitat Parameters											Rating	Stream Category
	Epifaunal Substrate / Cover	Embeddedness	Velocity/ Depth Regime	Sediment Deposition	Channel Flow Status	Channel Alteration	Frequency of Riffles / Bends	Bank Stability	Vegetation Protection	Riparian Vegetation Zone Width	Final Score		
7	13	15	15	12	13	20	18	19	11	20	156	Good	Head
8	14	15	16	14	16	19	16	11	11	20	152	Fair	Head
9	9	6	10	16	16	11	12	17	10	0	107	Poor	Head
10	7	5	8	14	13	10	10	6	7	2	82	Poor	Head

Habitat was assessed at Sites 7 through 10 and compared with benchmarks listed in Table 12. Three of the four sites scored below a "good" rating in accordance with *Methods for Assessing Habitat in Wadeable Waters* (DOWSOP03024), dated March 2011. Table 25 identifies the scoring value for each habitat parameter. The orange shading represents a "poor" rating (numeric value from zero to five). The blue shading represents a "marginal" rating (numeric value from six to 10). The green shading represents a "suboptimal" rating (numeric value from 11 to 15). The purple shading represents an "optimal" rating (numeric value from 16 to 20). All Phase Two sites scored low in the habitat parameters of epifaunal substrate/cover and vegetation protection. The habitat parameters of riparian vegetation zone width, embeddedness, channel alteration, and frequency of riffles/bends are also areas of concern at Sites 9 and 10.

Table 26. Phase Two Biological Assessment

Site #	MBI Calculation Matrices							MBI Score	Stream Rating	Stream Category
	G-TR	G-EPT	mHBI	m%EPT	%Ephem	%C+O	%ClingP			
7	32	19	4.20	43	6	10	30	58	Excellent	Headwater
8	31	18	4.23	36	30	2	42	65	Excellent	Headwater
9	10	0	6.04	0	0	7	8	26	Poor	Headwater
10	9	0	6.26	0	0	14	0	22	Poor	Headwater

The benthic macroinvertebrates were assessed and compared with the benchmarks listed in Table 13. Table 26 displays the MBI calculation values for each monitoring location. Two of the four sites, Site 9 and Site 10, assessed did not meet biological benchmarks receiving a "poor" rating in accordance with *The Kentucky Macroinvertebrate Bioassessment Index*, dated September 2003. Samples from Site 9 and Site 10 had limited species diversity.

4.4.2. POLLUTANT LOAD PREDICTION

As with Phase One, pollutant load predictions in LHCW were based on the concentration of the pollutant and the discharge. The concentrations of the pollutants were utilized from the sampling results discussed in Section 4.4.1. Based on the requirements outlined in the *Watershed Planning Guidebook for Kentucky Communities*, pollutant loads were calculated for total nitrogen, total phosphorous, total suspended solids, and E. coli. Conductivity was noted to exceed water quality benchmarks, but pollutant loads were not calculated. Since there are no water gaging stations within the watershed, average discharge was estimated using the flow measurements taken at the sampling events. No historical flow information was available due to the absence of a USGS gaging station, so there was no basis for separating flows in low, moderate, and high events. The discharge values utilized in the loading calculations are listed in APPENDIX H. Areas were minimal flow were observed at the time of sampling were assigned a discharge value of 0.1 cubic feet per second.

Pollutant load predictions and target load reductions for E. coli were derived from the following formula:

$$\underset{\text{(CFU/yr)}}{\text{E. coli Loading}} = \underset{\text{(CFU/100mL)}}{\text{Concentration}} \times \underset{\text{(cfs)}}{\text{Discharge}} \times \underset{\text{(Annual Load Conversion)}}{8{,}907{,}973{,}920}$$

For E. coli loading calculations, the above formula was applied to the data from each sampling event. All sampling events were then averaged using the arithmetic mean to obtain an average annual load. One sample at Site 10 had a reading of greater than 2420 MPN/100mL because the sample was not diluted prior to processing. It was impossible to estimate the actual value, so 2420 MPN/100mL was used for the load calculations. The benchmark of 240 CFU/100 mL was used to calculate the target loads. Based on these calculations, the E. coli loading and target reductions are shown in Table 19. The reduction to achieve the target loading was calculated by subtracting the E. coli loading from the E. coli target loading. The percent reduction target was calculated by dividing the value for the reduction to achieve the target loading by the E. coli loading present expressed as a percentage. E. coli loadings exceed E. coli target loadings at two of the four Phase Two sites. The Phase Two E. coli loads verified the Phase One assessment that E. coli is a critical parameter of concern in the upper, developed portions of LHCW.

Table 27. Phase Two E. coli Loading and Target Reductions

Site #	E. Coli Loading (Trillion CFU/yr)	E. Coli Target (Trillion CFU/yr)	Reduction to Achieve Target (Trillion CFU/yr)	Percent Reduction Target
7	0.6	2.6	N/A	N/A
8	6.8	7.6	N/A	N/A
9	3.7	1.6	2.1	57%
10	19.6	1.3	18.3	93%

Pollutant load predictions and target load reductions for total nitrogen, total phosphorous, and total suspended solids were derived from the following formula:

$$\underset{\text{(lbs/yr)}}{\text{Nutrient/TSS Loading}} = \underset{\text{(mg/L)}}{\text{Concentration}} \times \underset{\text{(cfs)}}{\text{Discharge}} \times \underset{\text{(Annual Load Conversion)}}{1968.80}$$

For total nitrogen and total phosphorous, the above formula was used for each sampling event and then all the values were averaged together to obtain an average annual load. For total suspended solids, the arithmetic average of the samples collected from April through September was used. Total suspended solids results from December to March were excluded in accordance with the recommendations from KDOW in *Benchmark Recommendations for Nutrient Parameters*. Some sampling results for total nitrogen, total phosphorous, and total suspended solids were reported at below the detection limit. Since an exact value could not be assigned to these results, the value of the detection limit was used for load calculations. The water quality benchmark concentrations in Table 11 were used for target load calculations, which were: 0.25 mg/L for total phosphorous; 2.5 mg/L for total nitrogen; and 8.7 mg/L for total suspended solids. Based on these calculations, the loading and target reductions for total nitrogen are shown in Table 28 and for total phosphorous in Table 29.

Table 28. Phase Two TN Loading and Target Reductions

Site #	TN Loading (lbs/yr)	TN Target Loading (lbs/yr)	Reduction to Achieve Target (lbs/yr)	Percent Reduction Target
7	6,419	7,869	N/A	N/A
8	34,879	19,442	15,437	44%
9	2,115	4,569	N/A	N/A
10	1,274	3,013	N/A	N/A

Total nitrogen loadings exceeded target loads at Site 8. Total phosphorous loadings exceeded target loads at Site 7 and Site 8. The increased nutrient levels are consistent with previous sampling data. The 2007 Daniel Walker study sampled at a location on Deep Branch in close proximity to Site 7 and noted nitrate concentrations exceeding 2.0 mg/L in two of the three samples and phosphorous concentrations exceeding 0.25 mg/L in all three samples. Total nitrogen concentrations were not collected in the Daniel Walker study, so these values cannot be compared. DOW04022014 is located approximately 2.0 miles upstream of Site 8. The KDOW monitoring data from 2003 to 2004 shows a 30% required reduction in phosphorous loading based on a 0.25 mg/L benchmark and a 45% required reduction in nitrate loading based on a 2.0 mg/L benchmark. These load calculations only included sampling events where flow data was recorded. Total nitrogen loadings could not be calculated to be compared with Site 8 sampling data because nitrite and TKN concentrations were not collected; however, it appears that nutrient loading is not a localized issue around Site 8. DOW04022014 was considered as a possible sampling location for this report due to the information being unavailable at the time of site selection.

Table 29. Phase Two TP Loading and Target Reductions

Site #	TP Loading (lbs/yr)	TP Target Loading (lbs/yr)	Reduction to Achieve Target (lbs/yr)	Percent Reduction Target
7	1,006	787	219	22%
8	2,338	1,944	394	17%
9	260	457	N/A	N/A
10	161	301	N/A	N/A

As previously noted, algae growth was observed at Site 9 and Site 10 beginning in February 2012 indicating nutrient loads were present. It is suspected that the nutrient input was immediately consumed by the algal blooms, causing low nutrient readings in the sampling results. The Phase Two nitrogen and phosphorous loads and presence of algal blooms in the upper portion of the watershed verified the Phase One assessment that nitrogen and phosphorous are critical parameters of concern within LHCW.

Table 30. Phase Two TSS Loadings and Target Loadings

Site #	TSS Loading (lbs/yr)	TSS Target Loading (lbs/yr)
7	890	2,412
8	7,232	15,718
9	1,890	4,725
10	1,071	4,607

Total suspended solids loadings were below target loadings at all Phase Two sites. The Phase Two loads verified the Phase One assessment that total suspended solids do not appear to be a critical parameter of concern within LHCW and no further analysis will be performed in this report. As with Phase One, it is believed that elevated levels of conductivity occurred at Phase Two monitoring locations due to a combination of the limestone geology and clay soils of the region, and bacteria and nutrient contamination. Conductivity is also affected by water temperature. Typically warmer water has higher levels of conductivity. Due to the limited flow information and suspected causes of contamination, loading for conductivity was not calculated at Phase Two monitoring locations. The practices applicable to reduction in E. coli and nutrient loadings will also address reductions in conductivity. Conductivity will not be analyzed separately from E. coli and nutrients in the remainder of this report.

4.4.3. ANALYSIS OF RESULTS

4.4.3.1. E. COLI ANALYSIS

SITE 7

As previously stated, E. coli concentrations were shown to exceed water quality benchmarks at least twice at three of the four Phase Two monitoring locations. At Site 7, E. coli only exceeded water quality benchmarks in one sample and had the least significant E. coli impairments of the Phase Two locations. The one exceedance of water quality benchmarks occurred when over two inches of rain had been received in the five days prior to sampling. This exceedance did correspond with E. coli concentrations exceeding water quality standards at Site 1. It is suspected that Deep Branch contributed some to the higher E. coli loads at Site 1, but the load calculations show that they were only a small portion. The E. coli load at Site 7 is 77% lower than the target load for the monitoring period. The 30 day geometric average during primary contact recreation season was 40% below the 130 MPN/100 mL requirement. The level of bacteria impairment reported in the 2007 Daniel Walker study was not duplicated in the ten months of sampling that have occurred as of September 2012; however, the stream was dry during two sampling events. It had previously been noted that livestock had access to upstream portions of Deep Branch. It is not known if livestock no longer have direct access to Deep Branch or if the livestock are smaller in number, but the level of impairment expected has not been found. The suspected E. coli sources in order of anticipated greatest contribution are: 1. upstream livestock fecal matter; 2. fecal matter from wild life; and 3. upstream human fecal inputs. Based on the sampling results collected from December 2011 through September 2012, no additional BMPs are required to address E. coli impairments at Site 7.

SITE 8

E. coli only exceeded water quality benchmarks once prior to May 2012 at Site 8. Three of the five samples collected in May 2012 exceeded water quality benchmarks. During two of these sampling events, E. coli concentrations exceeding water quality standards were reported at Site 2. It is hypothesized that West Fork contributed to the higher E. coli loads at Site 2, although when load calculations were evaluated this was not the only source. The 30 day geometric average during primary contact recreation season was approximately 2.4 times greater than the requirement of 130 MPN/100 mL. The E. coli load at Site 8 is 11% lower than the target load for the monitoring period; however, E. coli concentrations exceeded benchmark concentrations in six of the 14 samples. The higher concentrations did not greatly impact the load because of the level of discharge at the time of sampling. The E. coli concentrations also never exceeded 900 MPN/100 mL in any sampling event. Site 8 is located on the same property as Site 2 where cattle are raised. However, the property owner has indicated that the cattle have not been in the field where they have access to West Fork since monitoring began. Site 8 was located within the livestock exclusion fence, but the effectiveness of this fence cannot be addressed since the livestock have not been in this field since the monitoring period began. As previously noted, this livestock exclusion fence has been damaged, but it is not known if cattle travel that far upstream due to the rough terrain. It is suspected that the sources of E. coli come from properties upstream of the fenced area. West Fork flows through a rural area with several agricultural properties used for both livestock and crop farming. West Fork flows into the portion of LHC included on the 303(d) list for impaired waters. The suspected E. coli sources in order of anticipated greatest contribution are: 1. upstream livestock fecal matter; 2. upstream human fecal inputs; and 3. fecal matter from wild life. BMPs will be evaluated later in this report to address E. coli impairments at Site 8 due to the multiple exceedances of benchmark concentrations.

SITE 9

Site 9 experienced E. coli concentrations that exceeded water quality benchmarks in four of the ten samples. The largest E. coli loading was reported on May 8, 2012 following a period where one inch of rain had been received in the previous five days. Also at the prior sampling event on May 3, 2012, the channel was completely dry. The 30 day geometric average during primary contact recreation season was approximately 3.3 times greater than the requirement of 130 MPN/100 mL. The E. coli loading has a target reduction of 57% to meet water quality benchmarks. There are limited properties with agricultural uses at the most upstream portion of the tributary where Site 9 is located. Most of the contributing area is developed, residential neighborhoods. There are no documented SSOs upstream of Site 9. The suspected E. coli sources in order of anticipated greatest contribution are: 1. leaking/exfiltration of the sewer system; 2. fecal matter from domestic pets; 3. fecal matter from wild life; and 4. undocumented SSOs. BMPs will be evaluated later in this report to address E. coli impairments at Site 9.

SITE 10

E. coli impairments at Site 10 were the most significant of the Phase Two monitoring locations. E. coli concentrations exceeded water quality benchmarks in 10 of the 16 samples. The largest E. coli loading and concentration occurred in August 2012 at the time of the wet weather sampling for MST. The second largest E. coli concentration occurred in December 2011 when concentrations exceeded 2,420 MPN/100 mL. This sampling event was classified as a wet weather event and the samples were collected in the rain. As previously stated, Site 10 is located partially downstream of an SSO at Snowfall Pump Station. A manhole that is directly upstream from the Snowfall Pump Station is located approximately 400 linear feet upstream of Site 10. This manhole often overflows at the same time Snowfall Pump Station overflows. Field personnel did not observe an SSO occurring at the time of sampling. According to data provided by WMU, three SSOs occurred at Snowfall Pump Station during the Phase Two monitoring period as listed in Table 22 on page 82. It is not known if the manhole upstream of Site 10 or just Snowfall Pump Station experienced a SSO on these occasions. The closest sampling event to a reported SSO was nine days after the overflow in December 2011. It is unknown if the direct effect of the SSO was seen in the sampling data. Approximately 600 feet farther upstream on this manhole is a location where a 15-inch sewer flows into an 8-inch sewer. The 15-inch was recently installed, replacing a line that was over 35 years old. This line had to be installed prior to the rest of the trunk sewer and pump station removal due to funding requirements. A temporary connection was made to the existing 8-inch line to maintain sewer service until the new WWTP is online. The existing 8-inch has been inspected using CCTV and no cracks were observed; however, due to the age of the infrastructure, it is expected that exfiltration is occurring when the pipe is under pressure. Unlike Site 5 and Site 6 where the pipe is only under pressure during high flow events caused by wet weather, this pipe is likely under pressure regularly due to the elevation of the pump station operating range and the connection elevation at the Snowfall Pump Station wet well. This problem will be removed one this portion of the line is replaced after the Snowfall Pump Station is decommissioned.

The MST results indicated SCV ranging from 0.24 to 1.06 on dry days and 1.78 during the wet weather sampling event. The most specific human source marker (qHF183) was detected in six of the seven samples, but was only quantifiable in two instances. Site 10 has an overall lesser fecal load and more aged fecal material than Site 6, but a more consistent human source marker. In the *Final Report and Executive Summary to Palmer Engineering on Water Quality Study on Lower Howards Creek*, Dr. Gail Brion suggests that human sewage inputs are being input at Site 10 due to the high fecal loads, fresh fecal source, and frequency of human-specific markers, making it the greatest health concern for human fecal matter of the sites where MST was conducted. These results validate the previously discussed concerns with existing upstream gravity sewer exfiltration.

Site 10 is also directly downstream from a veterinarian clinic. The floor drains in the clinic are not permitted to be connected to the public sanitary sewer system, so it is unknown how washoff water is disposed. This water would be a potential fecal source if these drains are connected to the storm sewer system or enter directly into the stream.

The 30 day geometric average during primary contact recreation season was approximately 3.9 times greater than the requirement of 130 MPN/100 mL. The E. coli loading has a target reduction of 93% to meet water quality benchmarks. As previously stated, areas upstream of Site 10 contain residential, commercial, and agricultural uses. Based on the varying land uses, this site was selected for MST to aid in bacteria source identification. The suspected E. coli sources in order of anticipated greatest contribution are: 1. SSOs; 2. leaking/exfiltration of the sewer system; 3. fecal matter from domestic pets; and 4. fecal matter from wildlife. BMPs will be evaluated later in this report to address E. coli impairments at Site 10.

4.4.3.2. NUTRIENT ANALYSIS

SITE 7

Sampling results indicate that total phosphorous is the largest nutrient concern at Site 7. Total phosphorous concentrations exceeded water quality benchmarks in all eight samples collected. The total phosphorous loading has a 22% target reduction to meet water quality benchmarks. Total phosphorous levels at Site 1 exceeded water quality benchmarks in one sample (June 27, 2012) during the Phase Two monitoring period. However, the stream channel was dry at Site 7 during this sampling event. The high total phosphorous load in Deep Branch does not appear to be causing exceedances downstream at Site 1. Nitrates also exceeded water quality benchmarks in three of the eight sampling events; however, this did not result in total nitrogen loads that surpassed target loads for the monitoring period. High nitrates were also observed at Site 1 during the two months of exceedance at Site 7, indicating some contribution to loading at Site 1. The load calculations indicate that input from Site 7 only makes up a small portion of the total at Site 1. No non-natural nutrient sources are suspected on the LHC Nature and Heritage Preserve, but are thought to be introduced upstream on Deep Branch through properties with agricultural uses. The fertilization practices of the agricultural property directly upstream from the LHC Nature and Heritage Preserve are not known. Manure used as a fertilizer may be a possible source due to the high phosphorous levels accompanied by relatively low nitrogen levels. Minimal algae growth was observed on Deep Branch during the monitoring period. The suspected nutrient sources in order of anticipated greatest contribution are: 1. fertilizers; 2. decaying plant material; and 3. fecal matter. Fecal matter is not suspected as a main contribution due to reported E. coli concentrations within water quality benchmarks. BMPs will be evaluated later in this report to address nutrient sources upstream of Site 7.

SITE 8

Total phosphorous and total nitrogen are both large nutrient concerns at Site 8. Total nitrogen and total phosphorous exceeded water quality benchmarks in five of the six sampling events each. The biggest contribution to total nitrogen was nitrates, which surpassed water quality benchmarks in nine of the ten sampling events. The total phosphorous loading has a 17% target reduction to meet water quality benchmarks and the total nitrogen loading has a 44% target reduction to meet water quality benchmarks. The two largest total nitrogen loadings corresponded with reported exceedances at Site 2.

In three of the five samples where nitrate exceeded water quality benchmarks, exceedances also occurred at Site 2. West Fork appears to be a nutrient source for Site 2. Multiple agricultural properties are located along West Fork. As previously stated concerning Site 2, the property owner at the location of Site 8 indicated that he does not use any nitrogen or phosphorous fertilizer on his property. Since it is more common to use nitrogen and phosphorous fertilizer on agricultural land used to grow crops, the farms used only to raise livestock are not suspected as prime sources. There are some agricultural lands used to grow crops near Becknerville Road and Combs Ferry Road in the headwaters of West Fork which are thought to be potential sources. Some of the ponds in the upper reaches of West Form appear to be covered with green algae according to aerial photography. The monitoring data collected by KDOW at DOW04022014 in 2003 and 2004 appears to be consistent with this hypothesis. As previously discussed, DOW04022014 is located approximately 2.0 miles upstream of Site 8. Nitrogen and phosphorous impairments were seen at this location in the previous monitoring data as discussed in Section 4.4.2. Minimal algae growth was observed on West Fork during the monitoring period. Due to some high E. coli concentrations, fecal matter is considered a potential nutrient source; however, it does not appear to be the main source due to elevated nutrient levels even in times of lower E. coli concentrations. The suspected nutrient sources in order of anticipated greatest contribution are: 1. fertilizers; 2. decaying plant material or algae; and 3. fecal matter. BMPs will be evaluated later in this report to address nutrient sources upstream of Site 8.

SITE 9

Although Site 9 did not exceed nutrient target loads for the monitoring period, the large algal blooms present signify a nutrient concern. No nitrogen or phosphorous exceedances were reported in the sampling data; however, the highest total nitrogen concentration was detected in January 2012 prior to most of the algae growth which was first detected in February 2012. The algae growth was so dense that flow was impeded and the substrate of the channel was completed covered. It is hypothesized that high nutrient levels were not found while the algae was present because the nutrients were immediately consumed by the algae. Algae growth is facilitated by the presence of both nitrogen and phosphorous. Based on the higher levels of nitrogen in January, it is hypothesized that phosphorous is the limiting nutrient. As previously stated, Site 9 is located downstream of a primarily residential area where property owners have indicated that yard waste is often dumped into the tributary. The suspected nutrient sources in order of anticipated greatest contribution are: 1. fertilizers; 2. decaying plant material; 3. leaking/exfiltrating sewer system; 4. fecal matter from domestic pets; and 5. fecal matter from other sources (wildlife and undocumented SSOs). Due to the observed algae growth, BMPs will be evaluated later in this report to address nutrient sources at and upstream of Site 9.

SITE 10

Total phosphorous only exceeded water quality benchmarks in one sample at Site 10. These exceedances occurred during the wet weather sampling event in December 2011. High levels of E. coli were also reported during this event indicating a potential fecal source. Ammonia-nitrogen exceeded water quality standard in two samples, one being the wet weather event in December 2011. Site 10 did not exceed nutrient target loads for the monitoring period, but some large algal blooms were observed. The algae growth at Site 10 was less than Site 5, 6, and 9, but is still a concern. Similar to Site 9, the highest total nitrogen concentration was detected in January 2012 prior to most of the algae growth which was first detected in February 2012. Based on the higher levels of nitrogen in January, it is hypothesized that phosphorous is the limiting nutrient at Site 10. Since Site 10 is downstream of residential, commercial, and agricultural uses, there are a variety of possible sources. The suspected nutrient sources in order of anticipated greatest contribution are: 1. fertilizers; 2. decaying plant material; 3. SSOs; 4. leaking/exfiltrating sewer system; 5. fecal matter from domestic pets; and 6. fecal matter from other sources (wildlife and undocumented SSOs). Due to the observed algae growth, BMPs will be evaluated later in this report to address nutrient sources at and upstream of Site 10.

4.4.3.3. HABITAT ANALYSIS

Site 7 satisfied project benchmarks by receiving a RBP rating of "good" in accordance with *Methods for Assessing Habitat in Wadeable Waters*. At Site 7, the largest concerns were vegetation protection and sediment deposition. The site was partially scored low for vegetation protection because the right bank is a tall rock face with no vegetation. No additional habitat specific BMPs will be evaluated for Site 7.

Site 8 received a “fair” rating in accordance with *Methods for Assessing Habitat in Wadeable Waters*, but was only three points away from receiving a “good” rating. At Site 8, the largest concerns are vegetation protection and bank stability. The right bank is vertical, unvegetated soil that is susceptible to erosion. BMPs will be evaluated later in this report to address habitat impairments at Site 8.

Site 9 and Site 10 both received a “poor” rating in accordance with *Methods for Assessing Habitat in Wadeable Waters*. The largest concerns are riparian vegetation zone width, embeddedness, and epifaunal substrate/cover. Site 9 has limited riparian vegetation width due to yard maintenance to the stream edge. Residents have indicated that portions of the tributary have been dredged potentially providing a sediment source that resulted in the embeddedness and the removal of epifaunal substrate/cover. Site 10 has limited riparian vegetation width due to the location within the right of way of Boonesboro Road (KY 627). The channel at Site 10 may have been altered at the time of the road construction. BMPs will be evaluated later in this report to address habitat impairments at Site 9 and Site 10.

4.5. MICROBIAL SOURCE TRACKING ANALYSIS

As previously stated, MST was included in the scope of the development of the LHCWMP to provide a way to identify samples that were indicative of contamination from human fecal waste, using fecal load, age, and source. Due to limited funding, not all sites could be analyzed. Sites 2, 4, 5, 6, and 10 were selected based on high E. coli concentration in February 2012. Samples were collected as indicated in Section 3.5. A total of six dry weather samples and one wet weather sample were collected for analysis. Originally only four samples were planned, but due to quality control issues with the media used for the AC/TC tests, three additional samples were collected to provide a SCV for each site. Samples were analyzed for indicators of fecal load (E. coli, and a non-host specific Bacteroides DNA marker AllBac), fecal source (two human host specific Bacteroides DNA markers, HuBac and qHF183), and fecal age (AC/TC ratio). The E. coli concentrations for the MST testing are located in Table 31. All values are reported in MPN/100 mL. There was a significant increase in E. coli loading noted at all sites in the watershed during the single rain event captured for MST. Site 5 and Site 10 were within one standard deviation of the dry weather mean value, but all other sites were over two standard deviations away from the dry weather mean value. Since there only one wet weather sample was collected, it is impossible to determine if this is a trend. The concentrations of E. coli seen at the wet weather event sampled in December 2011 were not nearly as high as the concentrations seen in the August 2012 samples.

The unitless AC/TC ratios are located in Table 32. The missing values in Table 32 are the AC/TC ratios that did not meet internal quality control standards. These values were not included in the analysis or calculated SCV values. On average the freshest fecal material was observed at Site 6 on dry days. The

AC/TC ratios dropped at all sites in the wet weather sampling, with the lowest value at Site 6. However, the AC/TC ratios indicate that that during dry conditions, the watershed is predominantly influenced by aged sewage.

Table 31. MST E. coli Concentrations (MPN/100 mL)

Site #	Date						
	3/21/2012	4/4/2012	4/11/2012	4/27/2012	5/3/2012	5/8/2012	8/28/2012
2	101.4	62.4	49.6	31.5	26.5	387.3	4,611
4	140.1	44.1	28.8	8.6	95.9	518.0	21,870
5	300.5	41.4	8.6	35.5	8664.0	260.2	41,060
6	365.4	71.5	47.3	248.1	1229.9	2755.0	28,680
10	115.3	387.3	154.0	150.0	79.4	3448.0	17,230

Table 32. MST AC/TC Ratios

Site #	Date						
	3/21/2012	4/4/2012	4/11/2012	4/27/2012	5/3/2012	5/8/2012	8/28/2012
2	---	---	---	30.95	54.19	44.41	10.65
4	---	---	---	44.50	23.60	26.41	19.68
5	---	---	---	94.44	6.73	46.40	14.59
6	---	---	---	18.26	15.50	16.82	6.14
10	---	---	---	13.83	46.67	25.27	14.69

Table 33. MST AllBac Concentrations (DNA copies/µL)

Site #	Date						
	3/21/2012	4/4/2012	4/11/2012	4/27/2012	5/3/2012	5/8/2012	8/28/2012
2	5.97E+03	2.18E+03	1.66E+03	7.68E+02	1.54E+03	2.27E+03	Inhibited
4	8.63E+03	6.66E+03	1.06E+04	6.02E+03	5.17E+03	5.29E+03	Inhibited
5	2.29E+03	5.22E+03	Inhibited	4.35E+02	Inhibited	8.63E+04	3.69E+05
6	5.09E+03	1.58E+03	2.41E+04	2.84E+04	2.53E+06	5.19E+04	1.28E+04
10	7.16E+03	5.75E+03	1.42E+03	1.99E+03	2.00E+03	9.58E+03	1.82E+04

Table 34. MST HuBac Concentrations (DNA copies/µL)

Site #	Date						
	3/21/2012	4/4/2012	4/11/2012	4/27/2012	5/3/2012	5/8/2012	8/28/2012
2	5.74E+02	1.14E+02	7.84E+01	5.79E+01	8.58E+01	1.28E+02	Inhibited
4	9.94E+02	5.62E+02	1.16E+03	6.17E+02	5.84E+02	4.03E+02	Inhibited
5	8.74E+01	2.66E+02	Inhibited	BDL	Inhibited	1.35E+03	8.48E+04
6	1.92E+02	3.53E+01	4.16E+02	1.40E+02	1.44E+04	1.42E+03	1.56E+03
10	1.58E+02	1.20E+02	2.99E+01	2.69E+01	4.86E+01	5.81E+02	1.47E+03

The non-host specific Bacteroides DNA marker AllBac concentrations are reported in Table 33 in units of DNA copies per microliter of extract. Four of the samples had untraceable inhibition (two at Site 5 during dry weather sampling and two at the sites lowest in the watershed during wet weather sampling). Inhibition in the sample matrix was determined by adding 0.2 micrograms per milliliter of

Salmon testes DNA. Sample extracts showing inhibition were diluted and cleaned up with a recommended kit, but the inhibition could not be resolved. There is a general census on the use of the AllBac marker to indicate the overall load of Bacteroides; there are differences in opinions among professionals on which human specific marker to use. There is a trade-off between sensitivity and specificity that must be assessed in relation to project objectives. The HuBac marker has been found to come from human sources in large quantities, but also from several animal sources in smaller quantities. Table 34 displays the human host specific Bacteroides DNA marker HuBac and is reported in DNA copies per microliter of extract. The abbreviation “BDL” denotes concentration below the detection limit (less than one copy per microliter of extract). Similar to the AllBac DNA marker, four of the samples were inhibited. Four the purpose calculation of the SCV, a HuBac value of 426 copies per µL was assigned to the May 3, 2012 sampling data at Site 5. The value was assigned based on the average of all other available dry day HuBac values for this site. Infilling of data could not be performed on the inhibited wet weather samples because no other wet weather data was available to interpolate from. Wet weather appears to increase human fecal signals in the watershed. However, the level of HuBac actually dropped in the wet weather sample when compared to the overall dry sample averages at Site 6.

The most specific human marker, qHF183, was also assessed in more of a presence/absence mode to bring more definition to sites with high levels of HuBac relative to sewage. The qHF183 values are reported in Table 35. The abbreviation “BDL” denotes concentration below the detection limit (less than one copy per microliter of extract) and the abbreviation “BQL” denotes concentrations below the quantifiable limit (less than 10 copies per microliter of extract). As with the HuBac and AllBac DNA markers, four of the samples were inhibited. No data infilling was assigned for qHF183 values. The presence of qHF183 in 100% of the dry day samples at Site 4 indicated a consistent fecal source. The next most frequent site for detection of qHF183 was Site 10. Site 6 has the highest transformed ratio of HuBac signal, but only had detectable qHF183 in one of the six samples indicating the HuBac may be not from a human source.

Table 35. MST qHF183 Concentrations (DNA copies/µL)

Site #	Date						
	3/21/2012	4/4/2012	4/11/2012	4/27/2012	5/3/2012	5/8/2012	8/28/2012
2	1.28E+02	BDL	BDL	BDL	BQL	BQL	Inhibited
4	1.21E+01	BQL	BQL	1.14E+01	2.15E+01	1.32E+01	Inhibited
5	BQL	BQL	inhibited	BDL	Inhibited	BQL	9.41E+03
6	BDL	BDL	BDL	BDL	BDL	2.14E+01	3.36E+01
10	BQL	BQL	BQL	BQL	BDL	1.20E+01	1.79E+01

Table 36. LHC SCVs

Site #	Date			
	4/27/2012 (Dry)	5/3/2012 (Dry)	5/8/2012 (Dry)	8/28/2012 (Wet)
2	0.25	0.27	0.47	N/A
4	0.39	0.39	0.54	N/A
5	0.00	2.04*	0.61	2.20
6	0.72	1.34	1.37	2.45
10	0.70	0.24	1.06	1.78

*Calculated using average HuBac values for non-inhibited dry samples.

Based on the E. coli concentrations, AC/TC ratios, and HuBac value, SCVs were assigned by Dr. Gail Brion as described in the *Final Report and Executive Summary to Palmer Engineering on Water Quality Study on Lower Howards Creek*, located in APPENDIX I. As previously discussed, SCVs could not be assigned to the first three sampling events (March 21, April 4, and April 11) due to quality control issues with the AC/TC media. The calculated SCVs are located in Table 36. Due to inhibition in the samples, SCVs could not be assigned to Site 2 and Site 4 for the wet weather sample. The May 3, 2012 sample at Site 5 was also inhibited, but the HuBac value was estimated as described above.

The average SCV is significantly different from that of sewage for all sites in LHCW, but fecal loading still appears to be a problem. In the three sites with uninhibited HuBac markers, significant increases in the SCVs were seen in the wet weather samples. The site located in the upstream, developed portions of the watershed, Sites 5, 6, and 10, have the highest SCVs calculated under dry conditions and are of the greatest concern. Site 6 has a fresh and fairly high fecal load entering the stream from the surrounding landscape. The fecal load appears to be from mixed sources, predominately non-human since the qHF183 marker is not consistently present. Site 10 has lesser fecal loads with an older fecal age, but contains a persistent human signal indicating the presence of human sewage inputs into the stream. Site 6 and Site 10 blend together and the result is seen at Site 5. Site 5 has a lower SCV than Site 6, but higher than Site 10. Although it appears that there is another source of fecal load input upstream of Site 5, but downstream of Site 6 and 10 due to increase seen during the wet weather sampling event. Site 4 has a lower SCV than the upstream sites, but a higher proportion of HuBac to sewage and detection of qHF183 in 100% of the uninhibited samples. The consistent signal of human fecal material is apparent and suggests that the site is receiving human fecal materials, in small, consistent quantities. The human signal at Site 4 appears to be input without the addition of fecal load or significant lowering of fecal age. Consistent with the notion of a leaking or improperly performing septic system, it is hypothesized that small amounts of anaerobically-treated human waste are regularly being input into the creek. The bacteria containing the source tracking markers could persist through treatment that removes a significant portion of the E. coli. Bacteria for the genetic markers are present in quantities more than 1000 times higher than E. coli in fecal material, allowing for the source markers to appear without a significant increase in E. coli loadings. The lowest SCV values were seen at Site 2. The consistent human signal input at Site 4 became very dilute and sporadic with a detection level of qHF183 below detection 50% of the time.

5. BEST MANAGEMENT PRACTICES (BMP)

5.1. GOAL, OBJECTIVE, AND BMP OVERVIEW

5.1.1. GOAL AND OBJECTIVE SELECTION

To direct BMP selection, the project team, with the assistance of stakeholders, established goals and objectives for the LHCW. Goals and objectives were selected based on existing watershed data, sampling results, stakeholder input, and engineering judgment. At Stakeholder Meeting Three on May 29, 2012, all attendees were provided the *Lower Howards Creek Watershed Stakeholder Survey*, which is located in APPENDIX A, to prioritize goals and objectives according to their personal opinions. Possible suggestions for goals and objectives were listed. The questionnaire was also provided to any party who had previously provided an email or street address at a previous public meeting or expressed interest in the project. This list of possible goals and objectives were developed by the project team. The questionnaire also included an area where additional goals and objectives could be listed by the stakeholder. The questionnaire asked the stakeholder to prioritize each goal and objective with a number one to five, with one being not important, three being moderately important, and five being most important. Only six questionnaire responses were received by June 1, 2012. It was indicated at the public meeting, as well as in the letters and emails, that all questionnaires must be received by this date to be considered. Stakeholder input was incorporated in goal and objective selection, but was not the primary consideration due to the limited number of responses received.

A list of potential goals was developed by the project team to be evaluated. The six goals that were considered for LHCW were:

1. Improve water quality for safe recreational use;
2. Improve watershed awareness and education in the community;
3. Diversify and increase the presence of aquatic and terrestrial wildlife;
4. Implement measures to protect the stream & riparian zone during future development;
5. Improve the aesthetic appeal of the stream; and
6. Improve stormwater management (reduce flooding), especially during large rain events.

The above goals were identified on the questionnaire provided to the stakeholders. A concise list of goals was desired to better simply for public involvement and direct objective and BMP selection. Items one, four, and six were the highest ranking goals on the questionnaires received. Based on the watershed data, sampling results, and engineering judgment, the project team also highly prioritized these goals. The project team felt that improving watershed awareness and education in the community was also a high priority goal because it would assist in accomplishing the other goals. Items three and five were not identified as high priority goals by the project team or the stakeholders. If the other goals were accomplished, items three and five would be positively impacted, eliminating the need for them to be separately listed. LHC is listed as impaired for not supporting aquatic life use. The initial potential goals outlined did not include improving aquatic life support; however, this was identified as a priority for KDOW. KDOW was concerned that if the improvement of aquatic life support was not explicitly included, then it may not be as a result of plan implementation. To address this concern, the project team altered Item 1 to include improving aquatic life support.

Based on the existing watershed data, sampling results, stakeholder and KDOW input, and engineering judgment, the following four goals were prioritized as most important for LHCW:

1. Improve water quality for aquatic life support and safe recreational use;
2. Improve watershed awareness and education in the community;
3. Implement measures to protect the stream & riparian zone during future development; and
4. Improve stormwater management (reduce flooding), especially during large rain events.

Goal selection provided a broad plan of action, but identified priorities that were not strictly measurable or tangible. Objectives were selected to assist in achieving the above identified goals. Objectives identified specific issues in the watershed and allowed for measurable benchmarks to be established to determine if they were accomplished. The objectives included for consideration in LHCW were:

1. Reduce human fecal inputs through SSO elimination and identification of failing septic systems and areas of sewer exfiltration to benchmark levels for bacteria;
2. Reduce fecal inputs from livestock to benchmark levels for bacteria;
3. Reduce algal blooms and eutrophication to improve water quality and aesthetic appeal;
4. Expand and/or preserve stream riparian zone to filter runoff and increase habitat;
5. Stabilize stream banks to reduce erosion;
6. Reduce flooding by reducing or slowing stormwater runoff;
7. Inform the public of the water quality status in LHC; and
8. Proposed revisions to codes and ordinances to incorporate water quality standards and issues.

The above objectives were identified on the questionnaire provided to the stakeholders. Items one, five, and six were the highest ranking objectives on the questionnaires received; however, since only six responses were received, it was determined that a representative sample was not provided. Based on the selected goals the project team felt that all the objectives considered were applicable for the selected goals and should be targeted for implementation. The objective of proposing revisions to codes and ordinances to incorporate water quality standards will be addressed within the other listed objectives, eliminating the need for it to be listed separately. The original objectives considered did not include reducing fecal inputs from domestic pets. Objective 2 was revised to include all non-human fecal inputs, mainly livestock and domestic pets. The project objectives were identified as:

1. Reduce human fecal inputs through SSO elimination and identification of failing septic systems and areas of sewer exfiltration to benchmark levels for bacteria;
2. Reduce fecal inputs from non-human sources to benchmark levels for bacteria;
3. Reduce algal blooms and eutrophication to improve water quality and aesthetic appeal;
4. Expand and/or preserve stream riparian zone to filter runoff and increase habitat;
5. Stabilize stream banks to reduce erosion;
6. Reduce flooding by reducing or slowing stormwater runoff; and
7. Inform the public of the water quality status in LHC.

5.1.2. POTENTIAL BMP IDENTIFICATION

Potential BMPs were also included on the questionnaire provided to the stakeholders. The list of potential BMPs was developed by the project team as a wide range of possible options. Research was conducted by the project team to identify practices used in other communities for inclusion on the BMP list. The stakeholders were asked to identify the BMPs that they felt would be most successful by placing a circle around the corresponding letter and the BMPs that they felt would be impractical or not successful by placing an "X" through the corresponding letter. The questionnaire provided a location for stakeholders to identify additional BMPs that they would like to see implemented. The potential BMPs listed for consideration on the questionnaire were:

A. SSO removal by WMU (scheduled for completion under Consent Decree);
B. CCTV or smoke test for areas experiencing exfiltration and repair/replace damaged areas;
C. Additional microbial source tracking (to identify the source of bacteria pollutants);
D. Identify and replace failing and improperly maintained septic systems or straight pipes;
E. Livestock exclusion fence;
F. Providing off stream watering for livestock;
G. Providing shade for livestock away from stream;
H. Requirement for minimum riparian buffer;
I. Install filter strips, rain gardens, and/or streamside wetlands;
J. Install wood chip bioreactors to reduce nutrients;
K. Tree and vegetation planting along streams;
L. Stream restoration to repair areas of eroded banks and limited access to floodplain;
M. Rain barrel program;
N. Provide regional detention areas to reduce flooding;
O. Provide wetland areas to improve water quality;
P. Provide and inform public of means to dispose of yard waste;
Q. Watershed health education programs for property owners;
R. Develop public displays to be posted at library or other public places;
S. Incorporate water quality education curriculum at local elementary, middle, and high schools;
T. Include water quality information on local governmental webpages;
U. Partner with City of Winchester MS4 activities;
V. Storm drain stenciling;
W. Pet waste program;
X. LHC Nature and Heritage Preserve acquisition of additional land along LHC; and
Y. Implement post construction stormwater program.

As previously noted, only six responses to the questionnaire were received. Due to a wide variation in responses and the limited number received, the project team could not accurately assess the community's response to several of the potential BMPs. The consistent responses were considered and are included in the discussion on BMP feasibility in Section 5.2. The list of potential BMPs provided to the project stakeholders included only generic BMPs. Specific Action Items for selected BMPs considered for implementation are discussed in Section 5.3.

5.2. BMP FEASIBILITY AND SELECTION

After receiving input from the project stakeholders, the project team assessed the feasibility of potential BMPs based on existing watershed data, sampling results, stakeholder input, and engineering judgment. The potential BMPs have been separated into three groups: BMPs recommended for implementation; BMPs not recommended for implementation; and BMPs that are not currently recommended for implementation, but should be reassessed in the future. Some of the items listed as BMPs on the questionnaire may also be listed as Action Items in Table 38, starting on page 110, as opposed to BMPs. At least one Action Item was designated for each selected BMP.

A large number of the considered BMPs were recommended for implementation. The following list was the BMPs recommended for implementation:

A. SSO removal;
B. Make provisions to identify and repair areas where the sanitary sewer system is experiencing inflow, infiltration and exfiltration;
C. Identify and replace failing or improperly maintained septic systems or straight pipes;
D. Provide off stream watering and shade for livestock;
E. Encourage livestock field rotation with limited time in fields with access to streams;
F. Install filter strips to reduce fecal input from runoff;
G. LHC Nature and Heritage Preserve expansion;
H. Implement proper pet waste disposal practices;
I. Install rain gardens and/or streamside wetlands;
J. Provide and inform public of means to dispose of yard waste;
K. Implement water quality requirements for new developments;
L. Conduct tree and vegetation planting along streams;
M. Require a minimum riparian buffer on all new construction projects;
N. Perform stream restoration to repair areas of eroded banks and limited access to floodplain;
O. Develop rain barrel program;
P. Ensure existing stormwater management measures are being properly maintained and all new developments have proper water quantity controls; and
Q. Increase public education of the watershed.

BMPs were selected to meet the objectives outlined in Section 5.1.1. Table 38, beginning on page 110, outlines the objectives with the associated contributing BMPs and Action Items.

Livestock exclusion fences were not recommended in lower portions of the watershed, especially along the main channel of LHC. Due to the location in the Palisades region and resulting topography in the lower areas, the floodplain is often restricted due to rock faces causing high velocity flows during wet weather events. Livestock exclusion fences are highly susceptible to damage due to high flows and/or large debris. The property owners expressed concerns with livestock exclusion fencing due to the cost of post fence construction maintenance. Even if grant money is used for installation, the property owners would be eventually responsible for repairing damaged fences. As previously mentioned, livestock exclusion fences have already been installed in the vicinity of Site 8. The fence was installed as a part of a grant, but has since been damaged due to high flows or large debris. None of the completed questionnaires received indicated that they felt livestock exclusion fences would be a successful BMP. Five of the six questionnaires indicated that installing livestock exclusion fence would be impractical or not successful. Although under certain circumstances livestock exclusion fencing can be beneficial in some areas, it is not recommended for installation in lower portions of LHCW due the topography and lack of community support. Livestock exclusion fence could be considered in the upper areas of the watershed where other BMPs are impractical or have failed.

Another BMP that was considered but not recommended for implementation was providing regional detention. Since flooding was such a large concern and the reduction of flooding by reducing or slowing of stormwater flows was listed as an objective, the project team investigated options for providing regional detention within the watershed. Due to the flooding experienced in the Stoneybrook neighborhood, areas upstream were considered for locating regional detention. The area that appeared to be best suited was along KY 627 (Boonesboro Road) near the northern most intersection of KY 627 and Old Boonesboro Road at the location where LHC crosses under KY 627 in a box culvert. The project team utilized the hydraulic model prepared by Palmer Engineering as a part of the Flood Study of LHC for WMU to assess the amount of relief provided by the installation of detention in this area. Table 37 summaries the analysis detailing the water surface elevations reductions and the required storage for those reductions. A large storage volume would be required to see minimal flooding relief. The new gravity sanitary sewer trunk sewer is also located in this area. The optimal location of the detention pond conflicts with the newly constructed sanitary sewer interceptor along LHC. The project team could not identify any other areas suitable for regional detention upstream of the Stoneybrook area. Regional detention was not recommended for implementation due to the large storage volume required to obtain minimal flooding elevation reductions and the location of the sanitary sewer interceptor line.

Table 37. Regional Detention Pond Storage and Water Surface Elevation Reductions at RM 7.9

Storm Event	Storage Required (Acre-Feet)	Water Surface Elevation Reduction (Feet)
2 Year	40.5	0.55
10 Year	83.4	0.70
25 year	105.2	0.74
50 Year	119.9	0.73
100 Year	135.6	0.73

The project team also considered recommending BMPs to reduce flooding in accordance with the 2003 USACE's *Flood Plain Management Service Program Special Study for Winchester, Kentucky* in the Hampton Manor neighborhood. As previously discussed, the report provided three alternatives for the flooding in the Hampton Manor neighborhood. All of the provided alternatives involved increasing the capacity of downstream culverts and/or bridges to prevent water from being detained from behind these structures. The increased capacity upstream would increase downstream flooding in the area of Stoneybrook neighborhood. The Stoneybrook neighborhood already experiences severe flooding in which Old Boonesboro Road becomes impassable. None of the three alternatives are recommended BMPs for implementation due to the increased flooding risk to downstream areas.

The BMPs not currently recommended for implementation, but should be reassessed in the future were installation of wood chip bioreactors to reduce nutrients and storm drain stenciling. These BMPs were not selected for implementation at this time due to lack of community support, cost of installation, or the potential for an alternative BMP to be more effective. Installation of woodchip bioreactors did not receive support from the community and would be costly to install due to the required excavation and material costs. Woodchip bioreactors may be considered in conjunction with a stream restoration project if excavation is already planned and a source for wood chips is available. Woodchip bioreactors may also be applicable in areas around concentrated feed operations due to the small, contained areas with only sheet flow. As a part of the City of Winchester’s MS4 program, all the storm drains are planned to be stenciled within the City limits. The project team felt that the largest source of yard waste in the streams came from property owners directly dumping into the stream, so storm drain stenciling may not be an effective BMP. Storm drain stenciling should be reevaluated for implementation in areas of the watershed located in the county based on the success of the efforts within the City.

5.3. ACTION ITEM IDENTIFICATION AND PRIORITIZATION

For each selected BMP, at least one action item was identified to provide a means to implement the BMP. Table 38, beginning on page 110, identifies each objective and the BMPs and Action Items that will assist in accomplishing the BMP. The BMPs are labeled by letters corresponding with the list provided in Section 5.2. The Action Items are labeled with numbers that correspond with the following discussion of each. Some Action Items help to satisfy more than one BMP, so the same number may be listed under different BMPs. A total of 17 BMPs and 33 Action Items were selected for implementation.

Following Table 38, the responsible party, technical assistance, total costs, funding mechanism, outcome indicators, prioritization, and measureable milestones for implementation will be discussed for each Action Item. The Action Items are prioritized into three categories for implementation. Category One items are the highest priority and have an implementation time of within two years. Category Two items are second priority with an implementation time frame of three to seven years. Category Three items are the lowest priority and have an implementation time frame of over seven years.

The project team has prioritized subwatersheds for implementation for Objectives 1 through 6. Since Objective 7 focuses on informing the public of water quality issues, it should be implemented on a watershed wide scale and cannot be broken down for implementation in specific subwatersheds. Up to the top five subwatersheds for each objective have been prioritized in the following manner:

- Objective 1: Reduction of human fecal impacts
    1. Subwatershed beginning at Site 10 (Vaught Road area)
    2. Subwatershed from Site 5 to northern intersection of Old Boonesboro Road and KY 627 (Stoneybrook neighborhood and Calmes Blvd area)
    3. Subwatershed beginning at Site 6 (Hampton Manor neighborhood)
    4. Subwatershed at Site 4 (including failing septic system)
    5. Subwatershed beginning at Site 9 (Fontaine Blvd area)

- Objective 2: Reduction of non-human sources
    1. Subwatershed between Site 2 and Site 3 including Dry Fork
    2. Subwatershed beginning at Site 6 (Hampton Manor neighborhood)
    3. Subwatershed beginning at Site 9 (Fontaine Blvd area)
    4. Subwatershed from Site 5 to northern intersection of Old Boonesboro Road and KY 627 (Stoneybrook neighborhood and Calmes Blvd area)
    5. Subwatershed beginning at Site 8 (West Fork)

- Objective 3: Reduction of algal blooms and eutrophication
    1. Subwatershed beginning at Site 8 (West Fork)
    2. Subwatershed beginning at Site 7 (Deep Branch)
    3. Subwatershed from Site 5 to northern intersection of Old Boonesboro Road and KY 627 (Stoneybrook neighborhood and Calmes Blvd area)
    4. Subwatershed beginning at Site 6 (Hampton Manor neighborhood)
    5. Subwatershed beginning at Site 9 (Fontaine Blvd area)

- Objective 4: Expansion of stream riparian zone
    1. Subwatershed beginning at Site 8 (West Fork, particularly upstream of RM 2.15)

    2. Subwatershed from Site 5 to northern intersection of Old Boonesboro Road and KY 627 (Stoneybrook neighborhood and Calmes Blvd area)
    3. Subwatershed beginning at Site 6 (Hampton Manor neighborhood)
    4. Subwatershed beginning at Site 9 (Fontaine Blvd area)
    5. Subwatershed north of Carroll E. Ecton Reservoir

- Objective 5: Stabilization of stream banks
    1. Subwatershed from Site 5 to northern intersection of Old Boonesboro Road and KY 627 (Stoneybrook neighborhood and Calmes Blvd area)
    2. Areas on the LHC Nature and Heritage Preserve (particularly in vicinity of Site 1)
    3. Subwatershed beginning at Site 9 (Fontaine Blvd area)
    4. Subwatershed beginning at Site 6 (Hampton Manor neighborhood)
    5. Subwatershed beginning at Site 10 (Vaught Road area)

- Objective 6: Reduction of flooding
    1. Subwatershed from Site 5 to northern intersection of Old Boonesboro Road and KY 627 (Stoneybrook neighborhood and Calmes Blvd area)
    2. Subwatershed beginning at Site 6 (Hampton Manor neighborhood)
    3. Existing WTP location (upstream of Site 4)

Table 38. BMP and Action Item Identification

OBJECTIVE	BMP	ACTION ITEMS
1. Reduce human fecal inputs through SSO elimination and identification of failing septic systems and areas of sewer exfiltration to benchmark levels for bacteria	A. SSO Removal	1. Remove SSOs in accordance with the Consent Decree
	B. Make provisions to identify and repair areas where the sanitary sewer system is experiencing inflow, infiltration and exfiltration	2. Continuation of existing programs for the LHCW in the WMU Continuous Sewer System Assessment Program (CSSAP) and Infrastructure Rehabilitation Program (IRP)
		3. Conduct additional MST at Site 9 and on other tributaries in LHCW to help determine fecal source.
		4. Develop a web based system for the public reporting of potential leaks and cross connections with the storm sewer system.
		5. Investigate exfiltration in lateral connections and remediate.
		6. Identify funding sources for necessary repairs to existing sanitary sewers.
	C. Identify and replace failing or improperly maintained septic systems or straight pipes	7. Develop a web based system for public reporting of potential straight pipes and failing septic systems.
		8. Notify property owners of any confirmed straight pipes or failing septic systems.
		9. Educate community on septic system maintenance.
2. Reduce fecal inputs from non-human sources to benchmark levels for bacteria	D. Provide off stream watering and shade for livestock	10. Hold an information session to inform the agricultural community on options for keeping livestock out of the stream.
		11. Investigate the feasibility of providing an alternative water source for livestock.
		12. Utilize NRCS Cost Sharing program for livestock exclusion fencing (Practice #472) in feasible locations of the upper portions of LHCW
		13. Utilize NRCS Cost Sharing program for spring development (Practice #574).
	E. Encourage livestock field rotation with limited time in fields with access to streams	14. Hold an information session to inform the agricultural community on the benefits of livestock field rotation.
	F. Install filter strips to reduce fecal input from runoff	15. Educate the community on the benefits filter strips can provide.
		16. Utilize NRCS Cost Sharing program for filter strip (Practice #393) installation.

Table 38. BMP and Action Item Identification (Continued)

OBJECTIVE	BMP	ACTION ITEMS
2. Reduce fecal inputs from non-human sources to benchmark levels for bacteria (continued)	G. LHC Nature and Heritage Preserve expansion	17. LHC Nature and Heritage Preserve to coordinate with land owners to acquire additional land in accordance with the *LHC Corridor Management Plan*
	H. Implement proper pet waste disposal practices	18. Educate the community on the hazards of improper animal waste disposal.
		19. Investigate connection of floor drains in veterinary clinic on KY 627 and remediate if no treatment is occurring.
3. Reduce algal blooms and eutrophication to improve water quality and aesthetic appeal	F. Install filter strips to reduce fecal input from runoff (See above)	15. (See above)
		16. (See above)
	I. Install rain gardens and/or streamside wetlands	20. Utilize in-lieu fee payments within the City of Winchester limits.
		21. Stabilize the banks and construct streamside wetlands along the portion of LHC on the new Clark County High School property.
		22. Upon WTP decommissioning, remove the lower impoundment and develop a restored channel with streamside wetlands and buffer zone.
		23. Perform a stream restoration project to stabilize the right bank of LHC in the vicinity of Site 1 on the LHC Nature and Heritage Preserve.
		24. Educate the community on the benefits of rain gardens and/or streamside wetlands and implement.
	J. Provide and inform public of means to dispose of yard waste	25. Investigate alternatives for the community to dispose of yard waste.
		26. Educate the community of the harmful effects of dumping yard waste in the stream and using excess fertilizer.
	K. Implement water quality requirements for new developments	27. Recommend updates to City and County Codes and Ordinances
4. Expand and/or preserve stream riparian zone to filter runoff and increase habitat	L. Conduct tree and vegetation planting along streams	28. Utilize NRCS Cost Sharing program for riparian forested buffer (Practice #391) and tree planting (Practice #612)
		20. (See above)
	M. Require a minimum riparian buffer on all new construction projects	27. (See above)

Table 38. BMP and Action Item Identification (Continued)

OBJECTIVE	BMP	ACTION ITEMS
5. Stabilize stream banks to reduce erosion	N. Perform stream restoration to repair areas of eroded banks and limited access to floodplain	21. (See above)
		22. (See above)
		23. (See above)
		29. Identify, design, and implement stream restoration on impaired reaches.
	L. Conduct tree and vegetation planting along streams (See above)	28. (See above)
		20. (See above)
6. Reduce flooding by reducing or slowing stormwater runoff	N. Perform stream restoration to repair areas of eroded banks and limited access to floodplain (See above)	21. (See above)
		22. (See above)
		23. (See above)
		24. (See above)
		29. (See above)
	O. Develop rain barrel program	30. Establish a rain barrel distribution program and educate the public.
	P. Ensure existing stormwater management measures are being properly maintained and all new developments have proper water quantity controls	27. (See above)
7. Inform the public of the water quality status of LHC	Q. Increase public education of the watershed	9. (See above)
		10. (See above)
		14. (See above)
		15. (See above)
		18. (See above)
		24. (See above)
		25. (See above)
		31. Develop public displays or educational flyers on water quality issues.
		32. Incorporate water quality education curriculum at local elementary, middle, and high schools.
		33. Include information on water quality in LHCW on local government and community web pages.

ACTION ITEM 1

Action Item 1: Remove SSOs in accordance with the Consent Decree.

Description: SSOs should be removed in accordance with the schedule and requirements outlined in the Consent Decree. Several construction projects are currently in progress to eliminate the identified SSOs. If additional SSOs not included in the Consent Decree are identified, they should be removed as soon as practical.

Responsible Party: WMU and the City of Winchester

Technical Assistance: Selected engineering consultants

Total Costs: $36,600,000 (for LHCW Consent Decree improvements only)

Funding Mechanism: Clean Water State Revolving Fund (CWSRF) Kentucky Infrastructure Authority (KIA) loan and City of Winchester

Outcome Indicators: E. coli and conductivity reduction

Prioritization: Category One

Measureable Milestones: Removal of SSOs in the vicinity of Snowfall and Stoneybrook Pump Stations by January 31, 2013 and removal of the SSOs in the Hampton Manor neighborhood by 2022. WMU anticipates the SSOs in the Hampton Manor neighborhood to be removed by January 31, 2013 due to increased downstream sewer system capacity.

ACTION ITEM 2

Action Item 2: Continuation of existing programs for the LHCW in the WMU Continuous Sewer System Assessment Program (CSSAP) and Infrastructure Rehabilitation Program (IRP)

Description: Areas identified with high E. coli concentrations (residential areas in the vicinity of Hampton Manor, Fontaine Drive, Vaught Road, and Stoneybrook) should have higher priority in the CSSAP and IRP, increasing the potential for replacement and maintenance activities by WMU.

Responsible Party: WMU

Technical Assistance: WMU staff and engineering consultants

Total Costs: No additional costs beyond existing programs expenses for CSSAP and IRP

Funding Mechanism: Not applicable

Outcome Indicators: Completed inspections

Prioritization: Category One

Measureable Milestones: Maintain compliance with policies for maintenance and replacement as set force in the CSSAP and IRP

ACTION ITEM 3

Action Item 3: Conduct additional MST at Site 9 and on other tributaries in LHCW to help determine fecal source.

Description: Conduct additional MST at Site 9, on tributaries upstream of the reservoir, and on other tributaries in LHCW where high E. coli concentrations are identified in KRWW or other testing results to help determine fecal source. Additional MST should only be conducted where the fecal source is not known and other BMPs cannot be implemented until the source is determined. Samples can be collected by volunteers and delivered to the laboratory for processing.

Responsible Party: Friends of LHC

Technical Assistance: University of Kentucky

Total Costs: $3,000 per site

Funding Mechanism: KRWW for sampling; 319(h) grants for laboratory expenses
Outcome Indicators: Completed testing
Prioritization: Category Two
Measureable Milestones: As necessary to identify fecal sources in areas of high E. coli concentration.

ACTION ITEM 4

Action Item 4: Develop a web based system for the public reporting of potential leaks and cross connections with the storm sewer system.
Description: Include an area on the Friends of LHC website for the public to report potential sanitary sewer system leaks and cross connections with the storm sewer system. The forum should include the location of the suspected leak or cross connection, why this location is suspected, and provide a place for contact information for the person reporting.
Responsible Party: Friends of LHC
Technical Assistance: WMU Staff
Total Costs: Not applicable
Funding Mechanism: Not applicable
Outcome Indicators: Legitimate public reports
Prioritization: Category One
Measureable Milestones: Update Friends of LHC website to include a method of public reporting within two years.

ACTION ITEM 5

Action Item 5: Investigate exfiltration in lateral connections and remediate.
Description: Perform testing for lateral connection leaks or exfiltration using smoke testing or other methods. Coordinate with WMU on necessary repairs. Areas of high E. coli concentrations in the vicinity of Hampton Manor, Fontaine Drive, Vaught Road, and Stoneybrook should be targeted for testing.
Responsible Party: Friends of Lower Howards Creek
Technical Assistance: Engineering and testing consultants
Total Costs: $400 per home for lateral connection investigations and $3,000 per home for lateral connection remediation
Funding Mechanism: 319(h) grants
Outcome Indicators: Identification and repair
Prioritization: Category One
Measureable Milestones: Begin investigation of lateral connections within three years.

ACTION ITEM 6

Action Item 6: Identify funding sources for necessary repairs to existing sanitary sewers.
Description: Identify funding sources (such as Community Development Block Grants, CWSRF KIA loans, local funding) to repair areas where leaks or exfiltration issues are identified within the existing sanitary sewer system.
Responsible Party: WMU
Technical Assistance: WMU Staff
Total Costs: Not applicable
Funding Mechanism: Community Development Block Grants (CWBG); CWSRF KIA loans; local funding

Outcome Indicators: Necessary funding available
Prioritization: As necessary repairs are identified
Measureable Milestones: As necessary repairs are identified

ACTION ITEM 7

Action Item 7: Develop a web based system for public reporting of potential straight pipes or failing septic systems.
Description: Include an area on the Clark County Health Department website for the public to report potential straight pipes or failing septic systems. The forum should include the location of the suspected straight pipe or failing septic system, why this location is suspected, and provide a place for contact information for the person reporting.
Responsible Party: Clark County Health Department
Technical Assistance: Not applicable
Total Costs: Not applicable
Funding Mechanism: Not applicable
Outcome Indicators: Web based system of reporting
Prioritization: Category One
Measureable Milestones: Place a method of public reporting of potential straight pipes and failing septic systems on the Clark County Health Department website within two years.

ACTION ITEM 8

Action Item 8: Remediate confirmed straight pipes or failing septic systems
Description: Owners of properties where confirmed straight pipes or failing septic systems are identified should be notified by the Clark County Health Department. These issues should be repaired by the property owner. A failing septic system is suspected based on the MST sampling results directly adjacent to Site 4. The LHC Implementation Coordinator will be responsible coordinating with the Clark County Health Department on notification and repairs.
Responsible Party: LHCWMP Implementation Coordinator, Clark County Health Department
Technical Assistance: Not applicable
Total Costs: Approximately $4000 per repair of failing septic system; $15,000 for new septic system installation
Funding Mechanism: Landowner expense or 319(h) grant
Outcome Indicators: E. coli and conductivity
Prioritization: As necessary straight pipes and failing septic systems are identified are repaired
Measureable Milestones: Elimination of straight pipes and failing septic systems as they are identified

ACTION ITEM 9

Action Item 9: Educate community on septic system maintenance.
Description: Provide education to the portion of the community with septic systems on proper maintenance and indicators of poor performance. Hold a training session on proper septic system maintenance and repair. Have educational materials available at the Clark County Extension Office, such as *A Homeowner's Guide to Septic Systems* developed by the EPA. Provide link on Clark County Extension Office website to educational materials. Mail copies of educational material to community residents who live outside of the sewer service boundary.
Responsible Party: Clark County Extension Office

Technical Assistance: Clark County Health Department
Total Costs: $500 per training session and $500 for distribution of educational materials
Funding Mechanism: Bluegrass PRIDE grants and 319(h) grants
Outcome Indicators: Hold one training session biannually and have educational information available
Prioritization: Category One
Measureable Milestones: Education materials on proper maintenance and indicators of poor performance available at the Clark County Extension Office within two years. Distribute copies of educational material to community residents who live outside of the sewer service boundary within two years. Hold first training session on proper septic system maintenance and repair within two years.

ACTION ITEM 10

Action Item 10: Hold an information session to inform the agricultural community on options for keeping livestock out of the stream.
Description: Conduct an information session on methods and techniques for keeping cattle out of the stream, such as off stream watering, planting for creating off stream shade, and livestock exclusion fence. Discuss benefits to water quality, livestock health, and available grant money. This information session can be held in conjunction with the ones in Action Item 14 and 15. Post information on Friends of LHC or Clark County Extension Office website.
Responsible Party: Friends of LHC
Technical Assistance: Clark County Extension Office and engineering consultant
Total Costs: $2,500 for engineering consultant presentation preparation and consultation
Funding Mechanism: 319(h) grants, other water quality grants, or private funding
Outcome Indicators: Successful events
Prioritization: Category One
Measureable Milestones: Conduct at least one informational session within two years.

ACTION ITEM 11

Action Item 11: Investigate the feasibility of providing an alternative water source for livestock
Description: Explore options for providing an alternative water source for livestock, such as spring development, water wells, or providing water using pumps. Assess the feasibility and cost of implementing these measures.
Responsible Party: Friends of LHC
Technical Assistance: WMU and Clark County Extension Office
Total Costs: Not applicable
Funding Mechanism: Not applicable
Outcome Indicators: Feasibility analysis
Prioritization: Category Two
Measureable Milestones: Provide a summary of the alternatives and their feasibility within seven years.

ACTION ITEM 12

Action Item 12: Utilize NRCS Cost Sharing program for livestock exclusion fencing (Practice #472) in feasible locations of the upper portions of LHCW
Description: Install livestock exclusion fencing on agricultural properties along the headwaters of West Fork and Deep Branch used for livestock grazing where there is direct access to streams. Priority

should be given to areas along West Fork, upstream of the Smith Family property where livestock exclusion fence has already been installed. Livestock exclusion fencing is not recommended in the lower potions of the watershed due to high velocity flows and flooding potential. Livestock exclusion fence is only recommended in areas where other BMPs are impractical or not successful. Property owners should utilize the NRCS Cost Sharing program for the installation of livestock exclusion fences in feasible locations.

Responsible Party: Friends of LHC and property owners with livestock

Technical Assistance: NRCS

Total Costs: $50 per foot, but will vary based on type of fencing and whether other improvements will also be necessary, such as providing an alternative water source

Funding Mechanism: NRCS EQIP Cost Share and land owner

Outcome Indicators: E. coli and conductivity

Prioritization: Category Two

Measureable Milestones: Implementation of approximately 3000 linear feet of livestock exclusion fence in areas along West Fork and Dry Fork and other tributaries between Site 2 and 3 within seven years.

ACTION ITEM 13

Action Item 13: Utilize NRCS Cost Sharing program for spring development (Practice #574).

Description: In conjunction with Action Item 12, an additional water source is often needed after the installation of livestock exclusion fences or for proper field rotation practices. Utilize NRCS Cost Sharing program for spring development to provide an additional water source.

Responsible Party: Property owners with livestock

Technical Assistance: NRCS

Total Costs: $5000 each

Funding Mechanism: NRCS EQIP Cost Share and land owner

Outcome Indicators: Developed springs

Prioritization: Category Two

Measureable Milestones: Implementation of approximately two alternative watering sources in conjunction with the livestock exclusion fence installation in areas along West Fork and Dry Fork and other tributaries between Site 2 and 3 within seven years.

ACTION ITEM 14

Action Item 14: Hold an information session to inform the agricultural community on the benefits of livestock field rotation.

Description: Conduct an information session on practices and benefits of livestock field rotation. Discuss benefits to water quality and property maintenance. This information session can be held in conjunction with the ones in Action Items 10 and 15. Post information on Friends of LHC or Clark County Extension Office website.

Responsible Party: Friends of LHC

Technical Assistance: Clark County Extension Office and engineering consultant

Total Costs: No additional costs in held in conjunction with Action Items 10 and 15

Funding Mechanism: Not applicable

Outcome Indicators: Successful events

Prioritization: Category One

Measureable Milestones: Conduct at least one informational session within two years.

ACTION ITEM 15

Action Item 15: Educate the community on the benefits filter strips can provide.

Description: Conduct an information session on practices and benefits of filter strips. Discuss benefits to water quality, livestock health, and available grant money. This information session can be held in conjunction with the ones in Action Items 10 and 14. Post information on Friends of LHC or Clark County Extension Office website.

Responsible Party: Friends of LHC

Technical Assistance: Clark County Extension Office and engineering consultant

Total Costs: No additional costs in held in conjunction with Action Items 10 and 14

Funding Mechanism: Not applicable

Outcome Indicators: Successful events

Prioritization: Category One

Measureable Milestones: Conduct at least one informational session within two years.

ACTION ITEM 16

Action Item 16: Utilize NRCS Cost Sharing program for filter strip (Practice #393) installation.

Description: Install filter strips along areas where contaminants run off directly from livestock fields and crop land to remove contaminants prior to the water entering in the stream. Utilize NRCS Cost Sharing program for filter strip installation in areas along Deep Branch, West Fork, and other identified tributaries.

Responsible Party: Property owners with livestock

Technical Assistance: NRCS

Total Costs: $5000 - $10,000 per acre depending on type of vegetated planted

Funding Mechanism: NRCS EQIP Cost Share and land owner

Outcome Indicators: E. coli, conductivity, and nutrients

Prioritization: Category Two

Measureable Milestones: Implementation of approximately 8,700 linear feet (in conjunction with Action Item 28) of filter strips or riparian buffers zones in areas along West Fork and Dry Fork and other tributaries between Site 2 and 3 within seven years to reduce nutrient and bacteria loading. Implementation along Dry Fork to reduce nutrient loads to within target loadings.

ACTION ITEM 17

Action Item 17: LHC Nature and Heritage Preserve to coordinate with land owners to acquire additional land in accordance with the *LHC Corridor Management Plan*

Description: The Friends of LHC should work with adjacent land owners to enlarge the size of the LHC Nature and Heritage Preserve as the property owners are willing and funds are available. The land that should be targeted should be in accordance with the *LHC Corridor Management Plan.*

Responsible Party: Friends of LHC and LHC Nature and Heritage Preserve

Technical Assistance: None required

Total Costs: Varied based on land acquiring

Funding Mechanism: Private donations, funding through KSNPC, and other grants

Outcome Indicators: Acquire land

Prioritization: Category Three

Measureable Milestones: Contact property owners to determine their willingness to sell their land within two years.

ACTION ITEM 18

Action Item 18: Educate the community on the hazards of improper animal waste disposal.

Description: Educate the community on the hazards of improper waste disposal through public displays, educational flyers, and/or an information session. This education can be combined with outreach activities required by the City of Winchester's MS4 program.

Responsible Party: City of Winchester's MS4 Program and Friends of Lower Howards Creek

Technical Assistance: City of Winchester Engineering Technician and engineering consultants

Total Costs: No additional cost if combine with other activities, otherwise $2,500 per event

Funding Mechanism: 319(h) grant

Outcome Indicators: Successful events and material available

Prioritization: Category One

Measureable Milestones: Conduct at least one educational activity within two years.

ACTION ITEM 19

Action Item 19: Investigate connection of floor drains in veterinary clinic on KY 627 and remediate if no treatment is occurring.

Description: Investigate how the water from the floor drains at the veterinary clinic on KY 627 is disposed and if the water could be a potential pollutant source in LHC. If the water directly enters the storm sewer system or stream and could be a pollutant source, contact the property owner and remediate.

Responsible Party: Friends of LHC

Technical Assistance: None required for investigation; engineering consultants for remediation

Total Costs: Not applicable for investigation; approximately $35,000 to install pre-treatment system

Funding Mechanism: Not applicable for investigation; 319(h) grant or landowner expense for remediation

Outcome Indicators: E. coli and conductivity

Prioritization: Category One

Measureable Milestones: Determine how floor drains are connected within two years.

ACTION ITEM 20

Action Item 20: Utilize in-lieu fee payments within the City of Winchester limits.

Description: With the adoption of the City of Winchester Ordinance 14-2011, new developments have the option of providing water quality treatment onsite or paying an in-lieu fee to the City of Winchester. The City of Winchester should utilize the in-lieu fee payments to install rain gardens or streamside wetlands and conduct tree planting and riparian zone enhancement within the City of Winchester limits. Areas targeted for implementation should include Hampton Manor and the residential area near Vaught Road.

Responsible Party: City of Winchester

Technical Assistance: Engineering consultants

Total Costs: Varied based on project selected and scope of work; property estimated at $12 to $20 a linear foot for conservation easement along the stream; rain garden installation and riparian zone enhancement estimated at $2 to $5 per square foot

Funding Mechanism: In-lieu fee payments made to the City of Winchester

Outcome Indicators: Nutrients

Prioritization: Category Two

Measureable Milestones: Establish the required in-lieu fee payment schedule within two years. Implement at least one project per year after three years.

ACTION ITEM 21

Action Item 21: Stabilize the banks and construct streamside wetlands along the portion of LHC along the new Clark County High School property.

Description: Design and construct an approximately 1500 linear foot stream restoration project in the vicinity of Site 5 on the property for the new Clark County high school. The stream restoration project should stabilize the eroding right bank, provide streamside wetlands, involve revegetation of disturbed areas, and provide an additional educational opportunity for the adjacent high school.

Responsible Party: Friends of LHC and Clark County Board of Education

Technical Assistance: Engineering consultants

Total Costs: $250 per linear foot (will vary based on project scope)

Funding Mechanism: Kentucky Department of Fish and Wildlife in-lieu fee mitigation funds, other offsite mitigation banking, or 319(h) grants

Outcome Indicators: Length restored

Prioritization: Category Two

Measureable Milestones: Design and construction completed within seven years.

ACTION ITEM 22

Action Item 22: Upon WTP decommissioning, remove the lower impoundment and develop a restored channel with streamside wetlands and buffer zone.

Description: After the new WTP is constructed and online, the old WTP near the Carroll E. Ecton Reservoir will be decommissioned. Once the lower impoundment is no longer required, remove the lower impoundment dam and develop a restored channel with streamside wetlands. Establish a dedicated riparian buffer zone and plant with native vegetation.

Responsible Party: Friends of LHC

Technical Assistance: Engineering consultants

Total Costs: $250 per linear foot (will vary based on project scope)

Funding Mechanism: Kentucky Department of Fish and Wildlife in-lieu fee mitigation funds or other offsite mitigation banking

Outcome Indicators: Length restored

Prioritization: Category Two

Measureable Milestones: Design and construction completed within seven years.

ACTION ITEM 23

Action Item 23: Perform a stream restoration project to stabilize the right bank of LHC in the vicinity of Site 1 on the LHC Nature and Heritage Preserve.

Description: Design and construct an approximately 1000 linear foot stream restoration project in the vicinity of Site 1 on the LHC Nature and Heritage Preserve. The stream restoration project should stabilize the eroding right bank, provide streamside wetlands, involve revegetation of disturbed areas, and provide an additional educational opportunity.

Responsible Party: Friends of LHC

Technical Assistance: Engineering consultants

Total Costs: $250 per linear foot (will vary based on project scope)
Funding Mechanism: Kentucky Department of Fish and Wildlife in-lieu fee mitigation funds or other offsite mitigation banking
Outcome Indicators: Length restored
Prioritization: Category Three
Measureable Milestones: Design and construction completed within ten years.

ACTION ITEM 24

Action Item 24: Educate the community on the benefits of rain gardens and/or streamside wetlands and implement.
Description: Coordinate with the public outreach efforts required by the City of Winchester's MS4 Permit to hold an informational meeting or workshop on the benefits of rain gardens and streamside wetlands to improve water quality. Include information on how rain gardens can be implemented by homeowners. This informational meeting can be held in conjunction with Action Items 26.
Responsible Party: City of Winchester MS4 Program and Friends of Lower Howards Creek
Technical Assistance: Engineering consultants
Total Costs: $2,500 for engineering consultant presentation preparation and consultation; property estimated at $12 to $20 a linear foot for conservation easement along the stream; rain garden installation and riparian zone enhancement estimated at $2 to $5 per square foot
Funding Mechanism: City of Winchester and 319(h) grants
Outcome Indicators: Nutrients
Prioritization: Category One
Measureable Milestones: Conduct at least one informational meeting or workshop within two years

ACTION ITEM 25

Action Item 25: Investigate alternatives for the community to dispose of yard waste.
Description: Develop alternatives and assess the feasibility of implementing each alternative for yard waste disposal, such as weekly collecting, composting, or designating a day and location for property owners to drop off yard waste.
Responsible Party: WMU and City of Winchester
Technical Assistance: Engineering consultants
Total Costs: Not applicable
Funding Mechanism: Not applicable
Outcome Indicators: Feasibility Analysis
Prioritization: Category One
Measureable Milestones: Provide a summary of the alternatives and their feasibility within two years.

ACTION ITEM 26

Action Item 26: Educate the community of the harmful effects of dumping yard waste in the stream and using excess fertilizer.
Description: Coordinate with the public outreach efforts required by the City of Winchester's MS4 Permit to hold an informational meeting or workshop on the harmful effects of dumping yard waste in the stream and using excess fertilizer. Include information on available alternatives for yard waste disposal and the effects of applying excess fertilizer. Provide information on soil

sampling to determine what nutrients are deficient in the soils. This informational meeting can be held in conjunction with Action Item 24.

Responsible Party: City of Winchester
Technical Assistance: Engineering consultants
Total Costs: $2,500 for engineering consultant presentation preparation and consultation
Funding Mechanism: City of Winchester and 319(h) grants
Outcome Indicators: Successful event
Prioritization: Category One
Measureable Milestones: Conduct at least one informational meeting or workshop within two years

ACTION ITEM 27

Action Item 27: Recommend updates to City and County Codes and Ordinances
Description: Assess the City and County Codes and Ordinances to find deficiencies in regulating water quantity and quality. Update the City and County Codes and Ordinances to address any deficiencies. Implement a water quality standard treatment requirement. Establish operation and maintenance procedures. Define inspection procedures for during and post construction.
Responsible Party: City of Winchester and Clark County Fiscal Court
Technical Assistance: City of Winchester Engineering Technician, engineering consultants
Total Costs: $120 per hour for review by engineering consultant
Funding Mechanism: City of Winchester, Clark County Fiscal Court, and 319(h) grants
Prioritization: Category One
Outcome Indicators: Revised codes and ordinances
Measureable Milestones: Assess and revise City and County Codes and Ordinances within two years. Reassess City and County Codes and Ordinances after seven years.

ACTION ITEM 28

Action Item 28: Utilize NRCS Cost Sharing program for riparian forested buffer (Practice #391) and tree planting (Practice #612).
Description: Install riparian forested buffer and/or tree planting in areas identified as lacking riparian zone on the map in Figure 38. Property owners should utilize the NRCS Cost Sharing program for the riparian forested buffer and tree planting.
Responsible Party: Friends of LHC and agricultural property owners
Technical Assistance: NRCS
Total Costs: $5000 - $10,000 per acre, varies based on amount and type of vegetation
Funding Mechanism: NRCS EQIP Cost Share and land owner
Outcome Indicators: Amount of land planted
Prioritization: Category Two
Measureable Milestones: Implementation of approximately 8,700 linear feet (in conjunction with Action Item 16) of filter strips or riparian buffers zones in areas along West Fork and Dry Fork and other tributaries between Site 2 and 3 within seven years to reduce nutrient and bacteria loading. Implementation along Dry Fork to reduce nutrient loads to within target loadings.

ACTION ITEM 29

Action Item 29: Identify, design, and implement stream restoration on impaired reaches.
Description: Locate and assess impaired reaches that would benefit from stream restoration to stabilize unstable banks or reestablish connection to the floodplain outside the scope of this study. Identify funding sources. Design and implement selected projects.
Responsible Party: Friends of LHC
Technical Assistance: Engineering consultants
Total Costs: Approximately $250 per linear foot, but varies based on selected project
Funding Mechanism: Kentucky Department of Fish and Wildlife in-lieu fee mitigation funds, other offsite mitigation banking, or 319(h) grants
Prioritization: Category Three
Measureable Milestones: Identify a list of prioritized reaches for restoration within seven years.

ACTION ITEM 30

Action Item 30: Establish a rain barrel distribution program and educate the public.
Description: In conjunction with the City of Winchester's MS4 program, educate the public on the benefits and installation of rain barrels during an informational session. Information session can be held in conjunction with Action Item 24 and 26. Develop a rain barrel distribution program or provide information on where rain barrels can be purchased.
Responsible Party: City of Winchester
Technical Assistance: City of Winchester Engineering Technician and engineering consultants
Total Costs: $75 per rain barrel
Funding Mechanism: Property owners
Outcome Indicators: Number of barrels installed
Prioritization: Category Two
Measureable Milestones: Hold at least one informational session within two years. Develop a rain barrel distribution program within seven years.

ACTION ITEM 31

Action Item 31: Develop public displays or educational flyers on water quality issues.
Description: In conjunction with the public outreach portion of the City of Winchester's MS4 Program, develop public displays to be posted at the library or other public spaces and/or education flyers that explain the importance of water quality. The displays should focus on water quality best management practices that directly affect property owners, such as yard waste, pet waste and chemical disposal; rain barrels and rain garden installation; and maintaining naturally vegetated riparian buffers along streams.
Responsible Party: City of Winchester and Clark County Library
Technical Assistance: City of Winchester Engineering Technician and engineering consultants
Total Costs: Varies based on type and number of displays
Funding Mechanism: City of Winchester
Outcome Indicators: Number of displays/flyers
Prioritization: Category One
Measureable Milestones: Develop at least one display to be posted within two years.

ACTION ITEM 32

Action Item 32: Incorporate water quality education curriculum at local elementary, middle, and high schools.

Description: Incorporate water quality education curriculum such as material developed by Bluegrass PRIDE into the Clark County school system and private schools within Clark County.

Responsible Party: Clark County Board of Education and private schools within Clark County

Technical Assistance: Bluegrass PRIDE

Total Costs: Not applicable

Funding Mechanism: Not applicable

Outcome Indicators: Water quality education of students

Prioritization: Category Three

Measureable Milestones: Implementation of water quality education into Clark County school system within ten years.

ACTION ITEM 33

Action Item 33: Include information on water quality in LHCW on local government and community web pages.

Description: Place water quality information concerning LHCW on the Friends of LHC, City of Winchester, and Clark County Fiscal Court websites. Information should include information on the LHCWMP, current projects, upcoming meetings or workshops, and a link to sign up to volunteer for activities within the watershed. Place a link the Friends of LHC website on Clark County Extension Office and Clark County Health Department websites. Create a database of emails of interested parties.

Responsible Party: Friends of LHC, City of Winchester, and Clark County Fiscal Court

Technical Assistance: None required

Total Costs: Not applicable

Funding Mechanism: Not applicable

Outcome Indicators: Information on websites

Prioritization: Category One

Measureable Milestones: Have information on Friends of LHC, City of Winchester, and Clark County Fiscal Court (or a link to a central location with all information) within two years.

The total cost estimates were based on research of similar projects implemented and will vary based on the scope of each Action Item applied. Some input on cost information was obtained from the Geist/Fall Creek Watershed Alliance located in central Indiana. The implementation of these Action Items will be discussed in Section 6.

5.3.1. EXPECTED OUTCOMES AND LOAD REDUCTIONS

Watersheds have varied responses to BMP application so it is difficult to predict with certainty the level of success and load reductions that will be achieved. The level of success is often determined by the level of community cooperation and involvement in implementation. A watershed model could not be prepared to estimate load reductions, so estimates from similar projects were used. To monitor the level of success and load reductions, monitoring should be performed as outlined in Section 6.4. BMPs should be implemented by the prioritization category listed above. Target loads for E. coli, total nitrogen, and total phosphorous may be achieved within seven years of the final date of this report. Many of the BMPs will assist in improvements in more than one aspect. For example, allowing unmowed natural riparian vegetation in an agricultural area can reduce E. coli and nutrients by slowing and filtering stormwater runoff and create better habitat. The aspects of the stream are dynamic and interconnected, making it difficult to specify expected outcomes. Objectives 1 and 2 most directly addresses E. coli impairments, Objective 3 most directly addresses nutrient impairment, Objectives 4 and 5 most directly addresses habitat impairments, and Objective 6 most directly addresses flooding. Objective 7 plays a role in each of the noted impairments. BMPs in addition or in place of those listed may be utilized it deemed favorable. The estimates are provided to estimate the scope of work and the expected outcome and resulting load reduction. Watersheds are continually changing as land owners move, development occurs, and conditions are altered. The monitoring and evaluation processes discussed in Section 6.4 and Section 6.5 should be followed to ensure that the BMPs recommended continue to be the most appropriate for LHCW.

5.3.1.1. E. COLI

No E. coli load reductions were required at Sites 1, 3, 7, and 8, although upstream BMPs will improve water quality and reduce the bacteria loading. No expected outcomes and load reductions will be discussed for these sites since load reductions are not required when compared with benchmark concentrations. The sites requiring E. coli load reductions will be discussed beginning upstream and continuing downstream to allow for downstream sites to realize loading reductions upstream.

Based on the MST results, the E. coli loading at Site 6 appears to be mixed with significant deterioration during wet weather events. The following outcomes and load reductions are expected from BMP implementation:

- SSOs and leaking/exfiltrating sewer are expected to be contributing 50% of the required reduction in E. coli loading (13.9 trillion MPN/year). Once the SSOs are eliminated in accordance with the Consent Decree and gravity sewer replaced in accordance with the preliminary plans, this E. coli load is expected to be removed. The E. coli load should be reevaluated after the removal and replacement of this infrastructure to determine if there are other sources of human fecal matter.
- The remaining 50% of the required reduction in E. coli loading (13.9 trillion MPN/year) is attributed to other sources such as exfiltrating sewer (especially in the lateral connections), domestic pets and runoff containing sediment with attached bacteria. The City of Tallahassee's *Think About Personal Pollution* website indicates that on average each human produces feces that contain 1.9 billion fecal coliform per day and each dog produces feces that contains 7.7 billion fecal coliform per day, which appears to be consistent with estimates in the EPA's Better Assessment Science Integrating Point and Non-Point Source (BASINS) modeling software. These reductions will be more difficult to implement because they mostly require a change in behavior from the community. Action Item 5 should be implemented to identify additional areas of

exfiltrating sanitary sewers. Action Item 18 should be implemented to assist in changing the behavior of the property owners. Action Items 20 and 24 should be implemented to assist in filtering runoff prior to it entering the stream for bacteria removal and infiltration.

As discussed in Section 4.2.3.1, the top three suspected E. coli sources at Site 10 were SSOs, leaking/exfiltrating sewers, and fecal matter from domestic pets. The following outcomes and load reductions are expected from BMP implementation:

- The MST sampling showed a consistent human signal in the detection of qHF183. The known SSO and suspected exfiltrating sewer directly upstream of Site 10 will be removed by January 31, 2013 in accordance with the Consent Decree. It is estimated that the infrastructure improvements and identification and remediation of exfiltration in Action Item 5 will remove 13.7 trillion MPN/year (75% of the required reduction) of the E. coli loading. The E. coli load should be reevaluated after the removal and replacement of this infrastructure to determine if there are other sources of human fecal matter.
- The remaining 25% of the required reduction in E. coli loading (4.6 trillion MPN/year) is attributed to other sources such as domestic pets and runoff containing sediment with attached bacteria. Similar to Site 6, these reductions will be more difficult to implement because they mostly require a change in behavior from the community. Action Item 18 should be implemented to assist in changing the behavior of the property owners. Action Item 24 should be implemented to assist in filtering runoff prior to it entering the stream for bacteria removal and infiltration. Site 10 is located downstream of a veterinary clinic which may also be contributing to the E. coli loading. The disposal of the water used to wash down the areas where animals are kept should be assessed as listed in Action Item 19.

The source of E. coli loading at Site 9 is suspected to be mixed, human and domestic pet, but MST was not performed at this location. As indicated it Action Item 3, it is suggested that additional MST be performed at this location if funding is available to determine the fecal source. Based on the information available at the time of this report, the following outcomes and load reductions are expected from BMP implementation:

- Action Items 2 through 6 should be implemented to identify areas of leaking or exfiltrating sewers along the tributary for removal of 1.1 trillion MPN/year (50% of the required E. coli reduction). There are no SSOs expected upstream of Site 9.
- Similar to Sites 6 and 10, the remaining 50% of the required reduction in E. coli loading (1.0 trillion MPN/year) is attributed to other sources such as domestic pets and runoff containing sediment with attached bacteria. These reductions will be more difficult to implement because they mostly require a change in behavior from the community. Action Item 18 should be implemented to assist in changing the behavior of the property owners. Action Items 24 should be implemented to assist in filtering runoff prior to it entering the stream for bacteria removal and infiltration.

As discussed in Section 4.2.3.1, the top three suspected E. coli sources at Site 5 were SSOs, leaking/exfiltrating sewers, and fecal matter from domestic pets. The wet weather event in August 2012 greatly impacted the E. coli load. The following outcomes and load reductions are expected from BMP implementation:

- If loads at Sites 6, 9, and 10 are reduced to target loads, a 48.2 trillion MPN/year reduction will be realized at site, bringing the required reduction to 386.2 trillion MPN/year.

- SSOs and leaking or exfiltrating sewers were a predominate source for E. coli loading during wet weather events at Site 5. The existing gravity sewer, force main, and Stoneybrook Pump Station will be removed by January 31, 2013. If the annual load is calculated without the wet weather event, where it is thought that a significant amount of exfiltration occurred due to water pressure on leaking joints in the aged force main and gravity sewer pipe, the required deduction would only be 4.4 trillion MPN/year. It is expected that 381.8 trillion MPN/year will be accomplished by removal and replacement of this infrastructure and identification and remediation of additional exfiltrating sanitary sewers and lateral connections in Action Item 5.
- The remaining 4.4 trillion MPN/year is attributed to other sources such as domestic pets and runoff containing sediment with attached bacteria as with the previous sites discussed. These reductions will be more difficult to implement because they mostly require a change in behavior from the community. Action Item 18 should be implemented to assist in changing the behavior of the property owners. Action Items 20 and 24 should be implemented to assist in filtering runoff prior to it entering the stream for bacteria removal and infiltration.

At Site 4, the top two E. coli source listed in Section 4.2.3.1 were the upstream failing septic system and lower impoundment washout during high flow events. The following outcomes and load reductions are expected from BMP implementation:

- If loads are reduced at Site 5 to target loads, a 434.4 trillion MPN/year reduction will be realized at site, bringing the required reduction to 234.4 trillion MPN/year.
- The MST results indicate that there is a constant human signal at Site 4. It is anticipated that this is due to the location of an upstream failing septic system. Repair or removal of this septic system is expected to eliminate all remaining dry weather E. coli loading exceedances (18 trillion MPN/year).
- The remaining wet weather E. coli impairments are suspected from washout of from the lower impoundment of the reservoir. Action Item 22 calls for removal of the lower impoundment and development of a restored channel with streamside wetlands and buffer zone, eliminating this cause of impairment. It is expected that the implementation of Action Item 22 will reduce E. coli loading by 150 trillion MPN/year with the most significant impact during wet weather events. Action Item 3 should also be implemented at the tributaries north of the reservoir. Additional BMPs should be implemented based on these results to obtain the remaining required load reduction.

As discussed in Section 4.2.3.1, the top two suspected E. coli sources for Site 2 were livestock fecal matter and the upstream failing septic system near Site 4. The following outcomes and load reductions are expected from BMP implementation:

- Based on the 50% detection rate of qHF183 and SCVs presented in the MST results, only a small portion of the daily load is anticipated to be human. It is expected that repair or removal of the upstream failing septic system will provide a 10% reduction (4.1 trillion MPN/year) in the overall fecal load due to comparison of HuBac values to AllBac values.
- The remaining 90% reduction will be required through removal of livestock fecal matter. The City of Tallahassee's *Think About Personal Pollution* website indicates that on average a cow produces approximately 5.4 billion fecal coliform per day. Using the ratio of 130 E. coli: 200 fecal coliform specified in the Kentucky water quality standards, cattle produce 3.5 billion MPN E. coli per day. It is estimated that cattle spend up to 30% of the time in the stream during July and August and up to 10% of the time in the stream during the rest of the year if access is granted. This assumption would result in 0.14 trillion MPN of E. coli per cow directly input into

the stream. To meet the remaining 37.1 trillion MPN/year required reduction, 265 cattle need to be removed from impacting the stream.

- Due to significantly increased loading during wet weather events, it is hypothesized that the E. coli loading predominately comes from runoff during these events. It is proposed that 9.3 trillion MPN/year of E. coli (25% of the remaining) be removed by implemented through installation of livestock exclusion fence in the subwatersheds of West Fork and Dry Fork and along other tributaries between Site 2 and Site 3. To meet this, 67 cattle would need to be excluded from these areas. It is anticipated that this would require approximately 3000 linear feet of fence and the development of two additional water sources. Exclusion fence should be placed only in areas where it is known that cattle have direct access to the stream. Due to the age of the fecal material in the MST results, it is expected that livestock exclusion fence will not be effective in removing the entire remaining E. coli loading. The community also appears to be opposed to livestock exclusion fencing, especially in the lower portions of the watershed, so alternatives may be installed.
- The remaining 27.8 trillion MPN/year should be removed through the installation of filter strips. To meet this, the fecal matter from 198 cattle will have to be removed from impacting the stream, requiring approximately 8,700 linear feet of filter strip or riparian buffer installation in the subwatersheds of West Fork and Dry Fork and along other tributaries between Site 2 and Site 3. Assuming a minimum width of 25 feet on one side of the stream, this will result in approximately 5 acres of filter strip or riparian buffer installation. The filter strips or riparian buffer installation used in conjunction with livestock exclusion fences in areas where livestock are adjacent to the stream would be most effective in removing E. coli loading.

If other BMPs (specifically those listed in Action Items 10 through 17) are installed in place of the above items, these estimates may be decreased. The above estimates were provided to project the scope of work required to achieve water quality standards.

5.3.1.2. NUTRIENTS

Nutrient load reductions were only required at Sites 7 and 8 based on the sampling data collected; however, due to the algae growth observed at all monitoring locations, BMPs associated with Objective 3 should be implemented. Action Items 1 through 27 should be implemented to reduce algal blooms and eutrophication to improve water quality and aesthetic appeal. The amount of improvement that will be achieved is unknown because the nutrient levels were often below detectable limits in the sampling data. It is unknown what level of nutrient contamination is resulting from the SSOs. The nutrient concentrations should be reassessed after the SSOs are removed and the stream is allowed to stabilize. The sites, especially Sites 5 and 6, should be monitored for excessive algae growth as detailed in Section 6.4.

The actual efficiency of each BMP is difficult to estimate and is based on several variables, such as location in the watershed, soils, contribution area, and upstream uses. Due to the variation in effectiveness, no one source exists specifying expected pollutant load removal. The Geist/Fall Creek Watershed Alliance evaluated percent load reductions for BMPs based on the review of the EPA's Stormwater Menu of BMPs, EPAs National Management Measures to Control Nonpoint Source Pollution from Agriculture, The Nature Conservancy of Indiana, The Center for Watershed Protection, and the Spreadsheet Tool for Estimating Pollutant Loads (STEPL). The reported load reductions are located in

Table 39. The project team suspects that these removal rates may be slightly higher than can be expected in LHCW, but they provide a means to estimate potential BMP benefits.

Table 39. Estimated Load Reductions per BMP

	Percent Removal		
BMP/Action Item	**TSS**	**TP**	**TN**
Alternative Water Source	80%	78%	75%
Exclusion Fence	70%	60%	65%
Filter Strips	65%	75%	70%
Naturalized Stream Buffer	75%	45%	40%
Nutrient Management	60%	90%	80%
Rain Gardens	80%	20%	20%
Rotational Grazing	40%	20%	20%
Stream Restoration	75%	75%	75%
Wetlands	80%	55%	45%

A combination of Action Items 1 through 27 should be used to achieve the target loads for nitrogen and phosphorous listed in Table 28 and Table 29. Some BMPs may reduce both E. coli and nutrient loads, such as rotational grazing, providing an alternative water source, and livestock exclusion fences. Numeric nutrient load reductions at Sites 7 and 8 may be achieved within seven years, but it is not expected that the total nitrogen reduction at Site 8 can be achieved within this time period. Implementation of BMPs for phosphorous reduction at Site 7 should occur along Deep Branch in areas north of the LHC Nature and Heritage Preserve. Implementation of BMPs for phosphorous and nitrogen reduction at Site 8 should occur along West Fork, particularly upstream of RM 2.15. The impact to nutrient loads and algae growth should be monitored and assessed at the end of the seven year period. Refer to Section 5.4 for the projected total nitrogen and total phosphorous reductions for each of suggested Action Items.

In the urban areas with the most excessive algae growth, public education will be the most important BMP. It is suspected that many residential properties apply excess fertilizer on their lawn. Most residential property owners purchase a bag of fertilizer and then apply it all so they do not have to dispose of the excess. The soil only absorbs the nutrients that it needs and the excess fertilizer enters the streams during rain events. Residential properties are small, so fertilization is not a large expense due to the limited quantity required, leading to over fertilization. This problem is compounded by the lack of natural riparian vegetation. Agricultural properties are much larger, requiring a large volume of fertilizer. Based on verbal communication with Soil Conservation Officer of the local NRCS office, approximately 70% or more of the larger (greater than five acres) agricultural properties perform soil analysis prior to fertilizer application. Fertilizer has greatly increased in cost over the past several years, so farmers want to maximize their profit by purchasing and applying the minimum amount of fertilizer required. The soil analysis will denote which nutrients are deficient so property owners do not waste money applying unnecessary expensive fertilizers. Several of the area residents also have indicated seeing their neighbors dump yard waste directly into the stream. The property owners seem to be unaware or ill-informed of the problems caused by excess fertilizer and the dumping of yard waste into the stream.

5.3.1.3. CONDUCTIVITY

As previously discussed in Section 4.2.2, conductivity can result from a number of factors, including the geology of the area, failing sewage systems, industrial discharges, fertilization, chemical application, and land disturbance. It is expected that the outlined improvements discussed in Section 5.3.1.1 and Section 5.3.1.2 will result in reduced conductivity levels. The level of reduction cannot be estimated due to the many factors that affect conductivity; however, future water samples are expected to show a noticeable reduction in conductivity. Conductivity should be monitored in accordance with Section 6.4.

5.3.1.4. HABITAT

Objectives 4 and 5 involve improving the habitat and riparian zone. Based on the visual and GIS assessment detailed in Section 4.2.1, it is estimated that 55 to 65 percent of the 95 miles of stream assessed in the watershed would not meet habitat rating benchmarks. It is unrealistic to expect all areas of the watershed to meet habitat rating benchmarks within the planning timeframe of seven years. The project team has set an objective of improving habitat at a rate of 1,000 linear feet per year. Improving the habitat will be considered providing a 25 foot buffer on either side of the stream (50 feet total width) by maintaining undisturbed filter strips, tree planting, constructing streamside wetlands, and allowing for unmowed natural vegetation along the channel or other similar activities. At this rate, 1.3 miles of habitat would be improved within the planning timeframe of seven years. While this is only a small portion of the noted deficiency, the project team does not believe that it is feasible for increased improvement due to limited resources and the upfront education of the community that must be completed.

5.3.1.5. FLOODING

BMPs associated with Objective 6 should be implemented to reduce flooding by decreasing or slowing stormwater runoff. As previously discussed, constructing regional detention and adding capacity to existing culverts are not suggested for implementation to reduce flooding. Flooding reduction will have to be accomplished by using a watershed wide approach. Stream restoration, implementation of rain barrels and rain gardens, ensuring existing stormwater management measures are being properly maintained, and requiring all new developments to have proper water quantity controls should be used to help control stormwater runoff. If residential property owners installed a rain garden or rain barrel on their property, allowing for water infiltration and reuse, runoff from these properties could be reduced by approximately one-fourth. The most important aspect in flooding reduction will be community acceptance and participation.

5.4. RECOMMENDED IMPLEMENTATION SUMMARY

As previously state in Section 5.3, the project team prioritized subwatersheds for implementation for Objectives 1 through 6 as listed below. Since Objective 7 focuses on informing the public of water quality issues, it should be implemented on a watershed wide scale and cannot be broken down for implementation in specific watersheds.

- Objective 1: Reduction of human fecal impacts
    1. Subwatershed beginning at Site 10 (Vaught Road area)
    2. Subwatershed from Site 5 to northern intersection of Old Boonesboro Road and KY 627 (Stoneybrook neighborhood and Calmes Blvd area)

3. Subwatershed beginning at Site 6 (Hampton Manor neighborhood)
4. Subwatershed at Site 4 (including failing septic system)
5. Subwatershed beginning at Site 9 (Fontaine Blvd area)

- Objective 2: Reduction of non-human sources
    1. Subwatershed between Site 2 and Site 3 including Dry Fork
    2. Subwatershed beginning at Site 6 (Hampton Manor neighborhood)
    3. Subwatershed beginning at Site 9 (Fontaine Blvd area)
    4. Subwatershed from Site 5 to northern intersection of Old Boonesboro Road and KY 627 (Stoneybrook neighborhood and Calmes Blvd area)
    5. Subwatershed beginning at Site 8 (West Fork)

- Objective 3: Reduction of algal blooms and eutrophication
    1. Subwatershed beginning at Site 8 (West Fork)
    2. Subwatershed beginning at Site 7 (Deep Branch)
    3. Subwatershed from Site 5 to northern intersection of Old Boonesboro Road and KY 627 (Stoneybrook neighborhood and Calmes Blvd area)
    4. Subwatershed beginning at Site 6 (Hampton Manor neighborhood)
    5. Subwatershed beginning at Site 9 (Fontaine Blvd area)

- Objective 4: Expansion of stream riparian zone
    1. Subwatershed beginning at Site 8 (West Fork, particularly upstream of RM 2.15)
    2. Subwatershed from Site 5 to northern intersection of Old Boonesboro Road and KY 627 (Stoneybrook neighborhood and Calmes Blvd area)
    3. Subwatershed beginning at Site 6 (Hampton Manor neighborhood)
    4. Subwatershed beginning at Site 9 (Fontaine Blvd area)
    5. Subwatershed north of Carroll E. Ecton Reservoir

- Objective 5: Stabilization of stream banks
    1. Subwatershed from Site 5 to northern intersection of Old Boonesboro Road and KY 627 (Stoneybrook neighborhood and Calmes Blvd area)
    2. Areas on the LHC Nature and Heritage Preserve (particularly in vicinity of Site 1)
    3. Subwatershed beginning at Site 9 (Fontaine Blvd area)
    4. Subwatershed beginning at Site 6 (Hampton Manor neighborhood)
    5. Subwatershed beginning at Site 10 (Vaught Road area)

- Objective 6: Reduction of flooding
    1. Subwatershed from Site 5 to northern intersection of Old Boonesboro Road and KY 627 (Stoneybrook neighborhood and Calmes Blvd area)
    2. Subwatershed beginning at Site 6 (Hampton Manor neighborhood)
    3. Existing WTP location (upstream of Site 4)

The proposed Action Items are summarized beginning on page 113. The information below summarizes the specific Action Items recommended for implementation for each required load reduction and identifies responsible party, technical assistance, total cost, funding mechanism, location for implementation, measurable parameter, target value, target load reduction, estimated load reduction, and milestones. The subwatersheds are discussed beginning upstream and continuing downstream to realize loading reductions upstream. Action Items are listed in numerical order.

REDUCTION OF E. COLI LOAD

- *Subwatershed beginning at Site 6 (Hampton Manor neighborhood):*

  Target Value: 1.5 trillion MPN/year
  Target Load Reduction: 27.8 trillion MPN/year
  Pollutant or Measurable Parameter: E. coli

  Action Item 1: Remove SSOs in accordance with the Consent Decree
  Responsible Party: WMU and the City of Winchester
  Technical Assistance: Selected engineering consultants
  Total Cost: $36,600,000 (for LHCW Consent Decree improvements only)
  Funding Mechanism: CWSRF KIA loan and the City of Winchester
  Location of BMP: SSOs identified at Mockingbird Valley Road and Bonnie Brook Lane and suspected exfiltrating trunk sewer
  Estimated Load Reduction: 13.9 trillion MPN/year
  Measureable Milestones: Removal of SSOs identified at Mockingbird Valley Road and Bonnie Brook Lane and suspected exfiltrating sewer by 2022. WMU expects that the two SSOs may be eliminated after the new WWTP is in operation due to increased downstream capacity. Exfiltration may need to be reassessed after construction is complete to see if it is occurring in other locations of the subwatershed in Action Item 5.

  Action Item 5: Investigate exfiltration in lateral connections and remediate
  Responsible Party: Friends of Lower Howards Creek
  Technical Assistance: Engineering and testing consultants
  Total Costs: $400 per home for lateral connection investigations and $3,000 per home for lateral connection remediation
  Funding Mechanism: 319(h) grants
  Location of BMP: Areas of Hampton Manor neighborhood
  Estimated Load Reductions: 5.9 trillion MPN/year
  Measureable Milestones: Begin investigation of lateral connections within three years

  Action Item 18: Educate the community on the hazards of improper animal waste disposal
  Responsible Party: City of Winchester's MS4 Program and Friends of Lower Howards Creek
  Technical Assistance: City of Winchester Engineering Technician and engineering consultants
  Total Cost: No additional cost if combined with other activities, otherwise $2,500 per event
  Funding Mechanism: 319(h) grant
  Location of BMP: Throughout watershed
  Estimated Load Reduction: 4.0 trillion MPN/year if residents practice measures
  Measureable Milestones: Conduct at least one educational activity within two years

  Action Item 20: Utilize in-lieu fee payments within the City of Winchester limits
  Responsible Party: City of Winchester
  Technical Assistance: Engineering consultants

Total Cost: Vary based on project selected and scope of work; property estimated at $12 to $20 a linear foot for conservation easement along the stream; rain garden installation and riparian zone enhancement estimated at $2 to $5 per square foot
Funding Mechanism: Not applicable
Location of BMP: Throughout watershed; approximately 9,000 linear feet of stream available for conservation easement and riparian zone enhancement and in subwatershed
Estimated Load Reduction: 4.0 trillion MPN/year (in conjunction with Action Item 24)
Measureable Milestones: Establish the required in-lieu fee payment schedule within two years. Implement at least one project per year after three years

Action Item 24: Educate the community on the benefit of rain gardens and/or streamside wetlands and implement
Responsible Party: City of Winchester MS4 Program and Friends of Lower Howards Creek
Technical Assistance: Engineering consultants
Total Cost: $2,500 for engineering consultant’s presentation preparation and consultation; property estimated at $12 to $20 a linear foot for conservation easement along the stream; rain garden installation and riparian zone enhancement estimated at $2 to $5 per square foot
Funding Mechanism: City of Winchester and 319(h) grants
Location of BMP: Throughout watershed; approximately 9,000 linear feet of stream available for conservation easement, riparian zone enhancement, and rain garden/streamside wetland installation in the subwatershed
Estimated Load Reduction: 4.0 trillion MPN/year (in conjunction with Action Item 20)
Measureable Milestones: Conduct at least one informational meeting or workshop within two years

- *Subwatershed beginning at Site 10 (Vaught Road area):*
  Target Value: 1.3 trillion MPN/year
  Target Load Reduction: 18.3 trillion MPN/year
  Pollutant or Measurable Parameter: E. coli

Action Item 1: Remove SSOs in accordance with the Consent Decree
Responsible Party: WMU and the City of Winchester
Technical Assistance: Selected engineering consultants
Total Cost: $36,600,000 (for LHCW Consent Decree improvements only)
Funding Mechanism: CWSRF KIA loan and the City of Winchester
Location of BMP: SSO identified at manhole upstream of Snowfall Pump Station and suspected exfiltrating trunk sewer in between SSO and Hubbard Road
Estimated Load Reduction: 12.0 trillion MPN/year
Measureable Milestones: Removal of SSO upstream of Snowfall Pump Station and suspected exfiltrating sewer by January 31, 2013. Exfiltration may need to be reassessed after construction is complete to see if it is occurring in other locations of the subwatershed in Action Item 5.

Action Item 5: Investigate exfiltration in lateral connections and remediate
Responsible Party: Friends of Lower Howards Creek
Technical Assistance: Engineering and testing consultants

Total Costs: $400 per home for lateral connection investigations and $3,000 per home for lateral connection remediation
Funding Mechanism: 319(h) grants
Location of BMP: Areas of neighborhood near Vaught Road
Estimated Load Reductions: 1.7 trillion MPN/year
Measureable Milestones: Begin investigation of lateral connections within three years

Action Item 18: Educate the community on the hazards of improper animal waste disposal
Responsible Party: City of Winchester's MS4 Program and Friends of Lower Howards Creek
Technical Assistance: City of Winchester Engineering Technician and engineering consultants
Total Cost: No additional cost if combined with other activities, otherwise $2,500 per event
Funding Mechanism: Not applicable
Location of BMP: Throughout watershed
Estimated Load Reduction: 1.6 trillion MPN/year if residents practice measures
Measureable Milestones: Conduct at least one educational activity within two years

Action Item 19: Investigate connection of floor drains in veterinary clinic on KY 627 and remediate if no treatment is occurring
Responsible Party: Friends of Lower Howards Creek
Technical Assistance: None required for investigation; engineering consultant may be required for remediation
Total Costs: Not applicable for investigation; approximately $35,000 to install pre-treatment system
Funding Mechanism: Not applicable for investigation; 319(h) grant and landowner expense for remediation
Location of BMP: Veterinary clinic on KY 627
Estimated Load Reduction: 1.5 trillion MPN/year if remediation is required
Measurable Milestones: Determine how floor drains are connected in two years

Action Item 20: Utilize in-lieu fee payments within the City of Winchester limits
Responsible Party: City of Winchester
Technical Assistance: Engineering consultants
Total Cost: Vary based on project selected and scope of work; property estimated at $12 to $20 a linear foot for conservation easement along the stream; rain garden installation and riparian zone enhancement estimated at $2 to $5 per square foot
Funding Mechanism: Not applicable
Location of BMP: Throughout watershed; approximately 1,500 linear feet of stream available for conservation easement and riparian zone enhancement in subwatershed
Estimated Load Reduction: 1.5 trillion MPN/year (in conjunction with Action Item 24)
Measureable Milestones: Establish the required in-lieu fee payment schedule within two years. Implement at least one project per year after three years

Action Item 24: Educate the community on the benefit of rain gardens and/or streamside wetlands and implement
Responsible Party: City of Winchester MS4 Program and Friends of Lower Howards Creek
Technical Assistance: Engineering consultants
Total Cost: $2,500 for engineering consultant's presentation preparation and consultation; property estimated at $12 to $20 a linear foot for conservation easement along the

stream; rain garden installation and riparian zone enhancement estimated at $2 to $5 per square foot
Funding Mechanism: City of Winchester and 319(h) grants
Location of BMP: Throughout watershed; approximately 1,500 linear feet of stream available for conservation easement, riparian zone enhancement, and rain garden/streamside wetland installation in the subwatershed
Estimated Load Reduction: 1.5 trillion MPN/year (in conjunction with Action Item 20)
Measureable Milestones: Conduct at least one informational meeting or workshop within two years

- *Subwatershed beginning at Site 9 (Fontaine Blvd area):*
  Target Value: 1.6 trillion MPN/year
  Target Load Reduction: 2.1 trillion MPN/year
  Pollutant or Measurable Parameter: E. coli

<u>Action Item 3: Conduct additional MST at Site 9 and other tributaries in LHCW to help determine fecal source</u>
Responsible Party: Friends of Lower Howards Creek
Technical Assistance: University of Kentucky
Total Cost: $3,000 per site
Funding Mechanism: KRWW for sampling; 319(h) grants for laboratory expenses
Location of BMP: Site 9
Estimated Load Reductions: Not applicable
Measureable Milestones: Complete sampling in five years

<u>Action Item 5: Investigate exfiltration in lateral connections and remediate</u>
Responsible Party: Friends of Lower Howards Creek
Technical Assistance: Engineering and testing consultants
Total Costs: $400 per home for lateral connection investigations and $3,000 per home for lateral connection remediation
Funding Mechanism: 319(h) grants
Location of BMP: Areas of Hampton Manor neighborhood
Estimated Load Reductions: 1.1 trillion MPN/year
Measureable Milestones: Begin investigation of lateral connections within three years

<u>Action Item 18: Educate the community on the hazards of improper animal waste disposal</u>
Responsible Party: Friends of Lower Howards Creek
Technical Assistance: Engineering consultants
Total Cost: No additional cost if combined with other activities, otherwise $2,500 per event
Funding Mechanism: 319(h) grants
Location of BMP: Throughout watershed
Estimated Load Reduction: 0.5 trillion MPN/year if residents practice measures
Measureable Milestones: Conduct at least one educational activity within two years

<u>Action Item 24: Educate the community on the benefit of rain gardens and/or streamside wetlands and implement</u>
Responsible Party: Friends of Lower Howards Creek
Technical Assistance: Engineering consultants

Total Cost: $2,500 for engineering consultant's presentation preparation and consultation; property estimated at $12 to $20 a linear foot for conservation easement along the stream; rain garden installation and riparian zone enhancement estimated at $2 to $5 per square foot

Funding Mechanism: 319(h) grants

Location of BMP: Throughout watershed; approximately 7,500 linear feet of stream available for conservation easement, riparian zone enhancement, and rain garden/streamside wetland installation in the subwatershed

Estimated Load Reduction: 0.5 trillion MPN/year

Measureable Milestones: Conduct at least one informational meeting or workshop within two years

- *Subwatershed from Site 5 to northern intersection of Old Boonesboro Road and KY 627 (Stoneybrook neighborhood and Calmes Blvd area):*

  Target Value: 6.6 trillion MPN/year
  Target Load Reduction: 434.4 trillion MPN/year
  Pollutant or Measurable Parameter: E. coli
  Load Reduction from Upstream Subwatersheds: 48.2 trillion MPN/year

Action Item 1: Remove SSOs in accordance with the Consent Decree

Responsible Party: WMU and the City of Winchester

Technical Assistance: Selected engineering consultants

Total Cost: $36,600,000 (for LHCW Consent Decree improvements only)

Funding Mechanism: CWSRF KIA loan and the City of Winchester

Location of BMP: SSO identified at Stoneybrook Pump Station and suspected exfiltrating trunk sewer along Old Boonesboro Road

Estimated Load Reduction: 381.8 trillion MPN/year

Measureable Milestones: Removal of SSO at Stoneybrook Pump Station and suspected exfiltrating sewer by January 31, 2013. Exfiltration may need to be reassessed after construction is complete to see if it is occurring in other locations of the subwatershed in Action Item 5.

Action Item 5: Investigate exfiltration in lateral connections and remediate

Responsible Party: Friends of Lower Howards Creek

Technical Assistance: Engineering and testing consultants

Total Costs: $400 per home for lateral connection investigations and $3,000 per home for lateral connection remediation

Funding Mechanism: 319(h) grants

Location of BMP: Areas of Stoneybrook neighborhood and near Calmes Drive

Estimated Load Reductions: 2.8 trillion MPN/year

Measureable Milestones: Begin investigation of lateral connections within three years

Action Item 18: Educate the community on the hazards of improper animal waste disposal

Responsible Party: Friends of Lower Howards Creek

Technical Assistance: Engineering consultants

Total Cost: No additional cost if combined with other activities, otherwise $2,500 per event

Funding Mechanism: 319(h) grants

Location of BMP: Throughout watershed

Estimated Load Reduction: 1.6 trillion MPN/year if residents practice measures
Measureable Milestones: Conduct at least one educational activity within two years

<u>Action Item 24: Educate the community on the benefit of rain gardens and/or streamside wetlands and implement</u>
Responsible Party: Friends of Lower Howards Creek
Technical Assistance: Engineering consultants
Total Cost: $2,500 for engineering consultant's presentation preparation and consultation; property estimated at $12 to $20 a linear foot for conservation easement along the stream; rain garden installation and riparian zone enhancement estimated at $2 to $5 per square foot
Funding Mechanism: 319(h) grants
Location of BMP: Throughout watershed; approximately 10,500 linear feet of stream available for conservation easement, riparian zone enhancement, and rain garden/streamside wetland installation in the subwatershed
Estimated Load Reduction: 2.8 trillion MPN/year
Measureable Milestones: Conduct at least one informational meeting or workshop within two years

- *Subwatershed from Site 4 to Site 5:*

  Target Value: 22.5 trillion MPN/year
  Target Load Reduction: 668.8 trillion MPN/year
  Pollutant or Measurable Parameter: E. coli
  Load Reduction from Upstream Subwatersheds: 434.4 trillion MPN/year

<u>Action Item 3: Conduct additional MST at Site 9 and other tributaries in LHCW to help determine fecal source</u>
Responsible Party: Friends of Lower Howards Creek
Technical Assistance: University of Kentucky
Total Cost: $3,000 per site
Funding Mechanism: KRWW for sampling; 319(h) grants for laboratory expenses
Location of BMP: Two tributaries north of reservoir
Estimated Load Reductions: Not applicable for sampling. Additional BMPs and Action Items should be implemented after testing is complete to reduce the E. coli load to target levels.
Measureable Milestones: Complete sampling in five years

<u>Action Item 8: Remediate confirmed straight pipes or failing septic systems</u>
Responsible Party: LHCWMP Implementation Coordinator, Clark County Health Department
Technical Assistance: None required
Total Cost: $4000 per repair of failing septic system; $15,000 for new septic system installation
Funding Mechanism: 319(h) grant or landowner expense
Location of BMP: Repair suspected failing septic system upstream of Site 4
Estimated Load Reduction: 18 trillion MPN/year (due to no time for dilution at sampling location)
Measureable Milestones: Repair of septic system within two years

Action Item 22: Upon WTP decommissioning, remove the lower impoundment and develop a restored channel with streamside wetlands and buffer zone
Responsible Party: Friends of LHC
Technical Assistance: Engineering consultants
Total Cost: $250 per linear foot of stream restoration
Funding Mechanism: Kentucky Department of Fish and Wildlife in-lieu fee mitigation funds or other offsite mitigation banking
Location of BMP: Lower impoundment at the reservoir
Estimated Load Reduction: 150 trillion MPN/year
Measureable Milestones: Design and constructed within seven years

- *Subwatershed between Site 2 and Site 3:*
  Target Value: 37.4 trillion MPN/year
  Target Load Reduction: 41.2 trillion MPN/year
  Pollutant or Measurable Parameter: E. coli

Action Item 8: Remediate confirmed straight pipes or failing septic systems
Responsible Party: LHCWMP Implementation Coordinator, Clark County Health Department
Technical Assistance: None required
Total Cost: $4000 per repair of failing septic system; $15,000 for new septic system installation
Funding Mechanism: 319(h) grant or landowner expense
Location of BMP: Repair suspected failing septic system upstream of Site 4 and other failing septic systems or straight pipes. The area of investigation should include areas along West Fork.
Estimated Load Reduction: 4.1 trillion MPN/year
Measureable Milestones: Repair of straight pipes and/or failing septic systems within two years of finding. Repair failing septic system at Site 4 within two years.

Action Item 11: Investigate feasibility of providing an alternative water source for livestock
Responsible Party: Friends of LHC
Technical Assistance: WMU and Clark County Extension Office
Total Costs: Not applicable
Funding Mechanism: Not applicable
Location of BMP: Identify approximately two areas along West Fork or Dry Fork where livestock exclusion fencing will also be installed
Estimated Load Reduction: Not applicable
Measureable Milestone: Provide a summary of the alternatives and their feasibility within seven years.

Action Item 12: Utilize NRCS Cost Sharing program for livestock exclusion fencing (Practice #472) in feasible locations of the upper portions of LHCW
Responsible Party: Friends of LHC and property owners with livestock
Technical Assistance: NRCS
Total Cost: $50 per foot, but will vary based on type of fencing and whether other improvements will also be necessary, such as providing an alternative water source
Funding Mechanism: NRCS EQIP Cost Share and land owner

Location of BMP: 3,000 linear feet in areas along West Fork and Dry Fork and other tributaries between Site 2 and Site 3

Estimated Load Reduction: 9.3 trillion MPN/year

Measureable Milestones: Implementation of approximately 3,000 linear feet of livestock exclusion fence in areas along West Fork and Dry Fork and other tributaries between Site 2 and 3 within seven years.

Action Item 13: Utilize NRCS Cost Sharing program for spring development (Practice #574)

Responsible Party: Property owners with livestock

Technical Assistance: NRCS

Total Costs: $5,000 each

Funding Mechanism: NRCS EQIP Cost Share and land owner

Location of BMP: Approximately two areas along West Fork or Dry Fork where livestock exclusion fencing will also be installed

Estimated Load Reduction: No direct load reduction, but may be necessary as livestock exclusion fence is installed

Measureable Milestones: Implementation of approximately two alternative watering sources in conjunction with the livestock exclusion fence installation in areas along West Fork and Dry Fork and other tributaries between Site 2 and 3 within seven years.

Action Item 16: Utilize NRCS Cost Sharing program for filter strip (Practice #393) installation

Responsible Party: Property owners with livestock

Technical Assistance: NRCS

Total Costs: $5,000 - $10,000 per acre depending on the type of vegetation planted

Funding Mechanism: NRCS EQIP Cost Share and land owner

Location of BMP: Implementation of approximately 8,700 linear feet (in conjunction with Action Item 28) of filter strips or riparian buffers zones in areas along West Fork and Dry Fork and other tributaries between Site 2 and 3.

Estimated Load Reduction: 27.8 trillion MPN/year (in conjunction with Action Item 28)

Measureable Milestones: Implementation of filter strips and/or riparian buffer zones within seven years to reduce nutrient and bacteria loading.

Action Item 28: Utilize NRCS Cost Sharing program for riparian forested buffer (Practice #391) and tree planting (Practice #612)

Responsible Party: Friends of LHC and agricultural property owners

Technical Assistance: NRCS

Total Costs: $5,000 - $10,000 per acre depending on the type of vegetation planted

Funding Mechanism: NRCS EQIP Cost Share and land owner

Location of BMP: Implementation of approximately 8,700 linear feet (in conjunction with Action Item 16) of filter strips or riparian buffers zones in areas along West Fork and Dry Fork and other tributaries between Site 2 and 3.

Estimated Load Reduction: 27.8 trillion MPN/year (in conjunction with Action Item 16)

Measureable Milestones: Implementation of filter strips and/or riparian buffer zones within seven years to reduce nutrient and bacteria loading.

- *General watershed wide items for implementation:*

Action Item 2: Continuation of existing programs for the LHCW in the WMU CSSAP and IRP
Responsible Party: WMU
Technical Assistance: WMU staff
Total Cost: No additional costs beyond existing programs expenses for CSSAP and IRP
Funding Mechanism: Not applicable
Location of BMP: In accordance with CSSAP and IRP
Estimated Load Reductions: Not applicable
Measureable Milestones: Maintain compliance with policies for maintenance and replacement as set force in the CSSAP and IRP

Action Item 4: Develop a web based system for the public reporting of potential leaks and cross connections with the storm sewer system
Responsible Party: Friends of Lower Howards Creek
Technical Assistance: WMU staff
Total Cost: No additional costs beyond existing website hosting
Funding Mechanism: Not applicable
Location of BMP: Not applicable
Estimated Load Reductions: Not applicable
Measureable Milestones: Update Friends of LHC website to include public method of reporting within two years

Action Item 6: Identify funding sources for necessary repairs to existing sanitary sewers
Responsible Party: WMU
Technical Assistance: WMU staff
Total Cost: Not applicable
Funding Mechanism: CWBG; CWSRF KIA loans; local funding
Location of BMP: Not applicable
Estimated Load Reductions: Not applicable
Measureable Milestones: As necessary repairs are identified

Action Item 7: Develop a web based system for public reporting of potential straight pipes or failing septic systems
Responsible Party: Clark County Health Department
Technical Assistance: Not applicable
Total Cost: No additional costs beyond existing website hosting
Funding Mechanism: Not applicable
Location of BMP: Not applicable
Estimated Load Reductions: Not applicable
Measureable Milestones: Place a method of public reporting of potential straight pipes and failing septic systems on Clark County Health Department website within two years

Action Item 9: Educate community of septic system maintenance
Responsible Party: Clark County Extension Office
Technical Assistance: Clark County Health Department
Total Cost: $500 per training session and $500 for distribution of educational materials
Funding Mechanism: Bluegrass PRIDE grants and 319(h) grants

Location of BMP: Not applicable

Estimated Load Reductions: Not applicable

Measureable Milestones: Education materials on proper maintenance and indicators of poor performance available at the Clark County Extension Office within two years. Distribute copies of educational material to community residents who live outside of the sewer service boundary within two years. Hold first training session on proper septic system maintenance and repair within two years.

<u>Action Item 10: Hold an information session to inform the agricultural community on options for keeping livestock out of the stream</u>

Responsible Party: Friends of LHC

Technical Assistance: Clark County Extension Office and engineering consultant

Total Cost: $2,500 for engineering consultant presentation preparation and consultation

Funding Mechanism: 319(h) grants, other water quality grants, or private funding

Location of BMP: Not applicable

Estimated Load Reduction: Not applicable

Measureable Milestones: Conduct at least one informational session within two years

<u>Action Item 14: Hold an information session to inform the agricultural community on the benefits of livestock field rotation</u>

Responsible Party: Friends of LHC

Technical Assistance: Clark County Extension Office and engineering consultant

Total Cost: $2,500 for engineering consultant presentation preparation and consultation

Funding Mechanism: 319(h) grants, other water quality grants, or private funding

Location of BMP: Not applicable

Estimated Load Reduction: Not applicable

Measureable Milestones: Conduct at least one informational session within two years

<u>Action Item 15: Educate the community on the benefits filter strips can provide</u>

Responsible Party: Friends of LHC

Technical Assistance: Clark County Extension Office and engineering consultant

Total Cost: $2,500 for engineering consultant presentation preparation and consultation

Funding Mechanism: 319(h) grants, other water quality grants, or private funding

Location of BMP: Not applicable

Estimated Load Reduction: Not applicable

Measureable Milestones: Conduct at least one informational session within two years

<u>Action Item 17: LHC Nature and Heritage Preserve to coordinate with land owners to acquire land in accordance with the *LHC Corridor Management Plan*</u>

Responsible Party: Friends of LHC and LHC Nature and Heritage Preserve

Technical Assistance: None required

Total Cost: Varied based on land acquiring

Funding Mechanism: Private donations, funding through KSNPC, and other grants

Location of BMP: Not applicable

Estimated Load Reductions: Not applicable

Measureable Milestones: Contact property owners to determine their willingness to sell their land within two years.

REDUCTION OF NUTRIENT LOAD

- *Subwatershed beginning at Site 8 (West Fork):*

  Target Value: 19,442 lbs/year
  Target Load Reduction: 15,437 lbs/year
  Pollutant or Measurable Parameter: Total nitrogen

  Target Value: 1,944 lbs/year
  Target Load Reduction: 394 lbs/year
  Pollutant or Measureable Parameter: Total phosphorous

Action Item 12: Utilize NRCS Cost Sharing program for livestock exclusion fencing (Practice #472) in feasible locations of the upper portions of LHCW

Responsible Party: Friends of LHC and property owners with livestock
Technical Assistance: NRCS
Total Cost: $50 per foot, but will vary based on type of fencing and whether other improvements will also be necessary, such as providing an alternative water source
Funding Mechanism: NRCS EQIP Cost Share and land owner
Location of BMP: 2,000 linear feet in areas along West Fork
Estimated Load Reduction: 120 lbs/year of total nitrogen and 32 lbs/year of total phosphorous
Measureable Milestones: Implementation of approximately 2,000 linear feet of livestock exclusion fence in areas along West Fork within seven years.

Action Item 16: Utilize NRCS Cost Sharing program for filter strip (Practice #393) installation

Responsible Party: Property owners with livestock
Technical Assistance: NRCS
Total Costs: $5,000 - $10,000 per acre depending on the type of vegetation planted
Funding Mechanism: NRCS EQIP Cost Share and land owner
Location of BMP: Implementation of approximately 5,500 linear feet (in conjunction with Action Item 28) of filter strips or riparian buffers zones in areas along West Fork.
Estimated Load Reduction: 550 lbs/year of total nitrogen and 68 lbs/year (in conjunction with Action Item 28)
Measureable Milestones: Implementation of filter strips and/or riparian buffer zones within seven years to reduce nutrient and bacteria loading.

Action Item 28: Utilize NRCS Cost Sharing program for riparian forested buffer (Practice #391) and tree planting (Practice #612)

Responsible Party: Friends of LHC and agricultural property owners
Technical Assistance: NRCS
Total Costs: $5,000 - $10,000 per acre depending on the type of vegetation planted
Funding Mechanism: NRCS EQIP Cost Share and land owner
Location of BMP: Implementation of approximately 5,500 linear feet (in conjunction with Action Item 16) of filter strips or riparian buffers zones in areas along West Fork.
Estimated Load Reduction: 550 lbs/year of total nitrogen and 68 lbs/year (in conjunction with Action Item 16)
Measureable Milestones: Implementation of filter strips and/or riparian buffer zones within seven years to reduce nutrient and bacteria loading.

Action Item 29: Identify, design, and implement stream restoration on impaired reaches

Responsible Party: Friends of LHC

Technical Assistance: Engineering consultants

Total Cost: Approximately $250 per linear foot, but will vary based on location

Funding Mechanism: Kentucky Department of Fish and Wildlife in-lieu fee mitigation funds, other offsite mitigation banking, or 319(h) grants

Location of BMP: Areas with unstable banks along West Fork or its tributaries; estimated to need approximately 2,500 linear feet of restoration with a 25 riparian zone on either side of the stream

Estimated Load Reduction: 1,000 lbs/year of total nitrogen and 355 lbs/year of total phosphorous

Measurable Milestones: Identify a list of prioritized reaches for restoration and stabilization within seven years

- *Subwatershed beginning at Site 7 (Deep Branch):*

  Target Value: 787 lbs/year
  Target Load Reduction: 219 lbs/year
  Pollutant or Measureable Parameter: Total phosphorous

Action Item 12: Utilize NRCS Cost Sharing program for livestock exclusion fencing (Practice #472) in feasible locations of the upper portions of LHCW

Responsible Party: Friends of LHC and property owners with livestock

Technical Assistance: NRCS

Total Cost: $50 per foot, but will vary based on type of fencing and whether other improvements will also be necessary, such as providing an alternative water source

Funding Mechanism: NRCS EQIP Cost Share and land owner

Location of BMP: 1,000 linear feet in areas along Deep Branch

Estimated Load Reduction: 16 lbs/year of total phosphorous

Measureable Milestones: Implementation of approximately 1000 linear feet of livestock exclusion fence in areas along Deep Branch within seven years.

Action Item 16: Utilize NRCS Cost Sharing program for filter strip (Practice #393) installation

Responsible Party: Property owners with livestock

Technical Assistance: NRCS

Total Costs: $5,000 - $10,000 per acre depending on the type of vegetation planted

Funding Mechanism: NRCS EQIP Cost Share and land owner

Location of BMP: Implementation of approximately 3,200 linear feet (in conjunction with Action Item 28) of filter strips or riparian buffers zones in areas along Deep Branch.

Estimated Load Reduction: 40 lbs/year (in conjunction with Action Item 28)

Measureable Milestones: Implementation of filter strips and/or riparian buffer zones within seven years to reduce nutrient and bacteria loading.

Action Item 28: Utilize NRCS Cost Sharing program for riparian forested buffer (Practice #391) and tree planting (Practice #612)

Responsible Party: Friends of LHC and agricultural property owners

Technical Assistance: NRCS

Total Costs: $5,000 - $10,000 per acre depending on the type of vegetation planted

Funding Mechanism: NRCS EQIP Cost Share and land owner

Location of BMP: Implementation of approximately 3,200 linear feet (in conjunction with Action Item 16) of filter strips or riparian buffers zones in areas along Deep Branch.
Estimated Load Reduction: 40 lbs/year (in conjunction with Action Item 16)
Measureable Milestones: Implementation of filter strips and/or riparian buffer zones within seven years to reduce nutrient and bacteria loading.

Action Item 29: Identify, design, and implement stream restoration on impaired reaches
Responsible Party: Friends of LHC
Technical Assistance: Engineering consultants
Total Cost: Approximately $250 per linear foot, but will vary based on location
Funding Mechanism: Kentucky Department of Fish and Wildlife in-lieu fee mitigation funds, other offsite mitigation banking, or 319(h) grants
Location of BMP: Areas with unstable banks along Deep Branch or its tributaries; estimated to need approximately 1,200 linear feet of restoration with a 25 riparian zone on either side of the stream
Estimated Load Reduction: 163 lbs/year of total phosphorous
Measurable Milestones: Identify a list of prioritized reaches for restoration and stabilization within seven years

- *General watershed wide items for implementation (not including items previously mentioned):*

Action Item 21: Stabilize the banks and construct streamside wetlands along the portion of LHC along the new Clark County High School property
Responsible Party: Friends of LHC and Clark County Board of Education
Technical Assistance: Engineering consultants
Total Cost: Approximately $250 per linear foot (will vary based on project scope)
Funding Mechanism: Kentucky Department of Fish and Wildlife in-lieu fee mitigation funds, other offsite mitigation banking, or 319(h) grants
Location of BMP: Stream restoration and wetland creation on new Clark County high school property
Estimated Load Reduction: 0.4 lbs/linear foot/year of total nitrogen and 0.15 lbs/linear foot/year of total phosphorous
Measurable Milestones: Design and construction completed within seven years

Action Item 23: Perform a stream restoration project to stabilize the right bank of LHC in the vicinity of Site 1 on the LHC Nature and Heritage Preserve
Responsible Party: Friends of LHC
Technical Assistance: Engineering consultants
Total Cost: Approximately $250 per linear foot (will vary based on project scope)
Funding Mechanism: Kentucky Department of Fish and Wildlife in-lieu fee mitigation funds or other offsite mitigation banking
Location of BMP: Stream restoration and stabilization of right bank near Site 1
Estimated Load Reduction: 0.4 lbs/linear foot/year of total nitrogen and 0.15 lbs/linear foot/year of total phosphorous
Measurable Milestones: Design and construction completed within ten years

Action Item 25: Investigate alternatives for the community to dispose of yard waste
Responsible Party: WMU and City of Winchester

Technical Assistance: Engineering consultants
Total Costs: Not applicable
Funding Mechanism: Not applicable
Location of BMP: Not applicable
Estimated Load Reduction: Not applicable
Measureable Milestones: Provide a summary of alternatives and their feasibility within two years

Action Item 26: Educate the community of the harmful effects of dumping yard waste in the stream and using excess fertilizer
Responsible Party: City of Winchester
Technical Assistance: Engineering consultants
Total Costs: $2,500 for engineering consultant presentation preparation and consultation
Funding Mechanism: City of Winchester and 319(h) grants
Location of BMP: Not applicable
Estimated Load Reduction: Not applicable
Measureable Milestones: Conduct at least one informational meeting or workshop within two years

Action Item 27: Recommend updates to City and County Codes and Ordinances
Responsible Party: City of Winchester and Clark County Fiscal Court
Technical Assistance: City Engineering Technician and engineering consultants
Total Costs: $120 per hour for review by engineering consultant
Funding Mechanism: City of Winchester, Clark County Fiscal Court, and 319(h) grants
Location of BMP: Not applicable
Estimated Load Reduction: Not applicable
Measureable Milestones: Assess and revise City and County Codes and Ordinances within two years. Reassess City and County Codes and Ordinances after seven years.

REDUCTION OF FLOODING

- *In addition to those items previously listed, the following Action Item should be implemented for reduction of flooding:*

Action Item 30: Establish a rain barrel distribution program and educate the public
Responsible Party: City of Winchester
Technical Assistance: City Engineering Technician and engineering consultants
Total Costs: $75 per rain barrel
Funding Mechanism: Property owners
Location of BMP: Throughout the watershed
Estimated Load Reduction: Flooding reduction
Measureable Milestones: Hold at least one informational session within two years. Develop a rain barrel distribution program within seven years.

INCREASED PUBLIC AWARENESS

- *In addition to those items previously listed, the following Action Items should be implemented for to increase public awareness of the water quality status of LHC:*

Action Item 31: Develop public displays or educational flyers on water quality issues
Responsible Party: City of Winchester and Clark County Library
Technical Assistance: City of Winchester Engineering Technician and engineering consultants
Total Costs: Varies based on type and number of displays
Funding Mechanism: City of Winchester
Location of BMP: Information available in public spaces
Estimated Load Reduction: Not applicable
Measureable Milestones: Develop at least one display to be posted within two years.

Action Item 32: Incorporate water quality education curriculum at local elementary, middle, and high schools
Responsible Party: Clark County Board of Education and private schools within Clark County
Technical Assistance: Bluegrass PRIDE
Total Costs: Not applicable
Funding Mechanism: Not applicable
Location of BMP: Within schools in Clark County
Estimated Load Reduction: Not applicable
Measureable Milestones: Implementation of water quality education into Clark County school system within ten years.

Action Item 33: Include information on water quality in LHCW on local government and community web pages
Responsible Party: Friends of LHC, City of Winchester, and Clark County Fiscal Court
Technical Assistance: None required
Total Costs: Not applicable
Funding Mechanism: Not applicable
Location of BMP: On community websites
Estimated Load Reduction: Not applicable
Measureable Milestones: Have information on Friends of LHC, City of Winchester, and Clark County Fiscal Court (or a link to a central location with all information) within two years.

6. IMPLEMENTATION

6.1. IMPLEMENTATION ORGANIZATION

The LHCWMP is a dynamic, public document that is intended to assist in protection and enhancement of water quality within the LHCW in Winchester, Clark County, Kentucky. Since the goals of the LHCWMP align with those of the LHC Nature and Heritage Preserve and all water in the watershed will flow through the LHC Nature and Heritage Preserve, the person serving as the LHC Nature and Heritage Preserve Manager will serve as the LHCWMP Implementation Coordinator. The LHCWMP Implementation Coordinator will pursue BMP installation and construction; assist in securing funding through grants and other sources; ensure the LHCWMP is implemented in a manner consistent with its intent; and provide a main point of contact for volunteers and those interested in specific projects. A meeting was held with Clare Sipple, the current LHC Nature and Heritage Preserve Manager, on March 14, 2012 to discuss the possibility of the LHC Nature and Heritage Preserve Manager also serving as the LHCWMP Implementation Coordinator after this completion of the report. Ms. Sipple was very receptive to the idea and indicated that she felt that it would be a natural fit. As previously mentioned, the creation of the LHCWMP met one of the highest priority action items in the *Lower Howards Creek Management Plan* for the LHC Nature and Heritage Preserve through the development of a watershed wide WMP and supplemented the remaining action items by raising awareness of LHC on the community level. The LHCWMP Implementation Coordinator will begin implementation after the end date of the project schedule as defined in Exhibit D of the Consent Decree, which is scheduled for October 13, 2012.

To successfully implement the BMPs selected in Section 5.3, a collaborative effort will be required from many individuals, officials, and agencies. The LHCWMP Implementation Coordinator cannot be solely relied on for implementation; the following groups/people must also be involved:

- Bluegrass PRIDE
- City of Winchester and Clark County Planning and Zoning
- City of Winchester’s City Manager
- City of Winchester’s Engineering Technician
- City of Winchester's Mayor
- City of Winchester’s MS4 Program
- Clark County Extension Office
- Clark County Fiscal Court
- Clark County Judge/Executive
- Clark County Health Department
- Clark County Public Libraries
- Clark County Schools
- Community Volunteers
- Friends of Lower Howards Creek
- Kentucky Division of Water
- Kentucky River Watershed Watch
- Kentucky State Nature Preserves Commission
- Lower Howards Creek Nature and Heritage Preserve

- Palmer Engineering
- Property Owners within the Watershed
- Winchester Municipal Utilities
- University of Kentucky

The LHCWMP Implementation Coordinator will be primarily responsible for organization and management of the above listed parties with the assistance of the LHC Nature and Heritage Preserve and the Friends of LHC.

6.2. PLAN PRESENTATION AND OUTREACH

The draft LHCWMP was submitted to the EPA Region 4 and KDOW on June 15, 2012. No comments concerning the LHCWMP were received from EPA Region 4. Comments from KDOW were received from KDOW in a letter dated September 28, 2012. These comments have been addressed in this report. The plan will be presented in a public meeting to political leaders, stakeholders, civic and environmental groups, and the general public on October 11, 2012 in accordance with the deadlines outlined in Exhibit D of the Consent Decree. The public meeting will include a review of the plan, steps for implementation, and future monitoring efforts. The locations where the public can review the document will be announced.

Hard copies of the final plan will be provided to EPA Region 4, KDOW, WMU, City of Winchester, Clark County Fiscal Court, and LHC Nature and Heritage Preserve. A digital copy of the final plan will be posted online on the WMU website (wmutilities.com) and on the Friends of LHC website (lowerhowardscreek.org). Plan distribution will be completed prior to October 13, 2012. Since the final Phase Two monitoring will not be complete until November 2012, an addendum (Addendum #1) summarizing the October and November 2012 sampling results will be provided to plan holders by January 1, 2013. This addendum will also include the attendance list from the public meeting held on October 11, 2012. Additional updates to the LHCWMP will be provided to all plan holders when completed so an updated version of the plan and associated documents can be maintained by each plan holder. A list of plan holders is included in this report so that future parties are aware of the location of each plan.

6.3. FINANCIAL REQUIREMENTS AND BUDGETING

The estimated financial requirements for implementation of each Action Item are detailed in Section 5.3. The financial requirements for each Action Item vary greatly and may change based on the project scope once implementation begins. A number of potential funding sources have been identified to provide the financial assistance required for implementation. Potential funding sources include:

- 319(h) Non-Point Source Water Quality Grants
- City of Winchester
- City of Winchester MS4 Program
- Community Development Block Grant Program
- CWSRF KIA Loan
- In-Lieu Fee Payments made to the City of Winchester's MS4 Program
- Kentucky Department of Fish and Wildlife In-Lieu Fee Mitigation Funds
- KSPNC Funding

- Land Owner Payment
- NRCS EQIP Cost Share Program
- Other Offsite Mitigation Banking (such as through Kentucky Transportation Cabinet)
- Bluegrass PRIDE Community Grants
- Private Funding
- Volunteer Labor

Each funding source has different requirements for approval, so the LHCWMP Implementation Coordinator should fully understand the requirements of each funding source prior to applying for financial assistance. Although not required by the Consent Decree, the LHCWMP was prepared in accordance with the 319(h) funding requirements to allow for future 319(h) funding to be obtained for implementation.

6.4. MONITORING IMPLEMENTATION

All monitoring data available as of October 1, 2012 was included in this report. As previously stated, Phase Two monitoring was not complete as of the date of this report due to the requirements of the Consent Decree. Phase Two monitoring will be completed in November 2012. The Phase Two monitoring results from October and November 2012 will be provided to all plan holders in an addendum prior to January 1, 2013.

As a part of the required expenditures for the SEP outlined in the Consent Decree, two additional monitoring activities will be conducted. In May 2013 and May 2014, Palmer Engineering will sample Sites 1 through 10 for the parameters listed in Table 8, on page 46. The May 2013 results will be provided as Addendum #2 and the May 2014 results will be provided as Addendum #3 to the LHCWMP. Habitat and biological analyses are not planned to be completed. Since the SSOs will be removed by January 31, 2013, the May 2013 sampling event will provide an assessment of the impact of the SSO removal after the watershed has had a chance to stabilize. The May 2014 sampling event will be conducted to provide an update to the water quality status after the first full year of plan implementation (October 2012 through October 2013) during primary contact recreation season. The project team selected May for the additional monitoring since it is during primary contact recreation season and the five additional E. coli samples were collected in May 2012. The additional sampling data from May 2012 will provide a more complete baseline assessment. Since the largest E. coli concentration were following times when more than two inches of rain were received in the past five days, Palmer Engineering will aim to collect the samples following a notable rain event. It is unknown if there will be a period when more than two inches is received within a five day time frame, so samples will be collected following at least a five day period when at least one inch of rain has been received if possible.

To evaluate the effectiveness of BMP implementation and the progress made toward reaching benchmark concentrations, additional monitoring beyond the above described sampling events would be beneficial. It is suggested that monitoring be completed after three years, seven years, and ten years during spring or early summer. Monitoring should include three monthly sampling events from April to June in 2016, 2020, and 2023. Any sampling sites that show exceedances in the data collected in May 2014 should be included in the monitoring conducted in 2016. Once sites begin to meet target loadings, they can be removed from the scope of continued monitoring. It is suggested that these monitoring events should at a minimum include:

- E. coli concentration;
- total nitrogen concentration;
- total phosphorous concentration;
- specific conductivity;
- discharge;
- water temperature;
- dissolved oxygen concentration;
- pH;
- photographs of stream reach;
- visual inspection for algae; and
- total suspended solids.

All field measurements and water samples should be representative of the stream reach and collected by trained individuals. Chain of custody forms should be utilized for sample collection and transport. Collected samples should be in accordance with KDOW approved SOP as identified in Table 8 on page 46. If Section 319(h) grant funding is used, a QAPP must be provided and approved by KDOW. Habitat assessment should be conducted using RBPs. Biological assessment should be conducted using MBI to classify the water based on benthic macroinvertebrates that are found within a stream reach. Habitat and biological assessments should be completed once during each monitoring period from April to June at each site. The collected data will be used to evaluate the success of the BMPs implemented and allow for modification to the plan to meet water quality objectives.

6.5. EVALUATION AND UPDATING OF PLAN

Evaluation of the plan should be conducted following the monitoring activities described in Section 6.4. The LHCWMP Implementation Coordinator should organize a meeting with watershed stakeholders to discuss the collected results. The effectiveness of the BMPs should be discussed. Alternative approaches should be considered in areas where BMPs are shown to not be feasible and/or effective. Each Action Item detailed in Section 5.3 should be considered. Discussion should include if the Action Item is achieving the desired objective, if it should be continued to be pursued, and if the designated outcome indicator is the most effective measure. The effectiveness of public outreach activities should be evaluated based on the number of persons in attendance and the implementation of BMPs discussed at the activity (such as the number of rain barrels installed). As implementation progresses, the prioritization of Action Items may be altered based on a change in stakeholder involvement, project goals, or a variety of other factors. The LHCWMP is intended to be a living document, so modifications should be made based on changing conditions. Any modifications should be provided to all plan holders so that updated copies can be maintained by all parties.

APPENDIX A

CONTACTED STAKEHOLDERS, STAKEHOLDER MEETING ATTENDANCE LISTS, AND SIGNUP SHEETS

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Potential Stakeholders	Contact Name
Bluegrass ADD	David Duttlinger
City of Winchester/Manager	Ken Kerns
City of Winchester	Joe Tincher
City of Winchester	Ed Burtner
Clark County - Winchester Heritage Commission	Ramsey Flynn
Clark County EMA	Gary Epperson
Clark County Extension Agency for Agricultural and Natural Resources	Frank Hicks
Clark County Fiscal Court	Rick Smith
Clark Couny Health Department	Margaret Copenhaver
EKPC	Wes Moody
EKU	Sherry Harrell
Farm Bureau	Rick Mink
Halls on the River	Carl Crase
KDOW	Joyce Fry
KDOW (Nonpoint Source Department)	Margi Jones/Lajuanda Haight-Maybriar
Kentucky Department of Fish and Wildlife	Doug Dawson
Kentucky Heritage Conservation Land Fund	Bill Martin & Joe Deitz
Kentucky Heritage Council	
Kentucky River Authority	Clare Sipple
Kentucky River Keepers	Pat Banks
Kentucky Water Watch	JoAnn Palmer
Kentucky Waterways Alliance	Tessa Edelen
KSNPC	Joyce Bender
LHC Historic and Nature Preserve	Clare Sipple
NRCS	William Lacy
Sierra Club	
Strodes Creek Conservatory	Shanda Cecil
University of Louisville	Art Parola
University of Kentucky	Ned Crankshaw
USACE	
USFS	Jon Walker
Winchester Planning and Zoning	Rhonda Cromer
WMU	Mike Flynn
WMU	Ed Hightower
WMU	Duke Dyden
LHC Historic and Nature Preserve	Henry Enoch
	Will Hodgkin
LHC Historic and Nature Preserve	Bill Crankshaw
Kentucky Water Resources Institute	Malissa McAlister
Clark County Board of Education	Paul Christy

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Applicant should be energetic, organized, self-motivated, prepared, pro-active, forward thinking, community minded, have the ability to work with a wide range of people and business, and possess a high degree of adaptability. Administrative, computer and financial skills are essential.

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NOTICE OF PUBLIC MEETING

Winchester Municipal Utilities, 150 North Main Street, P.O. Box 4177, Winchester, KY 40392-4177 has contracted **Palmer Engineering**, 400 Shoppers Drive, P.O. Box 747, Winchester, KY 40392-0747 to prepare a Watershed Management Plan for the Lower Howards Creek Watershed in Clark County, Kentucky in accordance with the requirements of the Supplemental Environmental Project necessitated by the Consent Decree with the Environmental Protection Agency. A public meeting will be held on Thursday, July 14, 2011 beginning at 6:00 P.M. at the Clark County Extension Office, 1400 Fortune Drive, Winchester, Kentucky 40391.
The reason for this meeting is to explain the purpose of the Watershed Management Plan, what will be involved in developing the plan, and the benefits of the plan.
The public will have an opportunity to ask questions to project team members, express concerns, and volunteer to assist in preparing and implementing the plan.
The public is encouraged to attend this meeting.

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6/27/11

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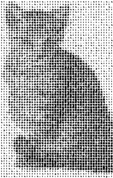

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859-556-0278

[illegible]

KENTUCKY STEEL BUILDINGS
PANEL & SUPPLY

PUBLIC NOTICE

NOTICE OF PUBLIC MEETING

Winchester Municipal Utilities, 150 North Main Street, P.O. Box 4177, Winchester, KY 40392-4177 has contracted **Palmer Engineering**, 400 Shoppers Drive, P.O. Box 747, Winchester, KY 40392-0747 to prepare a Watershed Management Plan for the Lower Howards Creek Watershed in Clark County, Kentucky in accordance with the requirements of the Supplemental Environmental Project necessitated by the Consent Decree with the Environmental Protection Agency. A public meeting will be held on Thursday, July 14, 2011 beginning at 6:00 P.M. at the Clark County Extension Office, 1400 Fortune Drive, Winchester, Kentucky 40391.

The reason for this meeting is to explain the purpose of the Watershed Management Plan, what will be involved in developing the plan, and the benefits of the plan.

The public will have an opportunity to ask questions to project team members, express concerns, and volunteer to assist in preparing and implementing the plan.

The public is encouraged to attend this meeting.

PETS

HOME FOR SALE

"Publisher's Notice"

All real estate advertised on this website or in our newspaper is subject to the Federal Fair Housing Act of 1968 which makes it illegal to advertise any preference, limitation or discrimination based on race, color, religion, sex or national origin, handicapped, families with children, or and intention to make an such preference, limitation or discrimination. Our website and newspaper will not knowingly accept any advertising for real estate which is in violation of the law. Our readers are hereby informed that all dwellings advertised in this newspaper are available on an equal opportunity basis. To complain of discrimination, call HUD toll free at

1-800-669-9777.

The toll free telephone number for the hearing impaired is **1-800-927-9275.**

Equal Housing Opportunity

HOME FOR SALE BY OWNER

215 Southwind Dr.
3 BR, 2BA, Lg Den,
Full Basement
2 Car Garage
Lg Yard
$122,500.
745-0886 / 749-7868

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Large Doublewide on 5 Acres
Sale, Trade-All options open
Fully Furnished
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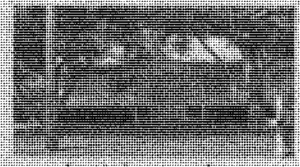
Wooded Area
Quick Sale!!!
$72,000
Call:744-0627-Home
859-644-2682-Cell



Located on a spacious
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with wood stove,
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and in ground POOL.

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Contact owner for showing at
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Rates are Low
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RENTALS

APARTMENT

APARTMENT FOR RENT

1 Magnolia Street
2 Bedroom with
large county kitchen
Washer/Dryer Hookup
Gas Stove/Refridgerator Furnished
$495/Mth $400/Dep
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Call: 859-808-0556

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1 Room
Efficiency
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Pay Deposit Get 1/2 Off
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Call 859-744-1262

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Water Included
$100.00 Off Move In for
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Leave message if no answer!

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All Utilities Included
Call:859-437-0332

---

3 Bedrooms 1 Bath
Upstairs Apt
Washer/Dryer Hook-up
$400/Mth $200/Dep
Plus Utilities
No Pets
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1 BR Appts
2 BR Mobile Home
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Income Based
Apts for Elderly & Disabled
108 South Main
859-744-0323,
Tuesday
8-4:30
Wednesday
12:30-4:30
Friday
8-4:30

TDD#
1-800-648-6056
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1 BD / Efficiencies
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Utilities Furnished.
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Rented under HUD Sect 8.
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Equal Housing Opportunity
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Nice, Private,
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1 Bedroom Effiency Apt
Utilities, Washer/Dryer,
Satellite Furnished
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2 & 3 Bedrooms
$500 - $900mo.
Options to Include Utilities
Kitchen Furnished
Lawn Care Provided
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---

427 Country Club Dr
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Washer/Dryer Hook-up
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Storage Shed
$525/Mth $525/Dep
Call: 859-745-4026

Public Notice

PUBLIC NOTICE

NOTICE OF PUBLIC MEETING

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PETS

PETS

Boykins Spaniel puppies. 6 Weeks old. 1st shots and wormed. Call 859 948-5834.

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FARM FOR SALE

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97.6 acres,
Modern Country Home
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Large Barn, 4 Ponds,

HOME FOR SALE

Publisher's Notice

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1-800-669-9777.

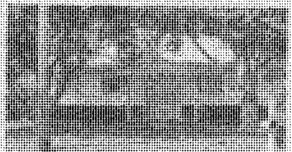
The toll free telephone number for the hearing impaired is

1-800-927-9275.

Equal Housing Opportunity.

HOME FOR SALE BY OWNER

5 Graves Street
3 Bedroom 1 Bath
Full Basement
with Garage
$79,900.00
Call: 859-744-6673
or 859-771-1083



Located on a spacious
corner lot, home has
3BDR, 2.5 Bath, LR, Den
with wood-stove,
recreational room,
and in ground POOL.

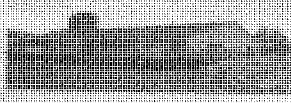
Many Updates!

Asking $169,000,
Contact owner for showing at
(859) 948-7454

Large Doublewide on 5 Acres
Sale, Trade-All options open
Fully Furnished
Everlasting Spring

HOME FOR SALE BY OWNER

215 Southwind Dr.
3 BR, 2BA, lg Den,
Full Basement
2 Car Garage
lg Yard
$122,500.
745-0836 / 749-7868



608 Boone: 2 bedroom,
1 bath, Could be 3 bedroom 1.5 bat
large fenced yard,
near total remodel,
carport, garage,
patio w/kitchen,
$119K OBO.
Call 749-2058.

For Sale By Owner

26+-Acres, 1/2 tillable.
Large 2-story house
with full basement,
barn and insulated shop.

This property is located next to
Lincoln County Produce
and has a creek
with irrigation water
and lots of room for
produce and greenhouse.

Price to Sell at **$132,500.00!**

Davis Kurtz 606-355-0020

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LOT FOR SALE

Earlymeade Estates
Lots For Sale
39,000
Rates are Low
Great Time To Build
Call: 859-808-0953

RENTALS

APARTMENT FOR RENT

1 Magnolia Street
2 Bedroom with
large county kitchen
Washer/Dryer Hookup
Gas Stove/Refridgerator Furnished

PUBLIC INFORMATIONAL MEETING
LOWER HOWARDS CREEK WATERSHED MANAGEMENT PLAN

July 14, 2011
Clark County Extension Office, 6:00 PM

Name	Agency/Company	Phone	Email
CL MORGAN		859-744-9008	BARBOWIRE@bellsouth.net
Bill Crankshaw	Lower Howards Cr. Pres.	737-9914	WBCrankshaw@Gmail.Com
Sherry Woodrum		859-745-6869	woodrum@bellsouth.net
JON WALKER		859-771-2513	JWALKERPS@FS.FED.US
Wes Moody		748-2666	WESMOODY@hotmail.Com
Kathy Whiteman		859-749-1812	kwhiteman@roadrunner.com
Margi Jones	KDOW	502-564-3410	margi.jones@ky.gov
Joe Dietz	KHLCF	859 533-7814	JOEDIETZ@aol.com
Zeb Weese	KHLCF	502-570-3080	zeb.weese@ky.gov
Shanda Cecil	Strodes Creek Cons.	595-2453	scecil@winchesterky.com
Clare Sipple	Lower Howard's Creek	859-771-5406	clarasipp@gmail.com
Jerry Enoch	" " "		
[illegible] Gay		744 3913	700 Old Stone Church Road letter
[illegible] Rogers		744 3913	
[illegible] McAlister	UKKWRRI	859-324-0845	mmcalister@uky.edu
Henry Branham	Judge/Executive	859-745-0200	clarkcountyjudge@yahoo.com

PUBLIC INFORMATIONAL MEETING
LOWER HOWARDS CREEK WATERSHED MANAGEMENT PLAN

July 14, 2011
Clark County Extension Office, 6:00 PM

Name	Agency/Company	Phone	Email
mail Bill Quisenberry	LANdowner	859-744-2364	2111 Waterworks Rd Winchester, Ky 40391
Jackie CALK	Landowner	859-771-4908	Jaqu1@bellsouth.net
[illegible]	Landowner	859 744 9068	[illegible] 51 Skylark Dr
Michael [illegible]	WMU	859-744-5434	
Ralph Palmer	PEC		
mail KENNETH BUSH		859-744 0198	3076 Waterworks Road 40391
CARLTON HEFNER	LANDOWNER	859-744-7502	
ELLIS HEFNER	–	–	
Joyce Bender	KSNPC	502 573-2886	
Julie Smoak	Citizen	859 967 8267	BLUGRSGRL @aol.com
Bob Casher	BGADD	859 269-8021	bcasher@bgadd.org

BIOLOGICAL AND HABITAT ASSESSMENT VOLUNTEERS
LOWER HOWARDS CREEK WATERSHED MANAGEMENT PLAN

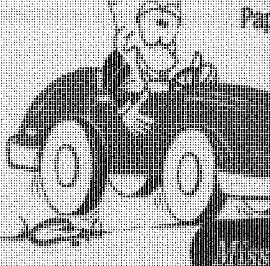
July 14, 2011
Clark County Extension Office, 6:00 PM

Name	Agency/Company	Phone	Email
JON WALKER		859-771-2513	JWALKER05@FS.FED.US
Kathy Whiteman		859-749-1812	kwhiteman@roadrunner.com
Wes Moody		859-749-2666	wesmoody@hotmail.com
Clare Sipple		771-5406	claresipp@gmail.com
Harry Enoch		737-9658	h_enoch@bellsouth.net

WATER SAMPLING VOLUNTEERS
LOWER HOWARDS CREEK WATERSHED MANAGEMENT PLAN

July 14, 2011
Clark County Extension Office, 6:00 PM

Name	Agency/Company	Phone	Email
Bill Crankshaw	LHC Preserve	737-9814	WBCrankshaw@Gmail.Com
Sherry Woodrum		745-6869	woodrum@bellsouth.net
Kathy Whiteman		859-749-1812	KWhiteman@roadrunner.com
Julie Smock	KYDOW/Donet Ck. citizen	859 967 8267	Blugrsgrl@aol.com *
JON WALKER		859-771-2513	JWALKER05@FS.FED.US
Clare Sipple	LHC Preserve	771-5406	claresipp@gmail.com



Public Notice

LEGAL
PUBLIC NOTICE
NOTICE OF PUBLIC MEETING
PROGRESS MEETING #2

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November 8, 2011

PUBLIC PROGRESS MEETING #2
LOWER HOWARDS CREEK WATERSHED MANAGEMENT PLAN

November 29, 2011
Clark County Extension Office, 6:00 PM

Name	Agency/Company	Phone	Email
KEN BUSH		744-0198	
Regenia Campbell		527·3535	
John Campbell		527 3535	
MITCHELL H. FLYNN	WMU	744-5434	—
TIM JOICE	KENTUCKY WATERWAYS ALLIANCE	502-589-8008	tim@kwalliance.org
✓ Clare Sipple	Lower Howard's Creek	771-5406	
✓ Beth Meredith		321 6681	ebeekeeper@aol.com 201 Lisletown Lane
Anna Williams			369 E. Washington St
Rick Smith			
Lajuanda Height-Maybrier	KDOW		
Henry Branham			34 S. Main Street
Lisa Martin	Strode Station		150 Spruce Ct Winchester Ky
William Quisenberry	2111 Waterworks Rd.		
James Gay	700 Old Stone Rd.		
~~Mike Flynn~~			
Shadonte Ragen	700 Old Stone Ch. Rd.		

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Junk house or Lot
Between $3 to $10,000
859-368-3170

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Apartments
& Efficiencies
call (859) 744-1188

1 Bedroom Apartment
&
2 Bedroom Trailers
&
1000 sq. ft. Commercial Building

859-519-8826

1 Room
Efficiency
Apartments
Call 859-744-1262

208 West Lexington
LARGE 3BD, 1BA
$300MO + Deposit
and Utilities
Leave message if no answer
859-808-0293.

Excellent Location 2BD Apt.
on Cul-de-sac,
W/D Hook-up
$600/mo
Includes Water, Sewer,
Garbage Pick-up
Dep/Lease Required
No Pets
859-744-7859

GREAT LOCATION US-27 IN NICHOLASVILLE. Short drive to Lexington and Danville. 2-BR, washer/dryer hookup, $350/deposit, $495/mo. 859-475-3845. EHO.

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One Month Free

Utilities Included
Rents starting at $500.00
Security Deposits
starting at $99.00

Section 8 Accepted
Restrictions Apply

Call 859-744-5974

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Large 2BD Downtown
Apartment (Upstairs)
Living Room and Eat in Kitchen
$290/mth $250/Dep
Central Heat and Air,
(859) 744-7653

Newly Remodeled
Townhouse
2 Bedrooms
1.5 Bath
Washer/Dryer Hookup
$600/mth Plus Utilities
Dep/Lease Required
No Pets
Call: 744-7859

NOW RENTING
1 BD Apts /seniors in downtown.
Rented under HUD Sect 8.
Beverly White Towers
Equal Housing Opportunity
744-0527

DUPLEX FOR RENT

2 & 3 Bedrooms
$500-$900mo.
Options to Include Utilities
Kitchen Furnished
Lawncare Provided
LITTRELL HOMES
(859)744-6118

Duplexes 2/3BD,
All Appl. W/D Hookup,
$525 to $650/Mth
Extra Nice
859-771-2400

DUPLEX FOR RENT

422 Paisley Ct.
3BD, 2BA, garage, stove,
refrigerator, dishwasher, microwave,
w/d hookup, $850/mo,
$850 deposit and lease,
no pets,
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GREAT LOCATION!!!
3 Bedrooms
2.5 Bath
Basement
$790-$850/Month
Pets Allowed with Deposit
Behind Walmart,
859-536-7791 or 749-6511

Heather Lane
2 Bedrooms 2Baths
Appliances Utilities including
Washer/Dryer are furnished
1 Car Garage and Deck
Lease/Deposit
Call:859-749-3416
or 744-1194

Westside Homes
2&3 BD, 2Full BA
W/D Hookup,
Appliances Included
Nice Yards, Free Lawn Care
Sec 8 Vouchers accepted
744-8313
M-F 10:00 to 4:00

Public Notice

LEGAL PUBLIC NOTICE
NOTICE OF PUBLIC MEETING
PROGRESS MEETING #3

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May 8, 2012

PUBLIC PROGRESS MEETING #3
LOWER HOWARDS CREEK WATERSHED MANAGEMENT PLAN

May 29, 2012
Clark County Extension Office, 6:00 PM

Name	Agency/Company	Phone	Email
[illegible] Bush			
Ed [illegible]			
Tricia Coakley			
Barbara Hardiman			
Joe Hardiman			
[illegible]	WMU	(859) 744-5434	MIKE@ WMUTILITIES, com
Brian Ward	Palmer	(859) 744-1218	bward@palmernet.com
Stephanie Hain	Palmer		
Shanda Cecil	SCC	859 745 4042	scecil@winchesterky.com
Doug Oliver		(859) 744-7178	coliver21648@bellsouth.net
Henry Branham	Judge / Executive	859-745-0200	
Harry Enoch & Clare Sipple		859-771-5406	
LajuandaHaight-Maybriar	KDOW	502 564 3410	lajuanda.haight-maybriar@ky.gov
Rick / Suzy Smith	C.C. Commissioner	(859) 749.0410	corgismith@aol.com

Lower Howards Creek Watershed Stakeholder Survey

Please note all items listed are potential goals, objectives and best management practices. Inclusion on this list does not necessarily mean these items will be implemented into the plan.

1. Please prioritize the **GOALS** outlined below by level of importance within Lower Howards Creek Watershed. Identify each goal with a number one to five, with one being not important, three being moderately important, and five being most important. If you do not feel the item listed should be a goal, please place an "X" instead of a number.

______ Improve water quality for safe recreational use
______ Improve watershed awareness and education in the community
______ Diversify and increase the presence of aquatic and terrestrial wildlife
______ Implement measures to protect the stream & riparian zone during future development
______ Improve the aesthetic appeal of the stream
______ Improve stormwater management (reduce flooding), especially during large rain events
______ ____
______ ____

2. Please prioritize the **OBJECTIVES** outlined below by level of importance within Lower Howards Creek Watershed. Identify each objective with a number one to five, with one being not important, three being moderately important, and five being most important. If you do not feel the item listed should be an objective, please place an "X" instead of a number.

______ Reduce human fecal inputs through sanitary sewer overflow (SSO) elimination and identification of failing septic systems and areas of sewer exfiltration to benchmark (acceptable) levels for bacteria
______ Reduce fecal inputs from livestock to benchmark (acceptable) levels for bacteria
______ Reduce algal blooms and eutrophication to improve water quality and aesthetic appeal
______ Expand and/or preserve stream riparian zone to filter runoff and increase habitat
______ Stabilize stream banks to reduce erosion
______ Reduce flooding by reducing or slowing stormwater runoff
______ Inform the public of the water quality status in Lower Howards Creek
______ Revise codes and ordinances to incorporate water quality standards and issues
______ ____
______ ____

3. Please identify the **BEST MANAGEMENT PRACTICES (BMPs)** that you feel will be most successful by placing a circle around the corresponding letter and the BMPs that you feel are impractical or will not be successful by placing an "X" through the corresponding letter. Please use the back of this survey to comment on reasons for your thoughts.

A. SSO removal by WMU (scheduled for completion under Consent Decree)
B. CCTV or smoke test for areas experiencing exfiltration and repair/replace damaged areas
C. Additional microbial source tracking (to identify the source of bacteria pollutants)
D. Identify and replace failing and improperly maintained septic systems or straight pipes
E. Livestock exclusion fence
F. Providing off stream watering for livestock

G. Providing shade for livestock away from stream
H. Requirement for minimum riparian buffer
I. Install filter strips, rain gardens, and/or streamside wetlands
J. Install wood chip bioreactors to reduce nutrients
K. Tree and vegetation planting along streams
L. Stream restoration to repair areas of eroded banks and limited access to floodplain
M. Rain barrel program
N. Provide regional detention areas to reduce flooding
O. Provide wetland areas to improve water quality
P. Provide and inform public of means to dispose of yard waste
Q. Watershed health education programs for property owners
R. Develop public displays to be posted at library or other public places
S. Incorporate water quality education curriculum at local elementary, middle, and high schools
T. Include water quality information on local governmental webpages
U. Partner with City of Winchester MS4 activities
V. Storm drain stenciling
W. Pet waste program
X. Lower Howards Creek Nature and Heritage Preserve acquisition of additional land along LHC
Y. Implement post construction stormwater program
Z. ____

Comments:

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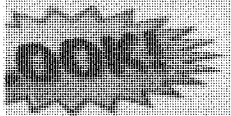
PARTMENT FOR RENT

For Rent
ses and Apartments
-5 Rental Properties
859-744-1090

Great Location*
1 BD / Efficiencies
Monthly / Weekly
tilities Furnished.
859-744-2520

NOW RENTING
ts /seniors in downtown.
ed under HUD Sect 8.
erly White Towers
l Housing Opportunity
744-0521



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2 & 3 Bedrooms
$500-$900mo.
ns to Include Utilities
Kitchen Furnished
awncare Provided
LITTRELL HOMES
(859)744-6118

232 Robert Ct.
Stoneybrooke
3 BR 2.5 Baths
Fireplace, Deck
1 Car Garage
795/Mth -$500/Dep.
Lease
859-771-4296

422 Paisley Ct.
), 2BA, garage, stove,
or, dishwasher, microwave,
'd hookup, $850/mo,
50 deposit and lease,
no pets,
859-771-0058

62 Country Club Ct.
2 BD, 2BA,
l basement, $575/mo
lease/deposit,
859-771-4296

Shanahan Lane,
3BD, 2BA,
75/mo $675/deposit
and Lease.
No pets.
859-771-0058

DUPLEX FOR RENT

Westside Homes
2&3 BD, 2Full BA
W/D Hookup,
Appliances Included
Nice Yards, Free Lawn Care
Sec 8 Vouchers accepted
744-8313
M-F 10:00 to 4:00

HOUSE FOR RENT

2 Bedrooms 1 Bath
$500/Mth $400/Dep
Plus Utilities
No Pets
Call:859-744-7004

3 Bedrooms 1.5 Baths
Central Heat/Air
$750/mth $750/Dep
No Pets, No Hud
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3 Bedrooms 2 Baths
Hardwood
Quiet Street
$850/Mth
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Scottish Highland Subdivision
Brand New Upscale
3 Bedroom 2.5 Bath
1 Car Garage
$800/mth
No Pets
Call:859-621-3966

TOWNHOUSES

2 Bedroom townhouse
1.5 Bath
W/D hookup, all electric,
no pets,
$485/mo, $300/deposit,
Plus Utilities
859-771-4827

***
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1 CAR GARAGE
ALL ELECTRIC
STARTING AT $625
AND $300 SECURITY DEPOSIT
CALL:859-737-1979

Excellent Location!
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Townhome
Fully Furnished Kitchen
Separate Laundry Room
Extra Clean
Privacy Fence
Off Street Parking
$650/mth $650/Deposit
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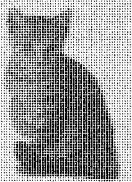
At It's Best
Low Rates
Excellent References
19 Years Experience
859-771-4859

Be a responsible pet owner – have your pet spayed or neutered!



OPEN HOUSE
Sat. & Sun. 1:00-4:00

210 W. Clark Dr.
Brick Ranch, 3 bedroom, 2 bath, full finished basement
$94,500

313 Maryland Ave.
1 1/2 story brick, 3 bedroom, 2 bath, full basement
$99,500

Milton and Associates Real Estate
Barry Milton 859-983-6045

TREE SERVICES

Bill Berryman Tree Service
Residential/Commercial
******Insured******

Land Clearing-Fence Rows
72' Bucket Truck,Chippers,
Stump Grinding,
Band Sawed Lumber,
Firewood

Call:744-0025 /749-0800

YARD SALES

YARD/GARAGE/ MOVING SALES

14 Long Ave.
Case knives,
glassware,
antique furniture,
tools,
old money,
auto parts,
collectible/antiques,
something for everyone.
Sat 9:00-?

14&15 Snowfall Drive
Saturday
8a.m.-1p.m.
2 Family Moving Sale on 1 Street
Rain or Shine
Furniture, Housewares, teaching Supplies-A lot of Stuff Cheap!

216 Ford Hampton Road
Friday 9/21
Saturday 9/22
8a.m.-?
Garage Sale
Rain Or Shine

YARD/GARAGE/ MOVING SALES

23 Churchill Drive
Friday /Saturday
8a.m.-?
Gigantic Yard Sale
Rain/Shine
Furniture-Home Decor-Clothing 0 to Plus, Flowers-Pictures-To much to mention!!!

337 Carolina Ave
Friday Sept. 21
Saturday Sept 22nd
9a.m.-5p.m.
Clothes, Misc household
and other items

GOT
STUFF?

NEED
STUFF?

The Classifieds
bring together
buyers and sellers
every day.

The Winchester Sun
CLASSIFIEDS
744-3198 or 744-7253

Public Notice

LEGAL
PUBLIC NOTICE
NOTICE OF PUBLIC MEETING
FINAL PLAN PRESENTATION MEETING

Winchester Municipal Utilities, 150 North Main Street, P.O. Box 4177, Winchester, KY 40392-4177 has contracted Palmer Engineering, 400 Shoppers Drive, P.O. Box 747, Winchester, KY 40392-0747 to prepare a Watershed Management Plan for the Lower Howards Creek Watershed in Clark County, Kentucky in accordance with the requirements of the Supplemental Environmental Project necessitated by the Consent Decree with the Environmental Protection Agency. The final plan will be presented at a meeting to be held on Thursday, October 11, 2012 beginning at 6:00 P.M. at the Clark County Extension Office, 1400 Fortune Drive, Winchester, Kentucky 40391. The reason for this meeting is to provide a summary of the final plan, including collected sampling data, identified goals and objectives for the watershed, and selected best management practices to protect and restore the watershed. The public will have an opportunity to ask questions to project team members and is encouraged to attend this meeting.

September 20, 2012

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APPENDIX B

FLOOD MAPPING

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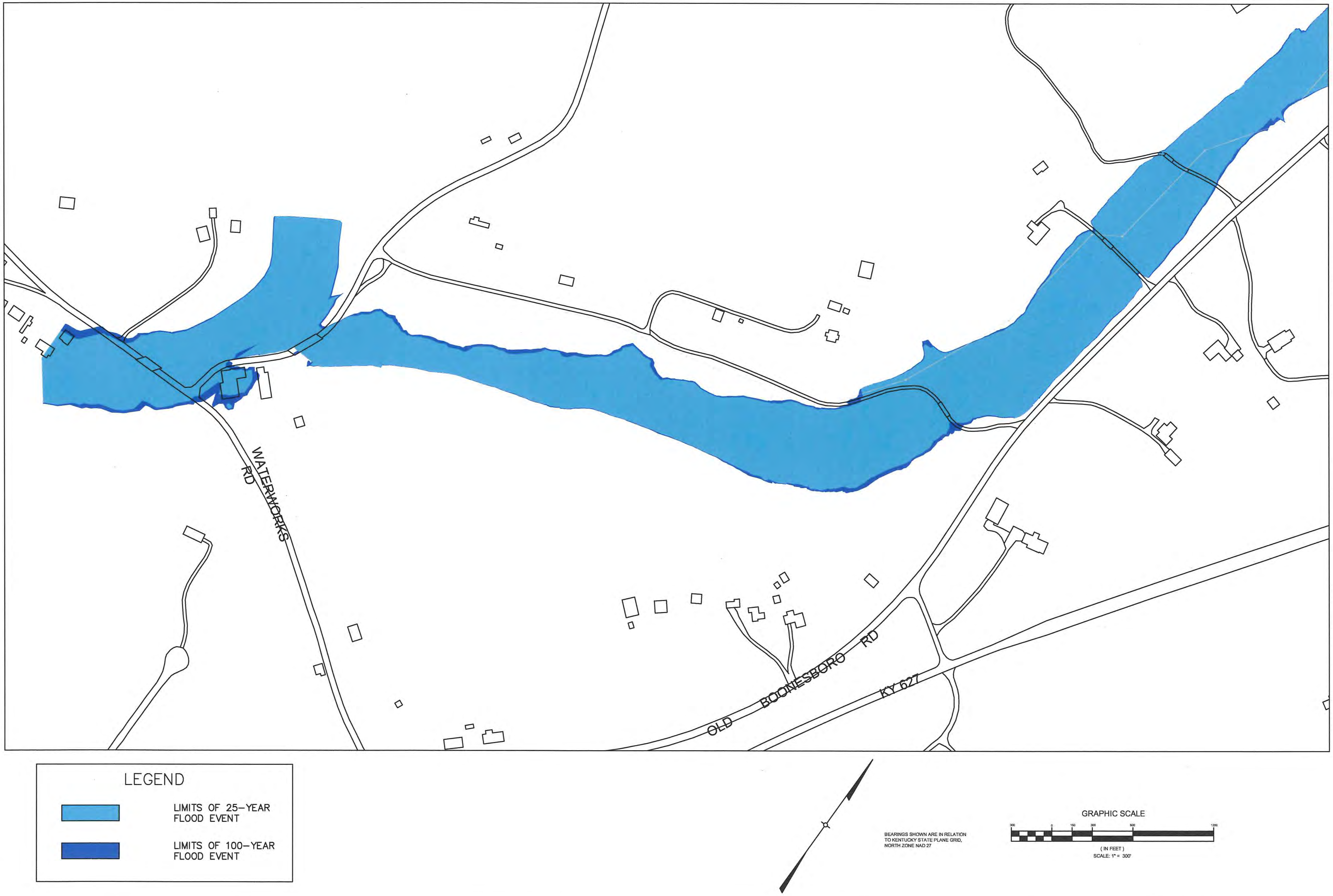


BEARINGS SHOWN ARE IN RELATION
TO KENTUCKY STATE PLANE GRID,
NORTH ZONE NAD 27

WINCHESTER MUNICIPAL UTILITIES
150 NORTH MAIN STREET
P.O. BOX 4177
WINCHESTER, KY 40392-4177
PH. (859) 744-5434
FAX (859)745-4146

LOWER HOWARDS CREEK FLOOD ANALYSIS MAP

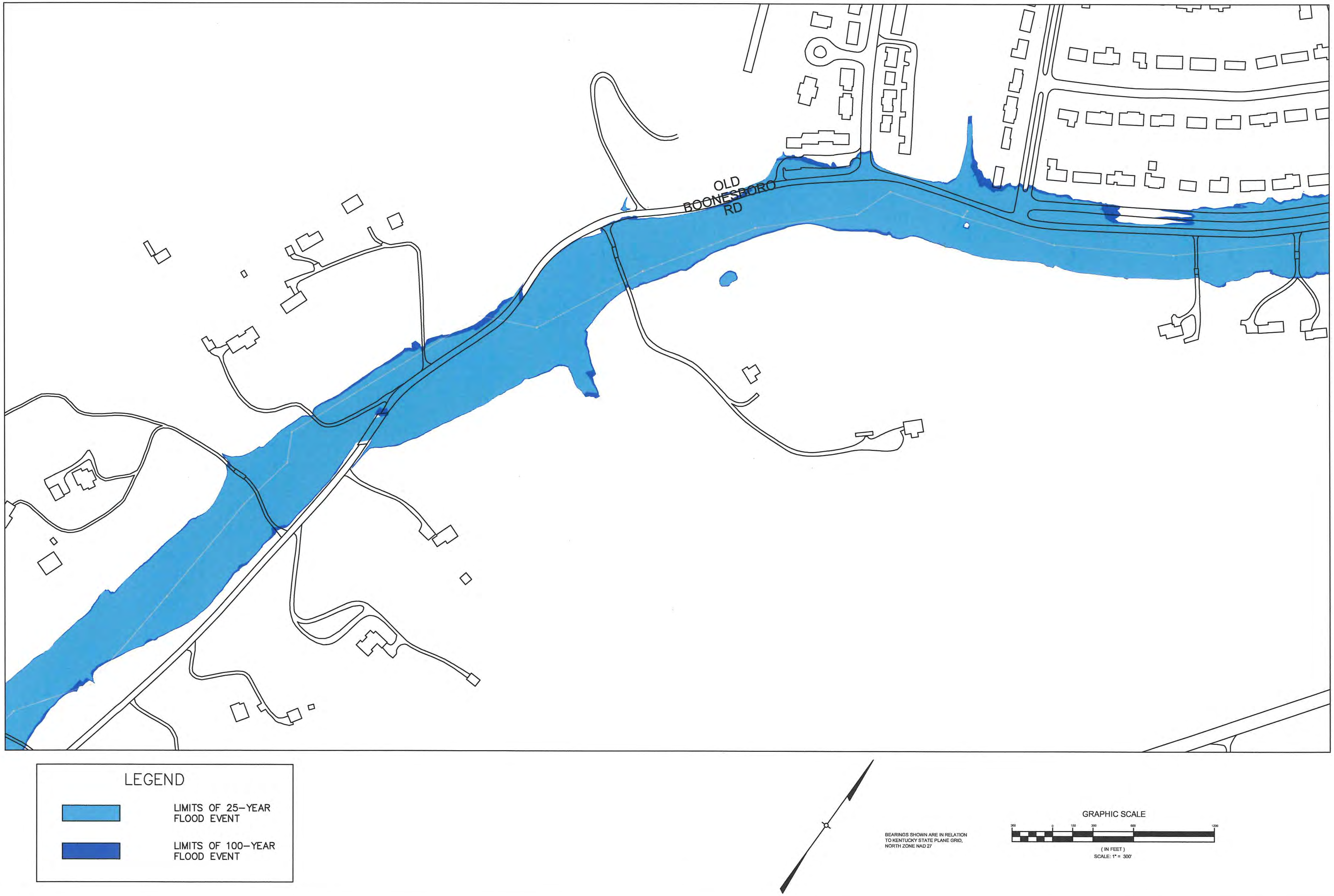
Palmer
ENGINEERING
400 SHOPPERS DRIVE
WINCHESTER, KY. 40391

REVISIONS:

DATE: 11/20/08
DRAWN: WCE
CHECKED: GBW

SCALE:
1"=300'

APPENDIX
1



LEGEND

🟦 LIMITS OF 25–YEAR FLOOD EVENT

🟦 LIMITS OF 100–YEAR FLOOD EVENT

BEARINGS SHOWN ARE IN RELATION
TO KENTUCKY STATE PLANE GRID,
NORTH ZONE NAD 27

GRAPHIC SCALE

(IN FEET)
SCALE: 1" = 300'

WINCHESTER MUNICIPAL UTILITIES
150 NORTH MAIN STREET
P.O. BOX 4177
WINCHESTER, KY 40392-4177
PH. (859) 744-5434
FAX (859)745-4146

LOWER HOWARDS CREEK
FLOOD ANALYSIS MAP

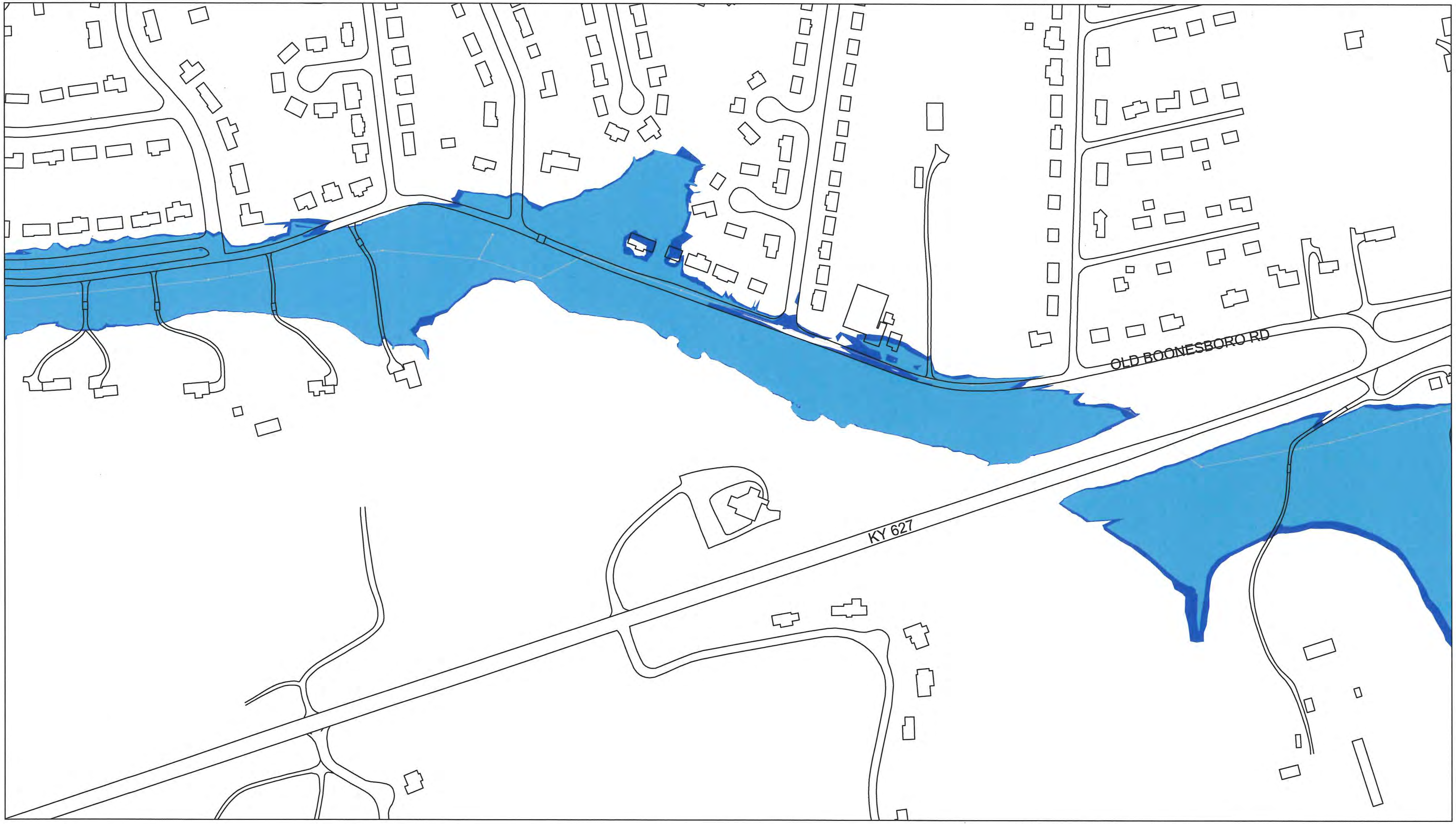
Palmer
ENGINEERING
400 SHOPPERS DRIVE
WINCHESTER, KY. 40391

REVISIONS:

DATE: 11/20/08
DRAWN: WCE
CHECKED: GBW

SCALE: 1"=300'

APPENDIX
2



LEGEND

🟦	LIMITS OF 25–YEAR FLOOD EVENT
🟦	LIMITS OF 100–YEAR FLOOD EVENT

BEARINGS SHOWN ARE IN RELATION
TO KENTUCKY STATE PLANE GRID,
NORTH ZONE NAD 27

GRAPHIC SCALE

(IN FEET)
SCALE: 1" = 300'

W INCHESTER
M UNICIPAL
U TILITIES

150 NORTH MAIN STREET
P.O. BOX 4177
WINCHESTER, KY 40392-4177
PH. (859) 744-5434
FAX (859)745-4146

LOWER HOWARDS CREEK
FLOOD ANALYSIS MAP

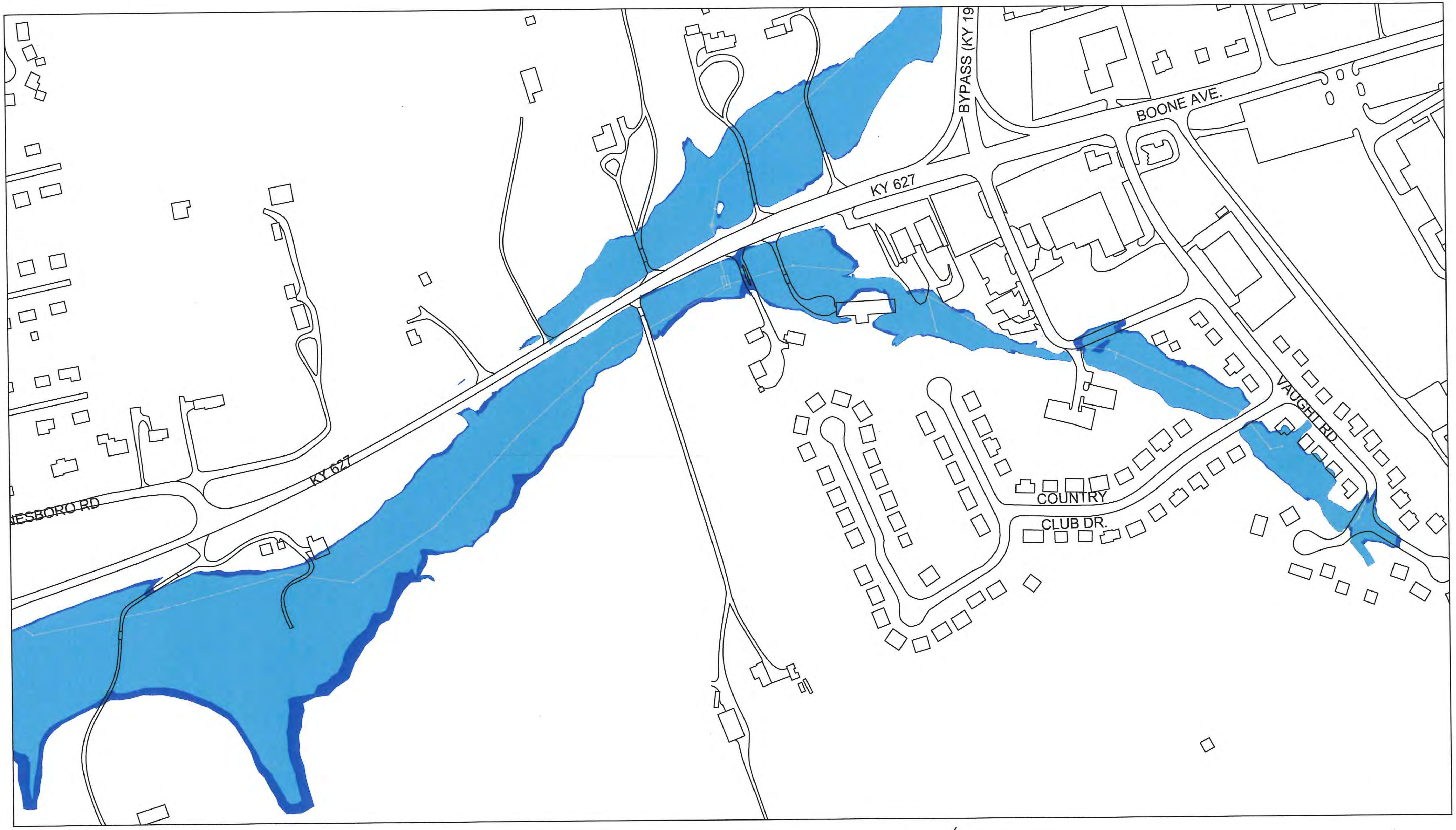
Palmer
ENGINEERING
400 SHOPPERS DRIVE
WINCHESTER, KY. 40391

REVISIONS:

DATE: 11/20/08
DRAWN: WCE
CHECKED: GBW

SCALE:
1"=300'

APPENDIX
3



LEGEND

🟦 LIMITS OF 25-YEAR FLOOD EVENT

🟦 LIMITS OF 100-YEAR FLOOD EVENT

BEARINGS SHOWN ARE IN RELATION
TO KENTUCKY STATE PLANE GRID,
NORTH ZONE NAD 27

GRAPHIC SCALE

300 0 150 300 600 1200

(IN FEET)
SCALE: 1" = 300'

W INCHESTER
M UNICIPAL
U TILITIES

150 NORTH MAIN STREET
P.O. BOX 4177
WINCHESTER, KY 40392-4177
PH. (859) 744-5434
FAX (859)745-4146

LOWER HOWARDS CREEK FLOOD ANALYSIS MAP

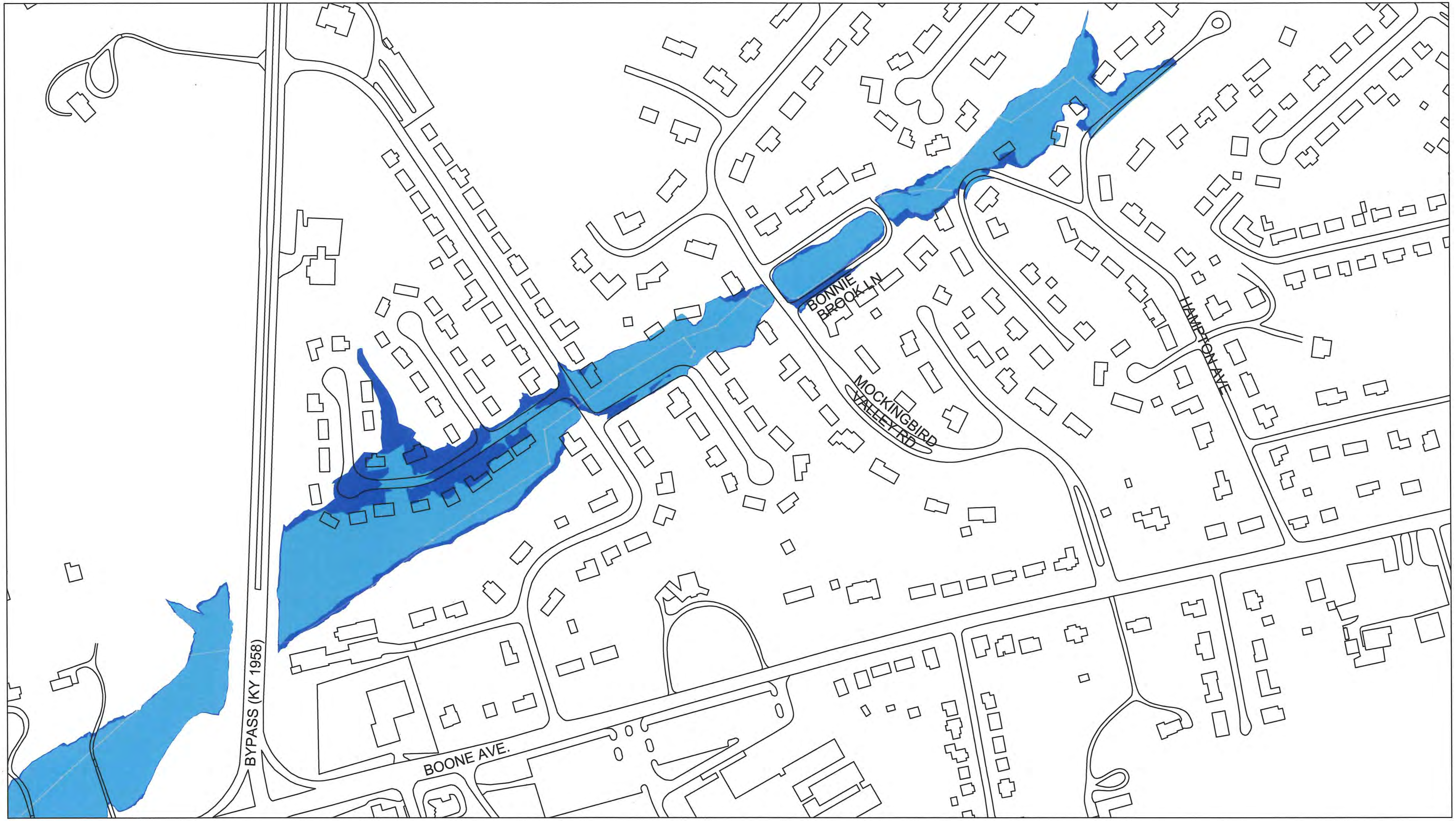
Palmer
ENGINEERING
400 SHOPPERS DRIVE
WINCHESTER, KY. 40391

REVISIONS:

DATE: 11/20/08
DRAWN: WCE
CHECKED: GBW

SCALE: 1"=300'

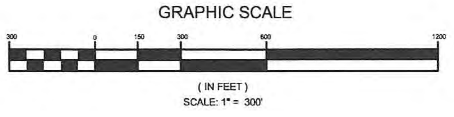
APPENDIX
4



LEGEND

🟦	LIMITS OF 25-YEAR FLOOD EVENT
■	LIMITS OF 100-YEAR FLOOD EVENT

BEARINGS SHOWN ARE IN RELATION
TO KENTUCKY STATE PLANE GRID,
NORTH ZONE NAD 27



W INCHESTER
M UNICIPAL
U TILITIES

150 NORTH MAIN STREET
P.O. BOX 4177
WINCHESTER, KY 40392-4177
PH. (859) 744-5434
FAX (859)745-4146

LOWER HOWARDS CREEK FLOOD ANALYSIS MAP

Palmer
ENGINEERING
400 SHOPPERS DRIVE
WINCHESTER, KY. 40391

REVISIONS:

DATE: 11/20/08
DRAWN: WCE
CHECKED: GBW

SCALE:
1"=300'

APPENDIX
5

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APPENDIX C

EXISTING WATER QUALITY DATA

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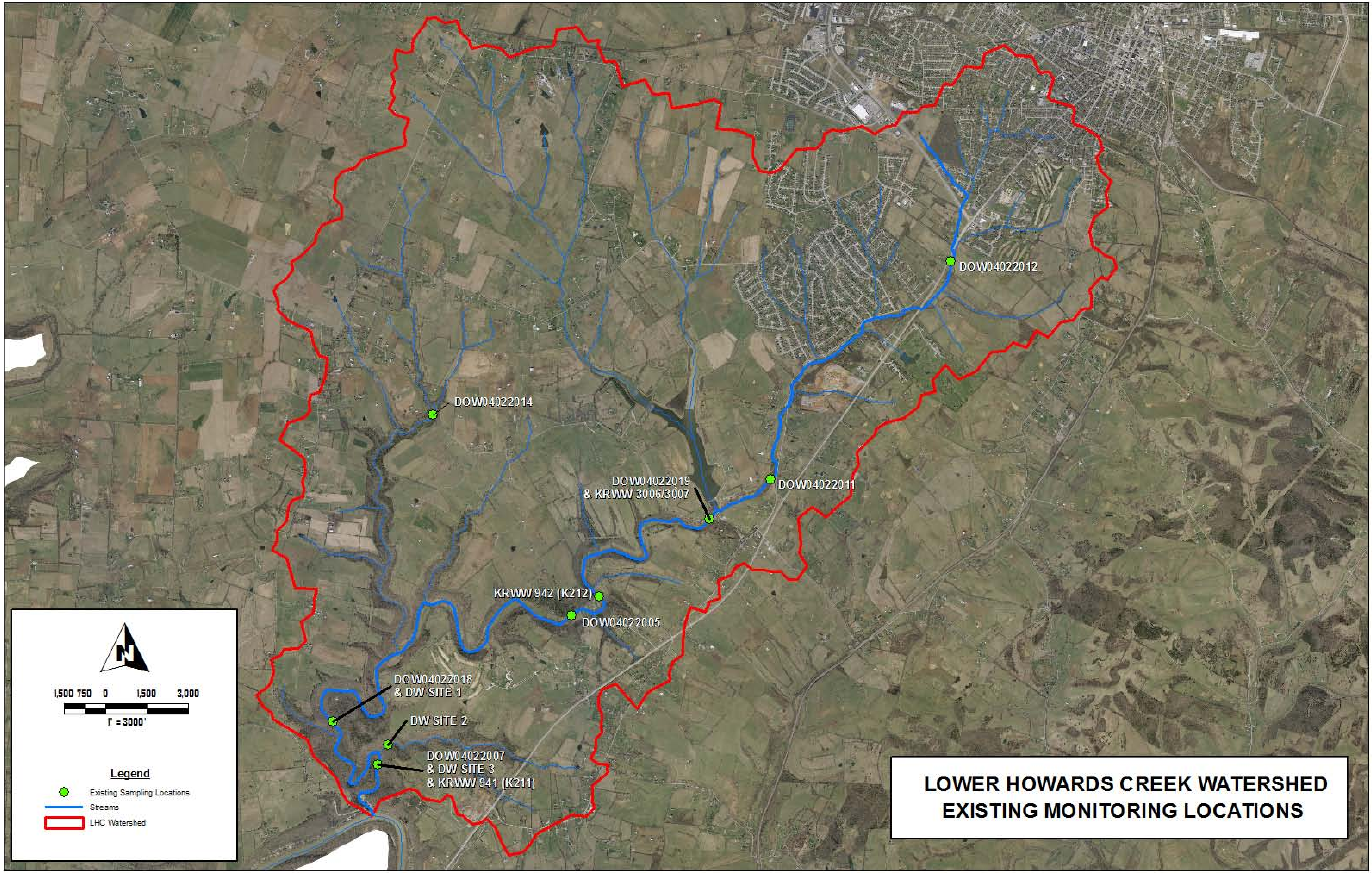

LOWER HOWARDS CREEK WATERSHED
EXISTING MONITORING LOCATIONS

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KRWW Sampling Sites in Lower Howard's Creek (HUC-11 #5100205010)

Historic ID	Site ID	Sampler LN	Creek	Location	HUC-11 #	Latitude	Longitude
K158	890	Daniel	Howards Cr	At Mouth of Creek	5100205010	37.918017	-84.273046
K212	942	Sipple	Howards Creek	Immediately behind Old Stone Church on Old Stone Church Rd	5100205010	37.900000	-84.120000
K270	996	Shear	Howards Creek	100 yards upstream of KY 89 & Howard's creek	5100205010	37.898900	-84.058500
	3006	Sipple	Lower Howard Creek	upstream of suspected pipe	5100205010	37.9391	-84.2439
	3007	Sipple	Lower Howard Creek	downstream of suspected pipe.	5100205010	37.9391	-84.2439

Field Sampling Results for Lower Howards Creek (2010-2011)

Site ID	Historic Site ID	Volunteer LN	Time	Date	Flow	Rainfall	Turbidity	DO	pH	Temp	Conductivity
941	**K211**	Sipple	9:15 AM	7/30/2011	2	0.0	0	0	7.5	24	790
3006		Sipple	8:05 AM	7/30/2011	2	0.0	0	6	8	23	340
3007		Sipple	8:15 AM	7/30/2011	2	0.0	0	6	7.5	23	340
941	**K211**	Sipple	10:00 AM	7/9/2011				4.5	8.0	22	900
942	**K212**	Sipple	9:30 AM	7/9/2011	3	1.0	1		8.0	20	430
3007		Sipple	8:45 AM	7/9/2011	3	1.0	2	7	7.5	20	460
3006		Sipple	9:10 AM	7/9/2011	3	1.0	2	6.5	7.5	20	450
3006		Sipple	9:45 AM	5/14/2011	3	0.1	0			16	
3007		Sipple	9:30 AM	5/14/2011	3	0.1	0			15	
3006		Sipple	8:35 AM	9/13/2010	3	0.1	0				
3007		Sipple	8:25 AM	9/13/2010	3	0.1	0				
941	**K211**	Sipple	10:45 AM	7/31/2010	2	0.1	0			22.2	
942	**K212**	Sipple	10:17 AM	7/31/2010	3	0.1	0			22.0	
3006		Sipple	10:00 AM	7/31/2010	3	0.1	0			21.2	
3007		Sipple	9:49 AM	7/31/2010	3	0.1	0			21	
941	**K211**	Sipple	8:25 AM	7/10/2010	3	>1.5	0				
942	**K212**	Sipple	8:00 AM	710/10	3	>1.5	0				

Site ID#	**Historic Site ID#**	**Collection Date**	**Stream**	**County**	**Triazines by Immunoassay (ug/L) ***	**2,4-D by Immunoassay (ug/L) ***
Method Detection Limit					**0.06 ug/L**	**0.9 ug/L**
Water Quality Standards					**3.0 for DWS *** **350 for Acute AL*** **12 for Chronic AL**	**70 ug/L for DWS (USEPA)**
3006		5/14/2011	Lower Howard Creek	Clark	**1.15**	0.45
3007		5/14/2011	Lower Howard Creek	Clark	**1.16**	0.45

KRWW Pathogen Data for Lower Howard Sites (2010-2011)

Site ID#	Historic Site ID#	Date	Stream	County	E. coli (cfu/100 ml)
Primary Contact Water Quality Standard					**240**
	K158	7/9/10	HOWARDS CREEK	CLARK	**82**
	K212	7/10/10	LOWER HOWARD CREEK	CLARK	**2,420**
3006		7/10/10	LOWER HOWARD CREEK	CLARK	**>2420**
3007		7/10/10	LOWER HOWARD CREEK	CLARK	**>2420**
	K212	31-Jul-10	LOWER HOWARD CREEK	CLARK	50
3006		31-Jul-10	LOWER HOWARD CREEK	CLARK	**620**
3007		31-Jul-10	LOWER HOWARD CREEK	CLARK	**340**
3006		**7/9/2011**	**LOWER HOWARD CREEK**	**CLARK**	**7,300**
3007		**7/9/2011**	**LOWER HOWARD CREEK**	**CLARK**	**5,500**
	K212	**7/9/2011**	**LOWER HOWARD CREEK**	**CLARK**	**1,700**
	K212	7/31/2011	LOWER HOWARD CREEK	CLARK	90
3006		7/31/2011	LOWER HOWARD CREEK	CLARK	20
3007		7/31/2011	LOWER HOWARD CREEK	CLARK	10

KRWW Chemistry Results for Lower Howards Creek (2010)

Site ID#	Historic Site ID#	Collection Date	Alkalinity (mg/L as CaCO3)	Chloride (mg/L)	Conductivity (uS/cm)	**Total Suspended Solids (mg/L)
Water Quality Standard			**>20 for AL***	**250 for DWS* 1,200 for acute AL 600 for chronic AL**	**800 for Ohio River**	**N/A**
Method Detection Limit*			**4 mg/L** Method EPA 310.1	**1.0 mg/L** Method EPA 300	**1 uU/cm** Method EPA 120.1	**3 mg/L** Method EPA 160.2
3006		13-Sep-10	124	9	324	5
3007		13-Sep-10	122	9	343	5

KRWW Nutrients Results for Lower Howards Creek (2010)

Site ID#	Historic ID#	Collection Date	Nitrate-N ** (NO3-N) mg/L	Total Nitrogen (mg/L)	Total Recoverable Phosphorus (mg/L)	Sulfate (mg/L)
Water Quality Standard			**10 mg/L (DWS*)**	**N/A**	**0.3 mg/L (KRWW unofficial)**	**250 mg/L (DWS*)**
Method Detection Limit			**0.004 mg/L** Method EPA300	**0.07 mg/L** SM 4500-N(C)	**0.03 mg/L** Method ASTM D515	**5 mg/L** Method EPA300
3006		13-Sep-10	0.23	0.2	0.28	32.8
3007		13-Sep-10	0.27	0.3	**0.32**	31.8

KRWW Metals Results for Lower Howards Creek (2010)

Site ID#	Sampling Date	Aluminum (µg/L)	Antimony (µg/L)	Arsenic (µg/L)	Barium (µg/L)	Beryllium (µg/L)	Boron (µg/L)	Cadmium (µg/L)
Water Quality Standard		N/A	5.6 µg/L (DWS)	10 µg/L (DWS); 340 µg/L (AL-acute); 150 µg/L (AL - chronic)	1,000 µg/L (DWS)	4 µg/L (DWS)		5 µg/L (DWS), 2.13 µg/L (AL-acute)*; 0.27 µg/L (AL-chronic)*
Method Detection Limit* (EPA 200.7)		**61**	**12**	**14**	**30**	**1**	**8**	**1**
3006	9/13/2010	220	6	7	50	0.5	40	0.5
3007	9/13/2010	170	6	7	50	0.5	40	0.5

Calcium (mg/L)	Chromium III (µg/L)	Cobalt (µg/L)	Copper (µg/L)	Site ID#	Gold (µg/L)	Iron (µg/L)	Lead (µg/L)	Lithium (µg/L)
	1803 µg/L (AL-acute)*; 86 µg/L (AL-chronic)*		1,300 µg/L (DWS); 14 µg/L (AL-acute)*; 9.33 µg/L (AL-chronic)*	Water Quality Standard		300 µg/L (DWS); 4,000 µg/L (AL-acute); 1,000 µg/L (AL-chronic)	15 µg/L (DWS); 82 µg/L (AL-acute)*; 3.18 µg/L (AL-chronic)*	
0.002	**24**	**1**	**5**	Method Detection Limit* (EPA 200.7)	**34**	**2**	**10**	**1**
42.5	12	0.5	2.5	3006	17	150	5	0.5
41	12	0.5	2.5	3007	17	160	5	1

Sulfur (mg/L)	Thallium (µg/L)	Tin (mg/L)	Vanadium (mg/L)	Zinc (µg/L)
	0.24 µg/L (DWS)			7,400 µg/L (DWS); 120 µg/L (AL-acute and chronic)*
0.014	**41**	**0.012**	**0.008**	**2**
9.32	20.5	0.006	0.004	6
8.98	20.5	0.006	0.004	7

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KDOW Chemistry Sample Results Data

Station ID: DOW04022007 **Ecoregion:** INTERIOR PLATEAU
Basin: KENTUCKY **Stream Name:** LOWER HOWARD CREEK
County: CLARK **Map Name:** FORD
Catchment Area: 19.2 **River Mile:** 0.4 **Stream Order:** 4
Lat Dec: 37.92261 **Long Dec:** -84.27183
Location: 0.4 MILES ABOVE KENTUCKY RIVER CONFLUENCE

Collection Date: *4/24/2001*
RepNum: *1* ***Equipment:*** *HYDROLAB*
Collector: *G. POND* ***Program:*** *REF*

Chemical Parameter	*Value*	*Collection Method*
Ammonia	0.05	Grab;reported
DO	10.28	Multi-Parameter Meter
Nitrate+Nitrite	0.913	Grab;reported
pH	8.52	Multi-Parameter Meter
Specific Conductance	354	Multi-Parameter Meter
Temperature	17.23	Multi-Parameter Meter
TKN	0.145	Grab;reported
Total P	0.196	Grab;reported

Collection Date: *6/12/2009*
RepNum: *1* ***Equipment:***
Collector: *John Brumley* ***Program:*** *INT*

Chemical Parameter	*Value*	*Collection Method*
Acidity	0	Grab;reported
Alkalinity	172	Grab;reported
Alkalinity, Bicarbonate	172	Grab;reported
Alkalinity, Carbonate	0	Grab;reported
Ammonia	0.0322	Grab;reported
Chloride	15.4	Grab;reported
Fluoride	0.22	Grab;reported
Hardness (EDTA)	195	Grab;reported
Nitrate+Nitrite	1.31	Grab;reported
Organic Carbon	2.24	Grab;reported
pH (Lab)	8.53	Grab;reported
Specific Conductance (LAB)	416	Grab;reported
Sulfate	29.3	Grab;reported
TDS	217	Grab;reported
TKN	0	Grab;reported
Total P	0.24	Grab;reported
TSS	5.5	Grab;reported
Turbidity	3.54	Grab;reported

Station ID: DOW04022018 **Ecoregion:** INTERIOR PLATEAU
Basin: KENTUCKY **Stream Name:** LOWER HOWARD CREEK
County: CLARK **Map Name:** FORD
Catchment Area: 17.83 **River Mile:** 1.2 **Stream Order:** 4
Lat Dec: 37.9269 **Long Dec:** -84.27751
Location: UNPAVED ROAD OFF SR 418; PARK AT KSNPC TRAILER AND HIKE DOWN

Collection Date: *6/12/2009*
RepNum: *1* ***Equipment:***
Collector: *John Brumley* ***Program:*** *INT*

Chemical Parameter	*Value*	*Collection Method*
Acidity	0	Grab;reported
Alkalinity	167	Grab;reported
Alkalinity, Bicarbonate	167	Grab;reported
Alkalinity, Carbonate	0	Grab;reported
Ammonia	0.0332	Grab;reported
Chloride	14.5	Grab;reported
Fluoride	0.22	Grab;reported
Hardness (EDTA)	197	Grab;reported
Nitrate+Nitrite	1.32	Grab;reported

Organic Carbon	2.22	Grab;reported
pH (Lab)	8.52	Grab;reported
Specific Conductance (LAB)	404	Grab;reported
Sulfate	28.3	Grab;reported
TDS	404	Grab;reported
TKN	0	Grab;reported
Total P	0.227	Grab;reported
TSS	5	Grab;reported
Turbidity	2.46	Grab;reported

APPENDIX D

HISTORICAL, CULTURAL RESOURCES, AND VEGETATION MAPPING

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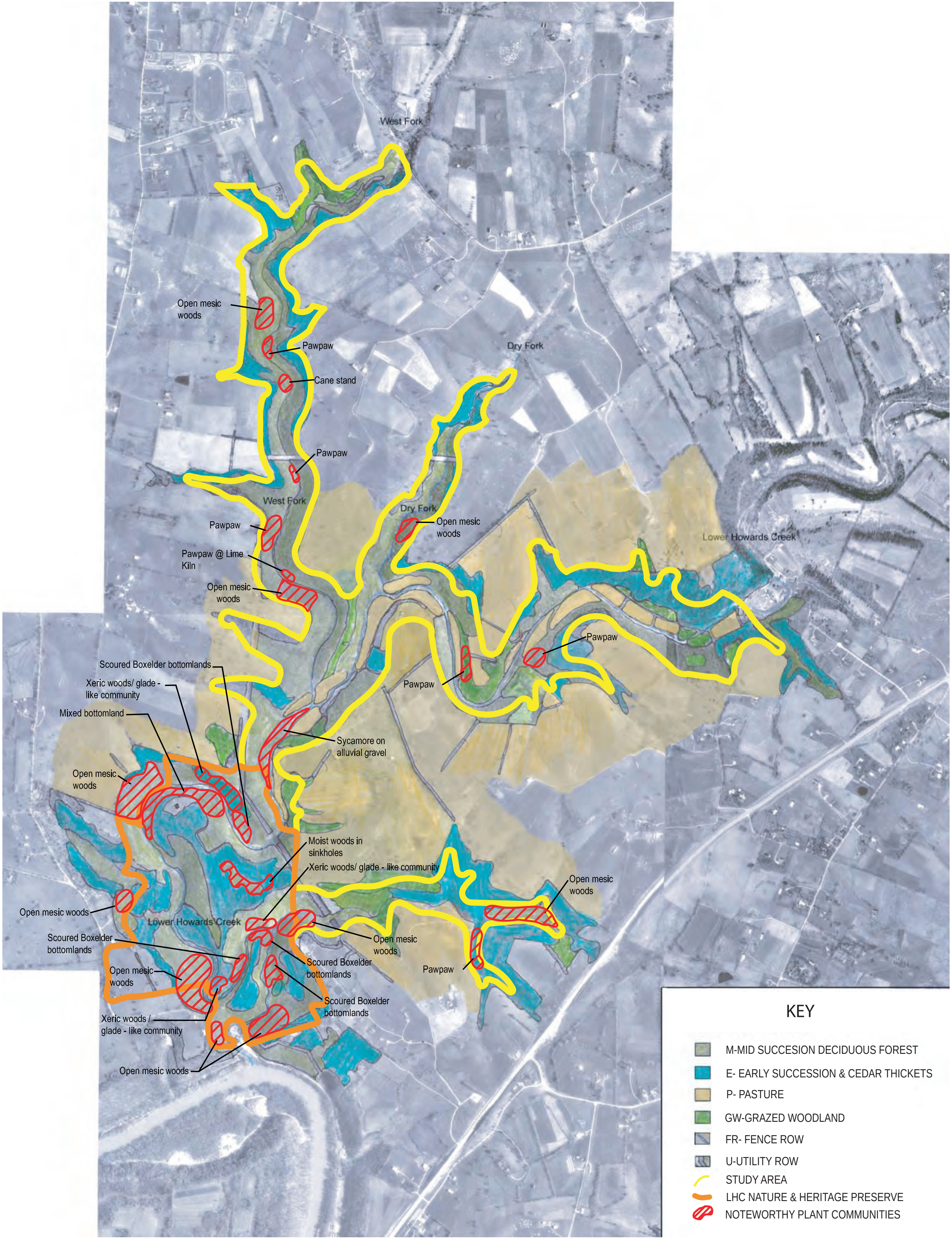
FIGURE 2.

Vegetation



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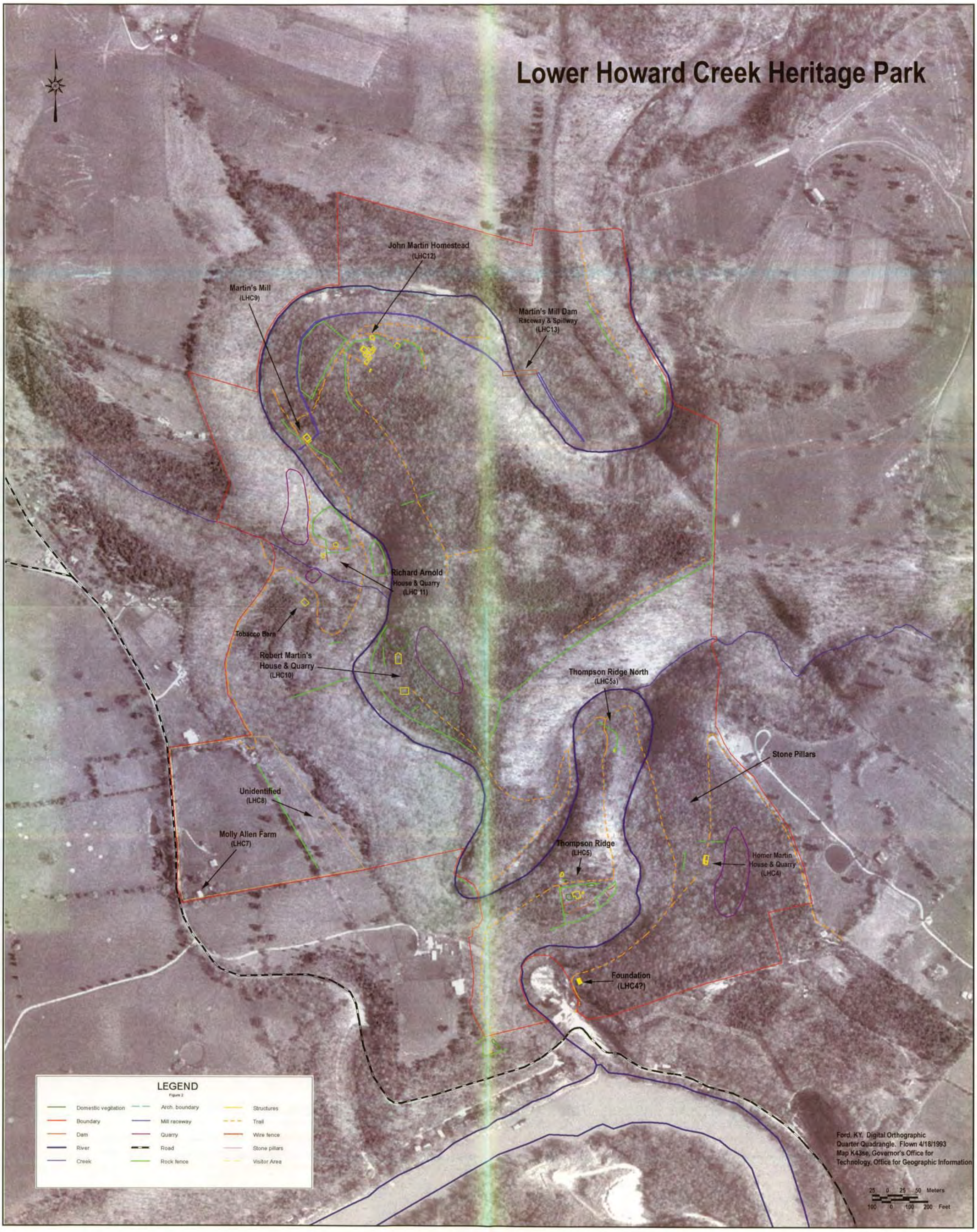

Ford, KY. Digital Orthographic Quarter Quadrangle. Flown 4/18/1993 Map K43se, Governor's Office for Technology, Office for Geographic Information

NOT TO SCALE

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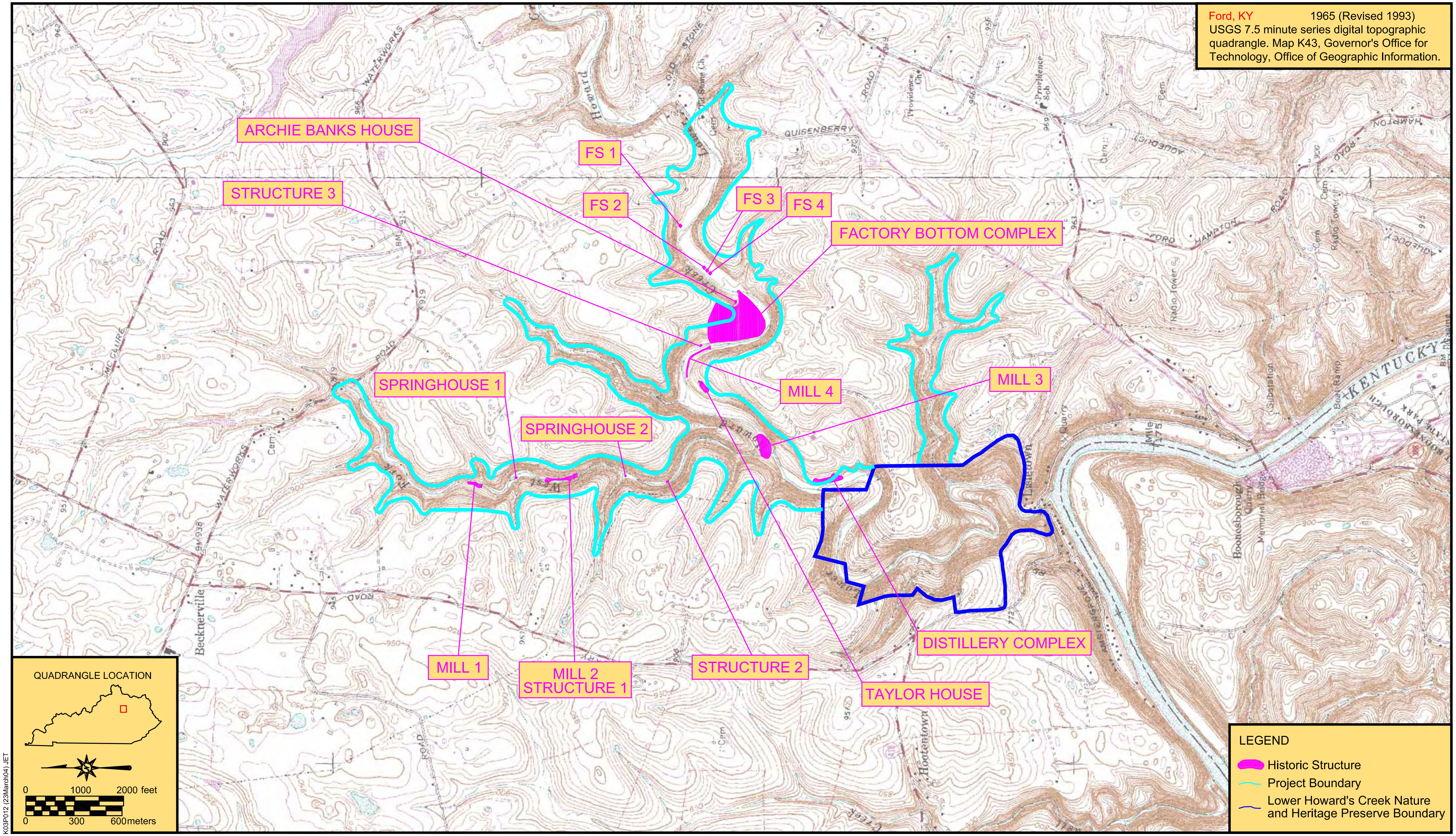

Figure 2. Location of project area on topographic quadrangle.

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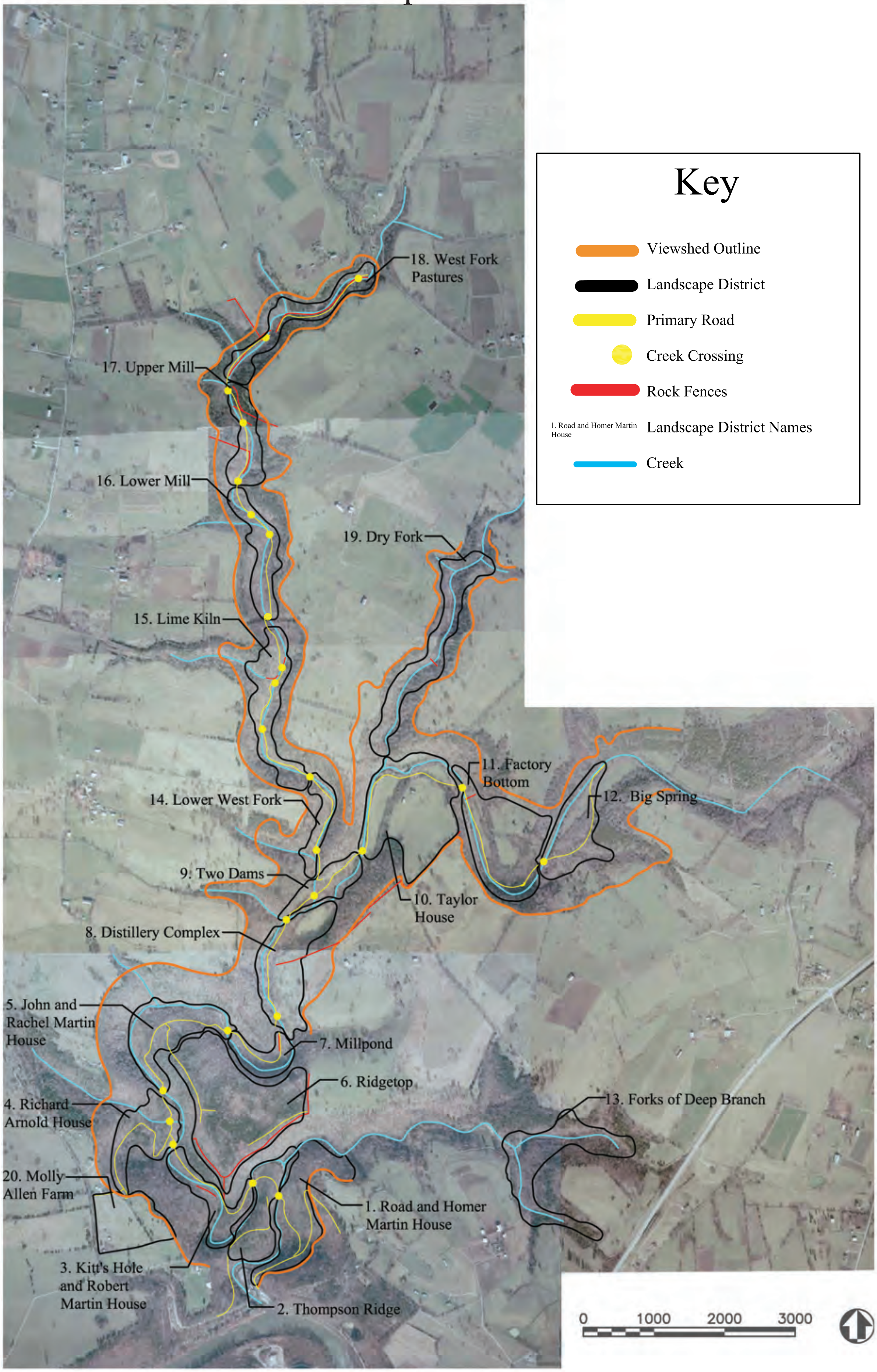
FIGURE 6.

Landscape Districts



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APPENDIX E

FUTURE LAND USE MAPPING

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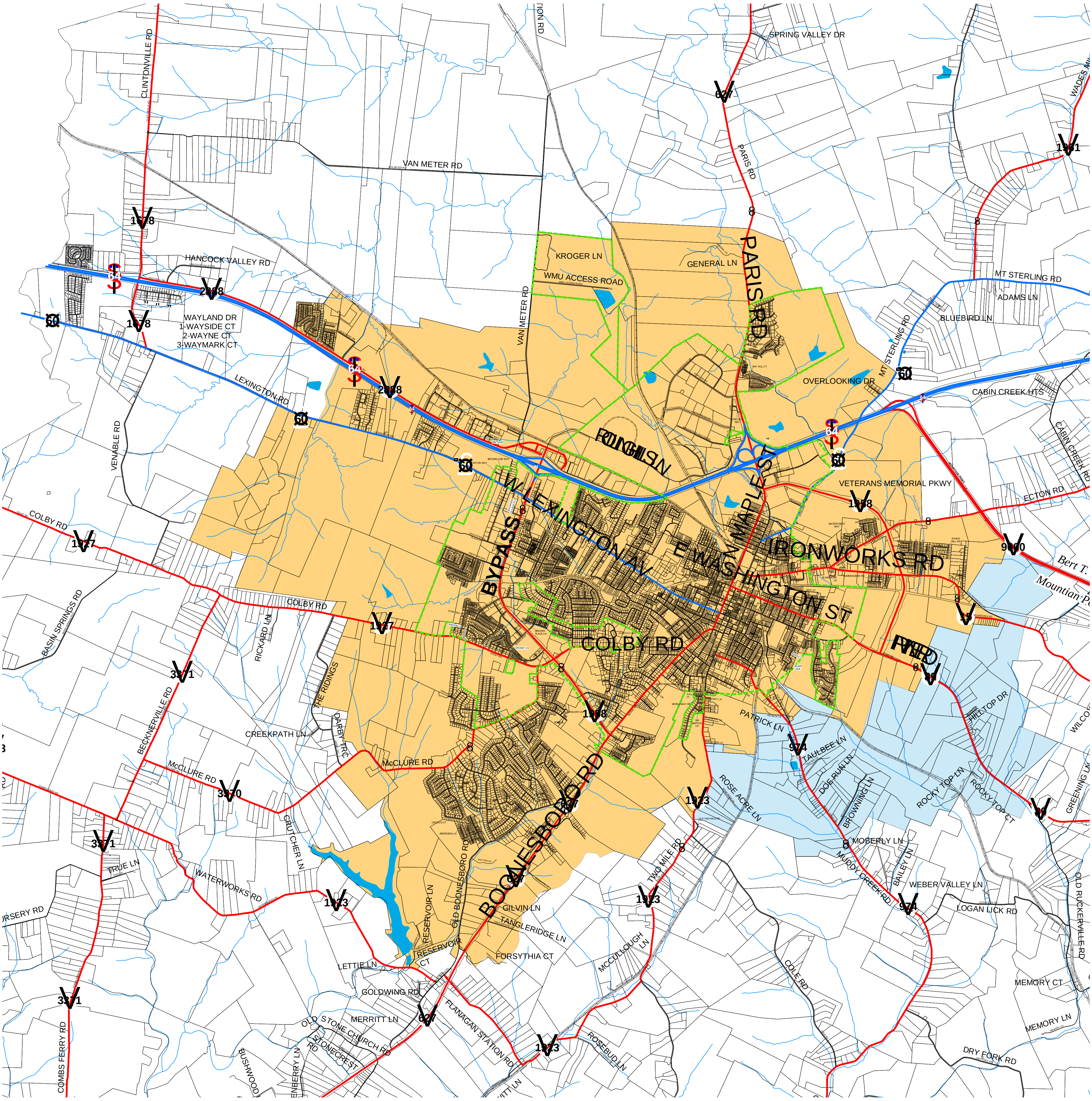
Comprehensive Plan Update

CITY OF WINCHESTER/ CLARK COUNTY, KENTUCKY

Source: Clark County GIS (Sept. 2008)

0 5,000 10,000 20,000 Feet



Legend

- 🟧 Urban Planning Boundary
- 🟦 Long Range Planning Area
- 🟩 City Limits

Exhibit 4-1

Planning Boundaries

City and Vicinity

June 14, 2011

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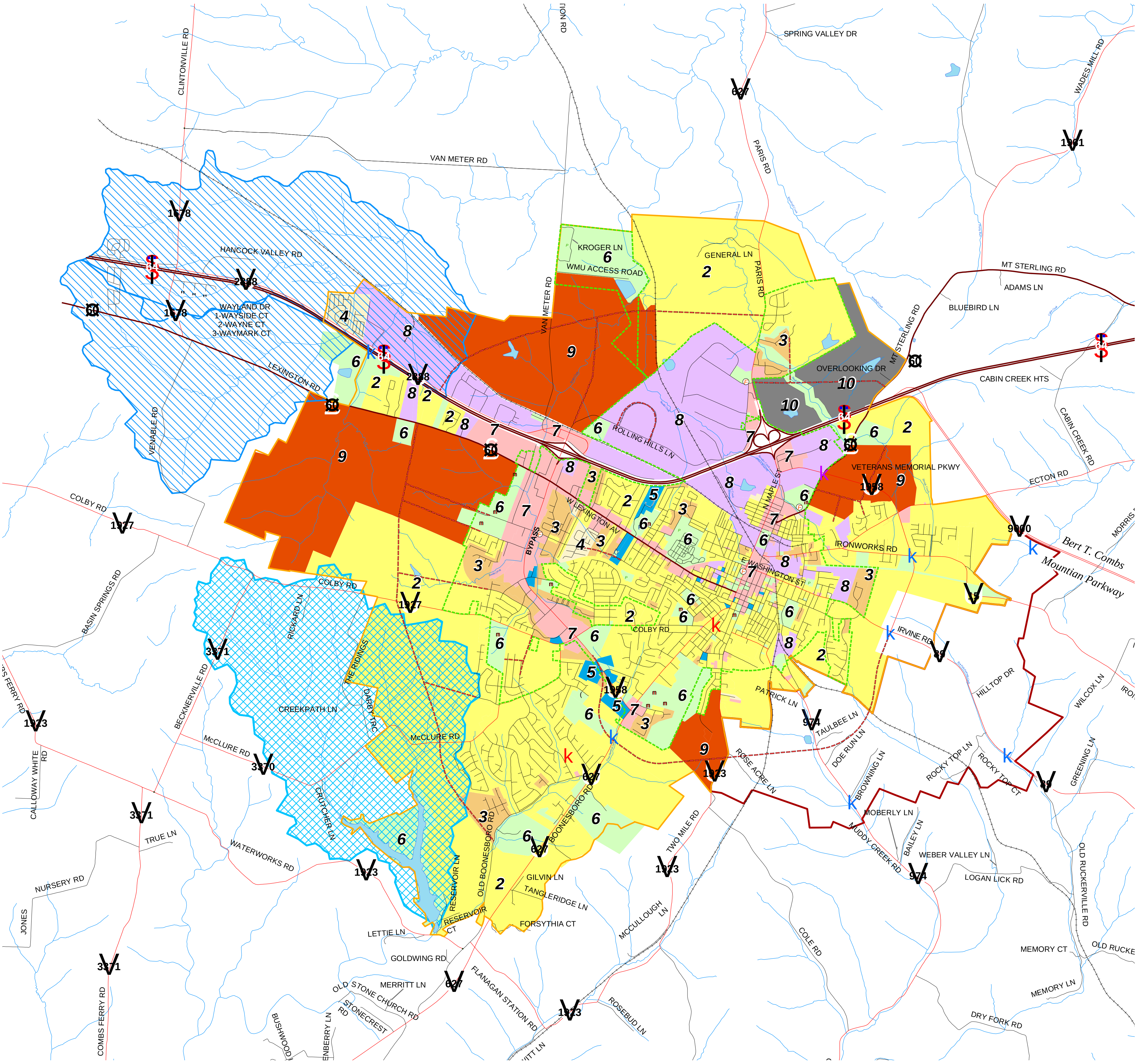
Comprehensive Plan Update

CITY OF WINCHESTER/ CLARK COUNTY, KENTUCKY

0 0.5 1 2 Miles

Source: USGS



Legend

- 1 Agricultural
- 2 Single Family Residential
- 3 Multi Family Residential
- 4 Mobile Home
- 5 Professional Office
- 6 Public/Semi Public
- 7 Commercial
- 8 Industrial
- 9 Planned Community Neighborhood
- 10 Planned Interstate Employment & Residential Center
- 11 Undeveloped
- Urban Planning Boundary
- Long-Range Planning Area
- Hancock Creek Watershed
- Reservoir Watershed

k This Area Includes Non-conforming Multi-Family Units

k Limited Neighborhood Commercial Proposed at this Intersection

k Development in this Watershed Area Contingent Upon Municipal Sewer Availability

Exhibit 4-2

Future Land Use

Urban Service Boundary

June 14, 2011

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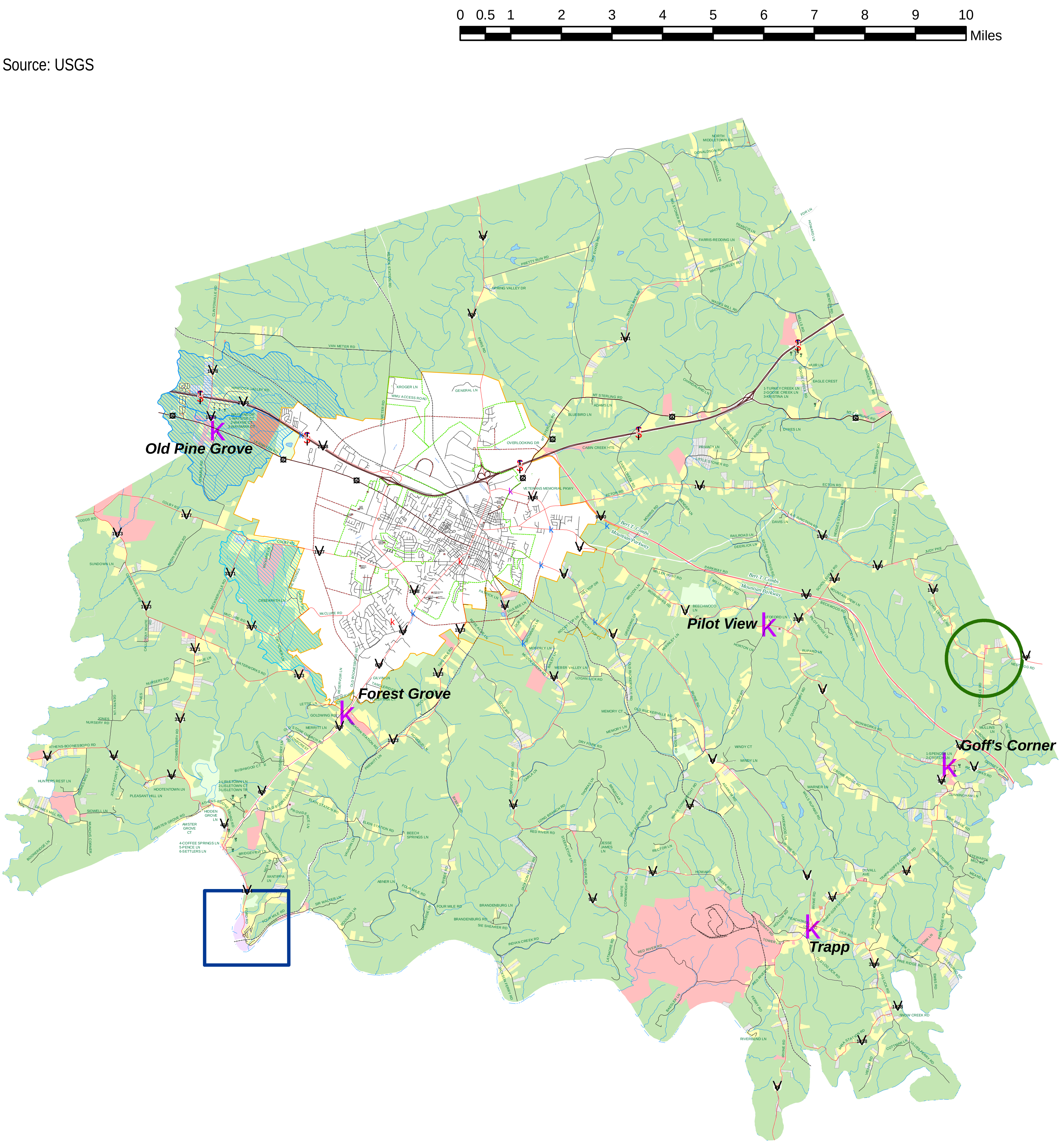
Comprehensive Plan Update

CITY OF WINCHESTER/ CLARK COUNTY, KENTUCKY

Source: USGS



Legend

🟩	Agriculture	🟪	Industrial	🟩	Public/Semi Public	☐	Urban Planning Boundary
🟨	Single Family Residential	🟥	Commercial	🟧	Utility Facilities	k	Crossroads Communities
🟧	Multi Family Residential	🟦	Professional Office	▨	Vacant	🟩	Kiddville/Oldfield Tourism Area
⬜	Mobile Home	🟥	Government Land	⬛	Parking Lot	🟦	Ford Tourism Area

Exhibit 4-3

Future Land Use

Rural Areas

June 14, 2011

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APPENDIX F

QAPPs AND MONITORING FORMS

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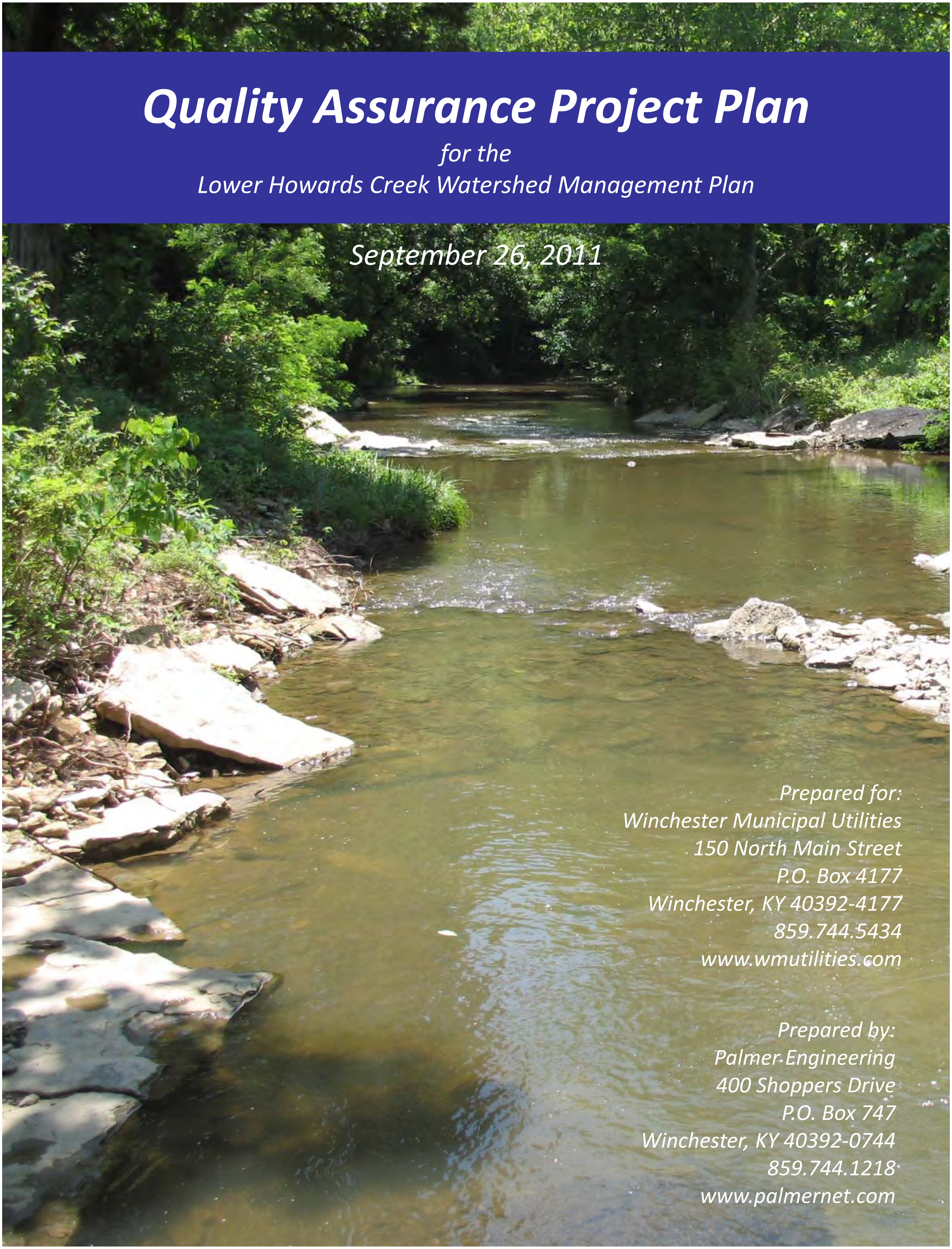
Quality Assurance Project Plan

for the

Lower Howards Creek Watershed Management Plan



September 26, 2011

Prepared for:
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QUALITY ASSURANCE PROJECT PLAN

for the
LOWER HOWARDS CREEK WATERSHED MANAGEMENT PLAN

Prepared by:

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September 26, 2011

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1. PROJECT MANAGEMENT

1.1 Approval Sheet

Brian Ward — 9/26/11

Mr. Brian Ward, PE, PLS — Date
Project Manager
Palmer Engineering

9/27/11

Ms. Lee Carolan — Date
Project QA/QC and Field Coordinator
Palmer Engineering

9-26-11

Mr. Michael H. Flynn — Date
General Manager
Winchester Municipal Utilities

Clare Sipple — 9-28-11

Ms. Clare Sipple — Date
Volunteer Coordinator
Preserve Manager
Lower Howards Creek Nature and Heritage Preserve

Ms. Lisa Hicks — Date
Division of Water Quality Assurance Officer
Kentucky Division of Water

1.2 Project Identification and Background

Winchester Municipal Utilities (WMU) has contracted Palmer Engineering to provide consulting services for the development of a Watershed Management Plan for the Lower Howards Creek Watershed (LHCW) in Winchester, Clark County, Kentucky. Lower Howards Creek (LHC) is listed as impaired in the Kentucky Division of Water (KDOW) 2010 Section 303(d) list from river mile (RM) 2.65 to RM 6.2. LHCW is located in the Kentucky River Basin in the southwestern portion of Clark County, Kentucky. The listed impairments are nutrient/eutrophication biological indicators and organic enrichment (sewage) biological indicators. KDOW completed monitoring of LHC in 2004 and the Total Maximum Daily Load (TMDL) is currently still under development.

The Kentucky River Basin Management Plan, prepared by the Kentucky Water Resources Research Institute, dated April 2002, identified LHCW as a Framework Mobilization Category II watershed, indicating that it is a watershed targeted for mobilization in the second cycle of the plan. Only three watersheds in the Kentucky River Basin were listed at a higher priority than the LHCW. The watershed contains a drinking water reservoir for the City of Winchester and is part of source water protection zones two and three for Kentucky American’s Lexington intake on the Kentucky River.

The Lower Howards Creek Watershed Management Plan (LHCWMP) is being developed as the Supplemental Environmental Project (SEP) mandated by the Environmental Protection Agency (EPA) in the Consent Decree (Civil Action No. 06-1-2KSF, April 10, 2007) with WMU and the City of Winchester. As outlined in the Consent Decree, significant sanitary sewer overflows (SSOs) have occurred in the LHCW, and several of the compliance projects in the Consent Decree have been targeted to eliminate these SSOs and improve water quality in the LHCW. The LHCWMP will be completed by sampling, studying, analyzing, and making recommendations to provide direction to the community. Prioritization of projects within the LHCW will also be a part of the project. The LHCWMP will provide the community with a plan that will lead to measureable results to improve water quality, watershed conditions, and enhance future funding opportunities for projects in this watershed.

This Quality Assurance Project Plan (QAPP) provides a general description of the sampling, assessment, and associated analytical work to be performed for the project, including data quality objectives (DQOs) and quality control (QC) procedures ensuring that the final product satisfies the project objectives.

1.3 Distribution List

Each individual listed on the approval page and each individual listed under Section 1.4, Project and Task Organization, will receive a copy of this QAPP. Other individuals taking part in the project may request additional copies of the QAPP from those listed in Section 1.4. Palmer Engineering will maintain an electronic copy of the QAPP. An electronic copy of the QAPP will be available on the WMU website (www.wmutilities.com) for the duration of Phase 1 and Phase 2 monitoring. Contact information for the parties for distribution is as follows:

Winchester Municipal Utilities
Mr. Michael Flynn
150 North Main Street
P.O. Box 4177
Winchester, KY 40392-4177
859-744-5434

Palmer Engineering
Mr. Brian Ward, Ms. Lee Carolan, Mr. Ralph Schuler, and Ms. Stephanie Blain
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Ms. Clare Sipple
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Kentucky Division of Water, Division of Water Quality
Ms. Lisa Hicks
200 Fair Oaks Lane, 4th Floor
Frankfort, KY 40601
502-564-0111

1.4 Project and Task Organization

The project team is made up of personnel from WMU and Palmer Engineering, as well as Clare Sipple, Preserve Manager of Lower Howards Creek Nature and Heritage Preserve, and community stakeholders and volunteers. Personnel involved in the project implementation and completion are identified below. The project team organizational structure is shown in Figure 1.

1.4.1 Project Manager – Mr. Brian Ward, PE, PLS

The Project Manager for this project will be Brian Ward, PE, PLS of Palmer Engineering. Mr. Ward has overall responsibility and authority to direct the technical, management, cost, and contractual matters related to the project. Mr. Ward serves as the primary contact to WMU. His specific responsibilities will include, but are not limited to, developing and maintaining project schedule, allocating resources, and ensuring project objectives are obtained in an effective and timely manner.

1.4.2 Project Quality Assurance/Quality Control and Field Coordinator – Ms. Lee Carolan

Lee Carolan of Palmer Engineering will serve as the Project Quality Assurance/Quality Control (QA/QC) and Field Coordinator. Ms. Carolan will be responsible for execution of overall project field activities and will coordinate all quality assurance and control operations. Her specific responsibilities include review and maintenance of the QAPP, enforcing the requirements of the QAPP, field and sampling operations procedures, data documentation procedures, coordinating sampling and assessment activities, creation and implementation of the project Health and Safety Plan, and conducting or ensuring worksite inspections.

1.4.3 General Manager of WMU – Mr. Michael Flynn

Michael Flynn, General Manager of WMU, will be responsible for oversight and approval of the project. Mr. Flynn serves as the primary contact with the EPA and KDOW. His specific responsibilities include approval of initial QAPP and amended documents, interim reports, approval of draft and final LHCWMP, fulfilling contractual obligations, and final approval of all materials made available to the stakeholders and general public. Mr. Flynn will be aided by WMU Staff, Duke Dryden, Eddie Hightower, and Killis Sinkhorn.

1.4.4 Volunteer Coordinator – Ms. Clare Sipple

Clare Sipple, Preserve Manager at the Lower Howards Creek Nature and Heritage Preserve, will serve as the Volunteer Coordinator for the project. Ms. Sipple will be responsible for coordinating volunteer sampling efforts, training volunteers in QA/QC procedures according to the practices and procedures set forth within the QAPP, and assisting the sampling efforts. Ms. Sipple's extensive knowledge of the area will be utilized to identify sampling locations, potential pollutant sources, and possible stakeholders.

1.4.5 Primary Sampling Technician – Mr. Ralph Schuler

Ralph Schuler will serve as the Primary Sampling Technician with the support of Lee Carolan, Clare Sipple, Stephanie Blain, and community volunteers. Mr. Schuler will be responsible for compilation of existing sampling data and coordinating sampling schedules. All Sampling Technicians are responsible for implementing sampling procedures and collecting data in accordance with the QAPP.

1.4.6 Primary Project Engineer and Data Manager – Ms. Stephanie Blain

Stephanie Blain will serve as the Primary Project Engineer and Data Manager for this project. Ms. Blain will be responsible for compilation of existing watershed data, review and organization of the laboratory analytical results and field observations, estimation of pollutant loads, development of a method for prioritization for critical sub-watersheds in conjunction with project team and stakeholders, identification and feasibility analysis of Best Management Practices (BMP), and development of the written LHCWMP.

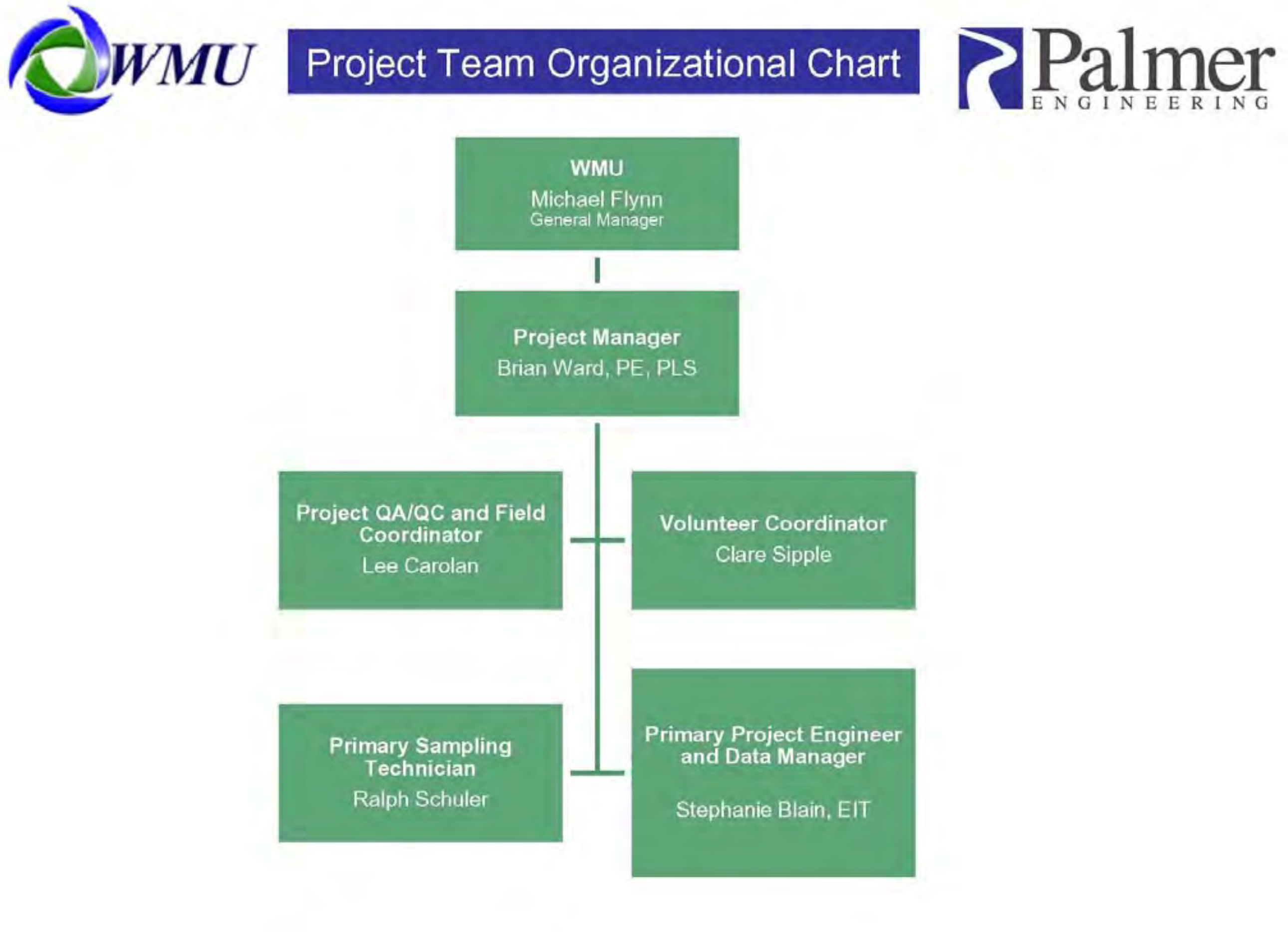

Figure 1. Project Team Organizational Chart

1.5 Project Description

1.5.1 Project Overview

The LHCWMP will be developed to identify collaborative, cost-effective ways to improve and protect streams and lakes within the watershed. The LHCWMP will enable the community to effectively focus efforts to get the most for their investment of time, energy, and resources. The plan will be developed in accordance with the EPA's *Handbook for Developing Watershed Plans to Restore and Protect Our Waters* and the State of Kentucky's *Watershed Planning Guidebook for Kentucky Communities*.

The LHCWMP is being developed as the SEP mandated by the EPA in the Consent Decree (Civil Action No. 06-1-2KSF, April 10, 2007) with WMU and the City of Winchester. The completion of the plan must be in accordance with the requirements set forth by the EPA in Exhibit D of the Consent Decree. It is the aim of the project team to follow the guidelines for 319 (h) grant funded projects as outlined in the *Watershed Planning Guidebook for Kentucky Communities* as close as possible given the timeline and budget constraints, allowing for the funding of future projects through the 319 (h) grant program.

In the development of the LHCWMP, comments and participation will be solicited from public officials from the City of Winchester and Clark County, Clark County Board of Education, Clark County Health Department, and various civic and environmental groups active within the community. The project team will also involve interested members of the general public and residents of the watershed through mailings, newspaper advertisements, and advertisement on the WMU website. Property owners along LHC and tributaries within the watershed will be contacted to obtain permission to enter their property to perform habit assessments and sampling.

The primary project tasks will include, but not be limited to, the following:

1. Identification of stakeholders in conjunction with state and local officials and civic and environmental groups;
2. Public notification of the creation of the LHCWMP and an invitation to comment or get involved;
3. Public meetings with stakeholders to explain project objectives, enlist support, identify problem areas and potential pollutant sources, and develop indicators and prioritization process;
4. Biological assessments of LHC and tributaries;
5. Collection of existing watershed data, including physical and natural features, population and land use, and previous studies and water quality sampling results;
6. Phase 1 and Phase 2 water quality monitoring and sampling as defined in the State of Kentucky's *Watershed Planning Guidebook for Kentucky Communities*;
7. Identification of pollutant sources through field investigation, water quality testing, and existing available data;
8. Establishment of benchmark concentrations and comparisons for each parameter;
9. Estimation of pollutant loads and target reductions;
10. Identification of Best Management Practices (BMPs) and feasibility analysis of selected measures;
11. Estimation of technical and financial assistance needed to implement identified BMPs;
12. Schedule for implementation of BMPs;
13. Identification of measureable milestones for BMP implementation;
14. Development of monitoring objectives to evaluate the effectiveness in achieving water quality standards;
15. Development of the written LHCWMP to be maintained for public use and benefit; and
16. Presentation of LHCWMP and progress reports with political leaders, stakeholders, civic and environmental groups, and the general public.

1.5.2 Project Schedule

The preliminary project schedule is outlined in Table 1. This schedule was developed around the conditions set in Exhibit D of the Consent Decree for completion of the SEP. The following deadlines were established:

- EPA Approval – 3/14/2011
- Selection of Consulting Engineer to assist with project – Within 60 days of approval (5/13/2011)
- Award of Contract and commencement of work – Within 90 days of approval (6/12/2011)
- Completion of the report – Within 455 days of approval (6/11/2012)
- Distribution of report and public presentation – Within 575 days of approval (10/9/2012)

Table 1. Preliminary Schedule of Major Project Tasks

Task Name	Start	Finish
Team Collaboration	5/24/2011	8/15/2011
QAPP Development, Review, and Approval	6/13/2011	9/9/2011
Existing Data Inventory and Collection	5/24/2011	8/15/2011
Biological Assessment 1 (Summer)	8/25/2011	8/30/2011
Phase 1 Stream Sampling and Monitoring	8/25/2011	7/25/2012
Stakeholder Meeting 1	7/14/2011	
Stakeholder Meeting 2	10/10/2011	
Phase 2 Stream Sampling and Monitoring	12/15/2011	11/14/2012
Stakeholder Meeting 3	3/7/2012	
Biological Assessment 3 (Spring)	2/15/2012	2/28/2012
Load Calculations and Analyzing Results	3/8/2012	4/2/2012
BMP Identification and Analysis	4/3/2012	4/23/2012
Implementation Plan	4/24/2012	5/14/2012
Stakeholder Meeting 4	5/14/2012	
LHCWMP Report Preparation	5/15/2012	6/11/2012
Regulatory Review of LHCWMP	6/12/2012	7/9/2012
Address Regulatory Comments	7/10/2012	8/6/2012
Stakeholder Meeting 5	8/6/2012	
EPA Concurrence	8/7/2012	9/3/2012
Report Distribution and Public Presentations	9/4/2012	10/9/2012
Evaluation and Minor Update 1	10/8/2012	4/23/2013
Evaluation and Minor Update 2	4/24/2013	4/22/2014

1.5.3 Stream Assessments and Sampling

For the stream assessments and sampling, critical parameters were identified by the project team. Critical parameters are those parameters that are necessary for the completion of the project. The following parameters are considered critical because they are directly related to the objectives of the study:

1. Water Quality
    a. Biochemical Oxygen Demand (BOD)
    b. Specific Conductivity
    c. Dissolved Oxygen (DO)
    d. Phosphorus – Total (TP) and Orthophosphate (OP)
    e. Nitrogen – Total (TN), Total Kjeldal Nitrogen (TKN), nitrite (NO2), & nitrate (NO3)
    f. pH
    g. Temperature
    h. Total Suspended Solids (TSS)
    i. Turbidity
    j. Percent Saturation (Percent of DO)
    k. Stream Discharge

2. Biological
    a. Bacteria – E. coli
    b. Macroinvertebrate indices – Macroinvertebrate Biotic Index (MBI)
3. Physical
    a. Habitat Assessments /Rapid Bioassessment Protocol (RBP) (minimum of one)
    b. Photographs (minimum of once during wet and dry seasons)
    c. GPS in WGS 84 coordinates

Critical parameters to be collected, when to collect, and the corresponding KDOW Standard Operating Procedure (SOP) manual describing each parameter are listed in Table 2.

Table 2. Critical Parameters

Group	**Parameter**	**Monthly**	**5X/30 days May or June**	**1X/year May or June**	**Every Time**	**Standard Operating Procedure (SOP)**
Bacteria	E. coli (*Esherichia coli*)	X	X			DOWSOP03015
	NO3/NO2 (Nitrate / Nitrite)	X				DOWSOP03015
	NH3-N (Ammonia – Nitrogen)	X				DOWSOP03015
	TKN (Total Kjeldahl Nitrogen)	X				DOWSOP03015
	TP (Total Phosphorus)	X				DOWSOP03015
	OP (Orthophosphate)	X				DOWSOP03015
	BOD5 (Biochemical Oxygen Demand)	X				DOWSOP03015
Sediment	TSS (Total Suspended Solids)	X				DOWSOP03015
Flow	Stream Discharge				X	DOWSOP03019
Field Data	Turbidity (actual or estimated)				X	DOWSOP03014/ DOWSOP0315
	pH				X	DOWSOP03014
	DO (Dissolved Oxygen)				X	DOWSOP03014
	Conductivity				X	DOWSOP03014
	% Saturation (Percent of DO)				X	DOWSOP03014
	Temperature				X	DOWSOP03014
Habitat	Habitat Assessment (KDOW Method)			X		DOWSOP03024
Biology	Biological Assessment (KDOW Method)			X		DOWSOP03003 / DOWSOP03005

The remaining parameters are either supplemental or could be estimated from other measurements based on previous monitoring or typical surface water interactions. These parameters are therefore designated as non-critical. The following parameters are considered non-critical, but would be beneficial to the overall watershed data base. As indicated below, recent studies have been completed where the data was collected on the fish indices. Further sampling may be completed during the Phase 2 monitoring if the parameters below are shown to be of potential concern.

1. Water Quality
    a. Metals
    b. Pesticides and Herbicides
2. Biological
    a. Fish indices – KY Index of Biotic Integrity (completed in 2009)

Habitat assessments (RBPs) and macroinvertebrate collections will be performed simultaneously at each of the sites selected by the project team. Kentucky has established specific criteria for sampling time of year based on stream size and drainage area. Streams are classified as "Headwater" and "Wadeable." Headwater streams have a surface drainage area less than 5 square miles and wadeable streams have surface drainage area more than 5 square miles. Refer to KY Energy and Environmental Cabinet, Department for Environmental Protection, KDOW standard operating procedures (SOP) "Methods for Assessing Habitat in Wadeable Waters" and "Methods for Sampling Benthic Macroinvertebrate Communities in Wadeable Waters" for collection methods and time frame, effective March 1, 2011. In the Phase 1 sampling, there will be four wadeable stream sites and two headwater sites. The number of sites for Phase 2 sampling will vary depending on the evolution of the project. In Table 3, the sampling timeline is identified.

Table 3. Sampling Timeline

Major Task Categories	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Monthly water temp, pH, conductivity, DO	X	X	X	X	X	X	X	X	X	X	X	X
Macroinvertebrate / RBP headwater streams		X	X	X	X							
Macroinvertebrate / RBP wadeable streams					X	X	X	X	X			
Identification of Macroinvertebrates and Calculation of Metrics				X	X			X	X			

The project team will develop benchmark concentrations and comparisons for each parameter prior to the selection of the sites for the Phase 2 monitoring. Benchmarks will be developed by utilizing applicable EPA guidance, Kentucky Administrative Regulations Title 401 KAR 5:301 Surface Water Quality Standards, Kentucky Water Watch Water Quality Standards, applicable KDOW SOPs, and KDOW Stream Nutrient Guidelines. The project team will also use existing and previously collected data to identify, compare and calibrate the benchmarks. After the first few months of monitoring, the project team will use the above identified information and data to specify the specific benchmarks to be used on the project.

1.5.4 Stream Biological Assessments

Kentucky uses seven core metrics in the Macroinvertebrate Biotic Index (MBI) computation: Taxa Richness (G-TR); Ephemeroptera, Plecoptera, Trichoptera Richness (EPT); Modified Hilsenhoff Biotic Index (mHBI); Modified Percent EPT Abundance (m%EPT); Percent Ephemeroptera (%EPHEM); Percent Chironomidae + Oligochaeta (%Chir+%Olig); and Percent Primary Clingers (%Clingers). Table

4 summarizes the metric functions and responses to disturbances. Metrics with negative responses decrease in value as water quality, habitat diversity, and/or habitat suitability decrease. Metrics with positive responses increase with degrading water quality, habitat diversity, and/or habitat suitability. MBI calculations for headwater streams use all seven metrics where as wadeable streams calculations exclude the %EPHEM. A set of Ecological Data Application System (EDAS) queries for calculating metrics and Excel spreadsheets for calculating MBI's were obtained from KDOW. The MBI that will be used for this study will be the "Riffle only Genus Species full pick MBI Excel Worksheet." Based on this worksheet, Table 5 shows the water quality classifications based on the MBI scoring values for wadeable and headwater streams.

Table 4. Metrics to Develop an MBI for Water Quality Analysis and Responses to Disturbances

Metric	Function	Response to Disturbance
G-TR	Refers to total number of taxa present	Negative
EPT	Number of taxa within these pollution-sensitive insect orders	Negative
mHBI	Assesses impacts other than organic enrichment	Positive
m%EPT	Measures relative abundance of pollution-sensitive organisms	Negative
%EPHEM	Measures impacts in response to metals and high conductivity	Negative
%Chir+%Olig	Measures relative abundance of pollution tolerant organisms	Positive
%Clingers	Habitat metric for organisms that need hard silt-free substrate	Negative

Table 5. Water Quality Classification Based on MBI Scoring Values

Water Quality Classification	Excellent	Good	Fair	Poor	Very Poor
Total MBI Score Wadeable	≥70	61-69	41-60	21-40	0-20
Total MBI Score Headwater	≥57	49-56	33-48	17-32	0-16

Biological indicator species will be used to partially determine water quality in the stream system for this project. "Biological monitoring or bioassessment is a systematic procedure to determine the water quality of a stream or a particular portion of a stream, and is based on the presence or absence of biological indicator species within that stream" (Compton and Schuster 1996). Macroinvertebrates are the best indicator species for this kind of monitoring due to their relatively short life span (most live only one year) and small home ranges. When a perturbation moves through their community, they cannot avoid disturbances as readily as fish species.

1.6 Data Quality Objectives for Measurement Data

1.6.1 Precision, Accuracy, and Measurement Range

Precision is the ability of a measurement to be consistently reproduced, accuracy is the ability of a measurement to match the actual value of the quantity being tested, and measurement range is the range of readable values for an instrument as specified by the manufacturer. The water quality instruments to be used for this project will be the YSI Professional Plus Water Quality Instrument and Flowatch flow meter. The instrument manufacturer's ratings for precision, accuracy, and measurement range as shown in Table 6.

Table 6. Precision, Accuracy, and Measurement Range of Water Quality Instruments

Instrument	Sensor Type	Parameter	Measurement Range	Accuracy	Resolution	Calibration
YSI Professional Plus Water Quality Instrument	Polarographic	Dissolved Oxygen (mg/L)	0 to 50 mg/L	0 to 20 mg/L (± 2% of the read or 0.2 mg/L whichever is greater) 20 to 50 mg/L (± 6% of reading)	0.1 or 0.01 mg/L (user selectable); 0.1% air saturation	1 or 2-points with zero
	Polarographic	% DO	0 to 500%	O to 200% (± 2% of reading or 2% air saturation, whichever is greater) 200 – 500% (± 6% of reading)	1% or 0.1% air saturation (user selectable)	1 or 2-points with zero
	Four electrode cell	Conductivity (us/cm)	0 to 200 mS/cm (auto range)	±0.5% of reading or 0.001 mS/cm, whichever is greater (4m cable)	0.001 mS/cm to 0.1 mS/cm (range dependent)	1 point, 10,000 calibration solution
		Temperature (°C)	-5 to 70°C	± 0.2° C	0.1° C	
	Glass Combination Electrode	pH	0 to 14 units	± 0.2 units	0.01 units	1, 2, or 3 point US Buffers, 4.01, 7.00, and 10.01
	Propeller	Flow (m/sec)	0.1 to 16.5 m/sec		± 2%	
Flow Watch						

Macroinvertebrates collected will be identified by a North American Bethological Society (NABS) certified taxonomist to control precision and accuracy. Approximately 10-20% of macroinvertebrates samples will be reevaluated as a method of providing accuracy and precision. If discrepancies of 5% or greater are discovered in the reevaluation of the macroinvertebrate samples, then all samples will be reevaluated. All identified organisms will be labeled in separate vials and then grouped by collection site as part of the voucher collection. MBI data analysis (KDOW SOP DOWSOP03005) will consist of the Riffle Only Genus Species Full Pick Method, utilizing the template provided by KDOW at http://water.ky.gov/Pages/SurfaceWaterSOP.aspx. This template automatically computes the MBI.

The precision and accuracy of the RBP scores and the general habitat assessment precision will be controlled by the experience of the personnel completing the assessment. All RBP will be conducted in accordance with the KDOW SOP Document (DOWSOP03024). Assessments will only be conducted by qualified personnel who have received appropriate training, such as Eastern and Western Kentucky Headwater Stream Functional Assessment Protocol Training. Volunteers will not be used to make final assessment determinations.

Once every three sampling events (once each quarter) bacteria and nutrient water samples will either be duplicated or split and sent to the laboratory for analysis to check for accuracy and precision. If variations of over 20% are found, the QA/QC Coordinator will work with the laboratory to determine where errors are occurring. Once the errors are identified, samples will be collected and retested. A duplicate sample will be submitted to verify that the error has been eliminated. Once every three sampling events (once each quarter) a blank sample will be submitted with the field collected bacteria and nutrient samples for quality control. Duplicate and blank samples will not be submitted for the same sampling event unless approved by the project QA/QC Coordinator.

1.6.2 Bias

Bias is a systematic error introduced into sampling by selecting or encouraging one outcome over others. To reduce concerns about bias, potential biases will be indentified and justified in all final reports.

1.6.3 Representative

Representative is the degree to which the collected samples data represents the whole. Samples sites will be identified by a trained biologist, verifying that each site will be representative of the particular stream reach being sampled.

1.6.4 Completeness

Completeness is the necessary amount of data required to constitute a valid measurement. To help ensure completeness in sampling, the sampling will be conducted in two phases. It is expected that all samples identified in Table 2, on page 8, will be collected unless stream sites dry during summer months. Once sampling has begun, sites will not, unless absolutely necessary, be relocated to avoid the potential for sampling overlap.

1.6.5 Comparability

Comparability is the level to which the collected data can be compared to one another. Comparability of collected data will be ensured on this project through strict adherence to sampling protocols developed by KDOW in the SOPs associated with each parameter assessed.

1.7 Training Requirements and Certification

Jo Ann Palmer of KDOW provided water quality sampling training to project team members, including Brian Ward, Lee Carolan, Stephanie Blain, Eddie Hightower, and Killis Sinkhorn, on July 6, 2011 at Palmer Engineering. Ralph Schuler received the same training at Palmer Engineering on

August 10, 2011. Ms. Palmer demonstrated the proper techniques and handling procedures for collecting water quality samples.

Ralph Schuler is a certificated taxonomist to the North American Benthological Society – Aquatic Insect Family Level and has attended the Eastern and Western Kentucky Headwater Stream Functional Assessment Protocol Training in 2006. Mr. Schuler will be handling all the macroinvertebrate field sampling and subsequent identification.

1.8 Documentation and Records

To meet the project objectives and ensure traceability of results and decisions, documentation and record keeping is essential to project success. Project documentation and records will be made available to interested parties at the request and permission of WMU. Any applicable regulatory authority may review, inspect, and copy project documentation and records. All final documentation and records will be kept on file at Palmer Engineering for at least five years after project completion. Documentation and records that will be kept on file will include, but will not be limited to:

- Health and Safety Plan;
- Land Owners' Permission Documentation;
- Field observations recorded in the Sampling Technicians' field notes;
- RBP Worksheet;
- Data Characterization and Water Quality Datasheet;
- Riffle Only Genus Species Full Pick MBI Excel Worksheet;
- Macroinvertebrate Lab Bench Form;
- Photographs;
- Chain of Custody Forms; and
- Analytical Laboratory Reports.

Data will be stored in both paper and electronic forms. All final hand-recorded collected data records will be made in permanent ink and changes to such data will be made by drawing a single line through the error and initialed by the responsible person. Unbound hand-recorded collected data records will be scanned and converted to PDF documents. Electronic collected data records will be converted to PDF format upon completion and changes to such data will be made electronically in a similar format to the hand-recorded data. Appendix B contains some of the documentation used by the project team for sampling, including the water sampling field data sheet, chain of custody form, macroinvertebrate identification data sheet, and sampling bottle and jar labels.

Macroinvertebrate samples will have a standardized label completed in the field and inserted in the sample jar before leaving the sampling location. The label will include date, project name, site number, GPS coordinates, collectors, and type of collection, either qualitative or quantitative. Macroinvertebrate samples will be identified and logged on lab bench data sheets with the sample label information plus the date and person identifying. Each taxonomic group will be stored in separate individually labeled vials and then compiled into one sample. The samples will remain at Palmer Engineering for at least five years unless otherwise requested by a state university or other state agency with the permission of WMU.

Following the first sampling event, a copy of all raw data and lab reports will be submitted to KDOW for their review. A brief report will be included with the raw data and lab reports describing the results of the quality control sampling, any issues that arose from the sampling event, and any other notes of relevance to the sampling event.

Palmer Engineering will provide WMU with a Lower Howards Creek Watershed Management Plan developed in accordance with EPA's *Handbook for Developing Watershed Plans to Restore and Protect Our Waters* and the State of Kentucky's *Watershed Planning Guidebook for Kentucky Communities*. The plan will incorporate the requirements of 319 (h) watershed funded plans as of March 14, 2011 as allowed by the project schedule and budget to allow for the application of these funds for future projects.

2. MEASUREMENT AND DATA ACQUISITION

2.1 Sampling Process Design

A key task in this project is to establish baseline data that can be used to identify preservation areas and high impact areas where BMP's can be installed to improve water quality and stream habitat. The sampling and monitoring will be conducted in a system of two phases as outlined in the State of Kentucky's *Watershed Planning Guidebook for Kentucky Communities*. Palmer Engineering has identified initial monitoring locations for Phase 1 sampling, which will consist of six sites along the main Lower Howards Creek channel. Appendix A contains a map detailing the location of the Phase 1 sampling sites and table identifying the information for each site. Sites were selected based on the location of confluences, historical sampling locations, and suspected pollutant source locations. A detailed analysis of site selection procedure will be included in the final LHCWMP.

The purpose of monitoring for watershed planning at the Phase 1 stage is to determine the current overall water quality conditions of the watershed. The Phase 1 data will be used to identify areas of concern and prioritize sub-watersheds and/or specific stream sections for monitoring in Phase 2. The purpose of monitoring for watershed planning at the Phase 2 stage is to target implementation in the sub-watersheds. Phase 2 monitoring sites will be selected based on data collected during Phase 1 and comments/concerns expressed by property owners and stakeholders. The exact number and locations of samples are not definite at this time. The number of sites will be selected will depend on field conditions, stream size, accessibility from landowners, and time restraints. The Phase 1 and Phase 2 sampling timelines will overlap due to the time constraints on the project due to the consent decree deadline. The Phase 2 sampling will not begin until four months of Phase 1 sampling is complete. The Phase 1 data that is available at the time that Phase 2 sampling begins will be used to aid in site selection. The sampling parameters identified in Table 2 on page 8, will be collected as specified during Phase 1 and Phase 2 monitoring.

2.2 Sampling Methods

Sampling methods to be used on this project will be in accordance with the SOP developed by KDOW of each of the identified critical parameters. The KDOW SOPs contain information on sampling containers, holding times, and required preservatives. Table 2, on page 8, identifies each parameter that will be collected and the SOP that will be followed by all project team personnel and volunteers. The sampling methods will be conducted in accordance with the State of Kentucky's *Watershed Planning Guidebook for Kentucky Communities*. The specific SOP for each parameter will be strictly adhered to for the measurement and/or collection of the related data. For the water quality parameters regulated by SOP DOWSOP03015, *Sampling Surface Water Quality in Lotic Systems*, all samples will be collected using the grab sampling technique as outlined in the documentation. The method detection limits (MDLs) for the parameters measured using the water quality instruments are identified in Table 6. The MDLs for the parameters measured in by laboratory are listed in Table 7.

Table 7. MDLs and Analytical Methods for parameters measured in Laboratory

Parameter	MDL	Analytical Method
E. coli	1 MPN/100 ml	SM 9223 B
Nitrate	0.1 mg/L	EPA 300.0
Nitrite	0.1 mg/L	EPA 300.0
NH3-N	0.1 mg/L	EPA 350.1
TKN	0.1 mg/L	SM 4500-NH3 C
TP	0.033 mg/L	SM 4500-P E
OP	0.066 mg/L	SM 4500-P
BODs	0.1 mg/L	SM 5210 B
TSS	2 mg/L	SM 2540 D

2.3 Sample Handling and Custody Requirements

A chain of custody form will be used for all samples collected for this project. The chain of custody form will be maintained on file by Palmer Engineering for five years following the completion of the final LHCWMP. Transfer of samples to the laboratory will be accomplished using a signature on the chain of custody form that denotes the transfer time, date, and responsible personnel. If custody is not maintained, a note must be made on the accompanying chain of custody form. Handling and custody requirements will be followed for this project as defined in the corresponding SOP. Table 2, on page 8, includes a list of the SOPs that will be utilized for this project.

2.4 Analytical Requirements

Analytical requirements are based on the information provided in Table 2 and Table 3, on pages 8 and 9 respectively. Data collected will provide information for comparison of parameter concentrations or benchmarks, pollutant loads/yields and an inventory of the watershed for the Phase I process. Once these determinations have been made, prioritized locations for sampling to analyze the watershed during Phase 2 collections will be determined. From this overall analysis, BMPs will be explored to improve water quality of LHCW.

Water samples will be sent to a local laboratory, Fouser Environmental Services, for analysis. Fouser Environmental Services is located in Versailles, Kentucky and has an approved SOP on file with KDOW. The requirements of KDOW SOPs listed in Table 2, on page 8, will be followed during all sampling events and analysis of critical parameter data by both project team and laboratory personnel. The biological taxonomy work will be completed at Palmer Engineering by Mr. Ralph Schuler with assistance from Ms. Lee Carolan. Their resumes have been included in Appendix C.

2.5 Quality Control Requirements

Data collection quality will be ensured through adherence to the KDOW SOPs applicable to this project. Personnel assisting with the sampling will record all methods, results, dates, conditions, and data in yellow bound 350 N field books with permanent ink. Copies of the data from field books, field sheets, lab analysis sheets, and chain of custody sheets will be scanned and kept in a centralized file. A spreadsheet will be created with all the information that was collected. All copies of field books will be kept on file when the books are full of information. The books will be dated with sampling start and stop dates, i.e. months and year. Random records checks will occur on 10% of the sampling records. If errors are caught during this cross-checking procedure, files will be flagged and discussion between personnel who collected the data will take place to resolve the issues.

Field samples will be taken following KDOW *Standard Methods for Assessing Biological Integrity of Surface Waters in Kentucky*. Field equipment and sampling methods will follow the KDOW SOPs listed in Table 2, on page 8, sampling for water quality and species. Compromised samples will be discarded and not sent to the laboratory for analysis. Once every three sampling events (once each quarter) bacteria and nutrient water samples will either be duplicated or split and sent to the laboratory for analysis to check for accuracy and precision. If variations of over 20% are found, the QA/QC Coordinator will work with the laboratory to determine where errors are occurring. Once the errors are identified, samples will be collected and retested. A duplicate sample will be submitted to verify that the error has been eliminated. Once every three sampling events (once each quarter) a blank sample will be submitted with the field collected bacteria and nutrient samples for quality control. Duplicate and blank samples will not be submitted for the same sampling event unless approved by the project QA/QC Coordinator.

The Laboratory Director, Ray Fouser, is responsible for certifying all laboratory results. Cody Brenneman is responsible for quality assurance during sampling analyses. A laboratory control sample (LCS) is as important as the calibration standards and must be prepared at a frequency determined by the specific method requirements. The LCS results are acceptable if the percent recovery of each analytic is within the determined acceptance range. If the LCS results do not meet specification, sample analyses must be stopped until the problem is corrected, and all associated samples in the analysis batch must then be reanalyzed.

2.6 Instrument/Equipment Testing, Inspection, and Maintenance Requirements

All sampling equipment is acquired from professional companies that have proven track records of quality control and assurance. Sampling equipment will be inspected and serviced per the manufacturing recommendations that are provided. Equipment will be calibrated prior to each field sampling visit. The equipment the project team will use is listed in Table 6. Employees of Palmer Engineering, employees of WMU, Ms. Clare Sipple, or trained volunteers may assist in the sampling efforts.

Equipment type is the determining factor for maintenance frequency. Routine maintenance of laboratory equipment is scheduled and conducted prior to each use and per the manufacturers' recommendations. Accidental breakage, part failure, and incidental malfunctions will be addressed as necessary. Mr. Ralph Schuler will be responsible for performing all equipment maintenance and for any required corrective actions.

Laboratory maintenance is typically performed daily, weekly, or more often as required depending on the equipment used for processing samples.

2.7 Instrument/Equipment Calibration and Frequency

Detailed descriptions of specific calibration requirements are provided in the laboratory analytical method SOP for each method. Field personnel will be advised and trained on these methods.

2.8 Data Acquisition Requirements

New data acquisition will follow the standards set forth in the KDOW SOPs as listed in Table 2, on page 8. Collected data will be submitted to KDOW as requested, after the first sampling event, and with the final LHCWMP for review. All project equipment and supplies will be gathered, inspected, and maintained by Mr. Ralph Schuler. Project consumables will include, but are not limited to, sampling bottles and preservatives (provided by Fouser Environmental Services), cleaning supplies, water as specified for blank samples, and ice.

The project team will also acquire existing data available from a variety of sources. Topographic maps (historic and current), aerials, population census data, and geographical information have been obtained by the project team. The existing GIS database has been obtained from the City of Winchester for the project area. Previous studies and reports for the LHCW and LHC area have been obtained, reviewed, or requested. The Web Soil Survey will be used to identify existing soil groups. Existing data will be organized using excel and GIS databases. All found current documents of the area will be utilized, but some utilization may be limited due to quality assurance issues. Some of the previous reports and studies did not adhere to strict QA/QC guidelines or pre-dated current requirements limiting the utilization by the project team. All secondary information will be reviewed and assessed by the project team to determine the level of accuracy and precision of the data. A detailed review of the existing data will be included in the final LHCWMP.

2.9 Data Management

Field personnel will sign all data sheets and any other documents with recorded information daily. The QA/QC coordinator will collect this documentation within 24 hours of sampling. Field personnel and QA/QC coordinator will fill out chain of custody forms and ensure water samples are properly transported to the laboratory within the allocated times as specified in the KDOW SOPs. Data will be managed and organized using excel and GIS databases.

Paper copies of data from field books, lab reports and results will be stored in the Palmer Engineering Quality Control coordinator's office. Information will be input into the database promptly. Data management will be confined to Lee Carolan, Ralph Schuler, and Stephanie Blain. Lab reports will be reviewed by more than one project personnel as they are received.

Calculations will be completed after each monthly sampling occurs for quality control purposes. If extreme variances are noticed, then rectification will occur immediately.

Communication will occur between project team members, regulatory agencies, stakeholders, and the general public through email, telephone and mail correspondence. Any property that needs to be accessed by the project team will be contacted prior to entering. Permission will be obtained from property owners through written consent. All project related correspondence will be documented through an email system or excel log. All project related emails will be stored in an assigned project file folder. Telephone conversations with regulatory agencies, stakeholders, and the general public will be summarized in a designate call log excel file. All electronic files are stored in a central project folder accessible to appropriate personnel. All printed or hand-written correspondence will be maintained on file for a minimum of five years after project completion.

3. ASSESSMENT AND OVERSIGHT

3.1 Assessment and Response Actions

The Project Manager will have the authority to resolve any problems encountered during data collection or reporting. The QA/QC Coordinator will discuss sampling and assessment procedures and results with project personnel after each set of monthly data acquisition. The Project Manager and QA/QC Coordinator will identify any unanticipated or developing issues and take corrective action if necessary.

Data acquisition frequencies and timeline are shown in Table 2 and Table 3, on pages 8 and 9 respectively. To confirm that field sampling, field analysis and laboratory activities are occurring as planned, the Project Manager, field staff, and laboratory personnel will meet after the first sampling event to discuss the methods being employed and to review the quality assurance samples. At this time concerns regarding the sampling protocols and analysis techniques will be addressed and any changes deemed necessary will be made to ensure consistency and quality of subsequent sampling. Table 8 outlines the assessments that will be performed by the project team, frequencies, and responsible parties.

Table 8. Assessment and Response Actions

Assessment Type	Frequency	Person responsible for performing assessment	Person responsible for responding to assessment findings	Person responsible for monitoring effectiveness of corrective actions
Field Sampling Audit	After first sampling	Project Manager/QA Coordinator	QA Coordinator	QA Coordinator /Field Staff
Field analysis Audit	After first sampling	Project Manager/QA Coordinator	QA Coordinator	QA Coordinator /Field Staff
Laboratory Audit	Semi-Annual or Annual	Laboratory Director	Laboratory Director	QA Coordinator /Field Staff

3.2 Reports to Management

Interim and final reports will be submitted from Palmer Engineering to WMU. After WMU review, reports will be submitted to EPA and KDOW. All reports will be revised and updated after comments are returned and reviewed. Updated information will be added as deemed necessary between report submittals via email and possibly hard copy.

4. DATA VALIDATION AND USABILITY

4.1 Data Review, Validation, and Verification Requirements

All data from field sampling, field analysis and laboratory sampling will be reviewed by the Project Manager, QA/QC Coordinator and office/field personnel responsible for data entry. The Project Manager and QA/QC Coordinator will complete the completeness checklist and determine what, if any, verification or clarification of data is necessary. In addition, KDOW will review all project data. KDOW will not have personnel directly involved in the collecting, entering, or analyzing data for the project. The QAPP and the SOPs for each parameter, listed in Table 2, will govern the operation of the project at all times.

4.2 Validation and Verification Methods

Field personnel will review sample readings and will report readings that appear to be out of range to the QA/QC Coordinator. A second sample will be taken by the field personnel as soon as possible for verification purposes. Approximately 10-20% of macroinvertebrates samples will be reevaluated as a method of verifying data and data quality. If discrepancies of 5% or greater are discovered in the reevaluation of the macroinvertebrate samples, then all samples will be reevaluated.

Once every three sampling events (once each quarter) bacteria and nutrient water samples will either be duplicated or split and sent to the laboratory for analysis to check for accuracy and precision. If variations of over 20% are found, the QA/QC Coordinator will work with the laboratory to determine where errors are occurring. Once the errors are identified, samples will be collected and retested. A duplicate sample will be submitted to verify that the error has been eliminated. Once every three sampling events (once each quarter) a blank sample will be submitted with the field collected bacteria and nutrient samples for quality control. Duplicate and blank samples will not be submitted for the same sampling event unless approved by the project QA/QC Coordinator.

4.3 Evaluating Data in Terms of User Needs

The final LHCWMP will be compilation of all existing, collected, and acquired data, performed calculations and analysis, and resulting recommended BMPs. The final document will include, but not be limited to, the following:

- Identification of stakeholders involved in the development of the plan;
- Documentation of actions taken to notify the public of the plan;
- Meeting minutes from all public meetings;
- Summary of collected existing watershed information;

- Summary of results from biological and water quality sampling;
- Identification of pollutant loads and potential sources;
- Identification of BMPs and feasibility of measures;
- Estimation of technical and financial assistance required to implement BMPs;
- Schedule of implementation for BMPs;
- Outline of monitoring objectives to evaluate the effectiveness of installed measures;
- Identification of measureable milestones for BMP implementation; and
- Outline of plans for public presentations.

The LHCWMP will address the user's needs by meeting the requirements outlined for the SEP in the Consent Decree, specifically providing a plan that offers an opportunity for significant environmental or public health protection and improvements.

APPENDIX A

Phase 1 Sampling Site Map and Information

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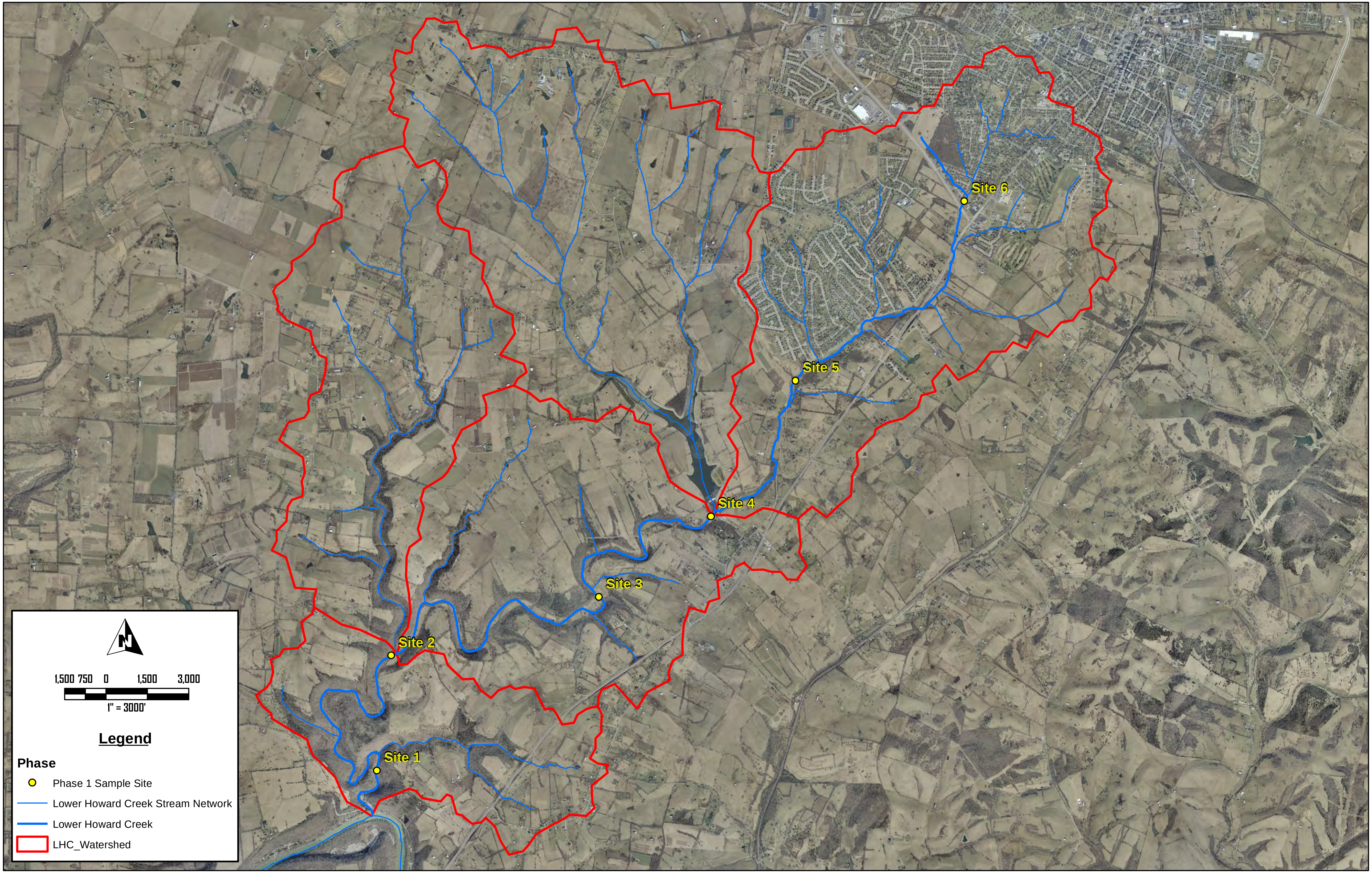
Site 6
Site 5
Site 4
Site 3
Site 2
Site 1
N
1,500 750 0 1,500 3,000
1" = 3000'
Legend
Phase
Phase 1 Sample Site
Lower Howard Creek Stream Network
Lower Howard Creek
LHC_Watershed

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Site Number	HUC 11	Latitude (WGS 84)	Longitude (WGS 84)	Receiving Stream	Directions	Previously Sampled
1	05100205050	37.92253°	84.27200°	Kentucky River	This site is located off KY 418 approximately 1.6 miles west of Boonseboro Road and downstream of Deep Branch. The property is owned by Kentucky State Nature Preserves Commission	Yes, KY Water Watch Location and KDOW 2009
2	05100205050	37.93344°	84.27032°	Kentucky River	This site is located downstream of confluence of West Fork on the Smith Family Trust property; 2110 Water Works Road.	No
3	05100205050	37.93928°	84.24383°	Kentucky River	This site is located at the end of Old Stone Church Road approximately 1.3 miles west of Boonseboro Road.	Yes, KDOW 1998, 2009
4	05100205050	37.94654°	84.23063°	Kentucky River	This site is located below the reservoir on the property of Harry Enoch, 290 Glodwing Road.	Yes, KY Water Watch Location
5	05100205050	37.96087°	84.21927°	Kentucky River	This site is located off Old Boonseboro Road upstream of Patton Lane on Clark County School Board Property.	No
6	05100205050	37.97869°	84.19814°	Kentucky River	This site is located behind the house of Joseph and Donna Hardiman, 414 Willowbrook Drive, Winchester.	No

APPENDIX B

Sampling Documentation Forms

Water Sampling – YSI Pro Plus Data

Date: ________________

Sample Site 1: KSNPC
Time _________________
Flow (m/s) ____________
Water temp (˚C) _______
% DO ________________
DO mg/l ______________
Specific Cond. _________
pH ___________________

Sample Site 2: Rick Smith
Time _________________
Flow (m/s) ____________
Water temp (˚C) _______
% DO ________________
DO mg/l ______________
Specific Cond. _________
pH ___________________

Sample Site 3: Old Stone Church
Time _________________
Flow (m/s) ____________
Water temp (˚C) _______
% DO ________________
DO mg/l ______________
Specific Cond. _________
pH ___________________

Sample Site 4: Harry Enoch
Time _________________
Flow (m/s) ____________
Water temp (˚C) _______
% DO ________________
DO mg/l ______________
Specific Cond. _________
pH ___________________

Sample Site 5: Patton Lane
Time _________________
Flow (m/s) ____________
Water temp (˚C) _______
% DO ________________
DO mg/l ______________
Specific Cond. _________
pH ___________________

Sample Site 6: 627 Bypass
Time _________________
Flow (m/s) ____________
Water temp (˚C) _______
% DO ________________
DO mg/l ______________
Specific Cond. _________
pH ____________________

FOUSER ENVIRONMENTAL SERVICES • 165 Camden Avenue • Versailles, Kentucky 40383 • Phone (859) 873-6211 • lab@fouser.com

SHADED AREA FOR LAB USE ONLY

CHAIN OF CUSTODY RECORD

Client/Company Ordering Test:
Palmer Engineering
Attn: Ralph Schuler

Location/Address:
400 Shoppers Drive
Winchester, KY 40391

Other Sample Related Remarks:

Sampler (Signature):

PWS ID#

PO#

FES Lab #	Collection Date	Collection Time (24hr)	**Customer Sample ID / Description** (for composites indicate start time and end time)	Sample Description Grab/ Comp	Sample Description Matrix	Sample Description Pres.	**Analyses Required**
			Sample Site	G	SU	ST	E. coli
				G	SU	X	Nitrate / Nitrite
				G	SU	ST	Ammonia – N
				G	SU	SA	Total Kjeldahl Nitrogen
				G	SU	SA	Total Phosphorus
				G	SU	X	Ortho-phosphorus
				G	SU	X	BOD5
				G	SU	X	Total Suspended Solids
				G	SU	X	Turbity

Relinquished By:	Received By:	Date	Time (24 hr)	**Shipping Conditions: ☐ Iced ☐Ambient** **Container Temperature: ___________**
Relinquished By:	Received By:	Date	Time (24 hr)	**Holding times acceptable? ☐ Yes ☐ No** **Data entered by: __________**
Relinquished By:	Received For Laboratory By:	Date	Time (24 hr)	**Method of Delivery:** **☐ FES ☐ Client ☐ UPS/Fed Ex ☐ Other**

MATRIX CODES:
dw - drinking water
sw - storm water
ww – wastewater
oil – oil
sl – sludge
gw – groundwater
s – solid
o - other
su – surface water
lt – leachate

PRESERVATION CODES:
NA – Nitric Acid (HNO_3)
SA – Sulfuric Acid (H_2SO_4)
I – Ice
ST – Sodium Thiosulfate ($Na_2S_2O_3$)
HA – Hydrochloric Acid (HCl)
SH – Sodium Hydroxide (NaOH)
X – None
ZA – Zinc Acetate ($Zn(O_2CCH_3)_2$)
AA - Ascorbic Acid ($C_6H_8O_6$)
PA – Phosphoric Acid (H_3PO_4)
AC – Ammonium Chloride (NH_4Cl)

Macroinvertebrate Identification Data Sheet

Project
Sample Site Location
Collection Date
Collectors
Identification Completion Date
ID by

MBI Score

Jar #	Order/Class	Family	Genus	Species	# of individuals*	Adjusted # of Individuals	Clinger	Taxa Value (TV)	# x TV

G-TR	**G-EPT**	**mHBI**	**m%EPT**	**%Ephem**	**Total ↑**	**Total ↑**	**%C+O**	**%ClngP=**	**Total ↑**
0	0	#DIV/0!	#DIV/0!	#DIV/0!	0	0	#DIV/0!	#DIV/0!	0.00

Site ID:
Site Location:
County:
Date:
Time:
Samplers’ Initials:
Bulk/Nutrients/Bacteria:

Site ID:
Site Location:
County:
Date:
Time:
Samplers’ Initials:
Bulk/Nutrients/Bacteria:

Site ID:
Site Location:
County:
Date:
Time:
Samplers’ Initials:
Bulk/Nutrients/Bacteria:

Site ID:
Site Location:
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Bulk/Nutrients/Bacteria:

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Bulk/Nutrients/Bacteria:

Site ID:
Site Location:
County:
Date:
Time:
Samplers’ Initials:
Bulk/Nutrients/Bacteria:

APPENDIX C

Biological Taxonomy Personnel Resumes

RALPH J. SCHULER, JR.
Environmental Biologist

EDUCATION:

Murray State University, Murray, Kentucky
Master of Science in Biology, May 1991
Concentration in Aquatic Ecology and Fisheries Biology
Thesis Title: “Growth and Condition of Kentucky Lake Channel Catfish, *Ictalurus punctatus*, During Years with Reduced Flow in the Tennessee River”.

Eastern Kentucky University, Richmond, Kentucky
Bachelor of Science in Fisheries Management May 1987
Chemistry Minor

CERTIFICATES:

Certified taxonomist for family level aquatic insects by the North American Benthological Society. Expires March 2015

EMPLOYMENT:

Palmer Engineering Inc. 400 Shoppers Drive, Winchester, Kentucky, 40391, Environmental Biologist (Nov. 05 to present)

Water Quality, Aquatic Macroinvertebrates, Fish and Freshwater Mussels Surveys.

- Conduct stream monitoring surveys which consist of: stream habitat assessments, macroinvertebrate collections, fish surveys, freshwater mussel surveys, and physiochemical water sampling on projects for the Kentucky Department of Transportation and the Tennessee Department of Transportation using the U.S. Environmental Protection Agency’s 1999 publication *Rapid Bioassessment Protocols for Use in Wadeable Streams and Rivers* and Kentucky Division of Water’s most current publication *Methods for Assessing Biological Integrity of Surface Water.* I have over 10 years studying the aquatic fauna in Kentucky, Tennessee and Florida. I have conducted numerous fish surveys on large river systems such as the Tennessee River, Kentucky and Tennessee, and the St. Johns River, Florida. I have personally contributed to the mussel collection at Murray State University by adding the federally endangered fanshell mussel (*Cyprogenia stegaria*) and to the Eastern Kentucky University fish collection by adding the undescribed sawfin shiner (*Notropis sp*.).

Terrestrial

- Conducted surveys for amphibians, reptiles, and birds. Surveys include identifying common and state and federally listed species and their habitat throughout Kentucky and Tennessee.

Mist-Netting/Bat Surveys

- Conducted mist-netting surveys in Eastern Kentucky and West Virginia for federally endangered bat species such as the Indiana bat (*M. sodalis*), and Gray bat (*M. grisescens*) following the USFWS “Indiana Bat, *Myotis sodalis*, Revised Recovery Plan” 1996 draft, also surveyed and marked potential roost trees in a 200-foot corridor across the state of Ohio.

Botanical Surveys

- Conducted numerous aquatic plant surveys throughout Florida studying the affects of triploid grass carp on native and exotic plant species. Techniques used consisted of combining line-transects with a paper-graph recorded to document the expansion or reduction in plant communities within lake systems containing triploid grass carp and lake systems without grass carp (ie. Control lakes).

Wetland and Stream Delineations

- Assisted with numerous wetland determinations following the US Army Corps of Engineer’s *Wetland Delineation Manual* in Kentucky and Tennessee. I have successfully completed the following courses taught by Bob Pierce of the Wetland Training Institute: *Basic Wetland Delineation* (May 2007), *Federal Wetland / Waters Regulatory Policy* (October 2008), and

Regional Supplement Seminar and Field Practicum (June 2010). In conjunction with Jackson Environmental Inc LLC, have conducted stream delineations in West Virginia and Ohio in fulfillment of obtaining a U.S. Army Corps of Engineers 404 coal strip mine permit.

PROJECT WORK EXPERIENCE:

Experience: 3+ years

Kentucky Transportation Cabinet (KYTC), 3 projects total, 2006.
I have conducted field investigations and office research for aquatic and terrestrial ecological assessments (EA) of proposed highway design projects. I have conducted a biological assessment (BA) for the Federally Threatened and Endangered Indiana Bat (*Myotis sodalis).* I have also served support to a stream mitigation project. A project list is as follows:

1. Aquatic and Terrestrial Baseline Report for US 127, Russell and Clinton Counties, KY (July 2007 – June 2008; 12 months)
2. Biological Assessment for the Indiana Bat (*Myotis sodalis*) KY 192 to KY 80 Frontage Road, Laurel County, KY (June - September 2006; 4 months)
3. Stream Mitigation and Monitoring Report, KY 11 Fleming County, KY (February – March 2006 & Nov 2008; 3 months)
4. Aquatic and Terrestrial Baseline Report for KY 9, Campbell County, KY (March – April 2006; 2 months)

Tennessee Department of Transportation (TDOT), 7 projects total, 2006 to 2010.
Conducted routine ecological field studies to document all natural resources in the project area for preparation of an Ecology Report Summary; conducted field work documenting impacts to streams, springs, seeps, ponds/quarries, lakes, waterfall, wetlands, potential wetland mitigation sites, caves, sinkholes, other specialized habitat and protected species for Impact Summary Report; conducted field investigation for species review of threatened and endangered species and critical habitat.

1. State Route 92 Improvements from US 25/70 Intersection to South of the French Broad River, Jefferson County, Tennessee (June 2008 – 2009)
2. Highway 52, Corridor J, Appalachian Highway Development System, Overton County, Tennessee (June 2008 – 2009)
3. State Route 54 (U.S. 641) from State Route 69/Wood Street in Paris, Henry County, Tennessee to State Street in Hazel, Callaway County, Kentucky (August 2009; 4 weeks)
4. State Route 19 from US 51 to the west end of the Brownsville By-pass, Lauderdale / Haywood Counties (December 2009 – present).
5. I-69 Independent Utility Segment # 8 Crossover Study, Lauderdale County (June 2006 –May 2007; 12 months)
6. Ecological Assessment, Giles Co., SR-15 (US 64) From Horn Hill Road to Pulaski Bypass (July – September 2006; 3 months)
7. Ecological Assessment, Overton Co., Beech Road bridge replacements over Bryan's Fork and Morgan Creek in Standing Stone State Park (January 2006; 3 weeks)
8. Ecological Assessment, Tipton Co., Jack Pond Road bridge replacement over unnamed tributary to Baxter Bottom (June 2006; 2 week)
9. Ecological Assessment, Tipton Co., Campground Road bridge replacement over Unnamed tributary to Hurricane Creek (June 2006; 2 week)
10. Ecological Assessment, Tipton Co., Kentwood Avenue bridge replacement over Unnamed tributary to Hatchel Creek (June 2006; 2 week)
11. Ecological Assessment, Anderson Co., Slatestone Road bridge replacement over Slatestone Creek (November 2005; 2 week)

Land Development Projects, Phase I Site Assessments and Stream/ Wetland Mitigation Monitoring, 5 projects total (January 2006 – Present; 30 months).

- Conducted field investigations and prepared preliminary environmental reports to determine the presence of streams, wetlands, or other ecological features that would create a constraint upon development of a commercial site (6 locations).
- Assisted in the long-term monitoring of a Stream and Wetland Mitigation Plan in support of a 404 permit (after the fact) acquired by Lowe's. The impact of 0.05 acres of wetland and 1,600 feet of stream (by previous land owner) was compensated for by the creation of a 0.15 acre wetland, the restoration of 1,619 feet of stream, and additional enhancement of 481 feet of the same stream in Woodford County, Kentucky. Primary responsibilities include long-term monitoring through annual stream assessments, vegetation surveys, and wetland delineations. Monitoring and assessment of the stream and wetland followed KDOW's *Methods for Assessing Biological Integrity of Surface Water*, USEPA's *Rapid Bioassessment Protocols for use in Wadeable Streams and Rivers*, and US Army Corps of *Engineer's Wetland Delineation Manual*. (1 project).

Camp Atterbury JMTC, Indiana (December 2007; 2 days)

In conjunction with AMEC Earth and Environmental; Performed wetland delineation and documented the presence of possible wetlands on 34 acres of the Multi-Purpose Machine Gun(MPMG) range at Camp Atterbury Joint Maneuver Training Center (JMTC); Two wetlands with a total of 1.3 acres were identified, and their boundaries were marked.

Jackson Environmental Consulting Services, LLC. October – November 2008 – Environmental Biologist; Conducted stream delineations on coal mine sites in West Virginia and Ohio in fulfillment for acquiring a U. S. Army Corps of Engineers 404 permit.

Jackson Environmental Consulting Services, LLC. January – March 2009 - Environmental Biologist; Surveyed and marked all potential bat roost trees and trees with raptor nest along a 200-foot Pipeline Right-of-Way across the entire state of Ohio with an extreme time sensitive deadline.

J K Smith Power Plant for East Kentucky Power Cooperative, Winchester, KY March – October 2009 - Environmental Biologist; Conducted biological assessments on 25 streams using benthic macroinvertebrates and fish fauna as indicators of water and stream quality as part of a 3200-acre stream and wetland mitigation site. Data collected, KY Index of Biotic Integrity (KIBI) and Macroinvertebrate Biotic Integrity (MBI), provides preconstruction baseline information which future monitoring will be compared against.

EMPLOYMENT HISTORY:

Experience: 7.75 years

Florida Fish and Wildlife Conservation Commission, Tallahassee, Florida
Biological Scientist II, July 1990-1995 (66 months)

I worked on a Freshwater Commercial Fisheries project that: determined economic significance of commercial, freshwater food fish valued at approximately $11 million through field investigations and mail and telephone surveys: answered study hypotheses using questionnaire surveys, statistically sound databases and field studies; from which, new recommendations and management strategies were introduced: produced six administrative reports, three technical papers in referred journals, and three oral presentations at various professional, state, regional, national, and international symposia. The project also worked on developing aquaculture techniques of native fish for the food and aquarium industries. Some notable projects were:

1. Determined a $2.3 million commercial hoop net fishery on the St. Johns River, FL, was non detrimental to recreational fishermen. This study received first runner-up for best

paper at the 1995 conference Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies.

2. Documented the blue tilapia from a sport fishing bust to a commercial fishing boon. This data was published by the American Fisheries Society.
3. Using a 3 year study, determined a striped mullet gill net fishery in the lower St. Johns River, FL, was non detrimental to recreational fishermen in this area. This paper was published in the 1996 Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies.
4. Conducted, the first ever, statewide study on the magnitude ($3.5 million) and importance of a single baitfish, the golden shiner, *Notemigonus crysoleucas*.

Florida Fish and Wildlife Conservation Commission, Tallahassee, Florida
Biological Scientist II, January – July 1990 (6 months)

I worked on an Aquatic Plant Project where the emphasis was on using triploid grass carp as biological control method for invasive aquatic plant species.

1. Recorded aquatic plant diversity and abundance in triploid grass carp study lakes using line-transects and paper-graph recorders.
2. Consulted pond owners on control and maintenance of aquatic vegetation through the use of triploid grass carp and herbicides.

Murray State University, Murray, Kentucky
Research Assistant, 1988-1989 (24 months**)**

My responsibilities included, completion of a master's thesis (May 1991) titled: *Growth and Condition of Kentucky Lake Channel Catfish During Years with Reduced Flow in the Tennessee River* , and provide technical support to fellow graduate students, provide field assistance to faculty research projects and provide class preparation support for faculty. Notable projects included:

1. Collected and maintained data bases on condition of sport fishes in Kentucky Lake using d-Base and SAS programs.
2. Captured and tagged paddlefish, *Polyodon spathula*, to determine movements and exploitation in the Tennessee and Cumberland Rivers.
3. Provided fish samples from the Mississippi and Ohio Rivers to Westvaco Paper Company's chlordane monitoring program.
4. Performed field and classroom demonstrations for undergraduate classes and school groups visiting the Hancock Biological Station.

Kentucky Department of Fish and Wildlife Resources (KDFWR), Frankfort, Kentucky
Fisheries Technician, 1986 (3 months)

My responsibilities were to assist the state black bass biologist with such task as: creel card returns, cove rotenone studies, electrofishing, trap netting, fish tag returns, stomach analysis, and maintaining equipment.

VOLENTEER EXPERIENCE:

Mussel survey on Lower Licking River: Assisted KDFWR malcologist Monte McGregor with a qualitative and quantitative mussel study on a large mussel bed in the Lower Licking River (Campbell & Kenton Counties, KY) whereby 28 species of mussels were identified including the federally endangered *Cyprogenia stegaria* (live) and *Pleurobema clava* (remnant)**.**

TRAININGS/WORKSHOPS:

Ohio Department of Transportation's Waterway Permits Training (6.5 hrs) 2006
Ohio Department of Transportation's Ecological Training (6.5 hrs) 2006
Mid-Atlantic Highland Stream Restoration Workshop (2 days) 2005
36th Annual North American Symposium on Bat Research (2.5 days) 2006

Tennessee and Kentucky Chapters of the American Fisheries Society Annual Meeting (2 days) 2006
Southeastern Association of Fish and Wildlife Agencies Annual Meeting (3 days) 1994
Kentucky Native Plant Society Certification Program in Native Plant Studies
- Field Techniques in Native Plant Research (September 2006)
- Sedges of Kentucky (November 2006)
- Basic Plant Taxonomy (September 2007)
- Woody Plants of Kentucky (October 2007)

Eastern and Western Kentucky Headwater Stream Functional Assessment Protocol (6 hrs) 2006
Federal Wetland/Waters Regulatory Policy (5 days) October 2008
Basic Wetland Delineation (5 days) May 2007
Taxonomy and Natural History of Southern Appalachian Mayfly, Stonefly, and Caddisfly Larvae (10 days) May 2007
Southern Division American Fisheries Society Annual Spring Meeting, Wheeling, West Virginia (2 days) February 2008
OSHA 10-hour training on Construction Safety and Health, February 2010
University of Louisville Stream Institute: Assessment and Sediment-Based Design of Stream Restorations, 2011 Short Course.

RELEVANT COURSEWORK:

EKU: (Undergraduate courses) Natural History of Invertebrates, Limnology, Botany, Zoology, Phycology, Plant systematics, Aquatic and Wetland Plants (audited 2009), Principles of biological systems, Principles of Microbiology, Ornithology, Ecology, Genetics, Quantitative biology, Microbiology, Fisheries biology, Fisheries management, Ichthyology, Biology Special Problems, Introductory chemistry 1 & 2, Organic chemistry 1 & 2, Introductory biochemistry, Quantitative analytical chemistry, (Graduate level course) Aquatic ecosystems.
MSU: (Graduate level courses) Applied Statistics, Animal ecology, Freshwater invertebrates, Fisheries management, Reservoir science, advanced Fisheries management, thesis 1 & 2.

PUBLICATIONS:

Hale, M. M., R. J. Schuler, Jr., and J. E. Crumpton. 1996. The St. Johns River, Florida, Freshwater Striped Mullet Gill Net Fishery: Catch Composition, Status and Recommendations. Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agency 50:98-106.

Hale*, M. M., R. J. Schuler, Jr., and J. E. Crumpton. 1995. Gamefish Bycatch and Mortality in Hoop Nets in the St. Johns River, Florida. Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agency 49:216-223.

*First Runner-up for Best Paper.

Hale, M. M., J. E. Crumpton, and R. J. Schuler Jr. 1995. From Sportfishing Bust to Commercial Fishing Boon: A History of the Blue Tilapia in Florida. American Fisheries Society Symposium 15:425-430

Schuler Jr., R. J. 1991. Growth and Condition of Kentucky Lake Channel Catfish during Years with Reduced Flow in the Tennessee River. Masters Thesis. Murray State University Biological Department. 30 pages.

Timmons, T. J., R. J. Schuler, Jr. and L. Duobinis-Gray. 1992. Prevalence of *Acetodextra amiuri* (Trematoda: Cryptogonimidae) in channel catfish, *Ictalurus punctatus*, from Kentucky Lake, Kentucky-Tennessee. Journal of the Helminthological Society of Washington 59:147-148.

ADMINTISTRATIVE REPORTS:

Aquatic and Terrestrial Baseline Report US 127 Realignment and Reconstruction Clinton and Russell Counties, Kentucky Item Numbers: 8-108.00 Northern Portion; 8-115.10 Southern Portion. 2008 Prepared for Kentucky Transportation Cabinet.

Proposed Interstate 69 Segemnt of Independent Utility #8 From State Route 19 to Double Branches. Aquatic and Terrestrial Crossover Corridor Study in Lauderdale County, Tennessee. 2007. Prepared for HMB Professional Engineers, Inc.

Florida Fish and Wildlife Conservation Commission, Six Administrative Reports 1990 - 1995. Tallahassee, Florida.

Annual Monitoring Reports – Lees Branch, Woodford County, KY for years 2006 (second), 2007 (third) and 2008 (forth). Prepared for United States Corps of Engineers, Louisville District for Permit Number: 200400667

Ecology Report State Route 92 Bridge Replacement Over French Broad River, Tennessee Department of Transportation PIN 45011-1217-94. 2009 Prepared for the Tennessee Department of Transportation

Ecology Report State Route 54 (U.S. Highway 641) Section IV: From 0.5 mile South of Intersection with Crossland Road and Brannon Lane to the Kentucky State Line PIN 101886.01 PE No. 40003-1213-14. 2009 Prepared for the Tennessee Department of Transportation.

LEE CAROLAN
Senior Environmental Biologist

EDUCATION AND EXPERIENCE:

Duke University
Nicholas School of Environment and Earth Sciences, 2005
(Implementation of NEPA course to earn Environmental Professional certification)

Arkansas Tech University
BS, Biological Science and Secondary Education, 1985

PROFESSIONAL REGISTRATIONS:

AHERA Asbestos Building Inspector; National and Kentucky--ASBIR0905158
Asbestos Inspector; Kentucky—I11-08-1688
Certified Environmental Specialist—11.5901

APPLICABLE TECHNICAL TRAINING

AHERA Asbestos Inspector Refresher; 2011 (ID# ASBIR11050979)
13th Annual KY Environmental Permitting and Reporting Conference; 2010
Regional Supplement Seminar and Field Practicum; 2010
FEMA EOC Management and Operations; 2010
OSHA Hazardous Waste Operations and Emergency Response (HAZWOPER) Refresher Training (8 hours); 2005-2011
OSHA Hazardous Waste Operations and Emergency Response (HAZWOPER) Training (40 hours); 2004
OSHA 10-hour Construction Safety Training; 2010
CHMM Refresher Course and Exam; 2009
Governor's Emergency Management Workshop; 2009
AHERA Asbestos Building Inspector; Initial, 2009 (ID # ASBBII0804062)
AHERA Asbestos Building Inspector; Refresher, 2009, 2010, 2011
Federal Wetland/Waters Regulatory Policy; 3-day Course; 2008
CHMM Continuing Education; 2008
Wetland Delineator Certification Program; 2007
Brownfields West Virginia: Risks and Rewards; 2006
A-E Selection and Contracting; 2006
Due Diligence at Dawn; 2006

PROFESSIONAL AFFILIATIONS:

National Association of Environmental Professionals
Air and Waste Management Association
The Society of American Military Engineers

EMPLOYMENT:

Palmer Engineering Inc.
400 Shoppers Drive,
Winchester, Kentucky 40391

PROJECT WORK EXPERIENCE:

Ms. Carolan joined **Palmer Engineering** in March 2006; project experience at Palmer and with previous employers includes:

Asbestos Survey, Estill County, KY for Community Economic Development Agency (CEDA), 2010 - Senior Environmental Biologist; performed an asbestos survey on five parcels for renovation and/or demolition of structures; approximately 70 samples were taken for analysis and sent to a United States

Environmental Protection Agency (USEPA) accredited laboratory (National Voluntary Laboratory Accreditation Program, or NAVLAP). Palmer inspectors reviewed the lab analysis reports and submitted a letter-report containing the method, findings, conclusions, recommendations, and the lab reports. The work was conducted by USEPA-credentialed asbestos building inspectors with Kentucky accreditation.

Bi-County Solid Waste Management Systems/Fort Campbell Military Reservation Land Transfer, (Trigg County, KY and Montgomery County, TN), 2003-2005 – Senior Environmental Biologist; Authored the Environmental Assessment, the Finding of No Significant Impact, Biological Evaluations, and the Environmental Baseline Surveys for a land transfer of 1,028 acres between Kentucky and Tennessee; performed threatened and endangered species file reviews and conducted terrestrial, botanical and aquatic surveys; these surveys included stream assessments for water quality, fish, freshwater mussels and aquatic macroinvertebrate species; wetland assessments and delineations as well as investigation for invasive species such as the Purple loosestrife were performed.

Boones Trail Road Improvements, Madison County, KY for Madison County Fiscal Court, 2009 - Environmental Project Manager; Conducted routine ecological field work documenting and delineating stream crossings, and wetlands for the road improvement on the project; Correspondence with USFWS and state DOW/KDFWR/DEP agencies; Prepared and submitted USACE 404 and Water Quality 401/Floodplain Construction Permits.

Broad Run Interceptor, Jefferson County, KY for Louisville and Jefferson County Metropolitan Sewer District, 2010-Present - Senior Environmental Biologist--Conducted routine ecological field studies to document any and all natural resources in the project area along Big Run Creek in Fern Creek, Kentucky for USACE 404 and Water Quality Certification permitting; Project Manager--Conducted field work documenting and delineating stream crossings, waterfalls, springs, seeps, wetlands and threatened and endangered species habitats; Performed Section 7 Consultation with USFWS regarding Indiana bats and Kentucky glade cress; Provided oversight of Phase I Archaeological Survey.

Confidential Client, Lawrenceburg, KY, 2006 - Senior Environmental Biologist; performed Phase I ASTM Standard Environmental Site Assessment

Confidential Client, Owensboro, KY, 2006 - Senior Environmental Biologist; performed Phase I ESA for Transaction Screen for a hotel.

Forest Park Sanitary Sewer Project, Winchester, KY for Winchester Municipal Utilities, 2007-Present - Senior Environmental Biologist for new public sanitary sewer system in a city subdivision; Conducted routine ecological field work documenting and delineating stream crossings, and wetlands for the road improvement on the project; Correspondence with USFWS and state DOW/KDFWR/DEP agencies; Prepared and submitted USACE 404 and Water Quality 401/Floodplain Construction Permits.

Fort Boone Pump Station, Franklin County, KY for City of Frankfort, 2009-Present - Performed Phase I ASTM 1527-05 ESA; Conducted routine ecological field studies to document any and all natural resources in the project area along Big Run Creek in Fairmount, Kentucky for USACE 404 and Water Quality Certification permitting; Project Manager conducted field work documenting stream crossings, waterfalls, springs, seeps, wetlands and threatened and endangered species habitats

Fort Campbell Military Reservation 159th Combat Aviation Brigade, 2006 - Senior Environmental Biologist; Authored the Environmental Assessment and the Biological Evaluation for the construction of the 159th Combat Aviation Brigade Complex and the realignment of the 101st Airborne Division Avenue; currently under consideration

Heartland Commerce and Technology Park, Campbellsville, KY, 2008 – Senior Environmental Biologist: Performed Jurisdictional Determination on the approximately 220-acre site. Co-authored a Jurisdictional Determination for a Section 404 Nationwide 29 Permit; Project Manager for oversight on Indiana Bat Habitat Assessment

Hodges Investment Properties, Shelbyville, TN for Brownfield’s Investigation, 2005 - Senior Environmental Biologist; Performed Phase I Environmental Site Assessment that led to a Phase II Environmental Site Assessment (ESA) for the former Eaton Heavy Truck Transmission Manufacturing Plant;

identified up to 30 locations for drilling and testing; water quality, sediment testing, and well placement were part of the duties required

I-69, Lauderdale County, TN for TDOT, 2008 – Senior Environmental Biologist; Performed Phase I ASTM 1527-05 Environmental Site Assessment on the approximate 11 mile project from SR-19 to Double Branches in Ripley, TN. The ESA included three independent corridors where recognized environmental conditions (RECs) were located. These included numerous landfills, gravel pits, ancient service stations with potential underground storage tanks, and leachate from a waste site; also performed threatened and endangered species survey and wetland delineations; Cost: $13,600

J K Smith Power Plant, Clark County, KY for East Kentucky Power Cooperative, 2009 – Senior Environmental Biologist; Project Team Leader overseeing 3200-acre stream and wetland mitigation, and benthic and fish surveys on approximately 81,460 linear feet of stream; Program Manager--provided oversight on stream and wetland assessments; Managed benthic surveys and sampling, meetings with EKPC and USACE; Construction Management oversight when construction occurs.

Kirby Parkway--Shelby Farms Area, Shelby County, TN for Shelby County Government and TDOT, 2006-2008 - Senior Environmental Biologist and co-author of DSEIS for a controversial project in Memphis, TN; performed Phase I ESA/UST/HAZMAT baseline survey, FEIS, and ROD; Involved with CSS and Public Involvement activities; Performed an Phase I ASTM Standard E 1527-05 ESA on segment from Walnut Grove Road to Macon Road that involved evaluation of possible environmental impacts to an important north-south connector. Field investigator and report author. Conducted Freedom of Information Act (FOIA) file reviews at TDEC and coordinated meeting with TDEC Memphis Environmental Field Office (EFO) personnel. Cost: $13,000

Knights Inn Asbestos Survey, Fayette County, KY for Gayatri Enterprises, LLC, dba American Inn, 2009 - Asbestos Inspector for a project that consisted of six buildings with approximately 36,000 total square feet; approximately 110 samples were taken for analysis and sent to a United States Environmental Protection Agency (USEPA) accredited laboratory (National Voluntary Laboratory Accreditation Program, or NAVLAP). Palmer inspectors reviewed the lab analysis reports and submitted a letter-report containing the method, findings, conclusions, recommendations, and the lab reports. The work was conducted by USEPA-credentialed asbestos building inspectors with Kentucky accreditation.

KY-4, Fayette County, KY for KYTC, 2009 - UST Specialist; performed an ASTM Standard Phase I ESA/UST/HAZMAT baseline survey on 1.3 miles of New Circle Road widening from Georgetown Road to Boardwalk Avenue, including Newtown Pike interchange, frontage road, and Georgetown Road ramps.

KY-9, Campbell County, KY for KYTC, 2007-Present - UST Specialist; Performed Phase I ASTM 1527-05 Environmental Site Assessment on four independent corridors where potential recognized environmental conditions (RECs) were located; A few existing superfund sites and a former steel factory with potential for further investigation were discovered.

KY-185, Warren County, KY for KYTC, 2007-Present - Senior Environmental Biologist; responsible for preparation of the EA/FONSI for reconstruction/relocation of approximately 3 miles of roadway from just south of Pruitt Road to the Green River Bridge

Lifepoint Hospitals, 2003-2005 - Senior Environmental Biologist; Performed numerous Phase I ESAs for Lifepoint Hospitals in Virginia, West Virginia, Texas, Louisiana, and North Carolina.

Lifestyle Communities–Georgetown, Scott County, KY for Lifestyle Communities, Inc., 2010-2011 - Senior Environmental Biologist; Performed an ASTM Phase I Environmental Site Assessment and an update on approximately 19 acres. This document included performing a stream, wetland, and sinkhole assessment on the property as well as performing assessments and documentation on potential threatened and endangered species habitat.

Lower Howard's Creek, Clark County, Winchester, KY for Winchester Municipal Utilities, 2007-Present – Senior Environmental Biologist; Performed Phase I ASTM Standard Environmental Site

Assessment for a 11-miles of pipeline within a 2-mile radius. Performed Phase I ASTM Standard Environmental Site Assessment on approximately 38-acres and 3.6-miles of pipeline for a Waste Water Treatment Plant Project; Performed Ecological Overview and Jurisdictional Determinations for Section 404 Permitting and Water Quality 401/Floodplain Construction Permits; Section 7 Consultation regarding Indiana Bat and Running Buffalo Clover habitats with USFWS was performed; Provided oversight of Phase I Archaeological Survey

Lowe’s Home Centers, Inc., Berea, KY for Lowe’s, Inc., 2007-2009 - Senior Environmental Biologist; performed Phase I ASTM Standard Environmental Site Assessment and Phase II for a 15.59-acre development at US-21 and South Dogwood Road; performed Jurisdictional Determination on wetlands and streams; Performed updated Phase I May 2009; Prepared and submitted USACE 404 and Water Quality 401/Floodplain Construction Permits; Provided oversight of Phase I Archaeological Survey

Lowe’s Home Centers; Evansville, IN, 2008 - Environmental Scientist, perform a Phase I Environmental Site Assessment on the approximate seven-acre commercial site containing approximately 167,000 square feet of buildings. Phase II ESA was recommended A Phase II ESA confirmed the presence of mold, animal droppings and parts, and asbestos in the ceiling and floor tiles mastic.

Lowe’s Home Centers, Inc., Lawrenceburg, KY for Lowe’s, Inc., 2006 - Senior Environmental Biologist; performed Phase I ASTM Standard Environmental Site Assessment for an 11-acre development

Lowe’s Home Centers, Inc., Louisville, KY for Lowe’s, Inc., 2008 - Senior Environmental Biologist; performed Phase I and ASTM 1527-05 Environmental Site Assessment and Phase II for a 23.25-acre development at New Cut Road and Outer Loop in South Central Louisville. Performed Jurisdictional Determination on wetlands and streams; ESA also included threatened and endangered species surveys, historical surveys and asbestos surveys; Prepared and submitted USACE 404 and Water Quality 401/Floodplain Construction Permits; Provided oversight of Phase I Archaeological Survey

Lowe’s Home Centers, Inc., Morehead, KY for Lowe’s, Inc., 2006 - Senior Environmental Biologist; performed Phase I ASTM Standard Environmental Site Assessment for an 18.44-acre development

Lowe’s Home Centers, Inc., Mt. Sterling, KY for Lowe’s, Inc., 2007 - Senior Environmental Biologist; performed Phase I ASTM Standard Environmental Site Assessment for a 25-acre development

Lowe’s Home Centers, Inc., Endlease, Richmond, KY for Lowe’s, Inc., 2007-2009 - Senior Environmental Biologist; performed Phase I ASTM Standard Environmental Site Assessment for a former Lowe’s in Richmond on a 10-acre development site; performed Phase II and Phase III including asbestos, lead paint and mold surveys; Oversight of remodeling of entire approximately 20,000 square feet of offices and showrooms;

Lowe’s Home Centers, Inc., Versailles, KY for Lowe’s Inc., 2008 - Senior Environmental Biologist; performed Phase I ASTM Standard Environmental Site Assessment and Phase II for a 10.77-acre development; Prepared and submitted USACE 404 and Water Quality 401/Floodplain Construction Permits.

Midway Station--Midway, Woodford County, KY for Anderson Communities, 2009 - Senior Environmental Biologist; performed an ASTM Phase I Environmental Site Assessment on 179 acres. This document included stream and wetland delineation that led to obtaining a USACE 404 Nationwide Permit. This assessment also included surveys for potential threatened and endangered species and coordination with US Fish and Wildlife Service.

Poor Man Properties, Inc., Lexington, KY for Retailer, 2006 - Senior Environmental Biologist; performed Phase I ASTM Standard Environmental Site Assessment for a 14,000 square feet retail warehouse

ServiceMaster, 2004-2006 - Senior Environmental Biologist; Performed numerous Phase I ESAs, Exit Assessments and Transaction Screen Assessments for ServiceMaster, Inc. in United States and Canada

Southern States--Franklin, Simpson County, KY for Southern States, Inc., 2010 - Senior Environmental Biologist; Performed an AHERA and Kentucky State Law 401 KAR 58:025 asbestos testing on a site for renovation; Obtained an above-ground storage tank permit from Kentucky Division of Fire Prevention-Hazardous Materials Section for a 250,000 gallon liquid fertilizer tank to be placed on site.

SR-19, Haywood and Lauderdale Counties, TN for TDOT, 2010-2011 - Senior Environmental Biologist; Performed ecological field studies to document all natural resources and invasive species for three alternatives on an 18.5 mile corridor for preparation of an Ecology Report Summary to be included in the NEPA documentation; Also performed Phase I ASTM Standard E 1527-05 where several sites were identified as recognized environmental conditions (RECs) and recommended for further environmental investigation.

SR-41 and SR-42, South Charleston, OH for the City of South Charleston, 2006 - Senior Environmental Biologist; performed Phase I Environmental Site Assessment for an intersection widening project in Clark County, Ohio

SR-52, Corridor J, Overton County, TN for TDOT, 2007-Present – SR. Environmental Biologist; Conducted routine ecological field studies to document any and all natural resources in the project area along the SR-52 corridor from SR-136 to SR-111 for preparation of an Ecology Report Summary to be included in a NEPA document; Conducted field work documenting impacts to streams, springs, seeps, ponds/quarries, lakes, waterfall, wetlands, potential wetland mitigation sites, caves, sinkholes, and other specialized habitat and protected species for Impact Summary Report; conducted field review for potential threatened and endangered species; Prepared Ecology Report (TDOT Scopes A, N); Performed Phase I ASTM Standard E 1527-05 ESA for NEPA Document; Report writer and editor.

SR-54, Henry County, TN for TDOT, 2009 - Performed Phase I ASTM Standard E 1527-05 ESA on two alternatives within four project sections of SR-54 (US-641, Section IV Corridor Study). The length of the corridor in which the addendum was prepared was approximately 2.1 miles. Several sites with recognized environmental conditions (RECs) were identified and recommended for further environmental investigation; Performed ecological field studies to document all natural resources and invasive species for preparation of an Ecology Report Summary to be included in the NEPA documentation. Cost: approximately $12,500

The Shoppes at Equestrian Crossing, Georgetown, KY for May Commercial Group, 2007-Present – Senior Environmental Biologist; Performed Phase I ESA for May Commercial Group on approximately 225-acres in Georgetown; interviewed residents and regulatory agencies, photographed sites and wrote site assessment. Performed Jurisdictional Determination and managed Archaeological Phase I and Phase II Survey and Cemetery removal; Prepared and submitted USACE 404 and Water Quality 401/Floodplain Construction Permits;

US Army Corps of Engineers, Huntington District, Milton, WV, 2005 - Senior Environmental Biologist; Performed Phase I ESA for the USACE on approximately 35 sites in Milton; interviewed residents on properties, located potential problem areas, photographed sites and wrote site assessment information for report

US Army Corps of Engineers, Huntington District, Prestonsburg, KY, 2005 - Senior Environmental Biologist; Conducted ASTM Standard Phase I Environmental Site Assessment on 11 properties for the COE to determine environmental concerns in a flood zone area.

US Army Corps of Engineers, Huntington District, Prestonsburg, KY, 2005-2006 - Senior Environmental Biologist; performed Phase I ESA for the US Army Corps of Engineers (USACE) on approximately 40 sites in Prestonsburg; interviewed residents on properties, located potential problem areas, and photographed sites.

US Army Corps of Engineers, Louisville District, Sioux Falls (SD) Armed Forces Reserve Center (AFRC), 2005 - Senior Environmental Biologist; authored the Environmental Assessment, FONSI and the Biological Evaluation for the purchase of 11-acres and the construction of a 300-member facility to be utilized by the Army and Naval Reserve units; performed the threatened and endangered species, terrestrial, aquatic and botanical surveys, and the Section 7 Consultation on the project; Prepared and submitted USACE 404.

US Army National Guard, Camp Joseph T. Robinson, North Little Rock, AR, 2004 - Senior Environmental Biologist; updated Integrated Natural Resources Management Plan (INRMP) for the Robinson Military Training Center (RMTC) at Camp Robinson; project included updating information on threatened and endangered (T&E) species, wildlife, wetland, and forest management projects, as well as including new information obtained by personnel at the RMTC.

USDA Forest Service, Ouachita National Forest, Jessieville District, (Jessieville, AR), 1990-1995 - District Biologist; responsible for various T&E, wildlife and educational programs; performed threatened and endangered species surveys, including terrestrial (bat, bear, beetles, birds, and salamanders), aquatic macroinvertebrate, fish, freshwater mussels, botanical, pond and stream surveys in Alabama and Arkansas; wrote Categorical Exclusions, Environmental Assessments, Biological Evaluations and Assessments on projects including wildlife, recreational, timber, and transportation in Alabama and Arkansas; performed Section 7 Consultation on all of the above projects; performed annual Migratory Bird surveys for the National Audubon Society; red-card firefighter and disaster relief team member

USDA Forest Service, Sabine National Forest, (Hemphill, TX), 1995-1999 - District Biologist; managed T&E, wildlife and educational programs; performed threatened and endangered species surveys, including terrestrial (bat, bear, birds, and otters), aquatic macroinvertebrate, fish, freshwater mussels, botanical, wetland, and stream surveys for the states of Texas and Louisiana; wrote Categorical Exclusions, Environmental Assessments, Biological Evaluations and Assessments on over 50 projects including wildlife, recreational, timber, oil and gas and transportation projects for the states of Texas and Louisiana. Performed Section 7 Consultation on all of the above projects; responsible for the Red-cockaded Woodpecker Translocation program on the Forest; member of the Southeastern RCW Translocation team in the states of Alabama, Arkansas, Georgia, Louisiana, Oklahoma and Texas; performed annual Partners in Flight Migratory Bird surveys; team member of the 1998 Storm Damage project on the National Forests and Grasslands of Texas; red-card firefighter and disaster relief team member

US-25, Boone County, KY for KYTC, District 6, 2009 - Performed Phase I ASTM Standard E 1527-05 Environmental Site Assessment (ESA) along approximately 4.3 miles of roadway to identify recognized environmental conditions (RECs) in connectioin with the project. Several sites with RECS were identified and recommended for further environmental investigation. Cost $7,000

US-31E, Nelson/Spencer/Bullitt Counties, KY for KYTC/FHWA, 2007 - Senior Environmental Biologist; edited the Finding of No Significant Impact for the Environmental Assessment on the 14-mile realignment and reconstruction of US-31E

US-68/KY 80 (Lake Bridges), Marshall and Trigg Counties, KY for KYTC, 2007-Present – Senior Environmental Biologist; Oversight of environmental compliance regarding NEPA; Responsible for permits submittal on two bridges to Tennessee Valley Authority (TVA), USACE Individual 404 permits, 401 Water Quality Certification, and Floodplain construction permits for KDOW; mitigation planning for impacts to *waters of the US*.

US-421, Madison County, KY for Madison County Fiscal Court, 2009-Present - Environmental Project Manager; Conducted routine ecological field work documenting and delineating stream crossings, and wetlands for road improvements near Kingston Elementary School; Correspondence with USFWS and state DOW/KDFWR/DEP agencies; Prepared and submitted USACE 404 and Water Quality 401/Floodplain Construction Permits.

US-460 (Draffin Bridge), Pike County, KY for KYTC, 2007 - Senior Environmental Biologist; Performed Phase I ESA/UST/HAZMAT baseline survey

Winchester Municipal Utilities Regional Facilities Plan, Winchester, KY for WMU, 2008-2010 – Senior Environmental Biologist; Performed QA/AC review of facilities plan for water and wastewater facilities in Clark County, KY; Provided environmental documentation for facilities plan.

OTHER PROFESSIONAL EXPERIENCE:

Senior Environmental Biologist, EnSafe, Inc., (Nashville, TN), 2004-2006

Project Supervisor on NEPA documents for US Army Corps of Engineers, Fort Campbell Military

Reservation, and local municipalities; Performed terrestrial, aquatic and wetland ecological surveys for Fort Campbell Kentucky on NEPA projects and TDOT; responsible for Phase I and Phase II projects for major clients; assisted on several wetland delineations

Director, KY Department of Fish and Wildlife Resources, (Frankfort, KY), 1999-2003
Division Director of Information and Education
Public Relations Manager for a 500-employee agency; worked directly with Tourism Cabinet

District Biologist, USDA Forest Service, Sabine National Forest, (Hemphill, TX), 1995-1999
Managed 14 wildlife related and educational programs: performed Threatened and Endangered Species (terrestrial and aquatic) ecological species conducted habitat surveys for state agencies and private industry; Prepared CE, EA, and EIS documents and biological opinions on forestry, wildlife, recreation and transportation;
Public affairs officer and public relations contact

Wildlife Biologist, USDA Forest Service, Ouachita National Forest (Jessieville, AR), 1990-1995
Prepared biological NEPA documents, Categorical Exclusions, and biological opinions on forestry, wildlife, recreation, transportation, and mining projects; performed terrestrial and aquatic ecological surveys on the forest for projects including timber, recreation and transportation

Forestry Technician, USDA Forest Service, (Tuskegee, AL), 1989-1990
Coordinated and conducted wildlife surveys; conducted conservation education programs; managed timber; fought wild land fires; maintained trails; participated on disaster relief projects; performed land surveys

OTHER APPLICABLE TRAINING:

Annual Partnership in Flight Migratory Bird Workshops; 1996-1998
Forest Plan Implementation/NEPA/NFMA; 1997
Assessing Cumulative Effects of Forest Service Projects; 1996
Forest Wildlife Management; 1996
Policy and Legal Aspects of Endangered Species Management (USFWS); 1994
Biological Evaluation of Threatened and Endangered Species; 1993
Knutson-Vanderberg/Salvage Sale Fund; 1992
Silvicultural Exam and Prescription School; 1991

APPENDIX D

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Kentucky Waterways Alliance and Kentucky Division of Water. 2010. *Watershed Planning Guidebook for Kentucky Communities*. Kentucky Department for Environmental Protection, Division of Water, Frankfort, Kentucky. 174pp.

Neel, J. K. 1938. *Lower Howard's Creek – a biological survey*. Master Thesis, University of Kentucky, Lexington, Kentucky. 233 pp.

Pond, G. J., S. M. Call, J. F. Brumley and M. C. Compton. 2003. *The Kentucky Macroinvertebrate Bioassessment Index: Derivation of Regional Narrative Rating for Wadeable and Headwater Streams*. Kentucky Department for Environmental Protection, Division of Water, Frankfort, Kentucky.

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United States Environmental Protection Agency. 2008. *Handbook for Developing Watershed Plans to Restore and Protect Our Waters*. U.S. Environmental Protection Agency, Washington, DC, EPA Document Number: EPA 841-8-08-002. 407pp.

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SHADED AREA FOR LAB USE ONLY

CHAIN OF CUSTODY RECORD

Client/Company Ordering Test:

Palmer Engineering
Attn: Ralph Schuler

Location/Address:

400 Shoppers Drive
Winchester, KY 40391

Other Sample Related Remarks:

Please dilute E. coli samples so results are over 2420.

Sampler (Signature):

PWS ID#

PO#

FES Lab #	Collection		Customer Sample ID / Description (for composites indicate start time and end time)	Sample Description			Analyses Required
	Date	Time (24hr)		Grab/ Comp	Matrix	Pres.	
			Sample Site	G	SU	ST	E. coli
				G	SU	X	Nitrate / Nitrite
				G	SU	ST	Ammonia – N
				G	SU	SA	Total Kjeldahl Nitrogen
				G	SU	SA	Total Phosphorus
				G	SU	X	Ortho-phosphorus
				G	SU	X	BOD5
				G	SU	X	Total Suspended Solids
				G	SU	X	Turbity

Relinquished By:	Received By:	Date	Time (24 hr)	**Shipping Conditions: ☐ Iced ☐ Ambient** **Container Temperature: ___________**
Relinquished By:	Received By:	Date	Time (24 hr)	**Holding times acceptable? ☐ Yes ☐ No** **Data entered by: __________**
Relinquished By:	Received For Laboratory By:	Date	Time (24 hr)	**Method of Delivery:** **☐ FES ☐ Client ☐ UPS/Fed Ex ☐ Other**

MATRIX CODES:
dw - drinking water
sw - storm water
ww – wastewater
oil – oil
sl – sludge
gw – groundwater
s – solid
o - other
su – surface water
lt – leachate

PRESERVATION CODES:
NA – Nitric Acid (HNO_3)
SA – Sulfuric Acid (H_2SO_4)
I – Ice
ST – Sodium Thiosulfate ($Na_2S_2O_3$)
HA – Hydrochloric Acid (HCl)
SH – Sodium Hydroxide (NaOH)
X – None
ZA – Zinc Acetate ($Zn(O_2CCH_3)_2$)
AA - Ascorbic Acid ($C_6H_8O_6$)
PA – Phosphoric Acid (H_3PO_4)
AC – Ammonium Chloride (NH_4Cl)

Date: ______________________________

Time: ______________________________

Site: ______________________________

Weather: ______________________________

Distance from Left Bank (ft)	**Total Depth (ft)**	**Depth of Average Velocity (0.2, 0.6, or 0.8D)**	**Velocity (m/s)**	**Velocity (f/s)**

*Note: When D<2.5' average V occurs at 0.6D, when D>2.5, measure V at 0.2D and 0.8D and then average values

**0=Left Bank when looking downstream

Water Sampling – YSI Pro Plus Datalogger

Date:____________________

Sample Site 1: KSNPC
Time________________
Flow (m/s)____________
Water temp (˚C)_________
% DO ________________
DO mg/l ______________
Specific Cond.__________
pH ___________________

Sample Site 2: Rich Smith
Time________________
Flow (m/s)____________
Water temp (˚C)_________
% DO ________________
DO mg/l ______________
Specific Cond.__________
pH ___________________

Sample Site 3: Old Stone Ch.
Time________________
Flow (m/s)____________
Water temp (˚C)_________
% DO ________________
DO mg/l ______________
Specific Cond.__________
pH ___________________

Sample Site 4: Harry Enoch
Time________________
Flow (m/s)____________
Water temp (˚C)_________
% DO ________________
DO mg/l ______________
Specific Cond.__________
pH ___________________

Sample Site 5: Patton Lane
Time________________
Flow (m/s)____________
Water temp (˚C)_________
% DO ________________
DO mg/l ______________
Specific Cond.__________
pH ___________________

Sample Site 6: 627 Bypass
Time________________
Flow (m/s)____________
Water temp (˚C)_________
% DO ________________
DO mg/l ______________
Specific Cond.__________
pH ___________________

Sample Site 7: Deep Branch
Time________________
Flow (m/s)____________
Water temp (˚C)_________
% DO ________________
DO mg/l ______________
Specific Cond.__________
pH ___________________

Sample Site 8: West Fork LHC
Time________________
Flow (m/s)____________
Water temp (˚C)_________
% DO ________________
DO mg/l ______________
Specific Cond.__________
pH ___________________

Sample Site 9: Fontaine Tributary
Time________________
Flow (m/s)____________
Water temp (˚C)_________
% DO ________________
DO mg/l ______________
Specific Cond.__________
pH ___________________

Sample Site 10: Vaught Tributary
Time________________
Flow (m/s)____________
Water temp (˚C)_________
% DO ________________
DO mg/l ______________
Specific Cond.__________
pH ___________________

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High Gradient Bioassessment Stream Visit Sheet

STREAM NAME:	**LOCATION:**	
STATION #:	**COUNTY:**	**PROGRAM:** **PROJECT:**
INVESTIGATORS: Verify Site LAT/LONG vs GPS ☐YES ☐NO ☐N/A	**DATE:**	**TIME (24hr)** **Start:** **Finish:**

	Station	**Reach** **Downstream**	**Reach** **Upstream**
LAT			
LONG			

CANOPY COVER::
- ☐ Fully Exposed (0-25%)
- ☐ Partially Exposed (25-50%)
- ☐ Partially Shaded (50-75%)
- ☐ Fully Shaded (75-100%)

STREAM TYPE:
- ☐ Perennial
- ☐ Ephemeral
- ☐ Intermittent

WEATHER

Has there been a scouring rain in the last 14 days?
☐ Yes ☐ No

Now	Past 24 hours	
☐	☐	Heavy rain
☐	☐	Steady rain
☐	☐	Intermittent showers
☐	☐	Clear/sunny
☐	☐	Cloudy

LOCAL WATERSHED FEATUREES (Predominant Surrounding Land Use):
- ☐ Surface Mining
- ☐ Deep Mining
- ☐ Oil Wells
- ☐ Land Disposal
- ☐ Residential
- ☐ Construction
- ☐ Commercial
- ☐ Industrial
- ☐ Row Crops
- ☐ Forest
- ☐ Pasture/Grazing
- ☐ Silviculture
- ☐ Urban Runoff/Storm Sewers

INSTREAM FEATURES

Stream Width ________ ft
Maximum Depth ________ ft
Reach Length ________m

Riffle/Run/Pool Sequence
(No. Sampled in Reach)

_____Riffle _____Run _____Pool

HYDRAULIC STRUCTURES
- ☐ Dams
- ☐ Bridge Abutments
- ☐ Island
- ☐ Waterfalls
- ☐ Other:

STREAM FLOW
- ☐ Dry
- ☐ Pooled
- ☐ Low
- ☐ High
- ☐ Normal

RIPARIAN VEGETATION

Dominate Type:
☐ Trees ☐ Herbaceous
☐ Grasses ☐ Shrubs
Number of strata ____ Dom.
Tree/Shrub Taxa

CHANNEL ALTERATIONS
- ☐ Dredging
- ☐ Channelization
(☐Full ☐Partial)

P-CHEM Instrument Used: ______________________ Date Calibrated: ____________________

Temp(^{o}C)__________ D.O. (mg/l)___________ %Saturation___________ pH(S.U.)___________ Cond.___________ Turb.___________

Sample Collection Verification

Algae	Sample: ☐ QualMHC ☐ Other ☐ Visual Assessment	Lead Collector:
Fish	☐BPEF ☐ Seine ☐ Other Time: BPEF__________ Seine__________	Lead Collector:
Habitat	☐ RBP ☐ Substrate ☐ Other:	Lead Collector:
Invertebrates	☐ 1m^2 ☐ Qual ☐ Other: ☐ 20 Jab (#Jabs: Cobble_____ Snags_____ Veg. Banks_____ Sand_____ Macrophytes_____ Other ______)	Lead Collector:
Tissue:	No. of Samples collected________ Sp:	Lead Collector:
Water Chem	☐ Acid/Alk ☐ Bulk ☐ Nutrients ☐ Metals ☐ Low Hg ☐ Herbicides ☐ Pesticides ☐ Ortho P ☐ Other:	Lead Collector:

Duplicate Samples Taken:

Substrate Characterization

Substrate ☐Est. ☐P.C.	**Riffle_______%**	**Run_______%**	**Pool_______%**	**Reach Total**
Silt/Clay (<0.06 mm)				
Sand (0.06 – 2 mm)				
Gravel (2-64 mm)				
Cobble (64 – 256 mm)				
Boulders (>256 mm)				
Bedrock				

NOTES/COMMENTS:

SITE NOT SAMPLED:

☐ Land owner denial ☐ Dry ☐Too deep/Impounded

☐ Site not found/Secluded ☐Unsafe

☐ Other (indicate under comments)

RBP High Gradient Habitat

Habitat Parameter	**Condition Category**			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
1.Epifaunal Substrate/ Available Cover **Score**	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of new fall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
2.Embeddedness **Score**	Gravel, cobble, and boulder particles are 0-25% surrounded by fine sediment. Layering of cobble provides diversity of niche space.	Gravel, cobble, and boulder particles are 25-50% surrounded by fine sediment.	Gravel, cobble, and boulder particles are 50-75% surrounded by fine sediment.	Gravel, cobble, and boulder particles are more than 75% surrounded by fine sediment.
3.Velocity/ Depth Regime **Score**	All four velocity/depth regimes present (slow-deep, slow-shallow, fast-deep, fast-shallow). (Sow is < 0.3 m/s, deep is > 0.5 m.)	Only 3 of the 4 regimes present (if fast-shallow is missing, score lower than if missing other regimes).	Only 2 of the 4 habitat regimes present (if fast-shallow or slow-shallow are missing, score low).	Dominated by 1 velocity/ depth regime (usually slow-deep).
4. Sediment Deposition **Score**	Little or no enlargement of islands or point bars and less than 5% (<20% for low-gradient streams) of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 5-30% (20-50% for low-gradient) of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 30-50% (50-80% for low-gradient) of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 50% (80% for low-gradient) of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
5.Channel Flow Status **Score**	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
6.Channel Alteration **Score**	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr.) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
7.Frequency of Riffles (or bends) **Score**	Occurrence of riffles relatively frequent; ratio of distance between riffles divided by width of the stream <7:1 (generally 5 to 7); variety of habitat is key. In streams where riffles are continuous, placement of boulders or other large, natural obstruction is important.	Occurrence of riffles infrequent; distance between riffles divided by the width of the stream is between 7 to 15.	Occasional riffle or bend; bottom contours provide some habitat; distance between riffles divided by the width of the stream is between 15 to 25.	Generally all flat water or shallow riffles; poor habitat; distance between riffles divided by the width of the stream is a ratio of >25.
Left/Right Bank	10 9	8 7 6	5 4 3	2 1 0
8.Bank Stability LB RB	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
9. Vegetative Protection LB RB	More than 90% of the stream bank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the stream bank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the stream bank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the stream bank surfaces covered by vegetation; disruption of stream bank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
10. Riparian Vegetative Zone Width LB RB	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.

Total Score

NOTES/COMMENTS:

Palmer Engineering

A PLAN FOR IDENTIFYING HOT-SPOTS OF HUMAN FECAL POLLUTION BY ANALYSIS OF FECAL LOAD, SOURCE, AND AGE IN WATER QUALITY SAMPLES FROM LOWER HOWARDS CREEK WATERSHED

Quality Assurance Project Plan

University of Kentucky

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Abstract: This document details a quality assurance plan to guide the successful analysis of water quality indicators from sample collected within Lower Howards Creek Watershed. Over the past 15 years, Dr. Gail Brion has developed a systematic approach to water quality and data analysis that identifies hot-spots of human fecal wastes in local streams and rivers using a triad of water quality indicators for fecal age, load, and source. This system has been proven in other watersheds (Eagle Creek, Georgetown, Frankfort, Lexington) and is published in the scientific literature. The system relies upon utilizing the results from multiple indicators for fecal load, source, and age to create a relative risk classification rubric to categorize the relative impairment in water quality from samples collected from surface waters. This provides a systematic way to prioritize selected sections of a stream or creek for further investigation and remediation of significant sources based on a relative ranking of the water quality from representative sample sites. For this project, samples from Lower Howards Creek will be collected by Palmer Engineering and delivered to the University of Kentucky Environmental Research and Training Laboratories for analysis of multiple, fecally-associated, water quality indicators. Fecal load will be measured by enumeration of E. coli with Colilert media by IDEXX, fecal age by the AC/TC ratio obtained from membrane filtration testing for Total coliforms, and fecal source identified by quantifying two types of fecal source specific genetic markers for the strictly anaerobic bacterial group known as Bacteriodes, one of which is human specific. Dr. Brion will analyze the water quality data obtained from the analysis of provided water samples from sites selected by Palmer Engineering for the purpose of identifying samples that are indicative of hot-spots of human fecal waste intrusion.

Approval Sheet

Gail Brion Professor of Civil Engineering University of Kentucky	4-24-2012 Date
Stephanie Blain Stephanie Blain, PE Project Engineer Palmer Engineering	4/30/2012 Date
Brian Ward Brian Ward, PE, PLS Project Manager Palmer Engineering	4/30/12 Date
Michael H. Flynn General Manager Winchester Municipal Utilities	4-30-12 Date
Lisa Hicks Division of Water Quality Assurance Officer Kentucky Division of Water	05/03/12 Date

Distribution List

Each person listed on the approval sheet and each person listed under Project/Task Organization will receive a copy of this Quality Assurance Project Plan (QAPP). Individuals taking part in the project may request additional copies of the QAPP from personnel listed below.

Project/Task Organization

Personnel involved in project implementation are listed in Table 1, and shown as an organization chart in Figure 1.

Table 1: Project Implementation Personnel

Individual	**Role in Project**	**Organizational Affiliation**
Gail Brion, Ph.D.	Project Manager for Sample Analysis and Water Quality Data Modeling	University of Kentucky (UK)
Brian Ward.	Project Manager for Overall Watershed Study	Palmer Engineering
Stephanie Blain	Project Engineer in Charge of Sample Acquisition and Field Coordination	Palmer Engineer
Tricia Coakley	Lab Manager and Sample Analysis	UK ERTL Labs

The University of Kentucky Project Manager will be responsible for the following QAPP/project related activities:

- Serve as nexus of communications between all parties.
- Collaboration in sampling design as required.
- Provide direct oversight to ERTL laboratories and UK personnel.
- Maintain official, approved QAPP.
- Develop amended QAPP as required.
- Data analysis and interpretation.
- Issue final report to Palmer Engineering for dissemination.

Brian Ward of Palmer Engineering will be responsible for the following activities:

- Approval of final Analytical Methods QAPP and all amended documents.
- Approval of final report.

- Archival of final report and datafile.
- Coordination of technology transfer with appropriate parties.

Stephanie Blain of Palmer Engineering will be responsible for the following activities:

- Approval of initial Analytical Methods QAPP
- Coordination of watershed sampling efforts.
- Training of Palmer Engineering field samplers according to Lower Howards Creek Watershed QAPP, dated September 26, 2011.
- Technical assistance with secondary data as required.
- Quality Assurance officer for field activities.

Tricia Coakley of the ERTL labs at the University of Kentucky will be responsible for the following activities:

- Coordination with Palmer Engineering samplers for receipt of field samples.
- Processing and analysis of samples collected according to established SOPs and QA/QC procedures.
- Creation and maintenance of final spreadsheet of primary and secondary data.

Problem Definition/Background

Rationale for initiating the project

The surface water systems in Lower Howards Creek are contaminated with pathogen indicators from fecal sources of multiple origins; the most problematic in terms of human health risk from recreational contact with originate from sanitary sewage intrusion. Palmer Engineering is working with the City of Winchester and Winchester Municipal Utilities to improve the overall quality of surface waters with respects to pathogen indicators. However, the major sources of fecal contamination from sanitary sewage and other sources of human fecal materials need to be identified for remediation and their potential impact on the overall fecal load apportioned in support of watershed remediation schemes. As well, it is expected that the difference in the overall fecal indicator burden as represented by concentrations of E. coli may not provide the precision to denote improvements in watershed quality that happen as a result of remediation in these sites, due to the multiple sources of fecal wastes, many of which are not under the control of Winchester (urban and agricultural wildlife). Therefore, it has been agreed upon that a multi-indicator pilot study will be initiated along an urban watershed to: 1. Pinpoint and document areas within the selected watershed receiving proportionately large loadings of human fecal material for remediation, and 2. Create a baseline against which to assess water quality improvements with respects to the fecal age and proportion of human sourced fecal materials in the pilot areas.

Objectives of the project

- Define the unique pattern of indicators that define regions of local urban streams contaminated with proportionally great amounts of human/domestic sewage (hotspots) from those contaminated by other, less hazardous fecal sources.
- Establish baseline values for the indicators in these urban streams, and relative risk categorizations, to be used to evaluate future data against to illuminate water quality improvements or changes.

Anticipated Outcomes of the project

- Increased awareness of the impacts of sanitary sewage leaks, overflows, and spills on the environment.
- Improved understanding of opportunities to reduce environmental impacts in urban streams.
- Improvement of environmental quality in a target region or watershed.
- Increased recognition of environmental leaders of all involved parties among key stakeholders.
- Greater remediation efficiency and more effective allocation of municipal resources.
- Cost savings for the Winchester Municipal Utilities.
- Development of a policy approach that could be used in other urban areas, agricultural areas, states, and regions.
- Improved communication and understanding between regulators and the regulated community.
- Greater collaboration among involved parties and state agencies.
- Enhanced networking and peer mentoring within the community.

Anticipated Decisions arising from the project

- Based on the findings of this project, Palmer Engineering may modify its approach to monitoring Winchester's Lower Howards Creek watershed and suggest follow-up projects to demonstrate to the local, State and Federal agencies continuous water quality improvements as remediation of hot-spots of human pollution within this watershed are completed.

Sample Handling and Custody

This QAPP is for sample analysis and data modeling/analysis only. All watershed sampling design and field activities will be done by Palmer Engineering under a different QAPP. Therefore, what follows are the procedures that will be used to assure the best quality and most complete database upon which to a simple model will be applied to pinpoint samples that have elevated levels of human fecal material present.

A standard chain of custody form will be developed and used for all samples collected by Palmer Engineering and delivered to the ERTL facility for this project. Dry weather sampling will be defined as receiving less than 0.5 inches of rain in the last 48 hours and less than 1.0 inches of rain in the last five (5) days. Samples collected will be stored on ice in coolers and holding times will be met to insure the accuracy of the results. Sampling events will be arranged so that samples are delivered to the lab within 6 hours with analyses for *E. coli* to be initiated within 8 hours of sampling times (if this time not achieved, sample results will be flagged in reporting documents). All analyses for culturable *E. coli* bacteria analyzed by IDEXX quantitray and the filtration of samples for qPCR will be done on the day of sampling. Filters for qPCR will be stored at -20◦C until extraction. Sample aliquots used for the analysis of the AC/TC ratio will be processed within 24 hours of sampling times and will be stored under refrigeration until processing. Once samples are received in the laboratory, the SOP for normal custody will be followed. Transfer of samples to the laboratory will be accomplished using a signature on the field log sheet that denotes transfer time, date, and responsible lab personnel. If custody is not maintained, then a note must be made on the accompanying sample forms. All frozen and/or archived samples are to be stored in a freezer (-20oC) accessible only to authorized laboratory personnel. The laboratory analyst is responsible for the samples from arrival to analysis and final disposal.

Data entry QA procedures

ERTL personnel participating in the study will catalog all methods, results, dates, conditions, and data in lab books with permanent ink. Copies of the data from lab books, field sheets, lab analysis sheets, and chain of custody sheets will be kept in a centralized file until entry into electronic spreadsheet. Procedures for entering hand-written data into the database will follow standard quality assurance procedures (e.g., verification using independent double key entry). Files created from the centralized spreadsheet for modeling or analysis will have 10% of the data entries random record checked to assure that manipulation of the file did not corrupt the data. Errors caught during cross-checking will be flagged and corrected, to the extent possible, in consultation with data collection staff and appropriate parties.

Analytical Methods

This project will follow well-recognized analytical methods for surface and drinking water samples. The membrane filter and broth culture methods to be used are standardized (SM9222b for the AC/TC ratio obtained from the m-endo broth based, membrane filter analysis for total coliforms, IDEXX Quanti-Tray 2000 for *E. coli*). The IDEXX analysis will be done per published procedural manuals from IDEXX. Basically, 100 mL samples of water are mixed with pre-packaged amounts of media, and then distributed into a sterile multiple well Quanti-Tray and incubated at 35 degrees C for 24 hours ± 2 hours before counting the number of wells with blue florescence. The numbers of large and small positive wells are used to provide a statistical estimate of the most probable number of bacteria per 100 mL of sample to be read from a chart provided by IDEXX. The AC/TC ratio analysis will require colony counts for two types of bacterial colonies grown on m-endo fed membrane filters, those presenting as total coliforms (dark red with sheen) and those presenting as atypical colonies (pink to red, no sheen). The AC/TC ratio reported is produced by dividing the number of atypical colonies per 100 mL by the number of total coliform colonies per 100 mL (Brion, 2000). The AC/TC ratio reported is unitless.

DNA extraction methods for qPCR will be standardized using commercially available, pre-packaged kits or EPA methods. Sewage or cloned DNA product will be used for the positive controls. Records will be kept of PCR efficiency and qPCR results will be reported as DNA copies per unit volume. Dr. Brion will review all microbial data for consistency and quality. Data that shows substantial discrepancies from known precisions or variances will be discarded and the events surrounding the value investigated. Dr. Brion will determine and record the appropriate corrective action as required on a case-by-case basis.

Bacteroides qPCR analyses will use the Allbac and Hubac markers and protocol designed by Alice Layton at the University of Tennessee in Knoxville, TN. The PCR protocol for the analysis of Allbac and Hubac markers is as follows. The PCR reaction mixture consists of 10uL Life Technologies TaqMan Environmental Master Mix, 10 p moles of each forward and reverse primer (Layton, 2006), 5 p moles of the corresponding fluorescently labeled probe (Layton, 2006), 2uL of template DNA, and enough dilution water to produce a final reaction volume of 20uL. Calibration curves are made using serial dilutions of plasmid DNA containing the cloned 16s rRNA from Human fecal *Bacteroides*. (Layton, 2006) Calibration covers a range of 10^1 – 10^7 target copies/uL. All qPCR reactions are run in triplicate using an Applied Biosystems Step One Plus qPCR instrument. The thermocycler program consists of 1 cycle at 50◦C for 2 minutes and 95◦C for 10 minutes followed by 50 cycles of 95◦C for 30 seconds and 60◦C for 45 seconds. (Layton, 2006). Threshold cycles from samples are compared with the calibration curve to determine concentration of target in copies per uL and then the final report value in copies/mL is calculated based on the volume of original water sample filtered.

Quality Control

Standard laboratory QA/QC for membrane filtration and IDEXX Quantitray methods will include, but not be limited to the following practices: a positive control will be done for each new batch of media; a negative control in the form of a field blank will be run each sampling event; a negative control for media quality and laboratory aseptic technique will be done with each sampling event; each sample for membrane filtration will have a minimum of 3 dilutions/aliquots assayed with 2 replicate plates per dilution analyzed; only counts from plates with >20 or <80 colonies will be used to calculate sample concentrations; only counts from plates with clearly separable colonies will be used, and colonies that touch each other will be counted as a single colony; anomalous counts will be excluded from data reporting; duplicate samples run on 10% of samples and compared against the precision test and corrective measures taken as appropriate. When possible, calculations of the final concentration of microorganisms will be made from the maximum volume of sample, even if it includes counts from different dilutions/aliquots. The total number of colonies observed will be divided by the total amount of sample filtered, adjusted to CFU/100 mL, and reported. EPA QA/QC guidelines for PCR methods will be followed and include, but not be limited to: a PCR positive control per each PCR run; a PCR negative control; a PCR method blank with each batch of samples processed; a method positive control with every sample batch; an initial matrix spike/inhibition check repeated if water conditions change radically.

Crosschecking data

Dr. Brion will review all microbial data generated for consistency and quality. Data that shows substantial discrepancies from known precisions or variances will be discarded and the events surrounding the value investigated. Dr. Brion will determine and record the appropriate corrective action as required on a case-by-case basis.

Data anomalies

Procedures for handling data anomalies (such as outliers and missing data) will be handled based on standard statistical procedures.

Instrument/Equipment Testing, Inspection and Maintenance

The PCR equipment is on a maintenance contract that includes a yearly preventative maintenance visit by a Life Technologies specialist.

Instrument/Equipment Calibration and Frequency

Calibration is part of the yearly PM visit..

Inspection/Acceptance for Supplies and Consumables

Supplies and consumables are certified sterile or PCR grade. All media expiration dates are reviewed to assure fresh media was supplied.

Data Management

Hard copies of sample custody sheets, raw data, and laboratory records will be kept in a central file within the ERTL labs. These hard copies will be kept for a period of 1 year after the study is completed. The final data from the project will be compiled into an Excel spreadsheet form along with secondary information provided by Palmer Engineering, and comments as an appendix to the final report. A hard copy of the final data spreadsheet and final report will be printed and kept on file with the in-house data. Copies of the final report with appended data file will be sent both hardcopy and electronically to Brian Ward and Stephanie Blain of Palmer Engineering at the end of the study. Gail Brion and Brian Ward are responsible for controlling the dissemination and use of the report and data after the final report has been approved and submitted. Up till the time of the approved final report, data access is to be controlled by Project Manager Gail Brion and all requests for dissemination prior to the production of the final report must be approved by Gail Brion with input from Brian Ward. After the production and approval of the final report and the final spreadsheet of results, any and all parties may use and distribute the results. Requests for the results of this study after the project has closed can be made to Gail Brion, Brian Ward, Stephanie Blain (or their designees).

Approach to managing unusable or incomplete data

Upon occasion, methods of analysis do not provide data with known concentrations. Examples of this are when the analyte of interest is present in concentrations lower or higher than detectable with the method selected. Since microbial samples cannot be repeated due to time constraints, results that are either less than or greater than the detection limits of the analysis will be assumed to have the concentration of the relevant detection limit to prevent calculated values that are zero or undefined. If toxicity or matrix interferences prevent an analysis from producing results, then all attempts will be made to provide another estimate of the data (from a duplicate sample). If there is no reasonable way to fill a data point from other information (interpolation or simulation), then that datapoint will not be used in any statistical analysis, but may be presented in the final report and spreadsheet of results with notation as N/A. All statistical analyses and results that rely upon data simulated from other sources will be identified and the potential bias noted.

Literature Cited

APHA (1998). Standard methods for the examination of water and wastewater, 20th ed. Washington, DC: APHA, AWWA and WEF.

Brion, G. M., & Mao, H. H. (2000). Use of total coliform test for watershed monitoring with respect to atypicals. *Journal of Environmental Engineering*, *126*, 175.

Layton, A., McKay, L., Williams, D., Garrett, V., Gentry, R., & Sayler, G. (2006). Development of Bacteroides 16S rRNA gene TaqMan-based real-time PCR assays for estimation of total, human, and bovine fecal pollution in water. *Applied and environmental microbiology 72*(6), 4214-4224.

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APPENDIX G

PHASE ONE MONITORING RESULTS

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Site 1

Sampling Event Number	Date	Type	Air Temp (°F)	Velocity (m/s)	Flow (m^3/s)	Flow (ft^3/s)	Water Temp (°C)	%DO	DO (mg/L)	Specific Conductivity (µS/cm)	pH	Habitat Assessment (RBP Score)	Habitat Assessment Classification	Biological Assessment (MBI Score)	Biological Assessment Classification	Turbidity (NTUs)	E. Coli (MPN/100 mL)	TSS (mg/L)	BOD-5 (mg/L)	NH3-N (mg/L)	Nitrate-N (mg/L)	Nitrite-N (mg/L)	TKN (mg/L)	Orthophosphate (mg/L)	Total Phosphorus (mg/L)	Total Nitrogen (mg/L)
1	8/26/2011	Routine	86	0.7	---	---	21.3	80	6.9	367.6	8.1	146	Good	69.38	Excellent	1.56	31	<2	<3	<0.05	0.90	<0.10	0.193	0.221	0.315	1.19
2	9/8/2011	Routine	62	0.6	---	---	17.4	93	8.7	514.6	8.2	---	---	---	---	1.49	326	<2	<3	<0.05	1.72	<0.10	0.272	0.303	0.162	2.09
3	10/6/2011	Dry	81	0.3	0.14	5.08	13.4	111	11.4	404.8	8.06	---	---	---	---	0.507	38	4	<3	<0.05	1.03	<0.10	0.177	0.144	0.135	1.31
4	11/1/2011	Routine	63	1.2	0.66	23.59	8.4	108	12.6	523	8.36	---	---	---	---	0.74	23	<2	<3	<0.05	2.63	<0.10	<0.100	0.222	0.233	2.83
5	12/15/2011	Wet	61	1	0.80	28.20	10.1	104	11.5	420	8.44	---	---	---	---	4.83	32	5	4	<0.05	2.55	<0.10	0.271	0.196	0.233	2.92
6	1/16/2012	Routine	41	1.3	1.10	38.75	3.3	102	13.5	469.5	8.48	---	---	---	---	3.59	30	<2	<3	<0.05	2.49	<0.10	<0.10	0.191	0.229	2.69
7	2/23/2012	Routine	58	1.2	1.14	40.35	7.8	114	13.1	427.7	8.66	---	---	---	---	1.97	51	6	<3	<0.05	1.26	<0.10	0.198	0.133	0.143	1.56
8	3/21/2012	Routine	80	0.9	1.07	37.90	14.3	107	10.8	443.2	8.3	---	---	---	---	<0.50	63	7	<3	<0.05	1.83	<0.10	<0.100	0.145	0.165	2.03
9	4/11/2012	Dry	50	0.8	0.36	12.83	10.2	107	11.8	374.2	8.1	---	---	---	---	0.81	48	14	<3	<0.05	0.54	<0.10	<0.100	0.137	0.039	0.74
10	5/3/2012	Routine	80	0.9	0.27	9.61	20	69	6.2	380.9	7.86	---	---	---	---	1.04	100	<2	<3	0.153	0.18	<0.10	0.237	0.175	0.183	0.52
10A	5/8/2012	Routine	74	0.6	0.11	3.79	21	54	4.7	431.8	7.92	---	---	---	---	---	26	---	---	---	---	---	---	---	---	---
10B	5/10/2012	Routine	64	1.3	0.25	8.83	17	76	7.2	417.1	7.93	---	---	---	---	---	146	---	---	---	---	---	---	---	---	---
10C	5/15/2012	Routine	77	1.2	0.66	23.29	15.3	82	9.1	521.4	7.97	---	---	---	---	---	250	---	---	---	---	---	---	---	---	---
10D	5/17/2012	Routine	75	1.1	0.31	10.95	17.5	80	7.5	514.1	8.05	---	---	---	---	---	63	---	---	---	---	---	---	---	---	---
11	6/27/2012	Dry	90	0.6	0.07	2.35	19.1	78	7.1	399.9	8.11	---	---	---	---	1.43	75	<2	<3	<0.05	0.59	<0.10	<0.100	0.245	0.391	0.79
12	7/25/2012	Routine	96	0.6	0.19	6.57	24.7	87	7	488.5	8	---	---	---	---	2.5	73	4	<3	<0.05	0.88	<0.10	<0.100	0.159	0.23	1.08

Site 2

Sampling Event Number	Date	Type	Air Temp (°F)	Velocity (m/s)	Flow (m^3/s)	Flow (ft^3/s)	Water Temp (°C)	%DO	DO (mg/L)	Specific Conductivity (µS/cm)	pH	Habitat Assessment (RBP Score)	Habitat Assessment Classification	Biological Assessment (MBI Score)	Biological Assessment Classification	Turbidity (NTUs)	E. Coli (MPN/100 mL)	TSS (mg/L)	BOD-5 (mg/L)	NH3-N (mg/L)	Nitrate-N (mg/L)	Nitrite-N (mg/L)	TKN (mg/L)	Orthophosphate (mg/L)	Total Phosphorus (mg/L)	Total Nitrogen (mg/L)
1	8/29/2011	Routine	86	0.6	---	---	19.5	92	8.3	339.6	8.0	161	Good	65.42	Good	2.05	144	<2	<3	<0.05	1.07	<0.10	<0.10	0.231	0.256	1.27
2	9/8/2011	Routine	62	0.6	---	---	17.3	97	9.1	512.4	8.3	---	---	---	---	1.94	2420	4	<3	<0.05	1.90	<0.10	<0.10	0.281	0.101	2.10
3	10/6/2011	Dry	81	0.4	0.32	11.59	13.6	115	11.8	421.1	8.13	---	---	---	---	1.42	387	3	<3	<0.05	0.91	<0.10	0.126	0.143	0.176	1.14
4	11/1/2011	Routine	63	1.4	0.84	30.14	8.5	111	12.8	502.5	8.44	---	---	---	---	1.52	39	<2	<3	<0.05	2.73	<0.10	<0.10	0.203	0.244	2.93
5	12/19/2011	Routine	50	0.8	0.77	27.20	5.8	108	13.3	428.8	8.44	---	---	---	---	3.3	47	2	3	<0.05	2.36	<0.10	<0.10	0.191	0.132	2.56
6	1/16/2012	Routine	41	0.6	0.82	28.83	3.9	92	12	460.8	8.36	---	---	---	---	4.51	10	3	<3	<0.05	2.63	<0.10	<0.10	0.186	0.281	2.83
7	2/23/2012	Routine	58	0.6	0.46	16.35	8.4	116	13.1	444.5	8.74	---	---	---	---	2.04	72	2	<3	<0.05	1.72	<0.10	0.351	0.157	0.163	2.17
8	3/21/2012	Routine	80	0.4	1.09	38.69	13.7	101	10.3	436.1	8.15	---	---	---	---	0.73	68	4	<3	<0.05	1.98	<0.10	<0.10	0.22	0.128	2.18
MST-A	4/4/2012	MST Dry	76	0.55	0.33	11.54	---	---	---	---	---	---	---	---	---	---	62	---	---	---	---	---	---	---	---	---
9	4/11/2012	Dry	50	0.6	0.37	12.90	---	---	---	---	---	---	---	---	---	0.999	39	14	<3	<0.05	0.76	<0.10	<0.10	0.15	0.055	0.96
MST-B	4/27/2012	MST Dry	62	0.6	0.26	9.30	---	---	---	---	---	---	---	---	---	---	32	---	---	---	---	---	---	---	---	---
10	5/3/2012	Routine	80	0.9	0.29	10.31	19.3	91	8.2	371.1	8.32	---	---	---	---	1.26	27	<2	<3	<0.05	0.39	<0.1	0.206	0.118	0.078	0.70
10A	5/8/2012	Routine	74	1.3	0.60	21.25	19.9	75	6.6	434.6	8.1	---	---	---	---	---	308	---	---	---	---	---	---	---	---	---
10B	5/10/2012	Routine	64	0.4	0.21	7.48	15.7	89	8.7	421.2	8.18	---	---	---	---	---	20	---	---	---	---	---	---	---	---	---
10C	5/15/2012	Routine	77	0.9	0.52	18.37	14.9	93	9.2	512.8	8.29	---	---	---	---	---	435	---	---	---	---	---	---	---	---	---
10D	5/17/2012	Routine	75	0.6	0.36	12.66	16.5	87	8.3	495.4	8.25	---	---	---	---	---	97	---	---	---	---	---	---	---	---	---
11	6/27/2012	Dry	90	0.6	0.19	6.84	18.7	82	7.5	384.6	8.04	---	---	---	---	1.75	31	<2	<3	<0.05	0.57	<0.10	<0.100	0.172	0.245	0.77
12	7/25/2012	Routine	96	0.3	0.19	6.82	24.2	97	7.9	457.7	8.18	---	---	---	---	1.78	132	2	<3	<0.05	1.08	<0.10	<1.0	0.086	0.193	1.28
MST-C	8/28/2012	MST Wet	87	0.6	0.50	17.63	22.5	88	7.4	413.2	7.83	---	---	---	---	---	4611	---	---	---	---	---	---	---	---	---

Site 3

Sampling Event Number	Date	Type	Air Temp (°F)	Velocity (m/s)	Flow (m^3/s)	Flow (ft^3/s)	Water Temp (°C)	%DO	DO (mg/L)	Specific Conductivity (µS/cm)	pH	Habitat Assessment (RBP Score)	Habitat Assessment Classification	Biological Assessment (MBI Score)	Biological Assessment Classification	Turbidity (NTUs)	E. Coli (MPN/100 mL)	TSS (mg/L)	BOD-5 (mg/L)	NH3-N (mg/L)	Nitrate-N (mg/L)	Nitrite-N (mg/L)	TKN (mg/L)	Orthophosphate (mg/L)	Total Phosphorus (mg/L)	Total Nitrogen (mg/L)
1	8/26/2011	Routine	86	0.6	---	---	21.2	98	8.5	291.2	8.1	111/131	Poor/Good	65.71	Good	1.9	98	3	<3	<0.05	1.22	<0.10	<0.10	0.276	0.260	1.42
2	9/8/2011	Routine	62	0.4	---	---	17.8	98	9	499.8	8.2	---	---	---	---	1.54	921	<2	<3	<0.05	1.77	<0.10	0.231	0.222	0.110	2.10
3	10/6/2011	Dry	81	0.3	0.18	6.58	14.7	116	11.6	408.9	8	---	---	---	---	40.7	131	80	3	<0.05	0.5	<0.10	0.173	0.281	0.27	0.77
4	11/1/2011	Routine	63	0.3	0.20	7.09	8.9	114	13	517.6	8.28	---	---	---	---	1.44	57	<2	<3	<0.05	1.34	<0.10	<0.10	0.114	0.134	1.54
5	12/15/2011	Wet	61	0.65	0.36	12.71	10.3	101	11	396.7	8.32	---	---	---	---	11.9	51	8	5	<0.05	1.37	<0.10	<0.10	0.151	0.136	1.57
6	1/16/2012	Routine	41	0.6	0.55	19.28	4.6	102	12.9	469.5	8.36	---	---	---	---	5.49	80	4	<3	<0.05	1.22	<0.10	<0.10	0.101	0.177	1.42
7	2/23/2012	Routine	58	0.5	0.29	10.20	7.8	123	14.2	---	8.68	---	---	---	---	2.55	57	<2	<3	<0.05	0.59	<0.10	0.162	0.155	0.07	0.85
8	3/21/2012	Routine	80	0.5	0.48	16.87	15.3	123	12.1	423.5	8.64	---	---	---	---	<0.50	125	<2	3	<0.05	0.65	<0.10	<0.10	0.121	0.05	0.85
9	4/11/2012	Dry	50	0.4	0.14	5.09	9.5	146	16.4	369.2	8.74	---	---	---	---	1.34	15	3	<3	<0.05	<0.10	<0.10	<0.10	0.064	<0.033	<0.3
10	5/3/2012	Routine	80	0.3	0.05	1.80	18.6	99	9.1	390.6	8.39	---	---	---	---	0.77	200	<2	<3	<0.05	<0.10	<0.10	0.117	<0.033	<0.033	0.32
10A	5/8/2012	Routine	74	0.6	0.36	12.85	19	76	6.8	415.9	7.96	---	---	---	---	---	46	---	---	---	---	---	---	---	---	---
10B	5/10/2012	Routine	64	0.4	0.07	2.65	15.6	129	12.5	401.2	8.59	---	---	---	---	---	41	---	---	---	---	---	---	---	---	---
10C	5/15/2012	Routine	77	0.4	0.19	6.62	15.5	91	8.8	520.7	8.25	---	---	---	---	---	410	---	---	---	---	---	---	---	---	---
10D	5/17/2012	Routine	75	0.5	0.10	3.60	17.6	101	9.4	478.7	8.34	---	---	---	---	---	63	---	---	---	---	---	---	---	---	---
11	6/27/2012	Dry	90	0.5	0.12	4.17	17.8	93	8.6	354	8.26	---	---	---	---	1.9	86	<2	<3	<0.05	0.47	<0.1	<0.1	0.129	0.135	0.67
12	7/25/2012	Routine	96	0.3	0.15	5.29	24.3	103	8.3	422.8	8.21	---	---	---	---	1.96	63	3	<3	<0.05	1.07	<0.1	1.43	0.106	0.206	2.6

🟥 Indicates exceedance of water quality benchmarks

🟦 Indicates water quality benchmarks not comparable per KDOW

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Site 4

Sampling Event Number	Date	Type	Air Temp (°F)	Velocity (m/s)	Flow (m^3/s)	Flow (ft^3/s)	Water Temp (°C)	%DO	DO (mg/L)	Specific Conductivity (µS/cm)	pH	Habitat Assessment (RBP Score)	Habitat Assessment Classification	Biological Assessment (MBI Score)	Biological Assessment Classification	Turbidity (NTUs)	E. Coli (MPN/100 mL)	TSS (mg/L)	BOD-5 (mg/L)	NH3-N (mg/L)	Nitrate-N (mg/L)	Nitrite-N (mg/L)	TKN (mg/L)	Orthophosphate (mg/L)	Total Phosphorus (mg/L)	Total Nitrogen (mg/L)
1	8/26/2011	Routine	86	0.2	---	---	23.3	63	5.3	306.8	7.6	99	Poor	34.37	Poor	3.9	1314	6	9	0.888	0.4	0.23	0.903	0.265	0.335	1.53
2	9/8/2011	Routine	62	0.8	---	---	19	85	7.7	513.6	7.9	---	---	---	---	3.8	>2420	2	<3	0.581	1.05	0.19	0.310	0.192	0.076	1.55
3	10/6/2011	Dry	81	0.3	0.07	2.33	19.3	6	0.6	400.4	7.39	---	---	---	---	538	>2420	768	20	0.934	0.45	<0.10	1.97	3.05	5.7	2.52
4	11/1/2011	Routine	63	0.9	0.21	7.50	11.1	110	11.9	530.1	8.06	---	---	---	---	2.63	46	2	<3	0.086	1.38	<0.10	<0.10	0.121	0.136	1.58
5	12/15/2011	Wet	61	1.0	0.27	9.46	10.1	100	10.9	409.4	8.14	---	---	---	---	16.2	87	9	5	<0.05	1.37	<0.10	<0.10	0.154	0.17	1.57
6	1/16/2012	Routine	41	1.1	0.55	19.28	4.8	101	12.7	485.2	8.24	---	---	---	---	8.1	80	5	<3	<0.05	1.27	<0.10	0.184	0.111	0.203	1.55
7	2/23/2012	Routine	58	1.0	0.39	13.82	8.6	131	14.6	451.6	8.57	---	---	---	---	4.86	57	9	<3	<0.05	0.72	<0.10	0.308	0.074	0.1	1.13
8	3/21/2012	Routine	80	1.0	0.39	13.66	14.9	122	12	437.9	8.38	---	---	---	---	0.673	199	<2	<3	<0.05	0.74	<0.10	<0.10	0.133	0.118	0.94
MST-A	4/4/2012	MST Dry	76	0.9	0.28	10.02	---	---	---	---	---	---	---	---	---	---	44	---	---	---	---	---	---	---	---	---
9	4/11/2012	Dry	50	0.8	0.21	7.36	11.8	128	13.6	382.7	8.3	---	---	---	---	3.75	27	11	<3	<0.05	0.11	<0.10	<0.10	0.056	0.102	0.31
MST-B	4/27/2012	MST Dry	62	<0.1	0.00	0.02	---	---	---	---	---	---	---	---	---	---	9	---	---	---	---	---	---	---	---	---
10	5/3/2012	Routine	80	0.5	0.15	5.41	17.3	97	9.1	383.4	8.17	---	---	---	---	1.76	410	3	<3	<0.05	<0.10	<0.10	0.113	0.053	<0.033	0.31
10A	5/8/2012	Routine	74	0.1	0.01	0.32	18.7	85	7.7	425	8.44	---	---	---	---	---	548	---	---	---	---	---	---	---	---	---
10B	5/10/2012	Routine	64	<0.1	0.01	0.35	15.6	101	9.6	413.9	8.16	---	---	---	---	---	2105	---	---	---	---	---	---	---	---	---
10C	5/15/2012	Routine	77	1.0	0.27	9.65	17	102	9.6	488.6	8.11	---	---	---	---	---	272	---	---	---	---	---	---	---	---	---
10D	5/17/2012	Routine	75	0.6	0.13	4.52	17.3	106	9.9	435.6	8.16	---	---	---	---	---	98	---	---	---	---	---	---	---	---	---
11	6/27/2012	Dry	90	0.1	0.02	0.72	20.6	78	6.8	351	7.74	---	---	---	---	2.7	52	3	<3	0.254	0.23	<0.10	<0.100	0.125	0.128	0.43
12	7/25/2012	Routine	96	0.6	0.15	5.25	25	108	8.6	382.6	7.99	---	---	---	---	3.11	259	<2	3	0.711	0.39	<0.10	1.83	0.132	0.232	2.32
MST-C	8/28/2012	MST Wet	87	1.5	1.82	64.26	22.8	89	7.5	290.3	7.59	---	---	---	---	---	21870	---	---	---	---	---	---	---	---	---

Site 5

Sampling Event Number	Date	Type	Air Temp (°F)	Velocity (m/s)	Flow (m^3/s)	Flow (ft^3/s)	Water Temp (°C)	%DO	DO (mg/L)	Specific Conductivity (µS/cm)	pH	Habitat Assessment (RBP Score)	Habitat Assessment Classification	Biological Assessment (MBI Score)	Biological Assessment Classification	Turbidity (NTUs)	E. Coli (MPN/100 mL)	TSS (mg/L)	BOD-5 (mg/L)	NH3-N (mg/L)	Nitrate-N (mg/L)	Nitrite-N (mg/L)	TKN (mg/L)	Orthophosphate (mg/L)	Total Phosphorus (mg/L)	Total Nitrogen (mg/L)
1	8/26/2011	Routine	86	Pooled	---	---	20.3	20	1.8	361.8	7.6	---	---	---	---	2.45	389	2	<3	0.284	0.11	<0.10	0.469	0.396	0.475	0.68
2	9/8/2011	Routine	62	0.4	---	---	18.1	107	9.9	750	8.2	---	---	---	---	1.01	1300	<2	<3	0.061	1.11	0.12	<0.10	0.169	0.071	1.33
3	10/6/2011	Dry	81	0.1	0.004	0.14	15.4	101	9.8	794	7.85	---	---	---	---	4.7	146	2	<3	0.067	<0.10	<0.10	0.274	0.21	0.269	0.47
4	11/1/2011	Routine	63	0.1	0.017	0.60	8.5	11.4	13.1	697.8	8.23	---	---	---	---	4.58	74	2	<3	<0.05	0.97	<0.10	<0.10	0.102	0.102	1.17
5	12/15/2011	Wet	61	0.4	0.19	6.79	10.9	100	10.6	498.6	8.28	---	---	---	---	24.8	411	22	6	<0.05	1.01	<0.10	0.119	0.1	0.126	1.23
6	1/16/2012	Routine	41	0.3	0.10	3.43	5.7	99	12.1	687.3	8.23	---	---	---	---	28.9	50	21	<3	0.468	2.79	0.24	0.875	0.12	0.186	3.91
7	2/23/2012	Routine	58	0.3	0.06	2.12	10.8	150	16	551.6	8.72	---	---	---	---	5.98	34	8	<3	<0.05	0.63	<0.10	0.164	<0.033	0.05	0.89
8	3/21/2012	Routine	80	0.3	0.10	3.44	16.4	149	14.3	556.6	8.59	---	---	---	---	<0.50	154	<2	<3	<0.05	0.55	<0.10	<0.10	0.052	<0.033	0.75
acro/MST-	4/4/2012	MST Dry	76	<0.1	0.00	0.17	20.2	210	18.4	440.9	9.15	65	Poor	---	---	---	41	---	---	---	---	---	---	---	---	---
9	4/11/2012	Dry	50	<0.1	Minimal	Minimal	10.4	174	19.1	422.3	8.55	---	---	---	---	2.13	4	3	<3	<0.05	<0.10	<0.10	<0.10	0.053	0.038	<0.30
MST-B	4/27/2012	MST Dry	62	<0.1	0.01	0.24	---	---	---	---	---	---	---	---	---	---	36	---	---	---	---	---	---	---	---	---
10	5/3/2012	Routine	80	Pooled	---	---	20.9	28	2.5	527.5	7.26	---	---	---	---	17.5	8664	25	4	<0.05	<0.10	<0.10	0.211	0.146	0.175	0.41
10A	5/8/2012	Routine	74	<0.1	Minimal	Minimal	20.7	39	3.3	687	7.65	---	---	---	---	---	435	---	---	---	---	---	---	---	---	---
10B	5/10/2012	Routine	64	Pooled	---	---	14.9	40	3.9	791	7.56	---	---	---	---	---	86	---	---	---	---	---	---	---	---	---
10C	5/15/2012	Routine	77	0.3	0.03	0.94	18.1	93	8.5	698	8.03	---	---	---	---	---	1430	---	---	---	---	---	---	---	---	---
10D	5/17/2012	Routine	75	<0.1	Minimal	Minimal	16.9	53	4.8	716	7.67	---	---	---	---	---	410	---	---	---	---	---	---	---	---	---
11	6/27/2012	Dry	90	No Water	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
12	7/25/2012	Routine	96	No Water	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
MST-C	8/28/2012	MST Wet	87	0.9	0.50	17.75	23.2	80	6.7	225.7	7.59	---	---	---	---	---	41060	---	---	---	---	---	---	---	---	---

🟥	Indicates exceedance of water quality benchmarks
🟦	Indicates water quality benchmarks not comparable per KDOW

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Site 6

Sampling Event Number	Date	Type	Air Temp (°F)	Velocity (m/s)	Flow (m^3/s)	Flow (ft^3/s)	Water Temp (°C)	%DO	DO (mg/L)	Specific Conductivity (µS/cm)	pH	Habitat Assessment (RBP Score)	Habitat Assessment Classification	Biological Assessment (MBI Score)	Biological Assessment Classification	Turbidity (NTUs)	E. Coli (MPN/100 mL)	TSS (mg/L)	BOD-5 (mg/L)	NH3-N (mg/L)	Nitrate-N (mg/L)	Nitrite-N (mg/L)	TKN (mg/L)	Orthophosphate (mg/L)	Total Phosphorus (mg/L)	Total Nitrogen (mg/L)
1	8/26/2011	Routine	86	Pooled	---	---	20.6	15	1.3	748	7.5	---	---	---	---	4.18	383	6	<3	<0.05	<0.10	<0.10	0.167	0.171	0.193	0.37
2	9/8/2011	Routine	62	0.1	---	---	18.6	86	7.7	807	8.0	---	---	---	---	1.67	517	<2	<3	<0.05	1.17	<0.10	0.111	0.100	<0.033	1.38
3	10/6/2011	Dry	81	<0.1	0.008	0.30	15.9	118	11.4	917	7.88	---	---	---	---	2.7	1046	3	<3	0.053	<0.10	<0.10	0.136	0.096	0.111	0.34
4	11/1/2011	Routine	63	0.1	0.017	0.60	10.3	104	11.4	853	8.07	---	---	---	---	4.52	214	2	3	<0.05	0.88	<0.10	<0.10	0.097	0.115	1.08
5	12/15/2011	Wet	61	0.4	0.09	3.28	11.7	100	9.6	516	8.05	---	---	---	---	42.2	>2420	28	5	<0.05	1.11	<0.10	<0.10	0.094	0.127	1.31
6	1/16/2012	Routine	41	0.3	0.01	0.48	6.2	99	11.9	779	8.32	---	---	---	---	4.08	80	3	<3	<0.05	1.34	<0.10	0.105	0.071	0.116	1.55
7	2/23/2012	Routine	58	0.3	0.04	1.24	12.1	147	15	740	8.53	---	---	---	---	1.83	99	5	<3	<0.05	0.74	<0.10	0.245	<0.033	0.038	1.09
Macro	3/7/2012	Macro	---	---	---	---	8.4	124	14.3	718	8.16	104	Poor	22.02	Poor	---	---	---	---	---	---	---	---	---	---	---
8	3/21/2012	Routine	80	0.1	0.01	0.43	17.8	164	15.2	638	8.55	---	---	---	---	<0.50	150	<2	3	<0.05	0.51	<0.10	<0.10	0.068	<0.033	0.71
MST-A	4/4/2012	MST Dry	76	0.1	0.01	0.20	---	---	---	---	---	---	---	---	---	---	72	---	---	---	---	---	---	---	---	---
9	4/11/2012	Dry	50	<0.1	Minimal	Minimal	10.7	173	18.3	729	8.56	---	---	---	---	4.72	35	14	<3	<0.05	<0.10	<0.10	<0.10	0.07	0.185	<0.30
MST-B	4/27/2012	MST Dry	62	<0.1	0.01	0.29	---	---	---	---	---	---	---	---	---	---	248	---	---	---	---	---	---	---	---	---
10	5/3/2012	Routine	80	Pooled	---	---	20	8	0.7	837	7.12	---	---	---	---	5.01	1230	7	18	1.6	<0.10	<0.10	1.01	0.372	0.587	1.21
10A	5/8/2012	Routine	74	0.6	0.02	0.54	21.6	71	6.1	575	7.95	---	---	---	---	---	2420	---	---	---	---	---	---	---	---	---
10B	5/10/2012	Routine	64	<0.1	0.00	0.08	16	67	6.4	809	7.94	---	---	---	---	---	4352	---	---	---	---	---	---	---	---	---
10C	5/15/2012	Routine	77	0.2	0.02	0.78	18.5	111	10.1	761	8.16	---	---	---	---	---	1169	---	---	---	---	---	---	---	---	---
10D	5/17/2012	Routine	75	0.1	0.00	0.15	18.7	111	10	800	8.08	---	---	---	---	---	1291	---	---	---	---	---	---	---	---	---
11	6/27/2012	Dry	90	No Water	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
12	7/25/2012	Routine	96	No Water	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
MST-C	8/28/2012	MST Wet	87	0.3	0.04	1.3	23.1	74	6.2	354.6	7.45	---	---	---	---	---	28680	---	---	---	---	---	---	---	---	---

🟥 Indicates exceedance of water quality benchmarks

🟦 Indicates water quality benchmarks not comparable per KDOW

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QA/QC Water Sampling Data

Sampling Event Number	Date	Type	Air Temp (°F)	Velocity (m/s)	Flow (m/s)	Flow (ft/s)	Water Temp (°C)	%DO	DO (mg/L)	Conductivity	pH	Habitat Assessment (RBP Score)	Habitat Assessment Classification	Biological Assessment (MBI Score)	Biological Assessment Classification	Turbidity (NTUs)	E. Coli (MPN/100 mL)	TSS (mg/L)	BOD-5 (mg/L)	NH3-N (mg/L)	Nitrate-N (mg/L)	Nitrite-N (mg/L)	TKN (mg/L)	Orthophosphate (mg/L)	Total Phosphorus (mg/L)
1	8/29/2011	Blank	86	---	---	---	---	---	---	---	---	---	---	---	---	0.168	<10	<2	<3	<0.05	1.07	<0.10	<0.10	<0.033	<0.066
2	9/8/2011	Duplicate - Site 4	62	---	---	---	---	---	---	---	---	---	---	---	---	3.41	>2420	2	<3	0.593	1.06	0.18	0.177	0.254	0.073
5	12/15/2011	Blank	61	---	---	---	---	---	---	---	---	---	---	---	---	0.681	<1	<2	4	<0.05	<0.10	<0.10	<0.10	<0.033	<0.033
6	1/16/2012	Duplicate - Site 3	41	---	---	---	---	---	---	---	---	---	---	---	---	5.96	80	2	<3	<0.05	1.23	<0.10	<0.10	0.123	0.128
8	3/21/2012	Blank	50	---	---	---	---	---	---	---	---	---	---	---	---	<0.50	<1	<2	<3	<0.05	<0.10	<0.10	<0.10	<0.033	<0.033
9	4/11/2012	Duplicate - Site 9	50	---	---	---	---	---	---	---	---	---	---	---	---	<0.50	80	<2	<3	<0.05	<0.10	<0.10	<0.10	0.048	<0.033
10A	5/8/2012	E coli - Site 7	74	---	---	---	---	---	---	---	---	---	---	---	---	---	38	---	---	---	---	---	---	---	---
11	6/27/2012	Blank	90	---	---	---	---	---	---	---	---	---	---	---	---	<0.50	<10	<2	<3	<0.05	<0.10	<0.10	<0.100	<0.033	<0.033
12	7/25/2012	Duplicate - Site 4	96													2.2	327	5	3	0.677	0.39	<0.10	1.82	0.134	0.182

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APPENDIX H

PHASE TWO MONITORING RESULTS

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Site 7

Sampling Event Number	Date	Type	Air Temp (°F)	Max Velocity (m/s)	Flow (m^3/s)	Flow (ft^3/s)	Water Temp (°C)	%DO	DO (mg/L)	Specific Conductivity (µS/cm)	pH	Habitat Assessment (RBP Score)	Habitat Assessment Classification	Biological Assessment (MBI Score)	Biological Assessment Classification	Turbidity (NTUs)	E. Coli (MPN/100 mL)	TSS (mg/L)	BOD-5 (mg/L)	NH3-N (mg/L)	Nitrate-N (mg/L)	Nitrite-N (mg/L)	TKN (mg/L)	Orthophosphate (mg/L)	Total Phosphorus (mg/L)	Total Nitrogen (mg/L)
5	12/15/2011	Wet	61	0.6	0.14	5.09	9.8	100	11.1	495.2	8.44	---	---	---	---	4.99	21	5	5	<0.05	2.00	<0.10	<0.10	0.357	0.36	2.20
6	1/16/2012	Routine	41	0.6	0.11	4.03	2.5	98	13.2	313.3	8.57	---	---	---	---	2.39	20	2	<3	<0.05	2.14	<0.10	<0.10	0.335	0.274	2.34
7	2/23/2012	Routine	58	0.4	0.03	1.16	6.7	106	12.6	596.6	8.65	---	---	---	---	3.18	36	8	<3	<0.05	1.55	<0.10	0.219	0.267	0.311	1.87
8	3/21/2012	Routine	80	0.6	0.06	2.02	13.8	101	10.3	540.2	8.5	---	---	---	---	1.22	115	12	<3	<0.05	1.17	<0.10	<0.10	0.351	0.306	1.37
Macro	4/4/2012	Macro	76	---	---	---	15.9	95	9.2	549.8	8.32	156	Good	57.76	Excellent	---	---	---	---	---	---	---	---	---	---	---
9	4/11/2012	Dry	50	0.3	0.01	0.21	9.5	102	11.5	578.4	8.1	---	---	---	---	2.5	10	<2	<3	<0.05	0.43	<0.10	<0.10	0.336	0.265	0.63
10	5/3/2012	Routine	80	0.1	0.00	0.05	17.2	52	4.9	675	7.82	---	---	---	---	1.65	100	2	<3	<0.05	<0.10	<0.10	<0.10	0.306	0.327	<0.30
10A	5/8/2012	Routine	74	0.6	0.01	0.43	19	52	4.7	788	7.78	---	---	---	---	---	50	---	---	---	---	---	---	---	---	---
10B	5/10/2012	Routine	64	<0.1	0.00	0.16	16.5	47	4.5	837	7.77	---	---	---	---	---	218	---	---	---	---	---	---	---	---	---
10C	5/15/2012	Routine	77	0.4	0.03	0.92	14.9	87	8.6	1004	8.18	---	---	---	---	---	272	---	---	---	---	---	---	---	---	---
10D	5/17/2012	Routine	75	0.1	0.01	0.20	16.4	71	6.7	1016	8.06	---	---	---	---	---	<10	---	---	---	---	---	---	---	---	---
11	6/27/2012	Dry	90	No Water	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
12	7/25/2012	Routine	96	0.1	0.00	0.13	22.8	51	4.3	1396	7.74	---	---	---	---	0.75	10	3	<3	<0.05	0.57	<0.10	<1	0.441	0.482	0.77
13	8/23/2012	Routine	88	No Water	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
14	9/4/2012	Routine	83	0.1	0.00	0.10	21.5	51	4.5	1232	7.7	---	---	---	---	0.96	166	9	<3	<0.05	2.5	<0.10	0.1	0.392	0.387	2.7

Site 8

Sampling Event Number	Date	Type	Air Temp (°F)	Max Velocity (m/s)	Flow (m^3/s)	Flow (ft^3/s)	Water Temp (°C)	%DO	DO (mg/L)	Specific Conductivity (µS/cm)	pH	Habitat Assessment (RBP Score)	Habitat Assessment Classification	Biological Assessment (MBI Score)	Biological Assessment Classification	Turbidity (NTUs)	E. Coli (MPN/100 mL)	TSS (mg/L)	BOD-5 (mg/L)	NH3-N (mg/L)	Nitrate-N (mg/L)	Nitrite-N (mg/L)	TKN (mg/L)	Orthophosphate (mg/L)	Total Phosphorus (mg/L)	Total Nitrogen (mg/L)
5	12/19/2011	Routine	50	0.4	0.19	6.89	7.7	106	12.5	431.6	8.5	---	---	---	---	3.04	111	<2	<3	<0.05	4.74	<0.10	<0.10	0.31	0.299	4.94
6	1/16/2012	Routine	41	0.4	0.31	10.86	6.7	105	12.7	431.7	8.48	---	---	---	---	3.67	30	<2	<3	<0.05	4.92	<0.10	<0.10	0.324	0.297	5.12
7	2/23/2012	Routine	58	0.3	0.17	5.98	9.4	113	12.5	427.6	8.73	---	---	---	---	2.51	261	6	<3	<0.05	3.72	<0.10	0.131	0.284	0.328	3.95
8	3/21/2012	Routine	80	0.4	0.31	10.98	12.5	110	11.5	424.8	8.22	---	---	---	---	4.53	88	5	<3	<0.05	4.24	<0.10	<0.10	0.366	0.27	4.44
Macro	4/4/2012	Macro	76	---	---	---	16	115	11.2	441.8	8.41	152	Fair	65	Excellent	---	---	---	---	---	---	---	---	---	---	---
9	4/11/2012	Dry	50	0.1	0.05	1.66	---	---	---	---	---	---	---	---	---	2.36	54	3	<3	<0.05	3.97	<0.10	<0.10	0.352	0.25	4.17
10	5/3/2012	Routine	80	<0.1	0.01	0.45	17.2	88	8.4	471.4	8.33	---	---	---	---	5.53	100	7	<3	<0.05	<0.10	<0.10	<0.10	0.414	0.445	<0.30
10A	5/8/2012	Routine	74	0.3	0.06	2.07	17.7	79	7.3	463.2	8.15	---	---	---	---	---	613	---	---	---	---	---	---	---	---	---
10B	5/10/2012	Routine	64	<0.1	0.02	0.58	13.3	94	9.6	480.7	8.32	---	---	---	---	---	243	---	---	---	---	---	---	---	---	---
10C	5/15/2012	Routine	77	0.4	0.11	4.04	13.5	97	9.9	492.4	8.27	---	---	---	---	---	880	---	---	---	---	---	---	---	---	---
10D	5/17/2012	Routine	75	0.3	0.11	3.87	14.6	95	9.5	490.1	8.38	---	---	---	---	---	216	---	---	---	---	---	---	---	---	---
11	6/27/2012	Dry	90	<0.1	0.01	0.33	15.9	88	8.4	506.9	8.35	---	---	---	---	2.64	175	<2	<3	<0.050	2.71	<0.10	<0.100	0.395	0.493	2.91
12	7/25/2012	Routine	96	0.1	0.03	0.93	21.6	97	8.4	569	8.25	---	---	---	---	3.68	197	7	<3	<0.050	2.98	<0.10	<1	0.449	0.442	3.18
13	8/23/2012	Routine	88	0.1	0.02	0.64	15.5	94	9.2	587.7	7.91	---	---	---	---	1.57	323	2	4	<0.050	2.3	<0.10	0.8	0.353	0.364	3.2
14	9/4/2012	Routine	83	0.2	0.02	0.78	20.5	90	7.9	582	8.12	---	---	---	---	1.29	866	7	<3	<0.05	2.52	<0.10	0.1	0.348	0.307	2.72

Site 9

Sampling Event Number	Date	Type	Air Temp (°F)	Max Velocity (m/s)	Flow (m^3/s)	Flow (ft^3/s)	Water Temp (°C)	%DO	DO (mg/L)	Specific Conductivity (µS/cm)	pH	Habitat Assessment (RBP Score)	Habitat Assessment Classification	Biological Assessment (MBI Score)	Biological Assessment Classification	Turbidity (NTUs)	E. Coli (MPN/100 mL)	TSS (mg/L)	BOD-5 (mg/L)	NH3-N (mg/L)	Nitrate-N (mg/L)	Nitrite-N (mg/L)	TKN (mg/L)	Orthophosphate (mg/L)	Total Phosphorus (mg/L)	Total Nitrogen (mg/L)
5	12/15/2011	Wet	61	0.1	0.08	2.68	11.6	96	10.1	362	8.17	---	---	---	---	62	727	<2	5	<0.05	0.94	<0.10	0.146	0.094	0.249	1.19
6	1/16/2012	Routine	41	0.1	0.02	0.79	6.2	101	12.2	651.9	8.43	---	---	---	---	3.51	10	2	<3	<0.05	1.68	<0.10	<0.10	0.064	0.064	1.88
7	2/23/2012	Routing	58	0.3	0.02	0.87	13.1	161	16.3	543.2	8.69	---	---	---	---	1.48	22	6	<3	<0.05	0.72	<0.10	0.114	0.034	<0.033	0.93
Macro	3/7/2012	Macro	---	---	---	---	9.9	150	16.6	621	8.54	107	Poor	25.04	Poor	---	---	---	---	---	---	---	---	---	---	---
8	3/21/2012	Routine	80	0.3	0.02	0.75	18.3	181	16.6	507	8.64	---	---	---	---	<0.50	206	<2	<3	<0.05	0.37	<0.10	<0.10	0.035	<0.033	0.57
9	4/11/2012	Dry	50	<0.1	0.00	0.11	14.5	164	16.3	505.4	8.7	---	---	---	---	<0.50	195	4	<3	<0.05	<0.10	<0.10	<0.10	0.039	<0.033	<0.30
10	5/3/2012	Routine	80	No Water	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
10A	5/8/2012	Routine	74	0.3	0.03	0.96	22.9	65	5.4	572	7.85	---	---	---	---	---	1414	---	---	---	---	---	---	---	---	---
10B	5/10/2012	Routine	64	<0.1	0.00	0.10	20.5	98	8.5	743	8.02	---	---	---	---	---	173	---	---	---	---	---	---	---	---	---
10C	5/15/2012	Routine	77	0.3	0.03	0.92	20.6	111	9.7	707	8.24	---	---	---	---	---	556	---	---	---	---	---	---	---	---	---
10D	5/17/2012	Routine	75	0.1	0.00	0.10	22.2	141	11.9	729	8.33	---	---	---	---	---	238	---	---	---	---	---	---	---	---	---
11	6/27/2012	Dry	90	No Water	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
12	7/25/2012	Routine	96	No Water	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
13	8/23/2012	Routine	88	No Water	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
14	9/4/2012	Routine	83	0.3	0.01	0.37	23.4	127	10.5	708	8.09	---	---	---	---	<0.50	308	4	<3	<0.05	1.16	<0.10	0.1	0.092	0.044	1.36

🟥	Indicates exceedance of water quality benchmarks
🟦	Indicates water quality benchmarks not comparable per KDOW

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Site 10

Sampling Event Number	Date	Type	Air Temp (°F)	Max Velocity (m/s)	Flow (m^3/s)	Flow (ft^3/s)	Water Temp (°C)	%DO	DO (mg/L)	Specific Conductivity (µS/cm)	pH	Habitat Assessment (RBP Score)	Habitat Assessment Classification	Biological Assessment (MBI Score)	Biological Assessment Classification	Turbidity (NTUs)	E. Coli (MPN/100 mL)	TSS (mg/L)	BOD-5 (mg/L)	NH3-N (mg/L)	Nitrate-N (mg/L)	Nitrite-N (mg/L)	TKN (mg/L)	Orthophosphate (mg/L)	Total Phosphorus (mg/L)	Total Nitrogen (mg/L)
5	12/15/2011	Wet	61	0.4	0.07	2.37	11.5	92	9.7	334.5	7.96	---	---	---	---	105	>2420	<2	5	0.054	0.68	<0.10	0.109	0.173	0.252	0.89
6	1/16/2012	Routine	411	0.3	0.02	0.67	6.1	100	12.1	495.2	8.3	---	---	---	---	4.49	270	6	<3	<0.05	1.3	<0.10	<0.10	0.076	0.059	1.50
7	2/23/2012	Routine	58	0.3	0.03	0.89	10.9	139	14.7	657	8.52	---	---	---	---	3.18	68	10	<3	<0.05	0.78	<0.10	0.205	0.051	<0.033	1.09
8	3/21/2012	Routine	80	0.3	0.01	0.41	16.3	161	15.5	608	8.51	---	---	---	---	1.27	86	<2	<3	<0.05	0.63	<0.10	<0.10	0.098	0.04	0.83
lacro/MST-	4/4/2012	MST Dry	76	0.2	0.00	0.15	19.4	167	14.8	683	8.43	82	Poor	21.83	Poor	---	387	---	---	---	---	---	---	---	---	---
9	4/11/2012	Dry	50	0.1	0.00	0.11	11	158	16.9	721	8.5	---	---	---	---	1.31	157	5	<3	<0.05	0.24	<0.10	<0.10	0.09	<0.033	0.44
MST-B	4/27/2012	MST Dry	62	<0.1	0.00	0.09	---	---	---	---	---	---	---	---	---	---	150	---	---	---	---	---	---	---	---	---
10	5/3/2012	Routine	80	<0.1	0.00	0.05	21.6	107	9.3	773	8.22	---	---	---	---	3.65	79	3	<3	<0.05	<0.10	<0.10	<0.10	<0.033	0.127	<0.30
10A	5/8/2012	Routine	74	0.5	0.03	1.04	20.5	77	6.7	618	8	---	---	---	---	---	3448	---	---	---	---	---	---	---	---	---
10B	5/10/2012	Routine	64	<0.1	0.00	0.15	16.5	126	11.8	823	8.3	---	---	---	---	---	160	---	---	---	---	---	---	---	---	---
10C	5/15/2012	Routine	77	0.6	0.03	1.07	16.8	105	9.9	713	8.18	---	---	---	---	---	862	---	---	---	---	---	---	---	---	---
10D	5/17/2012	Routine	75	0.3	0.02	0.64	17.6	106	9.8	746	8.2	---	---	---	---	---	862	---	---	---	---	---	---	---	---	---
11	6/27/2012	Dry	90	No Water	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
12	7/25/2012	Routine	96	<0.1	0.00	0.06	25.5	114	8.9	824	8.03	---	---	---	---	1.31	816	<2	<3	<0.05	0.57	<0.10	<1	0.058	0.057	0.77
13	8/23/2012	Routine	88	Minimal	Minimal	Minimal	18.2	58	5.3	883	7.85	---	---	---	---	7.66	1309	2	3	0.06	<0.10	<0.10	<0.10	0.098	0.044	<0.3
MST-C	8/28/2012	MST Wet	87	0.3	0.04	1.30	22.7	79	6.6	360.2	7.41					---	17230	---	---	---	---	---	---	---	---	---
14	9/4/2012	Routine	83	0.1	0.02	0.85	22.4	87	7.3	850	7.96	---	---	---	---	0.55	1733	<2	<3	<0.05	1.18	<0.10	0.2	0.072	0.043	1.48

🟥 Indicates exceedance of water quality benchmarks

🟦 Indicates water quality benchmarks not comparable per KDOW

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APPENDIX I

MICROBIAL SOURCE TRACKING RESULTS

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Final Report and Executive Summary to Palmer Engineering on Water Quality Study on Lower Howards Creek

Date of Final Report: September 30, 2012

Title: **IDENTIFYING HOT-SPOTS IN LOWER HOWARDS CREEK WATERSHED**

Investigators: Dr. Gail Brion

Institution: University of Kentucky

Research Category: Subcontract through ERTL

Project Period: 3-15-12 TO 12-30-2012

Description and Objective of Research:
To use a model blending signals from indicators representative of fecal load, source, and age to identify regions of Lower Howards Creek Watershed most impacted by sewage exfiltration under dry weather conditions.

Synopsis: A simple modeling system based on multiple water quality indicators was created and evaluated in prior LFUCG sponsored projects in the Wolf Run and West Hickman Watersheds. This system was proven to be applicable for ranking regions within the watershed with respects to the degree of sewage intrusion based upon a Sanitary Category Value (SCV). The SCV could be used to pinpoint hotspots of sewage intrusion into the watershed and prioritize areas for remediation. The same approach and modeling system was applied to water quality samples obtained from Lower Howards Creek Watershed under dry weather conditions. The overall results of this study show that while Lower Howards Creek does not have sites that are as severely impacted by fresh human sewage as was found in Wolf Run (i.e. SCV values statistically indistinguishable from influent sewage), there are some sample sites that show the continuous presence of human sewage, and all sites deteriorate in quality when it rains. These hotspots require further investigation to determine the source so that remediation can be undertaken and these potential sources of disease eliminated from the watershed.

Executive Summary:

Lower Howards Creek Watershed Quality Project. In concert with the consulting firm, Palmer Engineering, an intensive sampling program was initiated at 5 sites selected by Palmer engineering in Lower Howards Creek watershed during the period of March 21st through August 28th 2012. During this time, 7 rounds of sample events were completed under both wet (1) and dry (6) weather conditions. Grab samples from the selected sites were analyzed for indicators of fecal load (*E. coli*, and a non-host specific *Bacteroides* DNA marker Allbac), fecal source (two human host specific *Bacteroides* DNA markers, Hubac and qHF183), and fecal age (AC/TC ratio). The first 3 dry weather sampling events did not provide complete results for quality indicators that are used to compute the SCV due to receipt of improperly prepared laboratory media. Therefore more sample events were scheduled to provide for the contracted 4 complete sample event. A final, complete database of multiple indicator concentrations from 4 sampling events (3 dry, 1 wet) at the 5 sites was created. Infilling of 1 missing qPCR value for HuBac at LHC-05 on 5/3/2012 with an average of all other dry days HuBac concentrations was done after some samples showed intractable inhibition. Laboratory results from inlet sewage samples taken at Town Branch WW Treatment facility of Lexington during a prior study were used for comparison to the results collected in Lower Howards Creek for Palmer Engineering.

The resultant database was analyzed for the purpose of ranking the average water quality at each site with respects to degree of human sewage contamination. Individual indicator results for fecal load, source, and age were analyzed to determine the presence and impact of sewage in the surface water. Then indicator values were compared to conditions found in domestic sewage using a simple, categorical model developed by Dr. Gail Brion (Model II). Model II calculated a Sanitary Category Value (SCV) between 0.00 and 3.00 for each location and observation. The SCV calculated by the model was comprised of a summation of values between 0 and 1 for each of the three indicator classes selected: 1) fecal load (*E. coli*), 2) fecal age (AC/TC), and 3) relative strength of human fecal source ($\log_{10}$Hubac/log10HubacMax). Low SCVs (<1.0) are related to conditions associated with cleaner surface waters (low fecal load, little detectable human signal, and old fecal age). High SCVs (>1.5) are associated with higher values of fecal load, a greater detectable value for human specific qPCR markers, and a lower fecal age. Historical results for inlet sewage SCVs from the wastewater treatment plant on Town Branch in Lexington were used as a referent to compare the average SCVs at each site against. SCVs were used to rank water quality at the sites relative to inlet sewage, and to each other.

Common statistical analyses were done to determine if there were differences between the average, calculated SCVs at each site and average sewage SCVs. The purpose of the analysis of average SCVs found during dry weather conditions was to highlight sites within the watershed that were under the gross influence of domestic sewage during the sampling period. Two sample sites (LHC-05 and LHC-06) were found to have SCV values higher than all other sites in both dry and wet conditions with LHC-10 following next in rank. However, no site's average SCV was above 1.50 for dry conditions, the established level of concern from the model's application in prior studies. Three sites (LHC-05, LHC-6, and LHC-10) consistently had the highest *E. coli* levels on both dry days indicative of high fecal loading. Site LHC-06 had the lowest fecal age during both wet and dry sampling events, followed in rank by sites LHC-05 and LHC-10. These 3 sites, LHC-05, LHC-06, and LHC-10 are indicated to be hotspots by SCV relative to sites LHC-04 and LHC-02.

The results from the SCV model are brought into sharper focus by the measurement of a highly human fecal specific marker qHF183. The qHF183 marker has been shown to be more specific to human fecal materials than the HuBac marker, but is present at lower levels in inlet sewage samples by more than a factor of 1000. Hence, as suspected for a less-urbanized watershed than previous studies, the detection of the more specific, human-linked marker, qHF183, was sporadic and this marker was present only 8 times in 35 samples at quantifiable levels. All sites in the watershed had the presence of this marker detected at one time or another during the period of study. However, the qHF183 marker was detected consistently (6 of 6), in quantifiable levels (4 of 6), in samples from LHC-04. While the SCVs for LHC-04 are not as high as those for LHC-05, LHC-06, and LHC-10, the consistent signal of human fecal material is undeniable and marks this site as one that is receiving human fecal materials, in small, consistent quantities. In terms of percent positive samples for qHF183 prevalence, the sites can be ranked in descending order of: LHC-04 (100%), LHC-10 (83%), LHC-05 (75%), LHC-02 (50%), and LHC-06 (17%).

Putting the SCV values, the prevalence of qHF183 marker, and the direction of flow between the sites together, one can come up with a picture of what is going on in the watershed during dry days. Starting at LHC-06, there is a fresh and fairly high fecal load coming into the creek from the surrounding landscape. This load is from mixed sources; there is a human specific qHF183 signal that shows up, but it is not consistently present though HuBac is always present. So Lower Howards Creek starts at fairly fresh, high fecal loadings from mixed sources (predominantly non-human). Moving downstream, LHC-10 is located at a tributary draining another portion of the watershed into Howards Creek. LHC-10 has overall lesser fecal loads, and the fecal material is a bit more aged, than present at LHC-06. However, LHC-10 has a persistent human signal as indicated by 83% qHF183 marker presence. There are human sewage inputs to the creek from LHC-10. This site is a source for human fecal associated pathogens to be input into the creek.

The two signals from LHC-06 and LHC-10 are blended together and the result can be seen in the data collected at LHC-05, which shows a higher SCV than LHC-10 and a lower SCV than LHC-06. The blended signal also is seen in the increase in detection of human specific qHF183 at LHC-05 as compared to that found at LHC-06, and a less prevalent human signal than LHC-10. One day, 4-27, neither marker is present at LHC-05 although HuBac was detected in both LHC-06 and LHC-10, with qHF183 also detected at LHC-10. This indicates that the signals from LHC-06 and LHC-10 are being diluted with fresh, clean water inputs.

The creek continues to flow downstream, taking on cleaner water, diluting and aging the fecal load signals. However, at LHC-04 human signal is input w/o the addition of fecal load or significant lowering of fecal age. It is hypothesized that small amounts of anaerobically-treated human waste is consistently being input into the creek at this point adding human signal w/o adding fecal loading. Since the bacteria for the genetic markers are present in quantities more than 1000 times higher than *E. coli* in fecal material, the bacteria containing the source tracking markers could persist through treatment that removes a significant portion of *E. coli*. Hence the appearance of source marker signals without a significant increase in *E. coli* loadings. The impact of this can be seen further downstream, at site LHC-02 where it can be seen that the fresh, high level fecal loading of the creek is diminished as seen by the lowest SCV values for the watershed at LHC-02, while the consistent human signal input at LHC-04 has become very dilute and sporadic (qHF183 below detection level 50% of the time).

The fecal load hotspots in the watershed are at LHC-06 and LHC-10. These two sites had the highest loading and freshest fecal materials present in the watershed, but they differ in terms of prevalence of human source. LHC-10 is of greater health concern than LHC-06 because there was a greater frequency of human-specific markers, but both sites are of concern and should have the surrounding lands investigated further to find and repair leaks and mitigate the impacts of other non-human sources of fecal materials. LHC-04 had the most consistent signal for human fecal materials present, but this signal did not occur with increases in fecal loadings or decreases in fecal age. More investigation is needed at LHC-04 to determine the source of human signal and evaluate the potential for pathogen spread from this source.

There was only one rain event sampled. As expected, all SCV values and detection levels of human specific markers rose indicating more fresh fecal material from human and non-human sources being input into the watershed. The SCV at LHC-06 was above 2.45 during the rain event, a level that was within 2 standard deviations from the sewage SCV of 2.88. This is a significant shift in quality due to hydrological events precipitated by weather. Yet, looking at the values for the human-linked markers adds information that suggests there are other rain influenced sources impacting water quality along Lower Howards Creek. During the one rain event, the downstream site LHC-05 registered a 10 fold higher proportion of human-linked HuBac signal, and 100 fold more qHF183 signal, than upstream sites LHC-06 or LHC-10, suggesting that there are other sources of human sewage impacting the main channel of Lower Howards Creek in this region. However, with only 1 wet sampling event, and serious problems with PCR marker inhibitory substances in the stormwater samples (2 of 5 samples inhibited at farther downstream locations LHC-02 and LHC-04), our ability to form more conclusions about the lower half of the watershed. A larger study of rain events is required to understand the changes that occur under these conditions and more research into removing inhibition required.

<u>Conclusions:</u> The presence of human sewage in the Lower Howards Creek Watershed is undeniable at a few key locations. In general, under dry conditions, the sanitary quality of the water at any of the sites sampled did not approach that of sewage (using SCV). There were hotspots identified when ranking the sites according to SCV and prevalence of qHF183 marker. It is clear that there were consistent sources of leaking sewage impacting the tributary at LHC-10, impacting the water quality to a detectable degree and causing this tributary to negatively impact the overall quality of the main stem of Lower Howards Creek. At LHC-06, while there was significant fecal load, this load did not have a high probability of originating from gross human fecal sources. The contamination input by LHC-06 and LHC-10 becomes diluted with travel down the main stem of the creek, reducing the fecal load, increasing fecal age, and decreasing incidence of human source markers. At LHC-04 some form of human signal is coming into the watershed, but with little impact on fecal loading or age. By the time the creek flows past LHC-02, much of the human input signal is diluted and fecal load and age signals are improved. In wet weather, the quality of the entire watershed declined and it is assumed that there were unsampled sources of additional human sewage, presumably from overflows, in the upper reaches of the watershed.

The ability to separate sites from each other using average SCVs has been proven again in another Kentucky watershed, but more has been learned about applying this approach. This study has shown the value of adding the qHF183 marker to support and clarify the findings represented by the amalgamation of signals represented by the SCV model. This type of multiparameter monitoring and modeling scheme can provide critical information to municipalities and consultants to support effective planning and investigation for remediation of the “hottest spots” of human sewage impact within the watershed. By pinpointing regions for further investigation, resources can be utilized efficiently, first targeting only the regions within the watershed with consistent sewage leaks for repair and relining of sewers, thus removing the worst source of human pathogens from the environment and contact with people.

Supplemental Keywords: water quality, pathogens, indicators, modeling, *Bacteroides*

Relevant Web Sites: N/A

Introduction:

The purpose of this project was to identify regions within Lower Howards Creek Watershed that may be impacted by domestic human sewage during the time of study using a multivariate indicator approach and establish baseline conditions of fecal load, fecal source, and fecal age under dry conditions.

Objectives of the project:

- Apply a unique combination of indicators and a proprietary modeling system to define regions of the watershed contaminated with proportionally greater amounts of human/domestic sewage (hotspots) from those contaminated by other, less hazardous fecal sources.

- Establish baseline values for the individual indicators and a combined Sanitary Category Value in this watershed to be used to evaluate future data against to illuminate water quality improvements or changes.

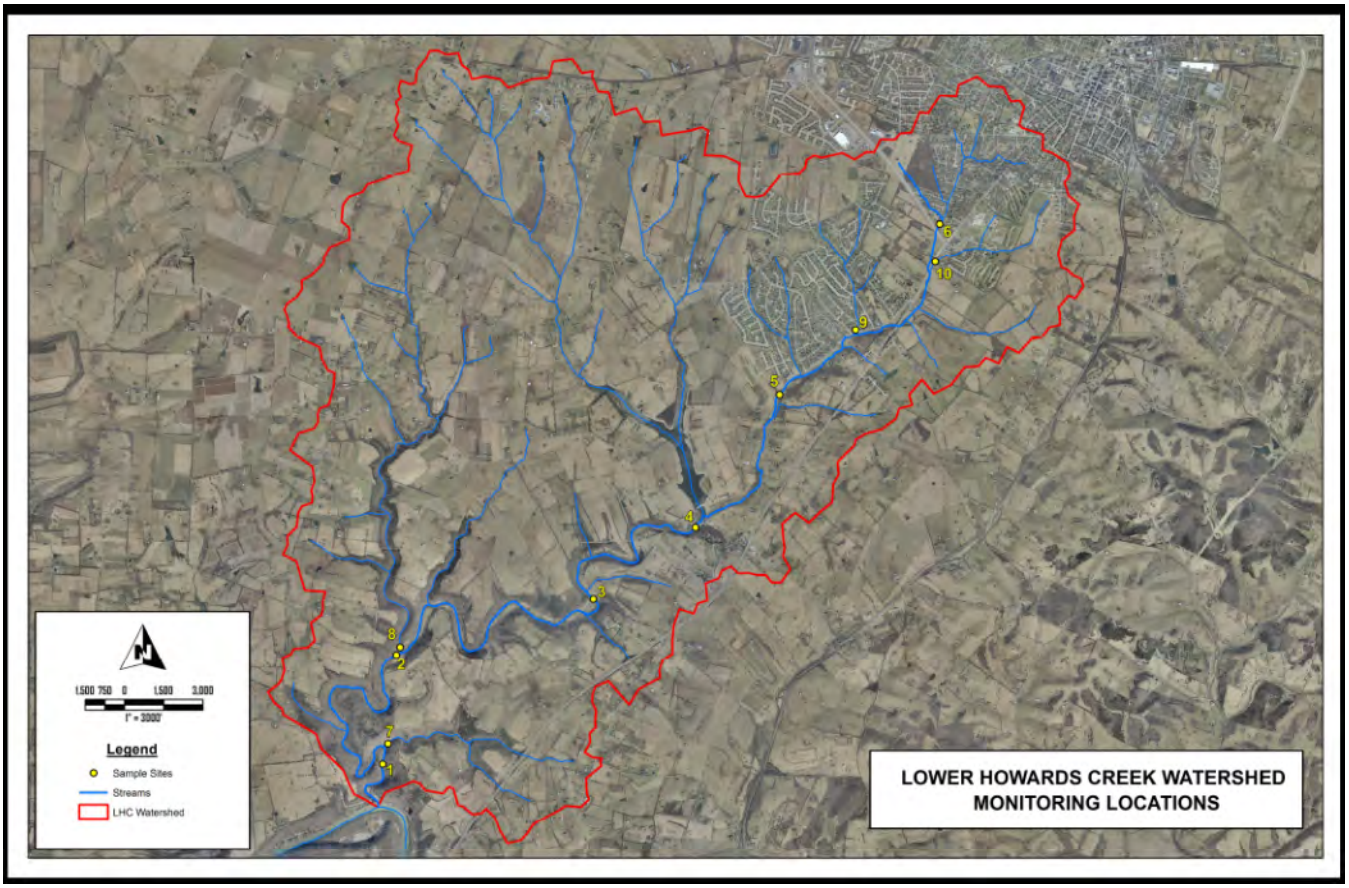
Approach:

The Quality Assurance Program Plan (QAPP) used in this study was based upon one used in a previous study in Wolf Run watershed. The QAPP for this study was approved by the Kentucky Division of Water on May 3, 2012 and is appended to this report. What follows here is a brief summary of the approach.

Five sites within the watershed were selected for study and assigned numeric identification of LHC-02, LHC-04, LHC-05, LHC-06, and LHC-10 (Figure 1). Grab sample at the 5 sites for 7 events were collected by Palmer Engineering staff and brought to the Environmental Research and Training Laboratories. The sampling occurred during the period of March 21st through August 28th in the year 2012. Dry weather samples were collected on days where significant rain had not fallen (5 days $\leq$ 1 inch and 48 hrs < 0.5 inch). There were a total of 6 dry weather sampling events. The one wet weather sampling event on August 28th had samples collected after documenting the area receiving 0.5 inches of rain in the previous 48 hours.

The water samples were measured for multiple indicators with the results input into a proprietary model created by Dr. Brion that produced a Sanitary Category Value (SCV) for each observation. Measures of the individual indicators, the modeled SCV, and the prevalence of human-source specific genetic markers were analyzed to pinpoint sites and regions within the watershed that were of concern with respects to the presence of human sewage, high fecal bacteria loadings, low fecal age, and elevated SCVs relative to those documented prior for sewage treatment plant influent at Town Branch in Lexington, KY.

Figure 1: Map of Sample Sites in Lower Howards Creek Watershed



Provided by Palmer Engineering

The grab samples collected were immediately transported to the Environmental Research and Training Laboratories (ERTL), which are under the direction of the PI, Dr.Gail Brion. Tricia Coakley, Microbial Laboratory Manager of ERTL, received the samples and directed the assay of the samples for *E. coli* bacteria (by IDEXX-Quantitray with Colilert media), the AC/TC ratio (by membrane filtration for Total Coliforms using m-Endo media), and 250 mL volumes filtered and archived for quantitative PCR assay (qPCR). Human-specific and non-specific DNA markers for *Bacteroides* were analyzed in the filter extract. The human-source linked Hubac marker (developed by Layton, *et.al.* 2006) and the more human-specific qHF183 (developed by Haugland, *et.al.* 2010) were measured by qPCR for the assessment of human-specific fecal contributions. The non-host specific fecal contributions were measured by qPCR for the Allbac marker (developed by Layton, *et.al.* 2006). All assays were run utilizing current standard, and evolving quality control standards. Briefly, duplicate samples were independently processed for 10% of the samples on a random selection basis. Replicate aliquots of samples were examined for the AC/TC analysis (2 replicates per dilution) and the qPCR (3 replicates per extracted sample or dilution of extract). An internal standard (0.2 µg/mL Salmon testes DNA) was added to determine the presence of PCR inhibition in the sample matrix. Sample extracts showing inhibition were diluted 10 fold and reanalyzed.

Results from these assays were combined into a final dataset (see Appendix) and analyzed for mean values, standard variation, and relationships between the indicators. Model II assigned a Sanitary Category Value (SCV) based upon the simple summation of values from 0 to 1.0 assigned for observed concentrations of indicators for fecal load (*E. coli*), fecal source (qPCR markers), and fecal age (AC/TC). Each of the three indicator classes could be assigned a value of 0 to 1.0 based on measured concentrations, with small values (<0.5) in each indicator class representative of low fecal loads, low proportion of human-specific qPCR signal, and high fecal age. Higher values (>0.5) represented higher fecal loads, higher proportion of human specific qPCR signal, and lower fecal ages. The midpoint values (0.5) for each indicator class were set with respects to threshold values of concern, so that any sample that met or exceeded midpoint values for all three input classes would have a summary SCV score of 1.5 or higher. Referent values for sewage were used as the top SCV obtainable with values near 3.0 (2.88 $\pm$ 0.25, n=4)). The input values to the SCV assigned for the indicator class ranges for *E. coli* and AC/TC are listed in Table 1. The input value for fecal source was created by proportioning the qPCR human sourced HuBac signal in any sample with the maximum signal found in sewage from a previous study in Wolf Run Watershed after log-transformation of the data. The equation for this model is as follows:

SCV = Categorical Value *E. coli* + Categorical Value AC/TC + Calculated Value $\log_{10}$Hubac/$\log_{10}$HubacMax

The midpoint (0.5) categorical value for *E. coli* and the AC/TC class values were set at a breakpoint for level of concern from state and federal water quality recommendations and past research experience, respectively. For example, while it is not expected that the water quality in Lower Howards Creek and its tributaries to meet the EPA recommended levels for full body immersion at a designated beach area at all times (<235 *E. coli*/100mL for any single sample), the Kentucky standards for secondary recreational contact state that fecal coliforms shall not exceed 1,000 colonies/100 ml as a thirty (30) day geometric mean based on not less than five (5) samples; nor exceed 2,000 colonies/100 ml in twenty (20) percent or more of all samples taken during a thirty (30) day period. This study did not measure fecal coliforms, but the subgroup *E. coli* that is generally present in numbers less than the total number of fecal coliforms. The proportion in freshwater of *E. coli* to fecal coliforms has been reported to range from 0.5 to 0.95, with higher proportions found in influent sewage. For the purposes of our model, we assumed the proportion to be equal to 1.0; that if fecal coliforms had been measured, they would have been equal to the numbers of *E. coli*. This was reflected in the categorical assignation for any single sample containing 1,000 to 2,000 *E. coli* MPN/100mL to be assigned a value of 0.5 for input into the SCV model; the midpoint value of concern.

Table 1: Indicator Class Categorical Values Assigned for Input to SCV Model

E. coli MPN/100mL = Value	AC/TC = Value	$Log_{10}Hubac:Log_{10}HubacMax$ [1]
<235 = 0	>20 = 0	
>235, <576 = 0.17	<20, >15 = 0.25	Not Categorized Value, but
>576, <1,000 = 0.33	<15, >10 = 0.50	Directly Calculated Value
>1,000, <2,000 = 0.50	<10 = 1.00	
>2,000, < 10,000 = 0.67		
>10,000, <24,000 = 0.83		
>24,000 = 1.00		

[1] HubacMax = 1.19 x 10^7 copies/uL extract from a 250 mL sample

Setting the top value of 1.0 for the *E. coli* class was done with the common application of the analytical test method to general surface-water quality in mind. The IDEXX-Quantitray method has a top range of about 2,400 *E. coli*/100 mL on an undiluted sample. Since surface-water quality in surrounding watersheds have reported values over 10 times higher than the analytical range of the test, 1:10 dilutions were always assayed, and during rain events 1:100 dilutions were assayed on water samples resulting in a maximum level of detection over 24,960 and 241,960 *E. coli* MPN/100mL, respectively.

The AC/TC fecal age indicator categorization scheme set 15 as the breakpoint or level of concern. In prior studies, it has been seen that levels below 15 are associated with fresh fecal inputs from cattle and other warm-blooded mammals. AC/TC values above 20 are associated with aged fecal materials, such as those found in water hazards at local golf courses. Prior studies have shown that surface waters with AC/TC values below the level of 10 are associated with significant, raw sewage inputs into local creeks, and the appearance of detectable human enteric viruses in the Kentucky River, so observations where the ratio was <10 were assigned the highest level of concern (1.0). As observed in many other studies, inlet sewage has a consistent AC/TC value below 2, with an average of 1.4 for the AC/TC age indicator. The levels of concern are set reflective of this prior knowledge.

There is insufficient data available at present to establish a level of concern for the proportion of human marker signal in environmental waters. Therefore, the values found in the watershed were related to sewage. After infilling the data file with values of 5 copies Hubac per uL extract for those observations recorded as below the quantifiable detection level (BQL= >1 and <10 copies/uL) and 1 copy at below detection level (BDL<1 copy/uL extract) of Hubac, a unitless value was calculated for each sample by taking the $\log_{10}$ transformed value for Hubac divided by the $\log_{10}$ transformed value for the maximum amount of Hubac detected during the prior Wolf Run study on 7/31/2010. This proportion is referred to as $\log_{10}$Hubac/$\log_{10}$HubacMax and is representative of the relative strength of human host associated signal found in a water sample with respects to that would be found in a similar volume of sewage. It is a proportional value that provides for the inspection of large differences into a small scale. This unitless value, which can vary from 0.00 to 1.0, was used directly in the calculation of the SCV value by the model. The midpoint (0.5) value for this indicator represents about 3,450 DNA copies of Hubac/uL of extract from a 250 mL sample, or a direct proportion of about 0.3% of the strongest signal found in sewage. As the lower level of detection for this study was set at 1 DNA copies/uL, this midpoint value is much greater than the established level of detection, and a significant increase in concentration as compared to that normally seen in other watersheds.

Standard Repeat Measures ANOVAs, with All Pairwise Multiple Comparison Procedures (Holms-Sidak or Tukey Test) were applied as appropriate to illuminate statistically significant differences between the indicators values and the SCVs found at the sites.

Methods:

Laboratory Assays. All assays applied were agreed upon and are referenced in the appended Quality Assurance Project Plan (QAPP). The membrane filter and broth culture methods used were standardized (SM9222b) (1.) for the AC/TC ratio obtained from the m-*endo* broth based, membrane filter analysis for total coliforms, IDEXX Quanti-Tray 2000 with Colilert media for *E. coli* (SM9223b)(2.)). The IDEXX analysis was done per published procedural manuals from IDEXX. Basically, 100 mL samples of water, or diluted water samples, were mixed with pre-packaged amounts of media, and then distributed into a sterile multiple well Quanti-Tray and incubated at 35 degrees C for 24 hours ± 2 hours before counting the number of wells with blue florescence under UV light. The numbers of large and small positive wells are used to provide a statistical estimate of the most probable number of bacteria per 100 mL of sample to be read from a chart provided by IDEXX. The AC/TC analysis required colony counts for two types of bacterial colonies grown on m-endo fed membrane filters. Three dilutions were analyzed, plated in duplicate. Those colonies presenting as total coliform colonies (dark red with sheen) and those presenting as atypical colonies (pink to red, no sheen) were counted and an average count value established and calculated per 100mL of sample. The AC/TC value reported was produced by dividing the number of atypical colonies per 100 mL by the number of total coliform colonies per 100 mL. The AC/TC ratio reported is unitless.

Filter extractions for qPCR analyses were done using commercially available, pre-packaged kits following guidance from USEPA and published literature. Briefly, 250 mL samples of surface water were filtered through 0.45um cellulose membranes and the resultant filters stored at -20°C until extraction. DNA extractions were done using the method described in the 2010 USEPA document, “Method B: *Bacteroidales* in Water by TaqMan(R) Quantitative Polymerase Chain Reaction (qPCR) Assay” (3.) with the adaptation of crushed garnet for bead beating rather than glass beads. The EPA method applied used AE buffer with a known concentration of Salmon sperm DNA added as an internal standard. The Salmon DNA was subsequently measured by real-time PCR to check for PCR inhibition.

The amplification and quantification of Allbac and Hubac genetic markers was performed according to published protocols (4.) which include a TaqMan fluorescently labeled probe, a 60°C annealing temperature and 50 PCR cycles. The qHF183 marker was analyzed according to protocols recently published by the USEPA (5.) with a couple of adaptations to template addition and PCR cycles. One change was that IAC template was not added to samples and Salmon internal standard was analyzed to determine inhibition. Another change was that the PCR was run for 50 cycles rather than 40. Threshold cycles from samples were compared with calibration curves to determine concentration of target in copies per uL and reported as DNA copies per uL of extract from a 250 mL sample.

Establishing Reportable and Quantifiable Levels of Detection (LOD). For the cultured bacterial analysis, the lower LOD was obtained by assuming 1 bacterium per volume of sample tested. For the IDEXX Quantitray, where samples were analyzed with a 10 fold dilution this value was recorded as <10 MPN/100mL. For the membrane filtration, an assumption of 1 bacterium per volume of sample assayed on the lowest dilution sample was assumed. For the qPCR marker analyses, the lowest LOD was established to be 1 DNA copies per uL of filter extract. Any sample with less than 1 copy/ul extract were entered into the database as below detection level (BDL) and assigned a value of 1 for numerical calculations and no presence signal for incidence analysis. The quantifiable level for reporting qPCR results was any sample with >10 copies/uL extract and the average of the 3 replicates was recorded in the database and used for numerical calculations. Values that ranged above 1 and below 10 copies/uL of extract were entered into the database as below quantifiable levels (BQL) and assigned a value of 5 copies/uL extract for numerical calculations.

Data Infilling. There were 4 samples that showed inhibition, and after dilution and cleanup with a recommended kit could not resolve the inhibition, values were assigned to one of these missing samples for calculations. Site LHC-05 was inhibited on 4/11 and 5/3, a day in the dataset that needed to have complete data to calculate the SCV. A Hubac value of 426 copies/uL was assigned based on the average of all other available dry day Hubac values for site LHC-05. The inhibited sample from 4/11 at site LHC-05 was not infilled or included in the calculation for the assigned value on 5/3. The other two inhibited samples occurred on the rain day of sampling (8/28) at sites LHC-02 and LHC-04. No HuBac values were assigned to infill for these samples as no other data was available to interpolate.

Statistical Analyses. All statistical analyses were done utilizing the statistical program embedded in Sigma Plot 11 with standard settings for significance. Data (raw and transformed) was checked for normality and equal variance for regressions and other procedures sensitive to these qualities. Where indicated, non-parametric tests were used when the data failed normality and equal variance testing.

SCV Model. A simple model was applied to classify the water quality at each site with respects to inlet sewage and other sites. The model utilized three input values from three indicator classes assigned equal weights and summarized. The model blended two categorization scales for fecal load and fecal age classes with a directly computed proportion of human specific qPCR marker at each site relative to sewage for fecal source. Sewage was set as the maximum value (3.0) that could be computed. Water meeting ambient quality criteria standards with < 1 copy HuBac/ul of extract was set as the lowest value (0.00). The value obtained from the model for individual observations was named the Sanitary Category Value (SCV) and used to compute averages, rank, and statistical significance between sites.

Results:

Summary of Indicator Values. There are differences in fecal loading in the watershed. The watershed is under significant fecal loading, with 33% (10 of 30) single sample observations greater than the EPA recommended value of 253 *E. coli* / 100mL, and 47% (14 of 30) of all 6 dry days sampling results. However, the fecal load is not evenly distributed. Three sites, LHC-05, LHC-06, and LHC-10 have the highest geometric means for all 6 (144, 318, and 256 MPN/100mL respectively) and also on just the 3 dry days (430, 994, and 345 MPN/100mL respectively) used to calculate the SCV values. The *E. coli* values presented in Table 2 are only representative of the complete sampling events used for the calculation of the SCV values, but statistical analyses were applied to the more complete dataset when possible. One way ANOVA on the $\log_{10}$ transformed *E. coli* values for the 6 dry days, and for the 3 dry days used for SCV calculation, only finds significant differences between sewage and all watershed samples ($P<0.001$). The sites within the watershed are not significantly different from each other ($P>0.084$). Of the sites, LHC-06 has the highest *E. coli* loading.

During the single rain event captured, there was a significant increase in *E. coli* loading at all sites in the watershed. Sites LHC-05 and LHC-10 were within 1 standard deviation of the dry mean value at that site, but LHC-02, LHC-04, and LHC-06 went beyond 2 standard deviations of the average dry day values presented in Table 2. Since these were only single observations on the rain event, there was no way to compare their difference from the mean other than investigating if they would fall within the expected range for a dry day sample.

Table 2: Summary Results for All Sites

Samples taken 4/27 to 8/28 in year 2012	**n**	**GeoMean *E. coli* MPN/100 mL (±Std Dev)*****	**AC/TC (±Std Dev)******	**LogHuBac $_{\text{sample}}$ / LogHuBac $_{\text{SewMax}}$**	**SCV (±Std Dev)******
LHC-02, dry	3	69 (5)	43.18 (11.66)	0.27	0.33 (0.12)
LHC-04, dry	3	75 (8)	31.50 (11.34)	0.39	0.41 (0.08)
LHC-05, dry	3	430 (16)	49.19 (43.92)	0.27*	0.88 (1.05)
LHC-06, dry	3	994 (3)	16.86 (1.38)	0.45	1.14 (0.36)
LHC-10, dry	3	345 (7)	28.59 (16.67)	0.28	0.67 (0.41)
Sewage	4	3,539,973 (1)	2.45 (0.95)	0.81	2.88 (0.25)
LHC-02, wet	1	4,611**	10.65**	Inhibited	NA
LHC-04, wet	1	21,870**	19.68	Inhibited	NA
LHC-05, wet	1	41,060	14.59	0.70	2.20
LHC-06, wet	1	28,680**	6.14**	0.45	2.45
LHC-10, wet	1	17,230	14.69	0.45	1.78**

* = Database in-filled before calculation

** = Wet Day Value outside 2 SDs as compared with Average Dry Value

*** = Standard deviation around log-transformed reported results that were normally distributed, not reflective of assay error.

**** = Standard deviation around non-transformed reported results that were normally distributed, not reflective of assay error.

E. coli values alone cannot determine the potential risk inherent in fecally impacted watersheds as there are many sources of fecal materials with differing degrees of hazard. Further complicating single, load indicator analysis is the fact that *E. coli* can come from many different places in the environment with widely varying potential for disease. *E. coli* is even known to grow to high numbers in nutrient enriched waters during warm weather, or be resuspended from sediments into the water column. The link between *E. coli* and water related disease is complicated. More information is needed to classify the relative cleanliness of these sites in the watershed. The predominate fecal age and fecal sources need to be considered along with fecal load information in order to obtain a more complete understanding of the potential risk indicated by *E. coli* values. Hence our use of another indicator class, one for fecal age.

The AC/TC value changes with the average age of fecal contamination, rising as fecal material ages in the environment from initial values less than 1 in freshly deposited fecal materials to values in the hundreds in water held in golf ponds. When applying the AC/TC age indicator, one looks for sites that have average values below expected values found in Kentucky watersheds. Low fecal age in inlet sewage samples was consistently measured in this study, and prior studies, by an AC/TC value below 2 for any individual sample and an average of 1.5. In prior studies on flowing creeks and rivers in the Bluegrass Region, when the AC/TC value fell below 15, it was indicative of sites that were impacted by human sewage, or fresh and copious quantities of agricultural fecal materials (cows in the creek). Water not impacted by sewage or fresh fecal material from other animal sources have AC/TC values >20 on average.

Prior study has shown the AC/TC value does not change appreciably in the time it takes wastewater to be treated in an activated sludge system or during anaerobic treatment, such as in a septic system. Prior studies at the Town Branch Sewage Treatment Plant have shown the AC/TC value in plant effluent before chlorination to be indistinguishable from inlet values. Therefore, creeks that receive a significant portion of their flow from sewage treatment plant effluents will present a low AC/TC value, even while the *E. coli* levels can be quite low. In contrast, creeks that receive significant influxes of untreated sewage will have low AC/TC values, but high *E. coli* concentrations. These relationships between fecal load and age allow one to begin to sort the most risky conditions in a watershed from those with less potential disease risk.

Sites in the Lower Howards Creek Watershed show the presence of both aged and fresh fecal materials during dry sampling days with LHC-06 having the freshest fecal material average age (AC/TC=16.86). During the rain event, all sites drop in AC/TC levels, indicative of fresh fecal inputs into the creek, with site LHC-06 dropping to levels seen when domestic sewage is impacting receiving streams. LHC-10 AC/TC drops from an average of 28.59 to 14.69, under the level of concern of 15 seen in other urban watersheds with sewage impacts. During dry conditions, the watershed is predominantly influenced by aged sewage

The next indicator class to investigate and add into the multivariate modeling approach is for fecal source. To indicate human host-specific fecal sources, the proportion of human-specific genetic material from select portions of the 16S rRNA region of the genome for the strictly anaerobic group of bacteria known as *Bacteroides* were utilized. There were three markers selected for use: 1) the non-host specific marker Allbac, 2) the mostly human specific marker Hubac, and 3) the more human specific qHF183 marker. While the community at large is united at this time in the use of the Allbac marker to indicate overall load of *Bacteroides*, there are differences of opinion on which human specific marker to use. There is a trade-off between sensitivity and specificity, and which marker to use is dependent upon which questions you intend to answer. In the previous Wolf Run watershed, the Hubac marker was used, which had been found to come from human sources in large quantities, and from several animal sources in smaller quantities. For the purpose of our study, to find significant sources of human sewage, and to maintain continuity with past studies, we included the less specific, but more sensitive qPCR marker Hubac to look for human contamination. The most specific marker, qHF183 is used in a presence/absence mode to bring m ore definition to sites with high levels of HuBac relative to sewage.

This decision was fortuitous as Hubac was detected more frequently above the LOD, and at reliably quantifiable concentrations, than the qHF183 human specific marker at all sites. In dry weather sampling, qHF183 was only detected in 18 of 35 (51%). To place this into comparison, consider that 32 of 35 (91%) samples had HuBac detected in dry weather samples, with only 1 below the level of detection of 1 copy/uL extract. The decreased level and reduced incidence of detection was expected based on prior results with Inlet sewage samples. In prior studies at Town Branch, inlet sewage had significantly less qHF183 marker signal than Hubac on average (8,220 versus 1,790,000 DNA copies/uL for a 100 mL sample respectively). Only 4 samples showed PCR inhibition based on the internal standard, so the infrequency of finding a signal from the qHF183 marker is not related to inhibition, but low concentration. However, when qHF183 marker was detected, it was meaningful. The presence of the more specific qHF183 confirmed that site LHC-04 had a consistent source of human fecal material as the incidence of detection was 100% during dry days (Table 3). The next most frequent site for detection of qHF183 was LHC-10. Both of these sites show consistent

Table 3: Incidence of qHF183 Detection at All Sites during All Dry Days (n=6) in Lower Howards Creek

Site	**% Detection Dry Days (#detects/#samples)**	**Wet Day Detection**
LHC 02	50% (3/6)	inhibited
LHC 04	100% (6/6)	inhibited
LHC 05	75% (3/4)	yes, quantifiable
LHC 06	17% (1/6)	yes, quantifiable
LHC 10	83% (5/6)	yes, quantifiable

Looking at the ratio of the $\log_{10}$ transformed HuBac signal to the $\log_{10}$ transformed HuBac signal from a maximum value found for sewage at Town Branch, it can be seen that LHC-06 has the highest ratio (Table2). The results obtained for this ratio were not normally distributed so a Kruskal-Wallis One Way ANOVA on Ranks was done that did not show any statistical difference between the median values at each site ($P=0.48$). Ranking in terms of average values, the descending order is LHC-06, LHC-04, LHC-10, and then tied values for LHC-02 and LHC-05. Referring to Figure 1, it can be seen that increased HuBac signal is present at the inputs LHC-06 and LHC-10, presumably being input from the surrounding suburban neighborhoods. Mixing and dilution of these inputs results in a lower proportion at the downstream point LHC-05, then more signal is input at LHC-04. More mixing and dilution occurs and the signal again drops at the farthest downstream point LHC-02.

Rain increases the human-related fecal signal in the watershed. The HuBac to HuBac max signal on the 3 wet samples that were not inhibited had all risen above the midpoint value of 0.5 for this component of the SCV model (0.5 = 3, 450 copies HuBac/ul of extract from a 250mL sample). Looking at the average HuBac concentration for dry days and comparing it to the signal found during wet days the increase in signal is indicative of more human-related fecal materials being input into the creek by weather events (Table 4). However, the levels input by the different tributaries vary considerably. Interestingly enough, the level of HuBac at LHC-06 actually drops during the rainy day, but rises at LHC-05 downstream to the maximum amount ever seen in this study (84,792 copies HuBac/uL extract). The level of HuBac at LCH10 is 10x that seen on dry days, but much less than seen downstream at LCH05. There must have been another input of fecal material not measured because the levels found in the other tributary LHC-10 are comparable to those in LHC-06, and an order of magnitude less than the amount found downstream at LHC-05.

Table 4. Concentrations of HuBac Marker in Lower Howards Creek

Site	Dry Days Average copies HuBac/uL	Wet Day HuBac copies/uL
LHC 02	173	inhibited
LHC 04	720	inhibited
LHC 05	426	84,792
LHC 06	2,759	1,559
LHC 10	161	1,473

Lower Howards Creek is under the influence of human fecal materials. Human contamination cannot be ruled out at these sites based on the presence of qHF183, and the higher than background levels of Hubac found during dry weather. All sites detected quantities of Hubac at greater than the reportable LOD at least one of the sampling times. Even the cleanest site, LHC-02 had on average 173 copies HuBac/uL of extract during dry weather. However, the presence of qHF183 was low and infrequent. This with the supporting information from *E. coli* and AC/TC measurements at this downstream site in the creek does not place it at a high level of concern, especially when comparing to sites LHC-06, LHC-10, and LHC-04. It may well be that the qHF183 marker is present, but not in large quantities. One must balance the presence of human signal with the information gathered on fecal load and age before assigning a ranking of concern.

Sanitary Category Value Modeling Results: While the previous analysis of the data is informative, the results of the SCV modeling are the most significant findings with respects to the original objectives and purpose of this project. One of the objectives of this project was to apply a scheme that can rank sites within the watershed relative to each other for the purpose of identifying priority areas for remediation, and for verifying the impact of remediation undertaken in the future. The rankings and values provide a baseline against which future studies can compare and a way to prioritize regions within the watershed for further investigations. This scoring and ranking was done as described prior by calculating a summary Sanitary Category Value (SCV) between 0.00 and 3 obtained by summing each indicator class and input values between 0 to 1.0 for fecal load, source, and age. At this time, each indicator class is given equal weight. Table 3 shows the calculated average SCVs for each site under dry weather conditions. While there are many combinations that could result in an elevated SCV, only average SCVs less than 2.0 were found to be significantly different from sewage SCV under all weather conditions in the prior Wolf Run study. The model sets tipping points at 0.5 for each of the input categories. Any single input above 0.5 is cause for concern. Therefore, any SCV value greater than 1.5 deserves closer attention. Changes in SCVat a site from dry to wet conditions are important as an additional piece of information upon which to rank sites for extra surveillance and remediation.

The summary of the study's significant findings can be easily visualized in the following figures. Figure 2 shows that under dry weather conditions, the average SCV is significantly different from that of sewage for all sites in the Lower Howard Creek Watershed. Three sample sites covering the wet day all show increased SCVs, reflective of the increases in fecal load, decreases in fecal age, and increase in human-linked fecal marker concentration relative to sewage. Three sites, LHC-05, LHC-06, and LHC-10 have the highest SCVs calculated for them under both dry and wet conditions. Clearly the regions should be top priority for further investigations to pinpoint the regions that are impacted, identify the human source, and remediation. Site LHC-04 has a lower SCV than the upstream LHC-05, but a higher proportion of HuBac to sewage, suggesting that this site is still of concern. The SCV graphically displayed is easy to interpret and pinpoints the hotspots in the watershed that require further study and remediation efforts, but each component of the SCV should be analyzed to understand the shifts that are taking place between loading, age, and sources of fecal materials. Figure 3 shows the variability in SCV at each site on the individual days sampled. It is easy to understand why repeat events are required to utilize the SCV model when viewing the variance present between event days for the same sites.

Figure 2: Average Sanitary Category Values in West Hickman under Dry Weather Conditions

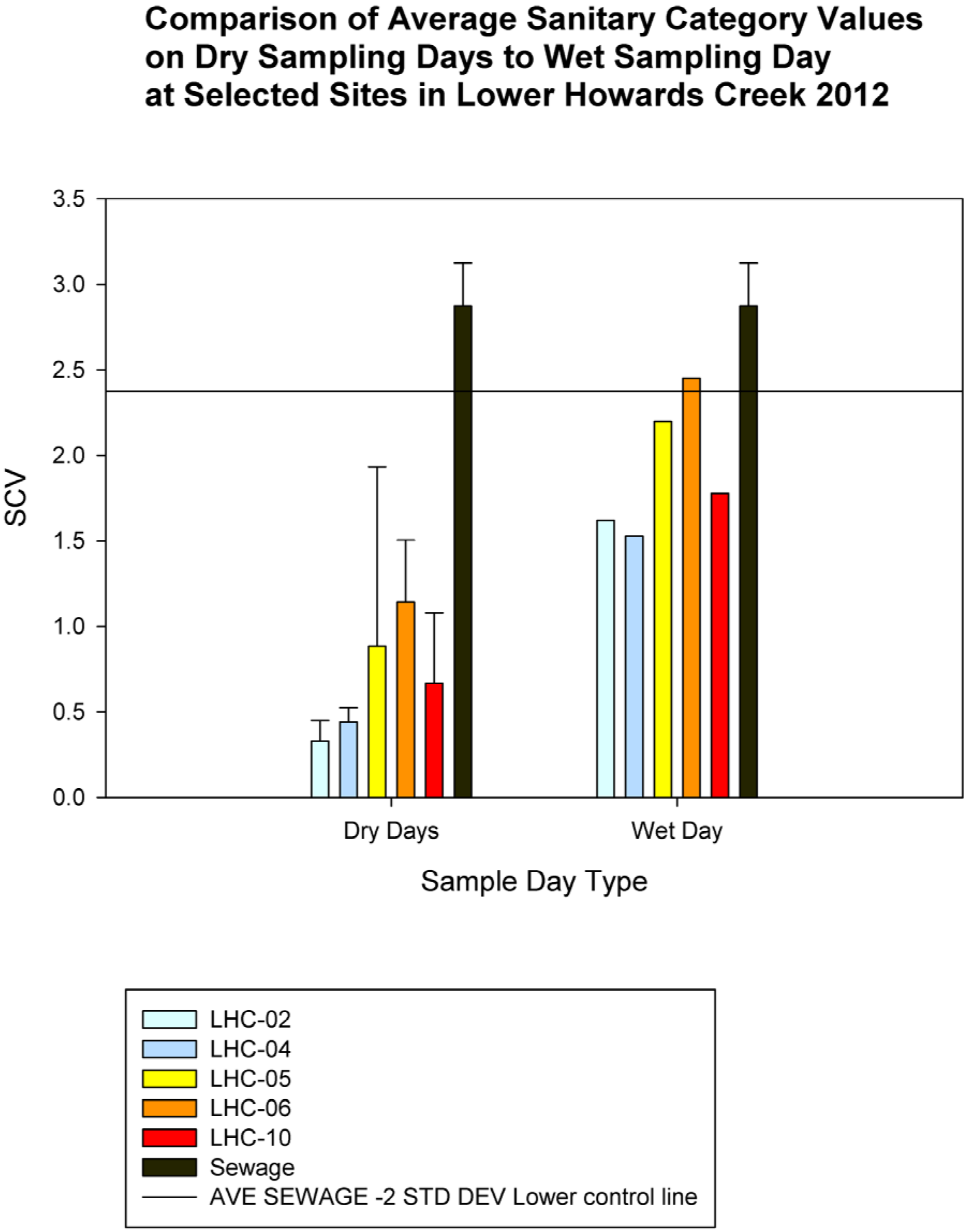
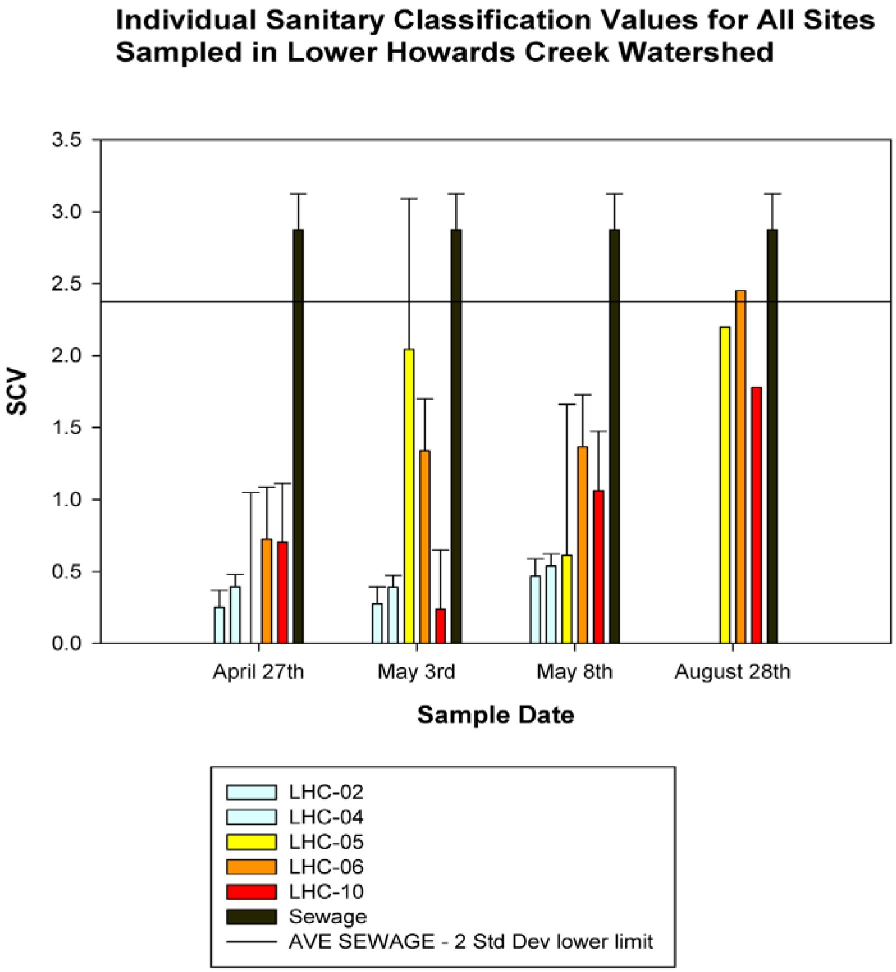


Figure 3. Sanitary Category Values for Each Event Sampled in Lower Howards Creek



Statistically, all sites were significantly different in average SCV from sewage during dry days. However, the SCVs for sites during the wet day when evaluated to see if they would be expected to be in the range of values from a sample of the normally distributed population of dry day observations showed significant differences from the average dry day SCV values. The wet weather SCV for sites LHC-02, LHC04, and LHC10 are all higher than the average SCV for dry weather plus 2 standard deviations. They are not in the pool of values one would expect to find for 95% of samples if they belonged to the population represented by the average and standard deviation in dry day SCV value at that site. Sites LCH-05 and LCH-06 change less during storm conditions, only having values greater than the average SCV plus one standard deviation; these wet SCVs are beyond where 68% of the SCV values one would expect to see if sampling a population with the dry mean SCV value and variance. So the water quality conditions at every site deteriorated with respects to increased fecal loads and decreased fecal ages, and the SCV value at the 3 sites it could be calculated rose.

One might ask, how bad did it get during the rainy day? An inspection of the distance of the individual SCVs against the average SCV for sewage can provide some statistical basis to evaluate and rank the sites. Site LHC-06's calculated SCV value is actually within the 95% pool expected for sewage values. Clearly, the increased fecal loading, decreased fecal age are driving the SCV higher at LHC-06 as the proportion of HuBac remains the same relative to the dry averages. The SCV at LHC-06 may not be significantly different from that of sewage. While the SCV at LHC-10 is not as high as that for LHC-06, all components of the SCV have risen, resulting in an SCV that might be in the range of sewage, if more samples had been taken under rainy conditions. Site LHC-05 is very likely, again with more sampling, to become indistinguishable from sewage during rains upon repeat sampling. However, with only one day of wet weather sampling, and incomplete results from qPCR inhibition, these rain results are of limited use to statistically separate which site is worst.

This study has pointed out the need to augment the SCV values with a presence/absence signal for the most specific human marker, qHF183. Increases in SCV can be driven by only increases in fresh fecal loads from non-human sources, or by increasing human marker signal without increases in fecal loading as was seen in this study. Hence the SCV model should not be applied w/o confirmation of human source by other measures, such as qHF183. As well, since there is a great deal of variance that can be seen in the SCV from day to day at a single site, it is necessary to have multiple samples at a single site to provide for a database upon which statistical analysis can be performed. While the inputs into the SCV model are not always normally distributed, nor do they show significant differences in the measured values underlying the inputs, the resultant SCV value built from categorized transformation of the raw data does allow for the ranking of sites against each other, often with statistical significance. The SCV model can bring clarity to very fuzzy environmental water quality data.

Summary Conclusions:

It is quite evident from this study that parts of Lower Howard Creek Watershed are under the influence of human sewage, from leaking sewers, septage systems or other sources. The multi-indicator approach used in this study has refined information gathered on fecal load with information about fecal age and source. The creation of a system to rank the sites relative to sewage, and to each other, with a Sanitary Category Value (SCV) is key to future planning decisions on appropriate remediation to obtain the best improvement for the investment. The approach has pinpointed areas in the watershed where camera inspection of the lines is required and reduced priority for camera inspection in areas with little leaking sewage impact. The categorized SCV Model applied to the analysis of the data produced by this study has demonstrated sensitivity in sorting sites from each other, and from sewage. The average SCVs documented in this report have established a baseline against which to measure improvements in future watershed quality. It is highly recommended that this approach be applied to the regions/tributaries within the watershed to identify remediation activites, and applied after remediation has occurred to document the impact of such actions.

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Appendices:

Summary Results for Analytical Measurements

E.COLI

MPN/100mL	3/21/2012	4/4/2012	4/11/2012	4/27/2012	5/3/2012	5/8/2012	8/28/2012
LHC 02	101.4	62.4	49.6	31.5	26.5	387.3	4,611
LHC 04	140.1	44.1	28.8	8.6	95.9	518.0	21,870
LHC 05	300.5	41.4	8.6	35.5	8,664.0	260.2	41,060
LHC 06	365.4	71.5	47.3	248.1	1,229.9	2,755.0	28,680
LHC 10	115.3	387.3	154.0	150.0	79.4	3,448.0	17,230
Blank	1	1	1	1	1	1	1

< values, but sign removed for calculations

underlined value= average of duplicates

Extra Data not Used for Calculations

AC/TC

	3/21/2012	4/5/2012	4/11/2012	4/27/2012	5/3/2012	5/8/2012	8/28/2012
LHC 02				30.95	54.19	44.41	10.65
LHC 04				44.50	23.60	26.41	19.68
LHC 05				94.44	6.73	46.40	14.59
LHC 06				18.26	15.50	16.82	6.14
LHC 10				13.83	46.67	25.27	14.69
Blank	1	1	1	1	1	1	1

< values, but sign removed for calculations

Bad media, No Reportable Results

HuBac-Human Specific 250 mL sample, 1 mL extract volume

DNA copies/uL extract	3/21/2012	4/4/2012	4/11/2012	4/27/2012	5/3/2012	5/8/2012	8/28/2012
LHC 02	5.74E+02	1.14E+02	7.84E+01	**5.79E+01**	8.58E+01	1.28E+02	Inhibited
LHC 04	9.94E+02	5.62E+02	1.16E+03	6.17E+02	5.84E+02	**4.03E+02**	Inhibited
LHC 05	8.74E+01	2.66E+02	Inhibited	BDL	inhibited	1.35E+03	8.48E+04
LHC 06	1.92E+02	3.53E+01	4.16E+02	1.40E+02	**1.44E+04**	1.42E+03	**1.56E+03**
LHC 10	1.58E+02	1.20E+02	2.99E+01	2.69E+01	4.86E+01	5.81E+02	1.47E+03
Blank				BDL	BDL	BDL	BDL

BDL = below 1 copy per uL of extract

Underlined Values are Averages of Duplicate Samples

All values presented are the average of triplicate aliquots extracted from a sample

AllBac- Non Specific DNA copies/uL extract	3/21/2012	4/4/2012	4/11/2012	4/27/2012	5/3/2012	5/8/2012	8/28/2012
LHC 02	5.97E+03	2.18E+03	1.66E+03	**7.68E+02**	1.54E+03	2.27E+03	Inhibited
LHC 04	8.63E+03	6.66E+03	1.06E+04	6.02E+03	5.17E+03	**5.29E+03**	Inhibited
LHC 05	2.29E+03	5.22E+03	Inhibited	4.35E+02	Inhibited	8.63E+04	3.69E+05
LHC 06	5.09E+03	1.58E+03	2.41E+04	2.84E+04	**2.53E+06**	5.19E+04	**1.28E+04**
LHC 10	7.16E+03	5.75E+03	1.42E+03	1.99E+03	2.00E+03	9.58E+03	1.82E+04
Blank				BDL	BDL	BDL	BDL

BDL = below 1 copy per uL of extract

qHF183 human confirmation

DNA copies/uL extract	3/21/2012	4/4/2012	4/11/2012	4/27/2012	5/3/2012	5/8/2012	8/28/2012
LHC 02	1.28E+02	BDL	BDL	**BDL**	BQL	BQL	Inhibited
LHC 04	1.21E+01	BQL	BQL	1.14E+01	2.15E+01	**1.32E+01**	Inhibited
LHC 05	BQL	BQL	inhibited	BDL	Inhibited	BQL	9.41E+03
LHC 06	BDL	BDL	BDL	BDL	**BDL**	2.14E+01	**3.36E+01**
LHC 10	BQL	BQL	BQL	BQL	BDL	1.20E+01	1.79E+01
Blank				BDL	BDL	BDL	BDL

Underlined=duplicate average

BDL = <1 copy/uL extract (undetected)

BQL= <10 copies/uL extract (detected but not quantifiable)

SCV	dry	dry	dry	wet
SITE	4/27/2012	5/3/2012	5/8/2012	8/28/2012
LHC 02	0.25	0.27	0.47	NA
LHC 04	0.39	0.39	0.54	NA
LHC 05	0.00	2.04	0.61	2.20
LHC 06	0.72	1.34	1.37	2.45
LHC 10	0.70	0.24	1.06	1.78

Calculated using the average HuBac value from PCR values for non-inhibited, dry samples

Could not calculate, no data from other wet sample days to interpolate

Palmer Engineering

A PLAN FOR IDENTIFYING HOT-SPOTS OF HUMAN FECAL POLLUTION BY ANALYSIS OF FECAL LOAD, SOURCE, AND AGE IN WATER QUALITY SAMPLES FROM LOWER HOWARDS CREEK WATERSHED

Quality Assurance Project Plan

University of Kentucky

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Abstract: This document details a quality assurance plan to guide the successful analysis of water quality indicators to be used to pinpoint areas within Lower Howards Creek Watershed receiving human fecal materials. Over the past 15 years, Dr. Gail Brion has developed a systematic approach to water quality and data analysis that identifies hot-spots of human fecal wastes in local streams and rivers using a triad of water quality indicators for fecal age, load, and source. This system has been proven in other watersheds (Eagle Creek, Georgetown, Frankfort, Lexington) and is published in the scientific literature. The system relies upon utilizing multiple indicators for fecal load, source, and age to create a relative risk classification rubric to categorize the relative impairment in water quality from samples collected from surface waters. This provides a systematic way to prioritize selected sections of a stream or creek for further investigation and remediation of significant sources based on a relative ranking of the water quality from representative sample sites. For this project, samples from Lower Howards Creek will be collected by Palmer Engineering and delivered to the University of Kentucky Environmental Research and Training Laboratories for analysis of multiple, fecally-associated, water quality indicators. Fecal load will be measured by enumeration of E. coli with Colilert media by IDEXX, fecal age by the AC/TC ratio obtained from membrane filtration testing for Total coliforms, and fecal source identified by quantifying two types of fecal source specific genetic markers for the strictly anaerobic bacterial group known as Bacteriodes, one of which is human specific. Dr. Brion will analyze the water quality data obtained from the analysis of provided water samples from sites selected by Palmer Engineering for the purpose of identifying samples that are indicative of hot-spots of human fecal waste intrusion.

PROJECT MANAGEMENT

Approval Sheet

Gail Brion Date
Professor of Civil Engineering
University of Kentucky

Stephanie Blain, PE Date
Project Engineer
Palmer Engineering

Brian Ward Date
Project Engineer
Palmer Engineering

Distribution List

Each person listed on the approval sheet and each person listed under Project/Task Organization will receive a copy of this Quality Assurance Project Plan (QAPP). Individuals taking part in the project may request additional copies of the QAPP from personnel listed below.

Project/Task Organization

Personnel involved in project implementation are listed in Table 1, and shown as an organization chart in Figure 1.

Table 1: Project Implementation Personnel

Individual	Role in Project	Organizational Affiliation
Gail Brion, Ph.D.	Project Manager for Sample Analysis and Water Quality Data Modeling	University of Kentucky (UK)
Brian Ward.	Project Engineer for Overall Watershed Study	Palmer Engineering
Stephanie Blain	Project Engineer in Charge of Sample Acquisition and Field Coordination	Palmer Engineer
Tricia Coakley	Lab Manager and Sample Analysis	UK ERTL Labs

The University of Kentucky Project Manager will be responsible for the following QAPP/project related activities:

- Serve as nexus of communications between all parties.
- Collaboration in sampling design as required
- Provide direct oversight to ERTL laboratories and UK personnel.
- Maintain official, approved QAPP.
- Develop amended QAPP as required.
- Data analysis and interpretation.
- Issue final report to Palmer Engineering for dissemination.

Brian Ward of Palmer Engineering will be responsible for the following activities:

- Approval of final Analytical Methods QAPP and all amended documents.
- Approval of final report.

- Archival of final report and datafile.
- Coordination of technology transfer with appropriate parties.

Stephanie Blain of Palmer Engineering will be responsible for the following activities:

- Approval of initial Analytical Methods QAPP
- Coordination of watershed sampling efforts.
- Training of Palmer field samplers according to Palmer QAPP.
- Technical assistance with secondary data as required.
- Quality Assurance officer for field activities.

Tricia Coakley of the ERTL labs at the University of Kentucky will be responsible for the following activities:

- Coordination with Palmer samplers for receipt of field samples.
- Processing and analysis of samples collected according to established SOPs and QA/QC procedures.
- Creation and maintenance of final spreadsheet of primary and secondary data.

Problem Definition/Background

Rationale for initiating the project

The surface water systems in Lower Howards Creek are contaminated with pathogen indicators from fecal sources of multiple origins; the most problematic in terms of human health risk from recreational contact with originate from sanitary sewage intrusion. Palmer Engineering is working with the City of Winchester to improve the overall quality of surface waters with respects to pathogen indicators. However, the major sources of fecal contamination from sanitary sewage and other sources of human fecal materials need to be identified for remediation and their potential impact on the overall fecal load apportioned in support of watershed remediation schemes. As well, it is expected that the difference in the overall fecal indicator burden as represented by concentrations of E. coli may not provide the precision to denote improvements in watershed quality that happen as a result of remediation in these sites, due to the multiple sources of fecal wastes, many of which are not under the control of Winchester (urban and agricultural wildlife). Therefore, it has been agreed upon that a multi-indicator pilot study will be initiated along an urban watershed to: 1. pinpoint and document areas within the selected watershed receiving proportionately large loadings of human fecal material for remediation, and 2. Create a baseline against which to assess water quality improvements with respects to the fecal age and proportion of human sourced fecal materials in the pilot areas.

Objectives of the project

- Define the unique pattern of indicators that define regions of local urban streams contaminated with proportionally great amounts of human/domestic sewage (hotspots) from those contaminated by other, less hazardous fecal sources.
- Establish baseline values for the indicators in these urban streams, and relative risk categorizations, to be used to evaluate future data against to illuminate water quality improvements or changes.

Anticipated Outcomes of the project

- Increased awareness of the impacts of sanitary sewage leaks, overflows, and spills on the environment.
- Improved understanding of opportunities to reduce environmental impacts in urban streams.
- Improvement of environmental quality in a target region or watershed.
- Increased recognition of environmental leaders of all involved parties among key stakeholders.
- Greater remediation efficiency and more effective allocation of municipal resources.
- Cost savings for the Winchester municipality.
- Development of a policy approach that could be used in other urban areas, agricultural areas, states, and regions.
- Improved communication and understanding between regulators and the regulated community.
- Greater collaboration among involved parties and state agencies.
- Enhanced networking and peer mentoring within the community.

Anticipated Decisions arising from the project

- Based on the findings of this project, Palmer Engineering may modify its approach to monitoring Winchester’s Lower Howards Creek watershed and suggest follow-up projects to demonstrate to the local, State and Federal agencies continuous water quality improvements as remediation of hot-spots of human pollution within this watershed are completed.
-

Sample Handling and Custody

This QAPP is for sample analysis and data modeling/analysis only. All watershed sampling design and field activities will be done by Palmer Engineering under a different QAPP. Therefore, what follows are the procedures that will be used to assure the best quality and most complete database upon which to a simple model will be applied to pinpoint samples that have elevated levels of human fecal material present.

A standard chain of custody form will be developed and used for all samples collected by Palmer Engineering and delivered to the ERTL facility for this project. Samples collected will be stored on ice in coolers and holding times will be met to insure the accuracy of the results. Sampling events will be arranged so that samples are delivered to the lab within 6 hours with analyses for *E. coli* to be initiated within 8 hours of sampling times (if this time not achieved, sample results will be flagged in reporting documents). All analyses for culturable *E. coli* bacteria analyzed by IDEXX quantitray and the filtration of samples for qPCR will be done on the day of sampling. Filters for qPCR will be stored at -20◦C until extraction. Sample aliquots used for the analysis of the AC/TC ratio will be processed within 24 hours of sampling times and will be stored under refrigeration until processing. Once samples are received in the laboratory, the SOP for normal custody will be followed. Transfer of samples to the laboratory will be accomplished using a signature on the field log sheet that denotes transfer time, date, and responsible lab personnel. If custody is not maintained, then a note must be made on the accompanying sample forms. All frozen and/or archived samples are to be stored in a freezer (-20oC) accessible only to authorized laboratory personnel. The laboratory analyst is responsible for the samples from arrival to analysis and final disposal.

Data entry QA procedures

ERTL personnel participating in the study will catalog all methods, results, dates, conditions, and data in lab books with permanent ink. Copies of the data from lab books, field sheets, lab analysis sheets, and chain of custody sheets will be kept in a centralized file until entry into electronic spreadsheet. Procedures for entering hand-written data into the database will follow standard quality assurance procedures (e.g., verification using independent double key entry). Files created from the centralized spreadsheet for modeling or analysis will have 10% of the data entries random record checked to assure that manipulation of the file did not corrupt the data. Errors caught during cross-checking will be flagged and corrected, to the extent possible, in consultation with data collection staff and appropriate parties.

Analytical Methods

This project will follow well-recognized analytical methods for surface and drinking water samples. The membrane filter and broth culture methods to be used are standardized (SM9222b for the AC/TC ratio obtained from the m-endo broth based, membrane filter analysis for total coliforms, IDEXX Quanti-Tray 2000 for *E. coli*). The

IDEXX analysis will be done per published procedural manuals from IDEXX. Basically, 100 mL samples of water are mixed with pre-packaged amounts of media, and then distributed into a sterile multiple well Quanti-Tray and incubated at 35 degrees C for 24 hours ± 2 hours before counting the number of wells with blue florescence. The numbers of large and small positive wells are used to provide a statistical estimate of the most probable number of bacteria per 100 mL of sample to be read from a chart provided by IDEXX. The AC/TC ratio analysis will require colony counts for two types of bacterial colonies grown on m-endo fed membrane filters, those presenting as total coliforms (dark red with sheen) and those presenting as atypical colonies (pink to red, no sheen). The AC/TC ratio reported is produced by dividing the number of atypical colonies per 100 mL by the number of total coliform colonies per 100 mL (Brion, 2000). The AC/TC ratio reported is unitless.

DNA extraction methods for qPCR will be standardized using commercially available, pre-packaged kits or EPA methods. Sewage or cloned DNA product will be used for the positive controls. Records will be kept of PCR efficiency and qPCR results will be reported as DNA copies per unit volume. Dr. Brion will review all microbial data for consistency and quality. Data that shows substantial discrepancies from known precisions or variances will be discarded and the events surrounding the value investigated. Dr. Brion will determine and record the appropriate corrective action as required on a case-by-case basis.

Bacteroides qPCR analyses will use the Allbac and Hubac markers and protocol designed by Alice Layton at the University of Tennessee in Knoxville, TN. The PCR protocol for the analysis of Allbac and Hubac markers is as follows. The PCR reaction mixture consists of 10uL Life Technologies TaqMan Environmental Master Mix, 10 p moles of each forward and reverse primer (Layton, 2006), 5 p moles of the corresponding fluorescently labeled probe (Layton, 2006), 2uL of template DNA, and enough dilution water to produce a final reaction volume of 20uL. Calibration curves are made using serial dilutions of plasmid DNA containing the cloned 16s rRNA from Human fecal *Bacteroides*. (Layton, 2006) Calibration covers a range of 10^1 – 10^7 target copies/uL. All qPCR reactions are run in triplicate using an Applied Biosystems Step One Plus qPCR instrument. The thermocycler program consists of 1 cycle at 50◦C for 2 minutes and 95◦C for 10 minutes followed by 50 cycles of 95◦C for 30 seconds and 60◦C for 45 seconds. (Layton, 2006). Threshold cycles from samples are compared with the calibration curve to determine concentration of target in copies per uL and then the final report value in copies/mL is calculated based on the volume of original water sample filtered.

Quality Control

Standard laboratory QA/QC for membrane filtration and IDEXX Quantitray methods will include, but not be limited to the following practices: a positive control will be done for each new batch of media; a negative control in the form of a field blank will be run each sampling event; a negative control for media quality and laboratory aseptic technique will be done with each sampling event; each sample for membrane filtration will have a minimum of 3 dilutions/aliquots assayed with 2 replicate plates per dilution analyzed; only counts from plates with >20 or <80 colonies will be used to calculate sample concentrations; only counts from plates with clearly separable colonies will be used, and colonies that touch each other will be counted as a single colony; anomalous counts will be excluded from data reporting; duplicate samples run on 10% of samples and compared against the precision test and corrective measures taken as appropriate. When possible, calculations of the final concentration of microorganisms will be made from the maximum volume of sample, even if it includes counts from different dilutions/aliquots. The total number of colonies observed will be divided by the total amount of sample filtered, adjusted to CFU/100 mL, and reported. EPA QA/QC guidelines for PCR methods will be followed and include, but not be limited to: a PCR positive control per each PCR run; a PCR negative control; a PCR method blank with each batch of samples processed; a method positive control with every sample batch; an initial matrix spike/inhibition check repeated if water conditions change radically.

Crosschecking data

Dr. Brion will review all microbial data generated for consistency and quality. Data that shows substantial discrepancies from known precisions or variances will be discarded and the events surrounding the value investigated. Dr. Brion will determine and record the appropriate corrective action as required on a case-by-case basis.

Data anomalies

Procedures for handling data anomalies (such as outliers and missing data) will be handled based on standard statistical procedures.

Instrument/Equipment Testing, Inspection and Maintenance

The PCR equipment is on a maintenance contract that includes a yearly preventative maintenance visit by a Life Technologies specialist.

Instrument/Equipment Calibration and Frequency

Calibration is part of the yearly PM visit..

Inspection/Acceptance for Supplies and Consumables

Supplies and consumables are certified sterile or PCR grade. All media expiration dates are reviewed to assure fresh media was supplied.

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APPENDIX J

REFERENCES

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APPENDIX K

LOAD CALCULATIONS

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Site 1 Load Calculations

Sampling Event Number	E. Coli Load	TSS Load	TN Load	TP Load
1	6.738E+12	96077.4	57310.19	15132.2
2	7.0858E+13	96077.4	100497	7782.27
3	1.7196E+12	40006	13071.97	6485.23
4	4.8332E+12		131436.5	11193
5	8.0386E+12		162174.4	11193
6	1.0356E+13		205222.8	11000.9
7	1.8331E+13		123769.2	6869.54
8	2.127E+13		151473.6	7926.39
9	5.4859E+12	353636	18692.18	1873.51
10	8.5606E+12	37840.3	9781.727	8791.09
10A	8.7779E+11			
10B	1.1484E+13			
10C	5.1867E+13			
10D	6.1452E+12			
11	1.57E+12	9253.36	3655.077	18783.1
12	4.2724E+12	51740.1	13969.82	11048.9
Average	1.4525E+13	97804.4	82587.87	9839.93

Sampling Event Number	E. Coli BM	TSS BM	TN BM	TP BM
1	5.217E+13	480387.2	120096.8	12009.68
2	5.217E+13	480387.2	120096.8	12009.68
3	1.086E+13	100015	25003.76	2500.376
4	5.043E+13		116110	11611
5	6.029E+13		138800.4	13880.04
6	8.284E+13		190727.5	19072.75
7	8.626E+13		198602.7	19860.27
8	8.103E+13		186543.8	18654.38
9	2.743E+13	252597	63149.26	6314.926
10	2.055E+13	189201.7	47300.42	4730.042
10A	8.103E+12			
10B	1.888E+13			
10C	4.979E+13			
10D	2.341E+13			
11	5.024E+12	46266.8	11566.7	1156.67
12	1.405E+13	129350.2	32337.54	3233.754
	4.02E+13	239743.6	104194.6	10419.46

Site 2 Load Calculations

Sampling Event Number	E. Coli Load	TSS Load	TN Load	TP Load
1	2.822E+13	86627.2	55008.272	11088.282
2	4.7426E+14	173254.4	90958.56	4374.6736
3	3.9955E+13	68455.18	25921.693	7623.1936
4	1.0471E+13		173865.12	10568.518
5	1.1388E+13		137091.48	5717.3952
6	2.5682E+12		160632.23	12171.122
7	1.0486E+13		69884.229	7060.1168
8	2.3436E+13		166056.86	5544.1408
MST-A	6.3735E+12			
9	4.4816E+12	355565.3	24381.619	2382.248
MST-B	2.651E+12			
10	2.4797E+12	40596.66	14127.636	3378.4608
10A	5.8303E+13			
10B	1.3326E+12			
10C	7.1183E+13			
10D	1.0939E+13			
11	1.8888E+12	26933.18	10369.276	10611.832
12	8.0193E+12	26854.43	17186.836	8359.5248
MST-C	7.2415E+14			
Average	7.8557E+13	111183.8	78790.318	7406.6256
	4.2691E+13			

Sampling Event Number	E. Coli BM	TSS BM	TN BM	TP BM
1	4.703E+13	433136	108284	10828.4
2	4.703E+13	433136	108284	10828.4
3	2.478E+13	228183.92	57045.98	5704.598
4	6.444E+13		148349.08	14834.91
5	5.815E+13		133878.4	13387.84
6	6.164E+13		141901.26	14190.13
7	3.495E+13		80474.7	8047.47
8	8.272E+13		190432.18	19043.22
MST-A	2.467E+13			
9	2.758E+13	253975.2	63493.8	6349.38
MST-B	1.988E+13			
10	2.204E+13	202983.28	50745.82	5074.582
10A	4.543E+13			
10B	1.599E+13			
10C	3.927E+13			
10D	2.707E+13			
11	1.462E+13	134665.92	33666.48	3366.648
12	1.458E+13	134272.16	33568.04	3356.804
MST-C	3.769E+13			
	3.735E+13	260050.35	95843.645	9584.365
	3.733E+13			

Site 3 Load Calculations

Sampling Event Number	E. Coli Load	TSS Load	TN Load	TP Load
1	1.2571E+13	85052.16	40258.022	7371.1872
2	1.1814E+14	85052.16	59536.512	3118.5792
3	7.6785E+12	1036376	9975.1221	7654.6944
4	3.6E+12		21496.54	3798.9965
5	5.7742E+12		39286.813	3855.6979
6	1.374E+13		53901.019	5018.0774
7	5.1791E+12		17069.496	1984.5504
8	1.8785E+13		28231.608	1417.536
9	6.8012E+11	30063.58	3006.3576	935.57376
10	3.2069E+12	7087.68	1134.0288	935.57376
10A	5.2655E+12			
10B	9.6785E+11			
10C	2.4178E+13			
10D	2.0203E+12			
11	3.1946E+12	16419.79	5500.6303	3827.3472
12	2.9688E+12	31244.86	27078.875	5840.2483
Average	1.4247E+13	184470.9	25539.585	3813.1718
		42486.7		

Sampling Event Number	E. Coli BM	TSS BM	TN BM	TP BM
1	3.079E+13	283507.2	70876.8	7087.68
2	3.079E+13	283507.2	70876.8	7087.68
3	1.407E+13	129547.04	32386.76	3238.676
4	1.516E+13		34896.98	3489.698
5	2.717E+13		62558.62	6255.862
6	4.122E+13		94896.16	9489.616
7	2.181E+13		50204.4	5020.44
8	3.607E+13		83034.14	8303.414
9	1.088E+13	100211.92	25052.98	2505.298
10	3.848E+12	35438.4	8859.6	885.96
10A	2.747E+13			
10B	5.665E+12			
10C	1.415E+13			
10D	7.696E+12			
11	8.915E+12	82098.96	20524.74	2052.474
12	1.131E+13	104149.52	26037.38	2603.738
	1.919E+13	145494.32	48350.447	4835.045
		148152.2		

Site 4 Load Calculations

Sampling Event Number	E. Coli Load	TSS Load	TN Load	TP Load
1	1.5334E+14	154747.7	39538.032	8640.0788
2	2.824E+14	51582.56	39976.484	1960.1373
3	5.0229E+13	3523049	11560.006	147010.3
4	3.0733E+12		23330.28	3507.6141
5	7.3314E+12		29241.011	4384.5176
6	1.374E+13		58987.453	5235.6298
7	7.0172E+12		30691.544	2579.128
8	2.4215E+13		25280.18	3043.371
MST-A	3.9273E+12			
9	1.7702E+12	159394	4492.0141	2630.7106
MST-B	1603435306			
10	1.9759E+13	31953.62	3333.8281	851.11224
10A	1.5621E+12			
10B	6.5629E+12			
10C	2.3382E+13			
10D	3.9459E+12			
11	3.3351E+11	4252.608	609.54048	3301.2838
12	1.2113E+13	20672.4	23979.984	5983.577
MST-C	1.2519E+16			
Average	6.9125E+14	563664.6	24251.696	15760.621
		70433.82		3828.8327

Sampling Event Number	E. Coli BM	TSS BM	TN BM	TP BM
1	2.801E+13	257912.8	64478.2	6447.82
2	2.801E+13	257912.8	64478.2	6447.82
3	4.981E+12	45873.04	11468.26	1146.826
4	1.603E+13		36915	3691.5
5	2.022E+13		46562.12	4656.212
6	4.122E+13		94896.16	9489.616
7	2.955E+13		68022.04	6802.204
8	2.92E+13		67234.52	6723.452
MST-A	2.142E+13			
9	1.574E+13	144903.68	36225.92	3622.592
MST-B	4.276E+10			
10	1.157E+13	106512.08	26628.02	2662.802
10A	6.841E+11			
10B	7.483E+11			
10C	2.063E+13			
10D	9.663E+12			
11	1.539E+12	14175.36	3543.84	354.384
12	1.122E+13	103362	25840.5	2584.05
MST-C	1.374E+14			
	2.252E+13	132950.25	45524.398	4552.44
				4862.041

Site 5 Load Calculations

Sampling Event Number	E. Coli Load	TSS Load	TN Load	TP Load
1	1.7673E+13	20081.76	6827.7984	4769.418
2	5.906E+13	20081.76	13354.37	712.90248
3	1.8208E+11	551.264	129.54704	2700.9967
4	3.9551E+11		1382.0976	1024.1698
5	2.4859E+13		16442.827	1265.1509
6	1.5277E+12		26404.167	1867.6037
7	6.4209E+11		3714.7318	502.044
8	4.7191E+12		5079.504	331.34904
Macro/MST-A	6.2089E+10			
9	3563189568	590.64	59.064	7.48144
MST-B	7.6965E+10			
10				
10A	3.875E+11			
10B				
10C	1.1974E+13			
10D	3.6523E+11			
11				
12				
MST-C	6.4923E+15			
Average	4.4095E+14	10326.36	8154.9009	1464.5684
	8.7091E+12			

Sampling Event Number	E. Coli BM	TSS BM	TN BM	TP BM
1	1.09E+13	100408.8	25102.2	2510.22
2	1.09E+13	100408.8	25102.2	2510.22
3	2.993E+11	2756.32	689.08	68.908
4	1.283E+12		2953.2	295.32
5	1.452E+13		33420.38	3342.038
6	7.333E+12		16882.46	1688.246
7	4.532E+12		10434.64	1043.464
8	7.354E+12		16931.68	1693.168
Macro/MST-A	3.634E+11			
9	2.138E+11	1968.8	492.2	49.22
MST-B	5.131E+11			
10				
10A	2.138E+11			
10B				
10C	2.01E+12			
10D	2.138E+11			
11				
12				
MST-C	3.795E+13			
	6.573E+12	51385.68	14667.56	1466.756
	4.332E+12			

Site 6 Load Calculations

Sampling Event Number	E. Coli Load	TSS Load	TN Load	TP Load
1				
2	4.6054E+12	3937.6	2716.944	64.9704
3	2.7953E+12	1771.92	200.8176	65.56104
4	1.1438E+12		1275.7824	135.8472
5	7.0708E+13		8459.5398	820.12333
6	3.4207E+11		1464.7872	109.62278
7	1.0935E+12		2661.0301	92.769856
Macro				
8	5.7456E+11		601.07464	27.937272
MST-A	1.2827E+11			
9	3.1178E+10	2756.32	59.064	36.4228
MST-B	6.4066E+11			
10				
10A	1.1641E+13			
10B	3.1014E+12			
10C	8.1225E+12			
10D	1.725E+12			
11				
12				
MST-C	3.3212E+14			
Average	2.9252E+13	2821.947	2179.88	169.15684

Sampling Event Number	E. Coli BM	TSS BM	TN BM	TP BM
1				
2	2.138E+12	19688	4922	492.2
3	6.414E+11	5906.4	1476.6	147.66
4	1.283E+12		2953.2	295.32
5	7.012E+12		16144.16	1614.416
6	1.026E+12		2362.56	236.256
7	2.651E+12		6103.28	610.328
8	9.193E+11		2116.46	211.646
MST-A	4.276E+11			
9	2.138E+11	1968.8	492.2	49.22
MST-B	6.2E+11			
10				
10A	1.154E+12			
10B	1.71E+11			
10C	1.668E+12			
10D	3.207E+11			
11				
12				
MST-C	2.779E+12			
	1.535E+12	9187.7333	4571.3075	457.1308

Site 7 Load Calculations

Sampling Event Number	E. Coli Load	TSS Load	TN Load	TP Load
5	9.522E+11		22046.62	3607.629
6	7.18E+11		18566.18	2173.988
7	3.72E+11		4270.721	710.2643
8	2.069E+12		5448.457	1216.955
Macro				
9	1.871E+10	826.896	260.4722	109.5637
10	4.454E+10	196.88	29.532	32.18988
10A	1.915E+11			
10B	3.107E+11			
10C	2.229E+12			
10D	1.782E+10			
11				
12	1.158E+10	767.832	197.0769	123.365
13				
14	1.479E+11	1771.92	531.576	76.19256
15	8.908E+10	3346.96	185.0672	87.02096
16	2.316E+11		634.7411	261.0629
Average	5.289E+11	1382.098	5217.044	839.8231

Sampling Event Number	E. Coli BM	TSS BM	TN BM	TP BM
5	1.0882E+13		25052.98	2505.298
6	8.61579E+12		19835.66	1983.566
7	2.47998E+12		5709.52	570.952
8	4.31859E+12		9942.44	994.244
Macro				
9	4.48962E+11	4134.48	1033.62	103.362
10	1.06896E+11	984.4	246.1	24.61
10A	9.19303E+11			
10B	3.42066E+11			
10C	1.96688E+12			
10D	4.27583E+11			
11				
12	2.77929E+11	2559.44	639.86	63.986
13				
14	2.13791E+11	1968.8	492.2	49.22
15	2.13791E+11	1968.8	492.2	49.22
16	5.55858E+11		1279.72	127.972
	2.26924E+12	2323.184	6472.43	647.243

Site 8 Load Calculations

Sampling Event Number	E. Coli Load	TSS Load	TN Load	TP Load
5	6.813E+12		67011.26	4055.945
6	2.902E+12		109471.6	6350.207
7	1.39E+13		46505.02	3861.683
8	8.607E+12		95981.36	5836.704
Macro				
9	7.985E+11	9804.624	13628.43	817.052
10	4.009E+11	6201.72	265.788	394.2522
10A	1.13E+13			
10B	1.255E+12			
10C	3.167E+13			
10D	7.446E+12			
11	5.144E+11	1299.408	1890.639	320.3041
12	1.632E+12	12816.89	5822.529	809.2949
13	1.841E+12	2520.064	4032.102	458.6516
14	6.017E+12	10749.65	4177.006	471.4488
15	3.563E+11	11025.28	1496.288	294.5325
16	4.721E+11		2243.448	627.1219
Average	5.996E+12	7773.947	29377.12	2024.766

Sampling Event Number	E. Coli BM	TSS BM	TN BM	TP BM
5	1.47302E+13		33912.58	3391.258
6	2.32177E+13		53452.92	5345.292
7	1.27847E+13		29433.56	2943.356
8	2.34743E+13		54043.56	5404.356
Macro				
9	3.54894E+12	32682.08	8170.52	817.052
10	9.62061E+11	8859.6	2214.9	221.49
10A	4.42548E+12			
10B	1.23999E+12			
10C	8.63717E+12			
10D	8.27373E+12			
11	7.05512E+11	6497.04	1624.26	162.426
12	1.98826E+12	18309.84	4577.46	457.746
13	1.36826E+12	12600.32	3150.08	315.008
14	1.66757E+12	15356.64	3839.16	383.916
15	8.55165E+11	7875.2	1968.8	196.88
16	1.13309E+12		2608.66	260.866
	6.81326E+12	14597.25	16583.04	1658.304

Site 9 Load Calculations

Sampling Event Number	E. Coli Load	TSS Load	TN Load	TP Load
5	1.736E+13		6278.897	1313.82
6	7.037E+10		2924.062	99.54253
7	1.705E+11		1592.956	56.52425
Macro				
8	1.376E+12		841.662	48.7278
9	1.911E+11	866.272	64.9704	7.146744
10				
10A	1.209E+13			
10B	1.541E+11			
10C	4.557E+12			
10D	2.12E+11			
11				
12				
13				
14	1.015E+12	2913.824	990.7002	32.05206
15				
16	1.254E+12		480.781	49.81064
Average	3.495E+12	1890.048	1882.004	229.6605

Sampling Event Number	E. Coli BM	TSS BM	TN BM	TP BM
5	5.72961E+12		13190.96	1319.096
6	1.68895E+12		3888.38	388.838
7	1.85998E+12		4282.14	428.214
Macro				
8	1.60344E+12		3691.5	369.15
9	2.35171E+11	2165.68	541.42	54.142
10				
10A	2.0524E+12			
10B	2.13791E+11			
10C	1.96688E+12			
10D	2.13791E+11			
11				
12				
13				
14	7.91028E+11	7284.56	1821.14	182.114
15				
16	4.70341E+11		1082.84	108.284
	1.52958E+12	4725.12	4071.197	407.1197

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LOAD REDUCTIONS

E. Coli

Site 2	
Target Value	37.4 trillion MPN/yr
Target Load Reduction	41.2 trillion MPN/yr
Reductions	Action Item 8 - 4.1 trillion MPN/yr
	Action Item 12 - 9.3 trillion MPN/yr
	Action Item 16&28 - 27.8 trillion MPN/yr
Site 4	
Target Value	22.5 trillion MPN/yr
Target Load Reduction	668.8 trillion MPN/yr
Reduction from Upstream	434.4 trillion MPN/yr
Reductions	Action Item 8 - 18 trillion MPN/yr
	Action Item 22 - 150 trillion MPN/yr
Site 5	
Target Value	6.6 trillion MPN/yr
Target Load Reduction	434.4 trillion MPN/yr
Reduction from Upstream	48.2 trillion MPN/yr
Reductions	Action Item 1 - 381.8 trillion MPN/yr
	Action Item 5 - 2.8 trillion MPN/yr
	Action Item 18 - 1.6 trillion MPN/yr
	Action Item 24 - 2.8 trillion MPN/yr
Site 6	
Target Value	1.5 trillion MPN/yr
Target Load Reduction	27.8 trillion MPN/yr
Reductions	Action Item 1 - 13.9 trillion MPN/yr
	Action Item 5 - 5.9 trillion MPN/yr
	Action Item 18 - 4.0 trillion MPN/yr
	Action Item 20 - 4.0 trillion MPN/yr
	Action Item 24 - 4.0 trillion MPN/yr
Site 9	
Target Value	1.6 trillion MPN/yr
Target Load Reduction	2.1 trillion MPN/yr
Reductions	Action Item 5 - 1.1 trillion MPN/yr
	Action Item 18 - 0.5 trillion MPN/yr
	Action Item 24 - 0.5 trillion MPN/yr
Site 10	
Target Value	1.3 trillion MPN/yr
Target Load Reduction	18.3 trillion MPN/yr
Reductions	Action Item 1 - 12.0 trillion MPN/yr
	Action Item 5 - 1.7 trillion MPN/yr
	Action Item 18 - 1.6 trillion MPN/yr
	Action Item 19 - 1.5 trillion MPN/yr
	Action Item 20 - 1.5 trillion MPN/yr
	Action Item 24 - 1.5 trillion MPN/yr

LOAD REDUCTIONS

Total Nitrogen

Site 8	
Target Value	19,442 lbs/yr
Target Load Reduction	15,437 lbs/yr
Reductions	Action Item 12 - 120 lbs/yr
	Action Item 16 & 28 - 550 lbs/yr
	Action Item 29 - 1,000 lbs/yr

Total Phosphorous

Site 7	
Target Value	787 lbs/yr
Target Load Reduction	219 lbs/yr
Reductions	Action Item 12 - 16 lbs/yr
	Action Item 16 & 28 - 40 lbs/yr
	Action Item 29 - 163 lbs/yr
Site 8	
Target Value	1,944 lbs/yr
Target Load Reduction	344 lbs/yr
Reductions	Action Item 12 - 32 lbs/yr
	Action Item 16 & 28 - 68 lbs/yr
	Action Item 29 - 355 lbs/yr

APPENDIX L

ADDDENDUM 1

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LOWER HOWARDS CREEK WATERSHED MANAGEMENT PLAN

ADDENDUM 1

WINCHESTER, CLARK COUNTY, KENTUCKY

Prepared for:
Winchester Municipal Utilities
150 North Main Street
P.O. Box 4177
Winchester, KY 40392-4177

Prepared by:
Palmer Engineering
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Winchester, KY 40392-0747
859.744.1218

December 2012

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1. ADDENDUM OVERVIEW

Winchester Municipal Utilities (WMU) contracted Palmer Engineering to provide consulting services for the development of a Watershed Management Plan (WMP) in Lower Howards Creek Watershed (LHCW) in Winchester, Clark County, Kentucky. The *Lower Howards Creek Watershed Management Plan* (LHCWMP) was developed as the Supplemental Environmental Project (SEP), as required by the Environmental Protection Agency (EPA) in the Consent Decree (Civil Action No. 06-1-2KSF, April 10, 2007) with WMU and the City of Winchester. This report shall serve as an addendum to the LHCWMP, dated October 11, 2012. The development of the LHCWMP and this addendum have been funded solely by WMU and the City of Winchester to meet the requirement of the SEP; however, after the finalization of the report, WMU and the City of Winchester shall be indemnified and held harmless to all actions taken by others as it relates to the implementation of the LHCWMP.

Preparation of the LHCWMP has been based on EPA's *Handbook for Developing Watershed Plans to Restore and Protect Our Waters* and the State of Kentucky's *Watershed Planning Guidebook for Kentucky Communities.* The objective of the LHCWMP was to meet the requirements of the SEP by providing direction to the community regarding sampling and gathering data; prioritizing projects within the LHCW; and producing a plan for the community that can lead to measureable results to improve water quality, watershed conditions, and enhance future funding opportunities for projects within the watershed. The project team proposed to meet the requirements for 319(h) grant funded projects, as outlined in the *Watershed Planning Guidebook for Kentucky Communities*, to allow for the funding of future projects through the 319(h) grant program as administered by KDOW.

The *Watershed Planning Guidebook for Kentucky Communities* specified that water quality monitoring should be completed in a system of two phases. Phase One monitoring allowed for sampling and analysis at a broad scale and helped to make general assessments of the watershed. Six sites were selected in LHCW along the main channel for Phase One monitoring. Phase Two monitoring followed Phase One monitoring and involved the selection of sub-watersheds for further monitoring and analysis. Ideally, 12 months of Phase One monitoring would be completed and analyzed prior to Phase Two site selection; however, due to the time constraints set forth within the Consent Decree only four months of Phase One monitoring was completed prior to selection of Phase Two monitoring locations. In November 2011, the available monitoring data was analyzed and an additional four sites were selected for Phase Two monitoring. Also due to the time constraints set forth in the Consent Decree, twelve months of Phase Two monitoring could not be completed prior to the submittal of the final report to the EPA on October 13, 2012. The purpose of this addendum is to present the sampling data and implication for the last two months of Phase Two monitoring conducted in October and November 2012. This addendum will also include any information that has been modified since the LHCWMP was issued on October 11, 2012.

As outlined in the Consent Decree, the LHCWMP was presented to the public on October 11, 2012 at a meeting held at 6:00 PM at the Clark County Extension Office. The presentation included an overview of the information collected, pollutant loads, and recommended best management practices. Those who attended the meeting were encouraged to view the LHCWMP and ask questions of the project team. The attendance list from this meeting is located in APPENDIX A.

2. ADDITIONAL PHASE TWO MONITORING

As documented in the LHCWMP, The *Watershed Planning Guidebook for Kentucky Communities* specifies parameters that must be collected for WMP development to be in compliance with 319(h) grant funded projects. These parameters, sampling frequencies, and related standard operating procedures are listed in Table 8 of the LHCWMP. The parameters that were indicated to be collected on a monthly basis or at each sampling event were collected in October and November 2012 at the Phase Two monitoring locations (Site 7 through Site 10 as identified on Figure 27 in the LHCWMP). These parameters were tested in accordance with *Quality Assurance Project Plan (QAPP) for the Lower Howards Creek Watershed Management Plan* prepared by Palmer Engineering dated September 26, 2011 and approved by KDOW October 14, 2011. Samples and field data at the time of sampling were collected by Palmer Engineering employees. Bacteria, nutrient, and sediment parameters were analyzed and processed at Fouser Environmental Services. The complete Phase Two sampling results are located in the table in APPENDIX B of this addendum, replacing the table in APPENDIX H of the LHCWMP. The updated quality control monitoring results are included in APPENDIX C, replacing the table in APPENDIX G of the LHCWMP. No quality control issues were identified in the additional sampling.

Table 1. Rainfall Preceding Sampling

Date	Sampling Event	Rain in Last 48 Hours (in)	Rain in Last 5 days (in)	Rain in Last 7 days(In)	Rain During Sampling (in)	WMP Sample Type
8/26/2011	1	0.37	0.47	0.47	0.00	Routine
9/8/2011	2	0.70	3.07	3.07	0.00	Routine
10/6/2011	3	0.00	0.00	Trace	0.00	Dry
11/1/2011	4	0.02	0.44	1.25	0.00	Routine
12/15/2011	5	0.00	0.00	0.00	0.37	Wet
1/16/2012	6	0.04	1.15	1.15	0.00	Routine
2/23/2012	7	0.00	0.06	0.12	Trace	Dry
3/21/2012	8	0.00	0.85	1.45	0.00	Routine/MST Dry
4/4/2012	MST-A	0.00	0.15	0.15	0.00	MST Dry
4/11/2012	9	0.00	0.00	0.45	0.00	Dry/MST Dry
4/27/2012	MST-B	0.05	0.20	0.68	0.00	MST Dry
5/3/2012	10	0.00	0.40	0.62	0.00	Routine/MST Dry
5/8/2012	10A	0.12	1.00	1.25	0.15	Routine/MST
5/10/2012	10B	0.15	0.27	1.15	0.00	Routine/MST Dry
5/15/2012	10C	1.55	2.00	2.27	0.00	Routine
5/17/2012	10D	0.00	2.00	2.00	0.00	Routine
6/27/2012*	11	0.00	0.00	0.00	0.00	Dry
7/24/2012*	12	Trace	0.05	0.80	0.00	Routine
8/23/2012*	13	0.05	0.05	0.05	0.00	Dry
8/28/2012*	MST-C	0.50	0.50	0.55	Trace	MST Wet
9/04/2012*	14	0.94	0.94	1.44	0.00	Routine
10/17/2012*	15	0.00	0.14	0.14	0.00	Routine
11/15/2012*	16	0.00	0.77	0.77	0.00	Routine

*Data from Kentucky Mesonet (http://www.kymesonet.org)

During the 12 months of sampling, the project team aimed to collect two wet weather samples and two dry weather samples. Wet weather, as defined in the *Watershed Planning Guidebook for Kentucky Communities*, is a "seven-day antecedent dry period (in which no more than 0.1 inch of precipitation occurs) followed by visible run-off conditions, such as sheet flow on impervious surfaces and visible surface flow in ephemeral channels." Dry weather, as defined in the *Watershed Planning Guidebook for Kentucky Communities*, is a "seven-day dry period, in which no more than 0.1 inch of precipitation occurs. A wet weather samples was collected in December 2011. However, wet weather sampling at Site 8 could not be conducted due to difficulties accessing the site and required sample hold times. Dry weather samples were collected in February 2012 and June 2012. The rainfall preceding each sampling event was identified in Table 10 in the LHCWMP, this table has been updated as Table 1 in this addendum to include information from October and November 2012.

Samples were only collected when there was visible flow between the pools of the stream; however, sometimes the flow was visible, but immeasurable because of the limitations of the Flow Watch meter. In these instances, a flow of 0.1 cubic foot per second was utilized for loading calculations.

3. PHASE TWO ANALYSIS

3.1. COMPARISON TO WATER QUALITY BENCHMARKS

To evaluate the nature and level of the impairments within LHCW, it was necessary to compare the monitoring results with a set of water quality benchmarks. The water quality benchmarks used for LHCW are a combination of documented legal limits and recommended benchmarks from KDOW. The water quality benchmarks are identified in Table 11 of the LHCWMP.

Table 2. Phase Two Number of Events Exceeding Water Quality Benchmarks

Site #	E. coli	Nitrate-Nitrite-N	NH3-N	TKN	TN	TP	BOD	TSS	Turbidity	Conductivity	DO
7	1/15	3/10	0/10	0/10	1/10	10/10	0/10	1/5	0/5	15/15	5/15
8	6/16	8/12	0/12	1/12	9/12	11/12	0/12	1/8	0/8	6/16	0/16
9	5/11	0/7	0/7	0/7	0/7	0/7	0/7	0/3	0/3	11/12	0/12
10	10/18	0/11	2/11	0/11	0/11	1/11	0/11	1/7	0/7	13/17	0/16

APPENDIX B contains a summary table for monitoring results at each site for the Phase Two monitoring period from December 2011 through November 2012. This table replaces the table included in APPENDIX H of the LHCWMP. Parameters that exceed water quality benchmarks are highlighted in red. Turbidity and BOD had no occurrences of exceeding water quality benchmarks at Phase Two monitoring locations. E. coli exceeded water quality standards at least five times during the monitoring period at three of the four sites. Conductivity exceeded water quality standards at all Phase Two sites at least six times. Table 2 replaces Table 23 in the LHCWMP and shows the number of sampling events that exceeded the water quality benchmarks by site. The first number represents the number of events exceeding water quality benchmarks and the second number represents the total number of sampling events (exceedances/number of samples). A total of 12 full sampling events were completed, but the total number of samples varies in some instances due to additional E. coli collection requirements, MST sampling, instances of no water flow, and limited equipment malfunction. Total suspended solids and turbidity were sampled at each of the 12 monthly sampling events, but the benchmarks are only valid for comparison from April to October. The project team designated that exceeding the water quality benchmark two or more times indicated a potential issue. The shading in Table 2 indicates that the critical parameter exceeded the project water quality benchmark at least twice at the indicated site.

3.2. POLLUTANT LOAD PREDICTION

As described in the LHCWMP, pollutant load predictions in LHCW were based on the concentration of the pollutant and the discharge. The pollutant loads were recalculated in the same manner described in the LHCWMP to include the monitoring results from October and November 2012 at the Phase Two sampling locations. The concentrations of the pollutants were utilized from the sampling results discussed in Section 3.1. Based on the requirements outlined in the *Watershed Planning Guidebook for Kentucky Communities*, pollutant loads were calculated for total nitrogen, total phosphorous, total suspended solids, and E. coli. Conductivity was noted to exceed water quality benchmarks, but pollutant loads were not calculated. The discharge values utilized in the loading calculations are listed in APPENDIX B. Areas were minimal flow were observed at the time of sampling were assigned a discharge value of 0.1 cubic feet per second.

Pollutant load predictions and target load reductions for E. coli were derived from the following formula:

$$\underset{\text{(CFU/yr)}}{\text{E. coli Loading}} = \underset{\text{(CFU/100mL)}}{\text{Concentration}} \times \underset{\text{(cfs)}}{\text{Discharge}} \times \underset{\text{(Annual Load Conversion)}}{8{,}907{,}973{,}920}$$

For E. coli loading calculations, the above formula was applied to the data from each sampling event. All sampling events were then averaged using the arithmetic mean to obtain an average annual load. As previously noted, one sample at Site 10 had a reading of greater than 2420 MPN/100mL because the sample was not diluted prior to processing. It was impossible to estimate the actual value, so 2420 MPN/100mL was used for the load calculations. The benchmark of 240 CFU/100 mL was used to calculate the target loads. Based on these calculations, the E. coli loading and target reductions are shown in Table 3. Table 3 replaces Table 27 in the LHCWMP. As done previously, the reduction to achieve the target loading was calculated by subtracting the E. coli loading from the E. coli target loading. The percent reduction target was calculated by dividing the value for the reduction to achieve the target loading by the E. coli loading present expressed as a percentage. E. coli loadings exceed E. coli target loadings at two of the four Phase Two sites. When the results from October and November 2012 were considered in the loading calculations, a significant difference was not seen. The average loading valves were reduced, but the percent target reductions remained consistent with what was reported in the LHCWMP dated October 11, 2012.

Table 3. Phase Two E. coli Loading and Target Reductions

Site #	E. Coli Loading (Trillion CFU/yr)	E. Coli Target (Trillion CFU/yr)	Reduction to Achieve Target (Trillion CFU/yr)	Percent Reduction Target
7	0.5	2.3	N/A	N/A
8	6.0	6.8	N/A	N/A
9	3.5	1.5	2.0	57%
10	17.5	1.3	16.2	93%

Pollutant load predictions and target load reductions for total nitrogen, total phosphorous, and total suspended solids were derived from the following formula:

$$\underset{\text{(lbs/yr)}}{\text{Nutrient/TSS Loading}} = \underset{\text{(mg/L)}}{\text{Concentration}} \times \underset{\text{(cfs)}}{\text{Discharge}} \times \underset{\text{(Annual Load Conversion)}}{1968.80}$$

For total nitrogen and total phosphorous, the above formula was used for each sampling event and then all the values were averaged together to obtain an average annual load. For total suspended solids, the arithmetic average of the samples collected from April through September was used. Total suspended solids results from November to March were excluded in accordance with the recommendations from KDOW in *Benchmark Recommendations for Nutrient Parameters*. Some sampling results for total nitrogen, total phosphorous, and total suspended solids were reported at below the detection limit. Since an exact value could not be assigned to these results, the value of the detection limit was used for load calculations. The water quality benchmark concentrations were used for target load calculations, which were: 0.25 mg/L for total phosphorous; 2.5 mg/L for total nitrogen; and 8.7 mg/L for total suspended solids. Based on these calculations, the loading and target reductions for total nitrogen are shown in Table 4, replacing Table 28 in the LHCWMP, and for total phosphorous in Table 5, replacing Table 29 in the LHCWMP.

Table 4. Phase Two TN Loading and Target Reductions

Site #	TN Loading (lbs/yr)	TN Target Loading (lbs/yr)	Reduction to Achieve Target (lbs/yr)	Percent Reduction Target
7	5,217	6,472	N/A	N/A
8	29,377	16,583	12,794	44%
9	1,882	4,071	N/A	N/A
10	1,133	2,747	N/A	N/A

Table 5. Phase Two TP Loading and Target Reductions

Site #	TP Loading (lbs/yr)	TP Target Loading (lbs/yr)	Reduction to Achieve Target (lbs/yr)	Percent Reduction Target
7	840	647	193	23%
8	2,024	1,658	366	18%
9	230	407	N/A	N/A
10	142	275	N/A	N/A

Total nitrogen loadings exceeded target loads at Site 8. Total phosphorous loadings exceeded target loads at Site 7 and Site 8. When the results from October and November 2012 were considered in the loading calculations, a significant difference was not seen. The average loading valves were reduced, but the percent target reductions remained consistent with what was reported in the LHCWMP dated October 11, 2012.

Table 6, which replaces Table 30 in the LHCWMP, identifies the total suspended solids loadings. All total suspended solids loadings were below the target loadings at the Phase Two sites. However, the average loadings did increase when compared to the values listed in the LHCWMP, dated October 11, 2012, due to higher concentrations in October 2012.

Table 6. Phase Two TSS Loadings and Target Loadings

Site #	TSS Loading (lbs/yr)	TSS Target Loading (lbs/yr)
7	1,382	2,323
8	7,773	14,597
9	1,890	4,725
10	1,523	4,364

3.3. ANALYSIS OF RESULT

When the pollutant loadings are modified to include the Phase Two monitoring results from October and November 2012 the average loadings are slightly modified, but no new pollutants were found to exceed target loadings at any site. The percentage target reduction remained consistent for sites that required pollutant reductions. Due to this, no additional analysis will be performed. The project team feels that the best management practices and action items outlined for the Phase Two reaches and subwatersheds in the LHCWMP, dated October 11, 2012, do not need to be modified based on the addition of the October and November 2012 sampling data.

4. IMPLEMENTATION MODIFICATION

Section 6.4 of the LHCWMP dated October 11, 2012 indicated that two additional monitoring activities were planned for May 2013 and May 2014. The funding for these monitoring activities was to be from the required expenditures for the SEP as outlined in the Consent Decree. WMU prepared the SEP Completion Report following the LHCWMP submittal and public presentation on October 11, 2012. The SEP Completion Report, dated November 20, 2012, indicated that WMU and the City of Winchester had exceeded the required expenditure by almost five percent as of the date of the preparation of the report. No money was budgeted for monitoring activities outside of the required expenditure. Since the required expenditure has been met, there is currently no funding available for the planned monitoring activities in May 2013 and May 2014. It is recommended that the LHCWMP Implementation Coordinator seek funding to complete these monitoring activities.

APPENDIX A

OCTOBER 11, 2012 MEETING ATTENDANCE LISTS

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PLAN PRESENTATION PUBLIC MEETING
LOWER HOWARDS CREEK WATERSHED MANAGEMENT PLAN

October 11, 2012
Clark County Extension Office, 6:00 PM

Name	Agency/Company	Phone	Email
Stephanie Blair	Palmer Engineer	859-744-1218	sblair@palmernet.com
Ralph Schuler	PEC	"	rschuler@palmernet.com
Brian Ward	PEC	"	bward@palmernet.com
Michael [illegible]	Winchester Municipal	859 744-5434	[illegible]@wmutilities.com
Mike Anderson	WMU	859 744-5521	andersonwin@bellsouth.NET
Casey Castle	Winchester San	606 367 7022	ccastle@winchester-san.com
Bill Quisenberry	Farm owner	859-744-2364	N/A
Jim Roe	Ky Division of Water	(502) 695-9450	james.roe@ky.gov
Paul Rodgers	WMU	859-745-4225	paul.rodgers@cedarcreekengineering.com
Vince Isaac	Home owner	771-3987	VandJIsaacs@bellsouth.net
KEN BUSH	3076 [illegible]	859-744-0198	
Karen Leverenz	Bluegrass Area Development District	8592698021	kleverenz@bgadd.org
Betsy Laski			blaski@ "
John Campbell	Home Own	859 771-2479	
Resenia Campbell	Home own	859 749-2774	
Rick/Suzy Smith	C.C. Commissioner/Farmer	749-0410	corgismith@aol.com
Lee Carlisle	Homeowner/PEC	859-744-1218	
Henry Branham	Judge/Executive	859-745-0200	clarkcountyjudge@yahoo.com
Claire Sipple	LHC W.H. preserve	859 744-4888	claresipp@gmail.com
Wes Moody	LHC	859-745-4319	wesmoody@hotmail.com

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APPENDIX B

PHASE TWO MONITORING RESULTS

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Site 7

Sampling Event Number	Date	Type	Air Temp (°F)	Max Velocity (m/s)	Flow (m^3/s)	Flow (ft^3/s)	Water Temp (°C)	%DO	DO (mg/L)	Specific Conductivity (µS/cm)	pH	Habitat Assessment (RBP Score)	Habitat Assessment Classification	Biological Assessment (MBI Score)	Biological Assessment Classification	Turbidity (NTUs)	E. Coli (MPN/100 mL)	TSS (mg/L)	BOD-5 (mg/L)	NH3-N (mg/L)	Nitrate-N (mg/L)	Nitrite-N (mg/L)	TKN (mg/L)	Orthophosphate (mg/L)	Total Phosphorus (mg/L)	Total Nitrogen (mg/L)
5	12/15/2011	Wet	61	0.6	0.14	5.09	9.8	100	11.1	495.2	8.44	---	---	---	---	4.99	21	5	5	<0.05	2.00	<0.10	<0.10	0.357	0.36	2.20
6	1/16/2012	Routine	41	0.6	0.11	4.03	2.5	98	13.2	313.3	8.57	---	---	---	---	2.39	20	2	<3	<0.05	2.14	<0.10	<0.10	0.335	0.274	2.34
7	2/23/2012	Routine	58	0.4	0.03	1.16	6.7	106	12.6	596.6	8.65	---	---	---	---	3.18	36	8	<3	<0.05	1.55	<0.10	0.219	0.267	0.311	1.87
8	3/21/2012	Routine	80	0.6	0.06	2.02	13.8	101	10.3	540.2	8.5	---	---	---	---	1.22	115	12	<3	<0.05	1.17	<0.10	<0.10	0.351	0.306	1.37
Macro	4/4/2012	Macro	76	---	---	---	15.9	95	9.2	549.8	8.32	156	Good	57.76	Excellent	---	---	---	---	---	---	---	---	---	---	---
9	4/11/2012	Dry	50	0.3	0.01	0.21	9.5	102	11.5	578.4	8.1	---	---	---	---	2.5	10	<2	<3	<0.05	0.43	<0.10	<0.10	0.336	0.265	0.63
10	5/3/2012	Routine	80	0.1	0.00	0.05	17.2	52	4.9	675	7.82	---	---	---	---	1.65	100	2	<3	<0.05	<0.10	<0.10	<0.10	0.306	0.327	<0.30
10A	5/8/2012	Routine	74	0.6	0.01	0.43	19	52	4.7	788	7.78	---	---	---	---	---	50	---	---	---	---	---	---	---	---	---
10B	5/10/2012	Routine	64	<0.1	0.00	0.16	16.5	47	4.5	837	7.77	---	---	---	---	---	218	---	---	---	---	---	---	---	---	---
10C	5/15/2012	Routine	77	0.4	0.03	0.92	14.9	87	8.6	1004	8.18	---	---	---	---	---	272	---	---	---	---	---	---	---	---	---
10D	5/17/2012	Routine	75	0.1	0.01	0.20	16.4	71	6.7	1016	8.06	---	---	---	---	---	<10	---	---	---	---	---	---	---	---	---
11	6/27/2012	Dry	90	No Water	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
12	7/25/2012	Routine	96	0.1	0.00	0.13	22.8	51	4.3	1396	7.74	---	---	---	---	0.75	10	3	<3	<0.05	0.57	<0.10	<1	0.441	0.482	0.77
13	8/23/2012	Routine	88	No Water	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
14	9/4/2012	Routine	83	0.1	0.00	0.10	21.5	51	4.5	1232	7.7	---	---	---	---	0.96	166	9	<3	<0.05	2.5	<0.10	0.1	0.392	0.387	2.7
15	10/17/2012	Routine	74	Minimal	Minimal	Minimal	11.2	62	6.7	1638	7.83	---	---	---	---	1.78	<100	17	<3	<0.05	0.74	<0.10	<0.100	0.471	0.442	0.94
16	11/15/2012	Routine	48	0.3	0.01	0.26	4.8	99	12.7	1125	7.97	---	---	---	---	2.5	<100	5	<3	<0.05	1.04	<0.10	<0.100	0.404	0.51	1.24

Site 8

Sampling Event Number	Date	Type	Air Temp (°F)	Max Velocity (m/s)	Flow (m^3/s)	Flow (ft^3/s)	Water Temp (°C)	%DO	DO (mg/L)	Specific Conductivity (µS/cm)	pH	Habitat Assessment (RBP Score)	Habitat Assessment Classification	Biological Assessment (MBI Score)	Biological Assessment Classification	Turbidity (NTUs)	E. Coli (MPN/100 mL)	TSS (mg/L)	BOD-5 (mg/L)	NH3-N (mg/L)	Nitrate-N (mg/L)	Nitrite-N (mg/L)	TKN (mg/L)	Orthophosphate (mg/L)	Total Phosphorus (mg/L)	Total Nitrogen (mg/L)
5	12/19/2011	Routine	50	0.4	0.19	6.89	7.7	106	12.5	431.6	8.5	---	---	---	---	3.04	111	<2	<3	<0.05	4.74	<0.10	<0.10	0.31	0.299	4.94
6	1/16/2012	Routine	41	0.4	0.31	10.86	6.7	105	12.7	431.7	8.48	---	---	---	---	3.67	30	<2	<3	<0.05	4.92	<0.10	<0.10	0.324	0.297	5.12
7	2/23/2012	Routine	58	0.3	0.17	5.98	9.4	113	12.5	427.6	8.73	---	---	---	---	2.51	261	6	<3	<0.05	3.72	<0.10	0.131	0.284	0.328	3.95
8	3/21/2012	Routine	80	0.4	0.31	10.98	12.5	110	11.5	424.8	8.22	---	---	---	---	4.53	88	5	<3	<0.05	4.24	<0.10	<0.10	0.366	0.27	4.44
Macro	4/4/2012	Macro	76	---	---	---	16	115	11.2	441.8	8.41	152	Fair	65	Excellent	---	---	---	---	---	---	---	---	---	---	---
9	4/11/2012	Dry	50	0.1	0.05	1.66	---	---	---	---	---	---	---	---	---	2.36	54	3	<3	<0.05	3.97	<0.10	<0.10	0.352	0.25	4.17
10	5/3/2012	Routine	80	<0.1	0.01	0.45	17.2	88	8.4	471.4	8.33	---	---	---	---	5.53	100	7	<3	<0.05	<0.10	<0.10	<0.10	0.414	0.445	<0.30
10A	5/8/2012	Routine	74	0.3	0.06	2.07	17.7	79	7.3	463.2	8.15	---	---	---	---	---	613	---	---	---	---	---	---	---	---	---
10B	5/10/2012	Routine	64	<0.1	0.02	0.58	13.3	94	9.6	480.7	8.32	---	---	---	---	---	243	---	---	---	---	---	---	---	---	---
10C	5/15/2012	Routine	77	0.4	0.11	4.04	13.5	97	9.9	492.4	8.27	---	---	---	---	---	880	---	---	---	---	---	---	---	---	---
10D	5/17/2012	Routine	75	0.3	0.11	3.87	14.6	95	9.5	490.1	8.38	---	---	---	---	---	216	---	---	---	---	---	---	---	---	---
11	6/27/2012	Dry	90	<0.1	0.01	0.33	15.9	88	8.4	506.9	8.35	---	---	---	---	2.64	175	<2	<3	<0.050	2.71	<0.10	<0.100	0.395	0.493	2.91
12	7/25/2012	Routine	96	0.1	0.03	0.93	21.6	97	8.4	569	8.25	---	---	---	---	3.68	197	7	<3	<0.050	2.98	<0.10	<1	0.449	0.442	3.18
13	8/23/2012	Routine	88	0.1	0.02	0.64	15.5	94	9.2	587.7	7.91	---	---	---	---	1.57	323	2	4	<0.050	2.3	<0.10	0.8	0.353	0.364	3.2
14	9/4/2012	Routine	83	0.2	0.02	0.78	20.5	90	7.9	582	8.12	---	---	---	---	1.29	866	7	<3	<0.05	2.52	<0.10	0.1	0.348	0.307	2.72
15	10/17/2012	Routine	74	0.1	0.01	0.40	10.4	93	10.2	602.7	8.03	---	---	---	---	1.57	<100	14	<3	<0.05	1.7	<0.10	<0.100	0.415	0.374	1.9
16	11/15/2012	Routine	48	<0.1	0.01	0.53	4.2	102	13.1	598	8.05	---	---	---	---	<0.50	<100	2	<3	<0.05	1.95	<0.10	<0.100	0.327	0.601	2.15

Site 9

Sampling Event Number	Date	Type	Air Temp (°F)	Max Velocity (m/s)	Flow (m^3/s)	Flow (ft^3/s)	Water Temp (°C)	%DO	DO (mg/L)	Specific Conductivity (µS/cm)	pH	Habitat Assessment (RBP Score)	Habitat Assessment Classification	Biological Assessment (MBI Score)	Biological Assessment Classification	Turbidity (NTUs)	E. Coli (MPN/100 mL)	TSS (mg/L)	BOD-5 (mg/L)	NH3-N (mg/L)	Nitrate-N (mg/L)	Nitrite-N (mg/L)	TKN (mg/L)	Orthophosphate (mg/L)	Total Phosphorus (mg/L)	Total Nitrogen (mg/L)
5	12/15/2011	Wet	61	0.1	0.08	2.68	11.6	96	10.1	362	8.17	---	---	---	---	62	727	<2	5	<0.05	0.94	<0.10	0.146	0.094	0.249	1.19
6	1/16/2012	Routine	41	0.1	0.02	0.79	6.2	101	12.2	651.9	8.43	---	---	---	---	3.51	10	2	<3	<0.05	1.68	<0.10	<0.10	0.064	0.064	1.88
7	2/23/2012	Routing	58	0.3	0.02	0.87	13.1	161	16.3	543.2	8.69	---	---	---	---	1.48	22	6	<3	<0.05	0.72	<0.10	0.114	0.034	<0.033	0.93
Macro	3/7/2012	Macro	---	---	---	---	9.9	150	16.6	621	8.54	107	Poor	25.04	Poor	---	---	---	---	---	---	---	---	---	---	---
8	3/21/2012	Routine	80	0.3	0.02	0.75	18.3	181	16.6	507	8.64	---	---	---	---	<0.50	206	<2	<3	<0.05	0.37	<0.10	<0.10	0.035	<0.033	0.57
9	4/11/2012	Dry	50	<0.1	0.00	0.11	14.5	164	16.3	505.4	8.7	---	---	---	---	<0.50	195	4	<3	<0.05	<0.10	<0.10	<0.10	0.039	<0.033	<0.30
10	5/3/2012	Routine	80	No Water	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
10A	5/8/2012	Routine	74	0.3	0.03	0.96	22.9	65	5.4	572	7.85	---	---	---	---	---	1414	---	---	---	---	---	---	---	---	---
10B	5/10/2012	Routine	64	<0.1	0.00	0.10	20.5	98	8.5	743	8.02	---	---	---	---	---	173	---	---	---	---	---	---	---	---	---
10C	5/15/2012	Routine	77	0.3	0.03	0.92	20.6	111	9.7	707	8.24	---	---	---	---	---	556	---	---	---	---	---	---	---	---	---
10D	5/17/2012	Routine	75	0.1	0.00	0.10	22.2	141	11.9	729	8.33	---	---	---	---	---	238	---	---	---	---	---	---	---	---	---
11	6/27/2012	Dry	90	No Water	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
12	7/25/2012	Routine	96	No Water	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
13	8/23/2012	Routine	88	No Water	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
14	9/4/2012	Routine	83	0.3	0.01	0.37	23.4	127	10.5	708	8.09	---	---	---	---	<0.50	308	4	<3	<0.05	1.16	<0.10	0.1	0.092	0.044	1.36
15	10/17/2012	Routine	74	Pooled	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
16	11/15/2012	Routine	48	0.2	0.01	0.22	9	119	13.5	517	8.03	---	---	---	---	1.93	640	9	3	<0.05	0.91	<0.10	<0.100	0.09	0.115	1.11

🟥 Indicates exceedance of water quality benchmarks

🟦 Indicates water quality benchmarks not comparable per KDOW

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Site 10

Sampling Event Number	Date	Type	Air Temp (°F)	Max Velocity (m/s)	Flow (m^3/s)	Flow (ft^3/s)	Water Temp (°C)	%DO	DO (mg/L)	Specific Conductivity (µS/cm)	pH	Habitat Assessment (RBP Score)	Habitat Assessment Classification	Biological Assessment (MBI Score)	Biological Assessment Classification	Turbidity (NTUs)	E. Coli (MPN/100 mL)	TSS (mg/L)	BOD-5 (mg/L)	NH3-N (mg/L)	Nitrate-N (mg/L)	Nitrite-N (mg/L)	TKN (mg/L)	Orthophosphate (mg/L)	Total Phosphorus (mg/L)	Total Nitrogen (mg/L)
5	12/15/2011	Wet	61	0.4	0.07	2.37	11.5	92	9.7	334.5	7.96	---	---	---	---	105	>2420	<2	5	0.054	0.68	<0.10	0.109	0.173	0.252	0.89
6	1/16/2012	Routine	411	0.3	0.02	0.67	6.1	100	12.1	495.2	8.3	---	---	---	---	4.49	270	6	<3	<0.05	1.3	<0.10	<0.10	0.076	0.059	1.50
7	2/23/2012	Routine	58	0.3	0.03	0.89	10.9	139	14.7	657	8.52	---	---	---	---	3.18	68	10	<3	<0.05	0.78	<0.10	0.205	0.051	<0.033	1.09
8	3/21/2012	Routine	80	0.3	0.01	0.41	16.3	161	15.5	608	8.51	---	---	---	---	1.27	86	<2	<3	<0.05	0.63	<0.10	<0.10	0.098	0.04	0.83
acro/MST-	4/4/2012	MST Dry	76	0.2	0.00	0.15	19.4	167	14.8	683	8.43	82	Poor	21.83	Poor	---	387	---	---	---	---	---	---	---	---	---
9	4/11/2012	Dry	50	0.1	0.00	0.11	11	158	16.9	721	8.5	---	---	---	---	1.31	157	5	<3	<0.05	0.24	<0.10	<0.10	0.09	<0.033	0.44
MST-B	4/27/2012	MST Dry	62	<0.1	0.00	0.09	---	---	---	---	---	---	---	---	---	---	150	---	---	---	---	---	---	---	---	---
10	5/3/2012	Routine	80	<0.1	0.00	0.05	21.6	107	9.3	773	8.22	---	---	---	---	3.65	79	3	<3	<0.05	<0.10	<0.10	<0.10	<0.033	0.127	<0.30
10A	5/8/2012	Routine	74	0.5	0.03	1.04	20.5	77	6.7	618	8	---	---	---	---	---	3448	---	---	---	---	---	---	---	---	---
10B	5/10/2012	Routine	64	<0.1	0.00	0.15	16.5	126	11.8	823	8.3	---	---	---	---	---	160	---	---	---	---	---	---	---	---	---
10C	5/15/2012	Routine	77	0.6	0.03	1.07	16.8	105	9.9	713	8.18	---	---	---	---	---	862	---	---	---	---	---	---	---	---	---
10D	5/17/2012	Routine	75	0.3	0.02	0.64	17.6	106	9.8	746	8.2	---	---	---	---	---	862	---	---	---	---	---	---	---	---	---
11	6/27/2012	Dry	90	No Water	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
12	7/25/2012	Routine	96	<0.1	0.00	0.06	25.5	114	8.9	824	8.03	---	---	---	---	1.31	816	<2	<3	<0.05	0.57	<0.10	<1	0.058	0.057	0.77
13	8/23/2012	Routine	88	Minimal	Minimal	Minimal	18.2	58	5.3	883	7.85	---	---	---	---	7.66	1309	2	3	0.06	<0.10	<0.10	<0.10	0.098	0.044	<0.3
MST-C	8/28/2012	MST Wet	87	0.3	0.04	1.30	22.7	79	6.6	360.2	7.41					---	17230	---	---	---	---	---	---	---	---	---
14	9/4/2012	Routine	83	0.1	0.02	0.85	22.4	87	7.3	850	7.96	---	---	---	---	0.55	1733	<2	<3	<0.05	1.18	<0.10	0.2	0.072	0.043	1.48
15	10/17/2012	Routine	74	0.2	0.00	0.16	12.5	86	8.9	791	8.01	---	---	---	---	2.47	137	12	<3	<0.05	<0.10	<0.10	<0.10	0.074	<0.033	<0.3
16	11/15/2012	Routine	48	0.3	0.01	0.47	6.4	105	12.7	487.1	8.08	---	---	---	---	<0.50	110	3	<3	<0.05	0.78	<0.10	<0.100	0.068	0.117	0.98

🟥 Indicates exceedance of water quality benchmarks
🟦 Indicates water quality benchmarks not comparable per KDOW

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APPENDIX C

QAQC MONITORING RESULTS

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QA/QC Water Sampling Data

Sampling Event Number	Date	Type	Air Temp (°F)	Velocity (m/s)	Flow (m/s)	Flow (ft/s)	Water Temp (°C)	%DO	DO (mg/L)	Conductivity	pH	Habitat Assessment (RBP Score)	Habitat Assessment Classification	Biological Assessment (MBI Score)	Biological Assessment Classification	Turbidity (NTUs)	E. Coli (MPN/100 mL)	TSS (mg/L)	BOD-5 (mg/L)	NH3-N (mg/L)	Nitrate-N (mg/L)	Nitrite-N (mg/L)	TKN (mg/L)	Orthophosphate (mg/L)	Total Phosphorus (mg/L)
1	8/29/2011	Blank	86	---	---	---	---	---	---	---	---	---	---	---	---	0.168	<10	<2	<3	<0.05	1.07	<0.10	<0.10	<0.033	<0.066
2	9/8/2011	Duplicate - Site 4	62	---	---	---	---	---	---	---	---	---	---	---	---	3.41	>2420	2	<3	0.593	1.06	0.18	0.177	0.254	0.073
5	12/15/2011	Blank	61	---	---	---	---	---	---	---	---	---	---	---	---	0.681	<1	<2	4	<0.05	<0.10	<0.10	<0.10	<0.033	<0.033
6	1/16/2012	Duplicate - Site 3	41	---	---	---	---	---	---	---	---	---	---	---	---	5.96	80	2	<3	<0.05	1.23	<0.10	<0.10	0.123	0.128
8	3/21/2012	Blank	50	---	---	---	---	---	---	---	---	---	---	---	---	<0.50	<1	<2	<3	<0.05	<0.10	<0.10	<0.10	<0.033	<0.033
9	4/11/2012	Duplicate - Site 9	50	---	---	---	---	---	---	---	---	---	---	---	---	<0.50	80	<2	<3	<0.05	<0.10	<0.10	<0.10	0.048	<0.033
10A	5/8/2012	E coli - Site 7	74	---	---	---	---	---	---	---	---	---	---	---	---	---	38	---	---	---	---	---	---	---	---
11	6/27/2012	Blank	90	---	---	---	---	---	---	---	---	---	---	---	---	<0.50	<10	<2	<3	<0.05	<0.10	<0.10	<0.100	<0.033	<0.033
12	7/25/2012	Duplicate - Site 4	96	---	---	---	---	---	---	---	---	---	---	---	---	2.2	327	5	3	0.677	0.39	<0.10	1.82	0.134	0.182
15	10/17/2012	Duplicate - Site 10	74	---	---	---	---	---	---	---	---	---	---	---	---	0.88	141	10	<3	<0.05	<0.10	<0.10	<0.100	0.084	<0.033

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