SECTION 4
WATER QUALITY DATA ANALYSIS

4.01 DATA COLLECTION AND ANALYSIS CHALLENGES

A. Water Quality Data Use

The following sections discuss how the data collected in Section 3 was used to identify or verify pollutants of concern (POC), identify potential pollutant sources, and identify priority areas for restoration and protection. Data results were divided into two categories for the purposes of identifying pollutant sources and selecting remediation measures: Primary Contact Recreation (PCR) and Warm Water Aquatic Habitat (WAH). PCR included bacteria data collected during the biweekly sampling in 2007 and 2009 and WAH included the physicochemical, biological, physical habitat, and geomorphic assessment data. For a full discussion of all monitored data and results, please refer to the Water Quality Data Report (WQDR) in Appendix D.

B. Project Challenges

Data collection for the Curry's Fork Watershed Plan (WP) consisted of numerous sampling and assessment programs performed by different agencies and organizations. A substantial amount of field work and coordination was required to obtain the necessary water quality data needed to develop the WP. As with any project of this magnitude and level of coordination, a number of challenges were encountered, some beyond what can reasonably be planned for. Before discussing the data results, it is important to note some of the challenges encountered during the data collection and analysis process and how they were addressed over the course of the project.

The University of Louisville (UL) Stream Institute originally planned to team with a professor from the UL Biology Department to perform the necessary biological and habitat assessments. The unfortunate passing of the UL Biology professor caused the UL Biology Department to be short-staffed and unable to perform the biological and habitat assessments, which delayed finalizing the contracts and the start of the assessments. Third Rock Consultants, LLC (Third Rock) was contracted in place of the UL Biology Department to perform the biological and habitat assessments. The delay resulted in some testing and analysis to be performed outside of the optimal periods.

During review of the biological and habitat data, concerns were raised over the identification of algal samples by an out-of-state subcontractor. A detailed review by the Curry's Fork Water Quality Data Analysis Team (WQDAT) led to the eventual exclusion of the algae data from the WP. Additional algae data collection was deemed unnecessary because enough nutrient data was collected within the WP sampling program to appropriately identify eutrophication concerns. Further, insufficient time remained to repeat the algal data collection, identification, and analysis. In lieu of funds spent on the algal data, Third Rock provided an additional and in-depth analysis on the macroinvertebrate data that was used extensively to target priority areas.

Unforeseen insurance issues were encountered between the organizations performing the sediment and geomorphological sampling and the watershed technical advisor that did not allow them to work as subconsultants. This caused delays while contracts were revised. The challenge was resolved by having the organizations contract directly with Oldham County Fiscal Court (OCFC). These challenges each added to delays in conducting and completing the geomorphic assessment in the watershed, a critical component to understanding stressors and impacts in the watershed.

Drought conditions in the 2007 recreational contact season resulted in a number of missed samples because of low or no flow conditions. This created data gaps and caused difficulties with establishing baseline conditions in Curry's Fork. With the approval from Kentucky Division of Water (KDOW), additional sampling was conducted in 2009 to supplement data collected in 2007 during the drought-like conditions. In addition, based on field conditions observed in 2007, three new sampling sites were added during the 2009 sampling program to further aid in the identification of pollutant sources.

Draft nutrient target ranges described later in Subsection 4.03 had not been established when nutrient samples were taken as part of the WP sampling program. When analyzing a water sample, the type of lab analysis used determines the detection limit or limit of detection. The lower detection limit is the lowest quantity of a substance the analysis can distinguish from a sample absent of that substance. Phosphorus sampling results are the only sampling results where lower detection limit of the lab analysis used was higher than the target values established for the WP. The typical detection limit for phosphorus for the sampling method used is 0.15 milligrams per liter (mg/l) and the draft phosphorus target ranges are 0.07 mg/l to 0.1 mg/l. Phosphorus concentrations at NC2, SC2, SC1, and AR1 were typically at the lower detection limit which is why sampling results for these sites are similar. Therefore, it is unknown whether the sampling results at NC2, SC2, SC1, and AR1 were at or below the established draft target range. Samples from NC1, CF3, CF2, and CF1 typically exceeded the phosphorus lower detection limit.

Originally, the bank erosion hazard index (BEHI) readings, near-bank stress (NBS) readings and erosion pin measurements were used to estimate bank erosion. BEHI is an assessment procedure that measures the potential for a streambank to erode when a stress is applied to it. NBS enables indexing of energy distribution within a stream reach. Unfortunately, none of the BEHI or NBS parameters were significantly correlated with erosion rates. The lack of a usable BEHI-NBS relationship can be attributed primarily to the lack of variability in key parameters within the watershed: bank materials were relatively similar, mass wasting was absent, and weathering, which is independent of NBS, appeared to be a strong control on erosion rate at all sites. Therefore, a simplified volumetric rate of sediment production was used for each subwatershed based on the erosion pin measurements. See the WQDR in Appendix D for more details and explanations.

The original intent of the data collection efforts was to perform all sampling and assessments during the same time period. Unfortunately, because of the delays discussed above, the various sampling programs were not on their original schedule and could not be implemented nor completed at the same time. To keep the Technical Committee (TC) and the community involved and to prevent significant delays with producing the WP, the Internal Project team moved forward with analyzing the PCR pollutants and developing potential sources and best management practices (BMPs) while WAH data was still being collected.

4.02 DATA ANALYSIS TEAM APPROACH

To ensure data conclusions were unbiased and that the decision making process was balanced among all data types, a team approach was taken to reviewing sampling results, assessment results, and identifying pollutants of concern.

First, the raw data was collected, compiled, and analyzed by the individual agencies and organizations that performed the sampling or assessment. Data results were divided into two categories for the purposes of identifying pollutant sources and selecting remediation measures: PCR and WAH. PCR included bacteria data collected during the biweekly sampling in 2007 and 2009 and WAH included the physicochemical, biological, physical habitat, and geomorphic assessment data. From this initial data review, a POC list was developed for PCR and WAH data.

To address the challenge of assessing multiple data conclusions from numerous monitoring approaches, a multidiscipline team was formed called the WQDAT. Representatives from Third Rock, Strand Associates, Inc.® (Strand), UL Stream Institute, KDOW, United States Geological Survey (USGS), independent consultants, and an independent watershed technical advisor participated on the WQDAT, which met three times. The WQDAT included water quality data expertise from the following disciplines: aquatic biologists, engineers, watershed managers, fluvial geomorphologists, total maximum daily load (TMDL) developers, nutrient specialists, and modelers. The first meeting of the WQDAT was in August 2009 and discussed the goals of the team as well as an overall review of available PCR and WAH data. The second in February 2010 focused on the PCR data and the third meeting in September 2010 focused on the WAH data. The value and contributions made by the WQDAT should not be understated. Having water quality data professionals with various areas of specialization evaluating multiple data sets of PCR and WAH data to reach subwatershed conclusions and identify priority areas for remediation and protection efforts was invaluable.

Data summaries from the WQDAT were then presented to the Curry's Fork TC, which met 20 times between August 2008 and February 2011. During TC meetings, members discussed the sampling results and compared it to characteristics of the Curry's Fork watershed discussed in Section 2. As discussed in Section 2, characteristics of the Curry's Fork watershed were documented through geographical information system (GIS) and the TC's local knowledge. A GIS analysis allowed the TC to review numerous characteristics about the watershed, including but not limited to land use, impervious area, point source locations, and potential development areas. Using their local knowledge of the watershed along with the sampling data, assessment results, and the GIS analysis, TC members identified potential pollutant sources within each of the Curry's Fork subwatersheds for each POC and data category. Potential pollutant sources were then further reviewed and placed into two categories: more probable sources and less probable sources. Finally, the data results were presented to watershed residents through a series of three Community Roundtables for community input, reaction, and support before being included in the WP. Figure 4.02-1 illustrates the data collection and dissemination process.

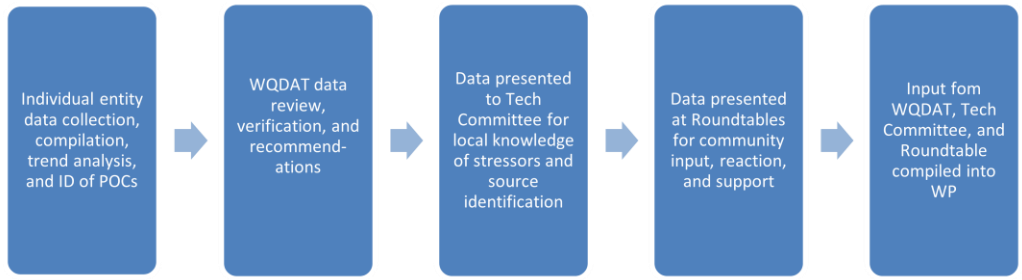


Figure 4.02-1 Data Collection and Dissemination Process

4.03 WATER QUALITY BENCHMARKS AND TARGETS

Establishing benchmarks and target water quality values is critical for determining watershed goals and for assessing data results. Benchmarks and target values can be Water Quality Standards (WQS), recommended values, average values from reference streams, or target goals set for the watershed. A mix of these benchmarks and targets as used for the WP.

As mentioned in Section 3 of this report, surface WQS for the Commonwealth of Kentucky are defined in 401 Kentucky Administrative Regulation (KAR) 10:031. This section of the regulation establishes specific in-stream criteria for a number of parameters. Applicable criteria for the POC in the Curry's Fork watershed are as follows:

1. Dissolved oxygen (DO) shall be maintained at a minimum concentration of 5.0 mg/L daily average; the instantaneous minimum shall not be less than 4.0 mg/L.

2. Un-ionized ammonia nitrogen (NH_3N) concentrations shall not be greater than 0.05 mg/L.

3. PCR: Fecal coliform and *Escherichia coli* (*E. coli)* content shall not exceed 200 colonies per 100 milliliters (col/100 mL) or 130 col/100 mL, respectively, as a geometric mean based on not less than five samples taken during a 30-day period. Content also shall not exceed 400 col/100 mL in 20 percent or more of all samples taken during a 30-day period for fecal coliform or 240 col/100 mL for *E. coli*.

   Secondary Contact Recreation (SCR): Fecal coliform shall not exceed 1,000 col/100 mL as a geometric mean based on not less than five samples taken during a 30-day period. Content also shall not exceed 2,000 col/100 mL in 20 percent or more of all samples taken during a 30-day period for fecal coliform.

In addition to the above parameters and the associated water quality criteria, the 303(d) List also included total suspended solids (TSS) as a POC in the Curry's Fork watershed. While Kentucky has narrative water quality criteria for sediment and TSS, numeric water quality criteria does not exist. Further, in-stream target values for TSS were not available either. Therefore, for purposes of comparing and evaluating TSS for this project, the commonly used Kentucky Pollutant Discharge Elimination System (KDPES) permit limit of 30 mg/L was used as a TSS benchmark value.

KDOW recently developed draft target ranges for phosphorous and total nitrogen for the Outer Bluegrass ecoregion. Nutrient data was collected from numerous streams in the ecoregion and reviewed to develop the average draft ranges. It is important to note these ranges are averages from different streams. While each stream was in the same ecoregion and will have similar characteristics, each stream is still subject to some unique conditions based on the surrounding land use and will have different baseline conditions. It is also important to note these are only draft ranges and do not represent WQS. Currently there are no numeric nutrient water quality standards for Kentucky surface waters for the designated uses of WAH and PCR. KDOW's draft nutrient ranges were used for this WP as a general target in the absence of specific numeric criteria. The following draft target average ranges are:

- Phosphorous: 0.07 mg/L to 0.1 mg/L
- Total Nitrogen: 1.2 mg/L to 1.4 mg/L

Habitat and biological data use a variety of metrics to determine the condition of a stream and whether or not it is meeting its intended use. Biological and habitat metrics for the WP were evaluated using the 2002 and 2008 KDOW versions of the Standard Methods for Assessing Biological Integrity of Surface Waters in Kentucky. Table 4.03-1 summarizes the habitat and biological assessment metric benchmarks for streams with a designated use of WAH from the 2002 and 2008 KDOW assessment methods. The metrics used for the WP sampling program shown on Table 4.03-1 are the Rapid Bioassessment Protocols (RBP), the Macroinvertebrate Biotic Index (MBI), Index of Biological Integrity (IBI) and Ephemeroptera-Plecoptera-Trichoptera taxa (EPT). Refer to Subsection 4.16 for additional information.

<table>
<tr><th rowspan="3">Designated Use:
Warm Water Aquatic Habitat</th><th colspan="5">Criteria</th></tr>
<tr><th colspan="2">Habitat</th><th colspan="2">Macroinvertebrates</th><th rowspan="2">Fish</th></tr>
<tr><th>Drainage Area > 5.0 mi^2</th><th>Drainage Area < 5.0 mi^2</th><th>Drainage Area > 5.0 mi^2</th><th>Drainage Area < 5.0 mi^2</th></tr>
<tr><td rowspan="2">Fully Supports</td><td>RBP ≥ 130</td><td>RBP ≥ 130</td><td>MBI ≥ 61
(Good or Excellent)</td><td>MBI ≥ 51
(Good or Excellent)</td><td rowspan="2">IBI ≥ 47: expected number of species and intolerant species present, few omnivores and tolerant species, balanced community.
(Good or Excellent)</td></tr>
<tr><td colspan="2">Stable Substrate with no embeddedness, good instream cover, riparian zones wide, no bank erosion.</td><td colspan="2">High number of EPT and sensitive taxa present, low modified Hilsenhoff biotic index (MHBI), high MBI.</td></tr>
<tr><td rowspan="2">Partially Supports</td><td>RBP =
114 to 129</td><td>RBP =
142 to 155</td><td>MBI =
41 to 60
(Fair)</td><td>MBI =
39 to 50
(Fair)</td><td rowspan="2">IBI = 31 to 46: lower species and intolerant forms, more omnivores and tolerant species, few top predators.
(Fair)</td></tr>
<tr><td colspan="2">Substrates moderately stable, some instream cover, more narrow riparian zone, some bank erosion.</td><td colspan="2">EPT lower than expected, reduction of sensitive taxa, higher MHBI</td></tr>
<tr><td>Does Not Support</td><td>RBP ≤ 113</td><td>RBP ≤ 141</td><td>MBI ≤ 40
(Poor or Very Poor)</td><td>MBI ≤ 38
(Poor or Very Poor)</td><td>IBI ≤ 30: no sensitive species present, omnivores and tolerant species dominate, hybrids and diseased fish often present.
(Poor or Very poor)</td></tr>
</table>

Table 4.03-1 Habitat and Biological Assessment Metrics

4.04 POLLUTANTS OF CONCERN

POC were identified based on the 303(d) List and verified through results from sampling data and assessments in Curry's Fork. POC for the Curry's Fork watershed are:

- Bacteria (Fecal Coliform)
- Nutrient/Eutrophication Biological Indicators
- DO
- Sedimentation/Siltation

After the primary stressors to the watershed were identified, the data was further analyzed on a subwatershed level following the process discussed in Section 4.02. The following subsections discuss the additional analysis for each POC and discuss the priority areas and potential pollutant sources identified from the analysis.

4.05 BOX-PLOT AND LOAD DURATION CURVE ANALYSES

Water quality parameters, such as bacteria, are commonly shown as box plots or "whisker" plots. Box plots are a quick way of examining data sets graphically by showing the data through five-number summaries: the 10th percentile value (10 percent of readings are lower than this value), the lower quartile (25 percent of readings are lower than this value), the median (50 percent of readings are lower than this value), the upper quartile (75 percent of readings are lower than this value), and the 90th percentile value (90 percent of readings are lower than this value). The average value of the data set is also sometimes shown for reference. For bacteria data, the average was calculated as a geometric mean to allow comparisons to WQS. By showing this wide range of information in a single figure, box plots can be used to quickly evaluate the range of readings for a sampling site and the distribution of the readings within that range. See Figure 4.05-1 for an example box plot. Box plots will be used to display bacteria sampling results for each project sampling site and nitrate results.

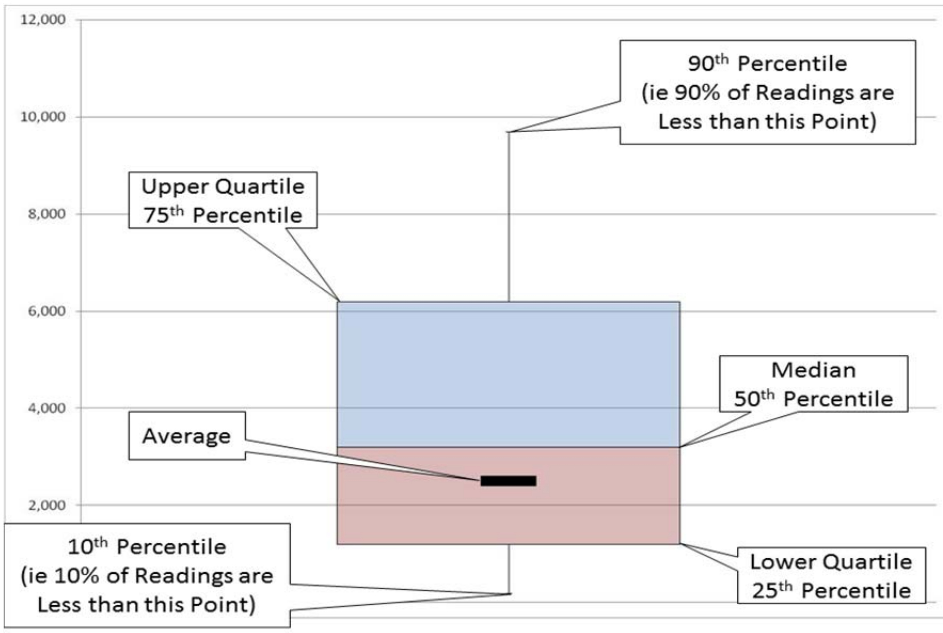


Figure 4.05-1 Example Box Plot

For subwatersheds with more than one project sampling site, the most upstream sampling site is always displayed on the left side of the box plot and the most downstream sampling site is always displayed on the right side of the box plot.

Initially to differentiate between normal and rain-influenced sampling events during biweekly sampling, sampling dates were compared with rainfall information from the Jeffries Farm rain gauge located on the South Curry's Fork subwatershed. Rainfall and stream flow conditions (depth and velocity) were also considered when determining if a sample was taken during normal or rain influenced conditions. Originally, any sampling event that occurred within 24 hours of precipitation (defined as greater than 0.1 inches) was tagged as a potential rain influenced event. Stream flow conditions were then reviewed for each potential rain influenced event. If stream flow conditions were elevated and indicative of runoff conditions in response to rainfall, the sample was counted as a rain influenced event. If stream flow conditions are indicative of baseline conditions, the rainfall did not impact the stream enough and the sample was considered a normal event. This process was repeated for each sample.

This data includes nearly two years of 15-minute interval flow data. While this provides an encompassing understanding of the flows at the time of the study, it does not have the breadth of a longer documentation period. Often load durations are constructed with at least 10 years of daily flow data. However, that extent of information was not available and the decision was made to use in-depth local data rather than data from a gauge outside the watershed.

Load Duration Curves (LDC) were also developed for selected parameters fecal coliform, nutrients, conductivity, and TSS. LDCs were developed to determine pollutant loads and to visually review pollutant loads over the streams flow regime. A LDC is developed by multiplying a numeric water quality target or benchmark and a conversion factor by all observed stream flow conditions to calculate an associated pollutant load for a particular parameter. The Y-axis represents the pollutant load, and the X-axis relates the flow values to the percent of time those values have been met or exceeded. Measured pollutant concentrations and stream flows are then plotted on top of this curve to see the actual pollutant loads in the stream compared to the acceptable load. Refer to the Curry's Fork WQDR to review LDCs for the WP sampling sites.

Two storm events were also targeted for additional sampling to help differentiate between normal and rain-influenced events, one on September 20, 2009, and one on October 30, 2009. Samples were collected at Hour 0 (start of the storm), Hour 4 (4 hours after the start of the storm), and Hour 12 (12 hours after the start of the storm). Refer to the Curry's Fork WQDR for a detailed listing of storm event sampling results.

After analyzing the normal events, rain-influenced events, and the LDCs, it was agreed upon by the WQDAT and the TC that weather conditions did not have a significant impact on the sampling results. All subwatersheds show the effects of rain-influenced nonpoint source (NPS) pollution with a slight tendency to more exceedances during higher flows, but the increase in exceedances was not observed to be substantial. Sampling sites found to have elevated pollutants levels typically showed elevated levels regardless of weather conditions.

To arrive at this conclusion, the WQDAT and TC considered normal and rain-influenced conditions extensively in their review of the sampling results. The WQDAT and TC sampling results review consisted of a significant amount of data to identify trends. Project specific sampling included 24 biweekly sampling events, of which 14 were determined to be under wet weather influence and 10 were determined to be dry. In addition, two wet weather events were sampled to examine the watershed's reaction to wet weather during an event. In total, over 300 bacteria samples, nearly 400 nutrient samples, and over 1,000 TSS samples were used as part of the WQDAT and TC review.

Certain sampling sites at times showed increased pollutant levels during or following rain events, but the more consistent trend was that weather did not have a significant impact on pollutant levels. For example, Figures 4.05-1 through 4.05-11 show the fecal coliform LDCs complied using data collected as part of the development of the WP. As shown in Figures 4.05-1 through 4.05-11, exceedances occur during every flow regime and wet weather-influenced samples are found across all flows. This made the targeting of sources or BMPs based on flow regimes caused by weather conditions questionable and, thus, the WQDAT and TC recommendations were not focused on wet weather. Fecal coliform LDCs are shown here only as an example. LDCs for nutrients (nitrogen and phosphorus) also show similar trends. All LDCs created as part of this WP are shown in Appendix D.

4.06 BACTERIA DATA ANALYSIS

Fecal coliform and *E. coli* bacteria is considered an indicator organism that, while not pathogenic themselves, may indicate the presence of waterborne pathogens such as Cryptosporidium or Giardia or those causing illnesses like typhoid fever, dysentery, and cholera. Therefore, elevated levels of the indicator organisms may represent an increased risk of disease to human beings that contact these waters. The term "pathogen" is used to reference data and discussion related to fecal coliform and *E. coli* bacteria.

A. Sampling and Assessment Results Analysis

Table 4.06-1 summarizes the fecal coliform data collected in the Curry's Fork watershed. Please note all bacteria summary data uses a geometric mean to allow for easier comparisons to WQS. Figure 4.06-1 shows the fecal coliform box plots for all sampling sites and the PCR (red line) and SCR (orange line) standards for comparison. For detailed sampling information, refer to the WDQR in Appendix D. Figures 4.06-2 through 4.06-5 show the fecal coliform LDCs for the most downstream sampling site in each watershed, which are NC1, SC1, AR1, and CF2, respectively. Refer to the WQDR to view LDCs for all sampling sites in Curry's Fork. Refer to Figure 3.02-1 for the location of the bacteria sampling sites.

Subwatershed	Site ID	Geometric Mean	Number of Samples	Percent Exceeding PCR Standard (>400)	Percent Exceeding SCR Standard (>2,000)
North Curry's	NC2	267	17	47%	12%
	NC1b	673	10	60%	40%
	NC1a	935	18	72%	39%
	NC1	1,276	24	77%	40%
South Curry's	SC2	789	30	53%	33%
	SC1	1,722	24	85%	37%
Asher's Run	AR1a	1,301	18	83%	44%
	AR1	908	26	65%	27%
Curry's Fork Main Stem	CF3	1,371	30	73%	30%
	CF2	1,264	30	73%	40%
	CF1	822	29	62%	31%

All values represent fecal coliform sampling results in col/100 mL

Table 4.06-1 Curry's Fork Bacteria Data Summary

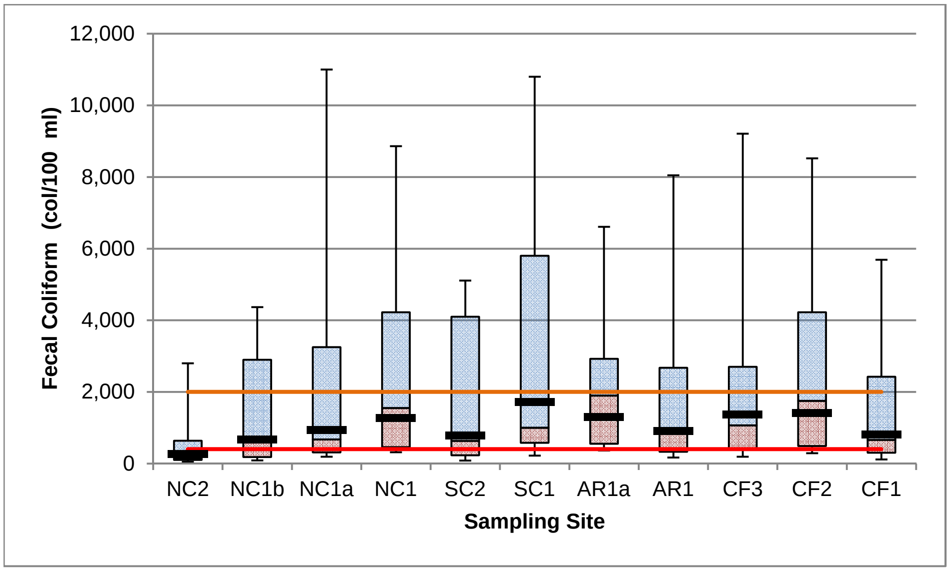


Figure 4.06-1 Curry's Fork Fecal Coliform Box Plots

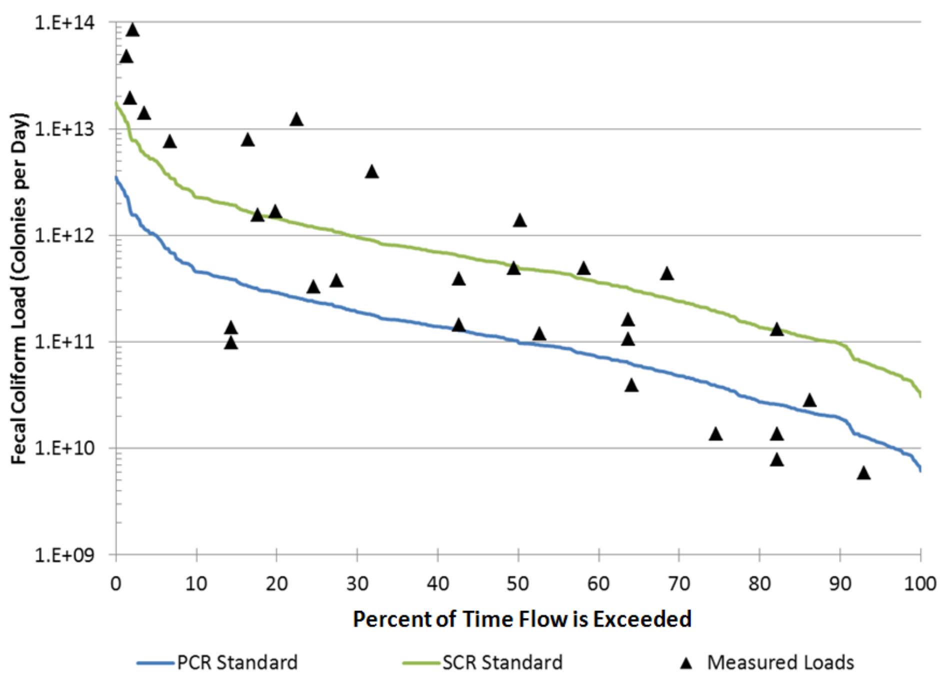


Figure 4.06-2 NC1 Fecal Coliform Load Duration Curve

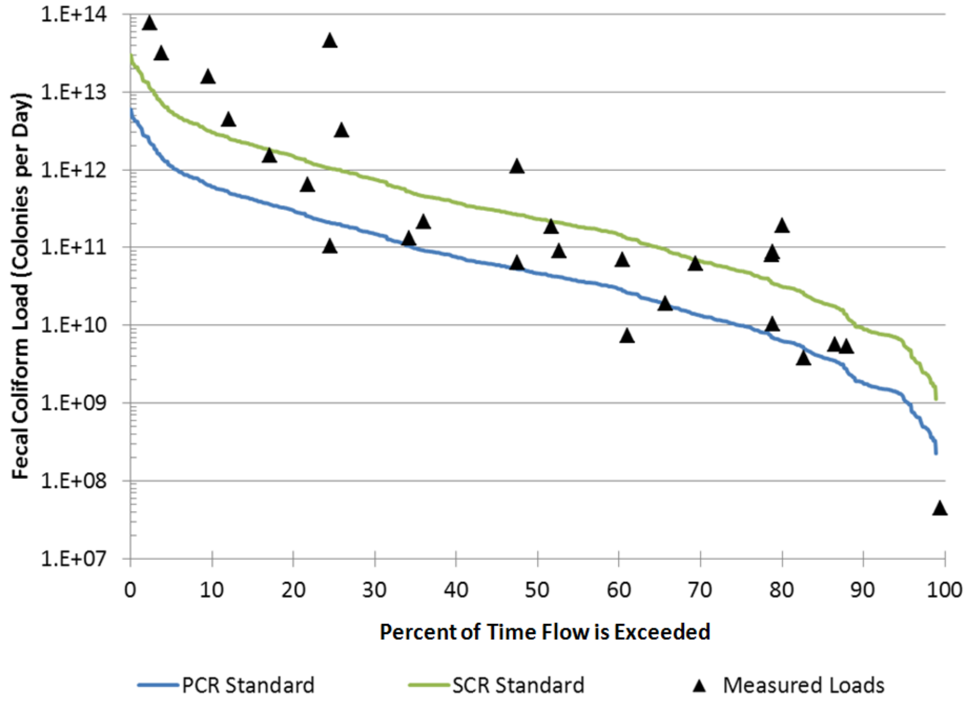


Figure 4.06-3 SC1 Fecal Coliform Load Duration Curve

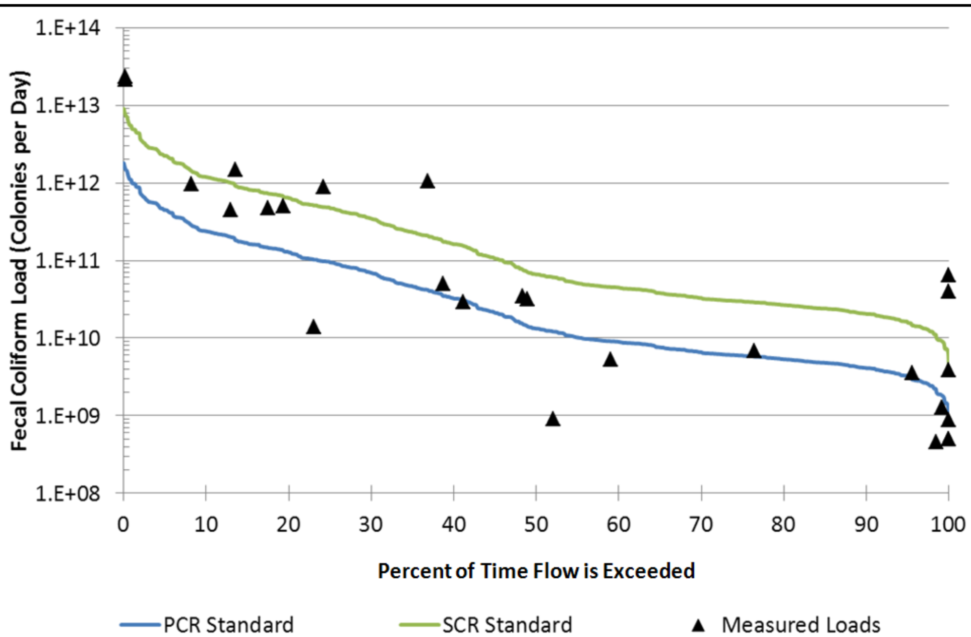


Figure 4.06-4 AR1 Fecal Coliform Load Duration Curve

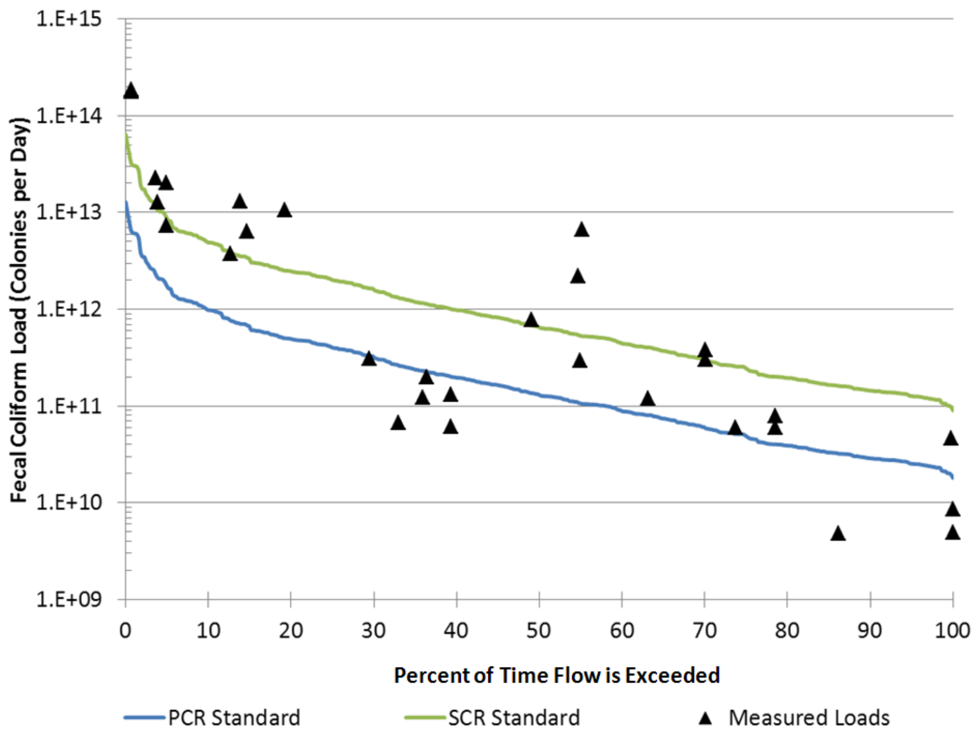


Figure 4.06-5 CF2 Fecal Coliform Load Duration Curve

As the LDCs display, fecal coliform levels exceeded PCR and SCR standards during high and low flow conditions for all sites. All sampling sites exceeded PCR and SCR standards; therefore, all sites considered fecal coliform as a POC. South Curry's Fork and Asher's Run subwatersheds generally showed the poorest results when compared to other subwatersheds. North Curry's upstream of NC1 yielded the best fecal coliform results.

While PCR exceedances were prevalent throughout Curry's Fork, it was indicated during the WQDAT meetings that bacteria concentrations in Curry's Fork are relatively low when compared to other streams in the same ecoregion. Fecal coliform levels observed in nearby streams (of similar size) are often orders of magnitude higher than levels observed in Curry's Fork. Therefore, while Curry's Fork had SCR and PCR exceedences, it can be considered in relatively good condition compared to neighboring streams in the same ecoregion.

4.07 BACTERIA PRIORITY AREAS

Priority areas for bacteria were identified by the WQDAT for each subwatershed by comparing data results to the benchmarks and target values discussed in Section 4.03 and reviewing watershed characteristics. Each subwatershed was designated as a restoration or protection area with a high, medium, or low priority. Subwatersheds designated as restoration areas generally had more exceedances of benchmarks and target values and have areas identified where remediation measures could be implemented to improve water quality. Subwatersheds designated as protection areas generally had fewer exceedances of benchmarks and target values and have the potential to be impacted in the future by land use changes. Subwatersheds designated as protection also had lower bacteria levels than upstream inputs indicating stream recovery and a lack of bacteria inputs, thus a need to protect the area of recovery. Protection areas will be targeted with solutions focused more on maintaining and protecting current water quality conditions and less on reducing bacteria inputs.

Figure 4.07-1 shows the priority restoration and protection designations for bacteria for each subwatershed. Discussions of each subwatershed explain the individual elements taken into consideration for each subwatershed that led to the final priority designations.

A. North Curry's Fork

The upper section of North Curry's Fork was designated as a Low Priority Restoration Area. Fecal coliform levels were the best compared to other subwatershed, therefore this area was considered a lower priority.

The lower section of North Curry's Fork (downstream of NC2) was designated as a Medium Priority Restoration Area. Table 4.06-1 and Figure 4.06-1 are data and fecal box plots showing an increase in bacteria levels in the downstream section. Based on this increase, the WQDAT considered the lower portion of North Curry's Fork warranted a higher priority designation than the upstream section. It was designated a medium priority restoration area.

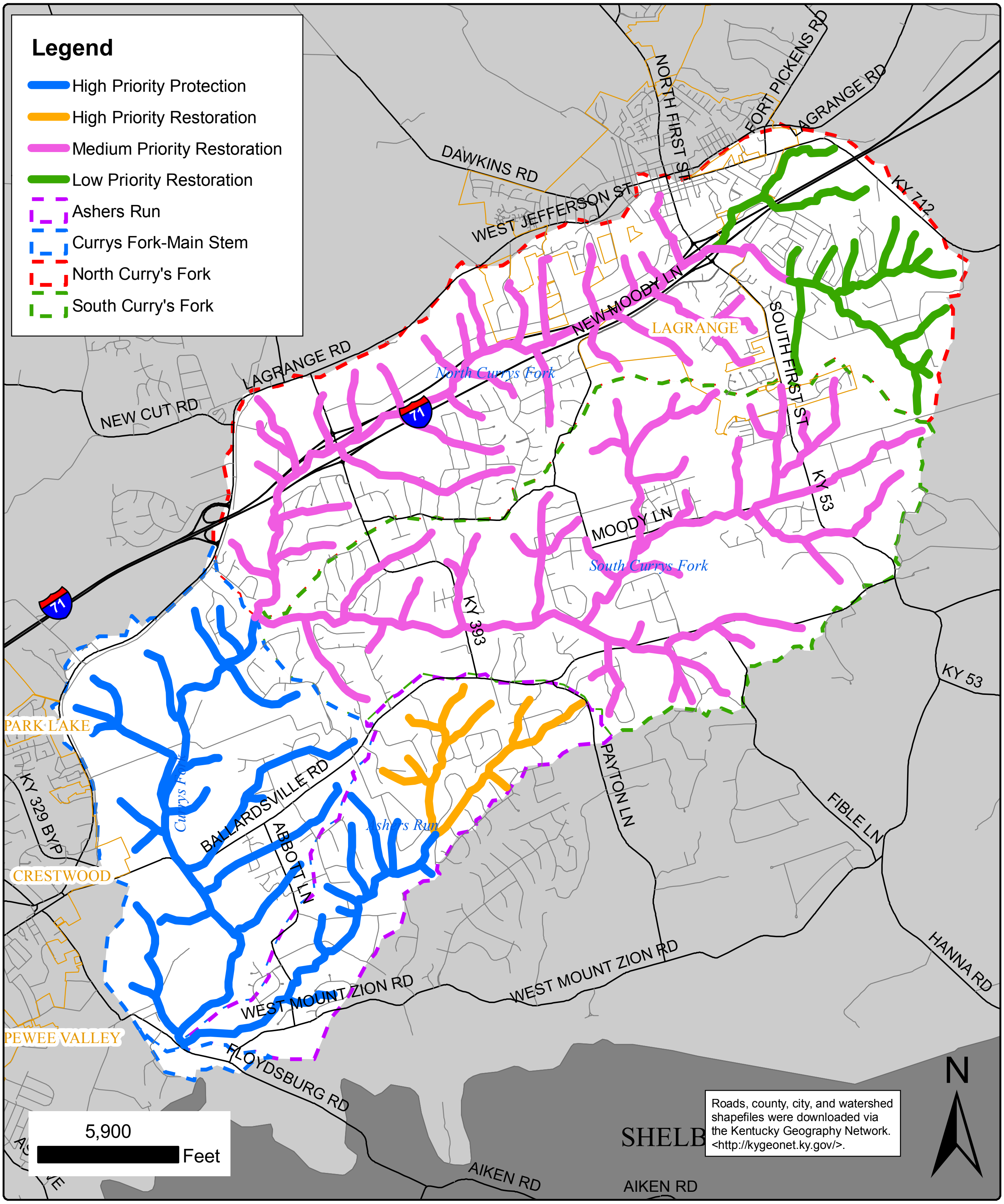
B. South Curry's Fork

South Curry's Fork showed low bacteria levels in the upper section (upstream of SC2) compared to other subwatersheds but had an increase in the downstream section. The downstream section had high bacteria levels compared to other subwatersheds. These factors would normally imply a High Priority Restoration Area designation but, as discussed in Section 4.08, the more probable bacteria pollution sources in the subwatershed are treatment plants slated to be eliminated from the subwatershed. To make certain that implementation funds are used in a cost-effective manner, the subwatershed was given a Medium Priority Restoration Area designation since the more probable pollutant sources would be removed from the subwatershed and additional efforts beyond the treatment plant decommissioning might not be necessary.

C. Asher's Run

The upper section of Asher's Run (upstream of AR1a) was designated a High Priority Restoration area. AR1a had high bacteria levels compared to other sampling sites, and the land use in the area is not predicted to change; therefore, without remediation measures, bacteria levels will remain elevated.

Bacteria levels improve from the upper section to the lower section of Asher's Run as shown in the results of sampling site AR1. Decreased bacteria levels in the lower section indicate that the stream is recovering and that there are no new significant bacteria sources in the lower section. The lower section of Asher's Run has fewer residential impacts, lower impervious area, and less corridor development than the upper section. Lower Asher's was designated a High Priority Protection Area to help ensure the downstream conditions are maintained and continue to reduce bacteria levels from the upper section.



PATHOGEN PRIORITY AREAS

CURRY'S FORK WATERSHED PLAN
OLDHAM COUNTY FISCAL COURT
OLDHAM COUNTY, KENTUCKY

STRAND ASSOCIATES, INC.®
ENGINEERS

FIGURE 4.07-1
5994.100

D. Curry's Fork Main Stem

While bacteria levels in Curry's Fork main stem are some of the highest in the watershed, they typically decline through the subwatershed from upstream (CF3) to downstream (CF1). CF3 yielded the highest geometric mean bacteria levels, directly after the confluence of North Curry's Fork at NC1 and South Curry's Fork at SC1. Bacteria levels are elevated in the Curry's Fork main stem subwatershed primarily as a result of upstream influences from North and South Curry's Fork. Bacteria levels actually show a slight decrease from upstream to downstream indicating there are no significant sources of bacteria in the subwatershed and that additional flow from tributaries decreases bacteria concentrations. The largely undeveloped stream corridor helps to insulate the creek from additional pollution. This effect of bacteria levels staying level to slightly decreasing from upstream to downstream is a positive attribute that would allow for improvements made upstream to be seen throughout the subwatershed and should be preserved. Therefore, the Curry's Fork main stem was designated a High Priority Protection area.

4.08 BACTERIA POTENTIAL POLLUTANT SOURCES

As discussed in Section 4.02, potential pollutant sources were identified using the data team approach and were separated in two categories: more probable sources and less probable sources. The term "sources" includes both point and nonpoint sources. Sources were categorized as more or less probable due to the lack of direct data to tie pollutant loads to sources. During the data review process, no obvious causes were found that would indicate specific sources. Therefore, identified potential sources were evaluated for their likelihood to contribute to water quality exceedances. In cases where permitted facilities are listed as sources, DMRs were reviewed to assist in the categorization process. Final pollutant sources identified for each subwatershed and unanimously agreed upon by the TC are listed below.

A. North Curry's Fork

Table 4.08-1 summarizes the location and sources of the more probable and less probable pollutant sources in the North Curry's Fork subwatershed.

Location	Category	Pollutant Source
Upper Area (Low Priority Restoration)	More Probable Source	Failing on-site wastewater systems in Crystal Lake subdivision
	Less Probable Source	Pets Resuspended sediment from Crystal Lake with bacteria loads as a result of dredging
Downstream Area (Medium Priority Restoration)	More Probable Source	Failing onsite wastewater systems in Borowick Farms subdivision Stormwater from MS4 Area (Oldham Co.–Permit No. KYG2000005) Package treatment plant (Buckner–Permit No. KY0103110) Wastewater treatment plant (La Grange–Permit No. KY0020001) Permitted household discharger (Permit No. KY400105) Stormwater leaking into sewers and taking up capacity, causing overflows and/or plant upsets
	Less Probable Source	Wildlife Pets Failing on-site wastewater systems (other than Borowick Farms subdivision)

Table 4.08-1 North Curry's Potential Pollutant Sources

In general, more probable bacteria sources include numerous permitted discharges within the North Curry's Fork subwatershed. North Curry's Fork is the most developed subwatershed, and has the most permitted dischargers. As discussed previously in this report, dischargers are compliant with their permits but still contribute toward the pollutant load. Other more probable sources include on-site wastewater systems in the Borowick Farms subdivision, which were specifically identified during the TC meetings as having problematic on-site wastewater systems.

B. South Curry's Fork

Table 4.08-2 summarizes the location and sources of the more probable and less probable pollutant sources in the South Curry's Fork subwatershed.

Location	Category	Pollutant Source
Upper Area (Medium Priority Restoration)	More Probable Source	Package treatment plant (Green Valley–Permit No. KY0029441)
	Less Probable Source	Wildlife Small farms/livestock operations (horse and cattle, primarily) Stormwater leaking into sewers and taking up capacity, causing overflows and/or plant upsets Failing on-site wastewater systems
Downstream Area (Medium Priority Restoration)	More Probable Source	Package treatment plant (Lakewood–Permit No. KY0054674) Package treatment plant (Lockwood–Permit No. KY0039870) Package treatment plant (Centerfield Elementary–Permit No. KY0076732)
	Less Probable Source	Wildlife Permitted household discharger (Permit No. KYG400289)

Table 4.08-2 South Curry's Potential Pollutant Sources

Similar to North Curry's Fork, the more probable bacteria sources include numerous permitted dischargers in the South Curry's Fork subwatershed, specifically the PTP discharges. South Curry's Fork also has residential impacts and a few isolated livestock operations which are considered to be the less probable bacteria sources.

C. Asher's Run

Table 4.08-3 summarizes the location and sources of the more probable and less probable pollutant sources in the Asher's Run subwatershed.

Location	Category	Pollutant Source
Upper Area (High Priority Restoration)	More Probable Source	Low intensity animal operations (small numbers of goats, horses, etc. as well as some 'nontraditional' livestock on relatively small properties) Failing on-site wastewater systems Wildlife
	Less Probable Source	Pets
Downstream Area (High Priority Protection)	More Probable Source	Wildlife Upstream contributions
	Less Probable Source	Small farms/livestock operations Pets Failing on-site wastewater systems

Table 4.08-3 Asher's Run Potential Pollutant Sources

Low intensity animal operations with some traditional and nontraditional livestock have been identified in the upper portion of the subwatershed during field investigations. The upper portion of Asher's Run has the most area contained within subdivisions (70 percent) of any subwatershed and has the second highest percent impervious area (8.5 percent) only following the lower portion of North Curry's Fork downstream of NC2 which contains the city of La Grange.

As mentioned previously, bacteria levels reduce downstream of AR1a, indicating no new significant pollutant sources in the downstream section.

D. <u>Curry's Fork Main Stem</u>

Table 4.08-4 summarizes the location and sources of the more probable and less probable pollutant sources in the Curry's Fork main stem subwatershed.

Location	Category	Pollutant Source
Main Stem (High Priority Protection)	More Probable Source	North Curry's upstream contributions South Curry's upstream contributions Permitted household discharger (Permit No. KYG401962) Package treatment plant (Country Village–Permit No. KY0060577)
	Less Probable Source	Pets Wildlife Agriculture Stormwater from MS4 areas (Oldham County–Permit No. KYG2000005) Failing on-site Wastewater Systems Permitted household discharger (Permit No. KYG400147)

Table 4.08-4 Curry's Fork Main Stem Potential Pollutant Sources

The Curry's Fork main stem had the lowest percent impervious and subdivision area (5.2 and 22 percent, respectively) of any subwatershed. Stream corridor development was low compared to other subwatersheds. The main stem has permitted dischargers identified as more probable pollutant sources for the Curry's Fork main stem. As discussed previously in this report, dischargers are compliant with their permits but still contribute toward the pollutant load. Because of elevated bacteria levels in North and South Curry's Fork, upstream contributions have also been identified as more probable bacteria sources.

4.09 NUTRIENT DATA ANALYSIS

Water bodies require nutrients to remain healthy and support life, but too many nutrients can be harmful. Nutrient enrichment can lead to blooms of algae, which eventually die and decompose. The process of decomposition removes oxygen from the water, reducing DO levels potentially insufficient enough to sustain aquatic life. Algae blooms and decaying matter can also add color, turbidity, odor, and objectionable tastes to water that are difficult to remove and reduce the waters acceptability as a drinking water source. This process of nutrient enrichment is called eutrophication (Masters, 1998).

Tables 4.09-1 and 4.09-2 summarize the phosphorus and total nitrogen data collected in the Curry's Fork watershed, respectively. The blue horizontal line in Figures 4.09-1 and 4.09-2 represents the lower draft target range and the orange horizontal line represents the upper draft target range, which is 0.07 mg/l to 0.1 mg/l for phosphorus and 1.1 mg/l to 1.4 mg/l for nitrogen. Refer to the WQDR in Appendix D to view detailed sampling results for all sampling sites in Curry's Fork. Figures 4.09-1 and 4.09-2 show the box plots for phosphorus and total nitrogen, respectively. Refer to Figure 3.02-1 for the location of sampling sites.

As discussed in Subsection 4.02, the lower detection limit for phosphorus was above the draft target ranges used for this WP. The lower detection limit for nitrogen samples was lower than the draft target range of 1.1 to 1.4 mg/l. Nitrogen levels at NC2, SC2, SC1, and AR1 were all within or below the draft target range. Because the phosphorus concentrations at these sites were typically at the lower detection limit and the nitrogen concentrations were acceptable, nutrient levels at NC2, SC2, SC1, and AR1 were not considered a concern.

Field observations and biological and habitat assessments also support that nutrients are not a concern at NC2, SC2, SC1, and AR1. No algae or eutrophication concerns were identified in the biological and habitat assessments.

Subwatershed	Site ID	Average	Number of Samples
North Curry's	NC2	0.41	8
	NC1	2.41	12
South Curry's	SC2	0.42	12
	SC1	0.39	9
Asher's Run	AR1	0.38	9
Curry's Fork–Main Stem	CF3	1.73	12
	CF2	0.71	12
	CF1	0.71	12

All values represent phosphorus sampling results in mg/l

Table 4.09-1 Curry's Fork Phosphorus Data Summary

Subwatershed	Site ID	Average	Number of Samples	Percent Above Upper Draft Target Range of 1.4 mg/l
North Curry's	NC2	0.82	17	6%
	NC1b	8.36	10	90%
	NC1a	6.06	18	78%
	NC1	8.44	30	90%
South Curry's	SC2	1.01	27	17%
	SC1	1.68	30	44%
Asher's Run	AR1a	1.01	27	17%
	AR1	0.92	30	15%
Curry's Fork Main Stem	CF3	6.29	30	67%
	CF2	3.97	30	77%
	CF1	3.65	30	70%

All values represent nitrogen sampling results in mg/l

Table 4.09-2 Curry's Fork Total Nitrogen Data Summary

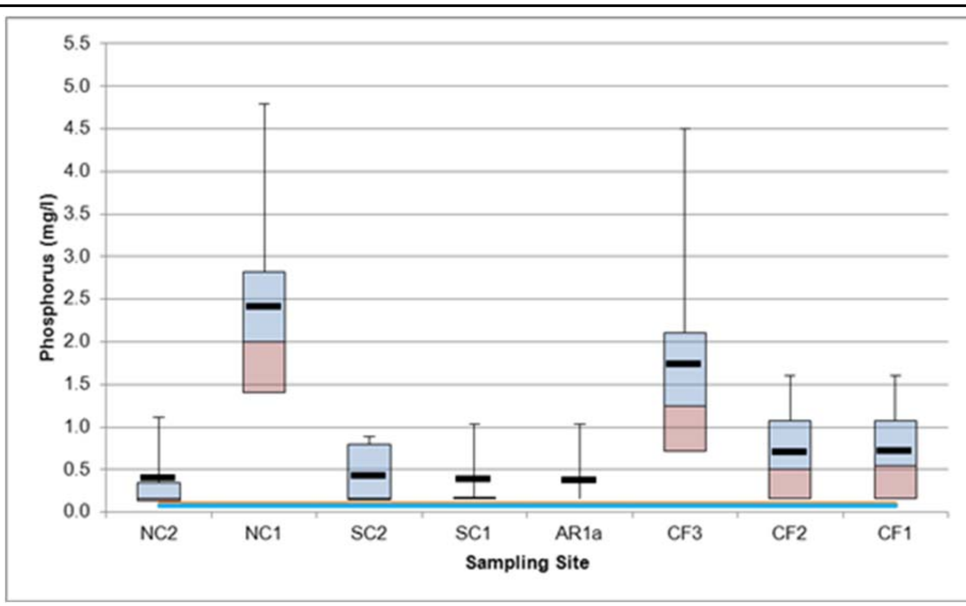


Figure 4.09-1 Curry's Fork Phosphorus Box Plots

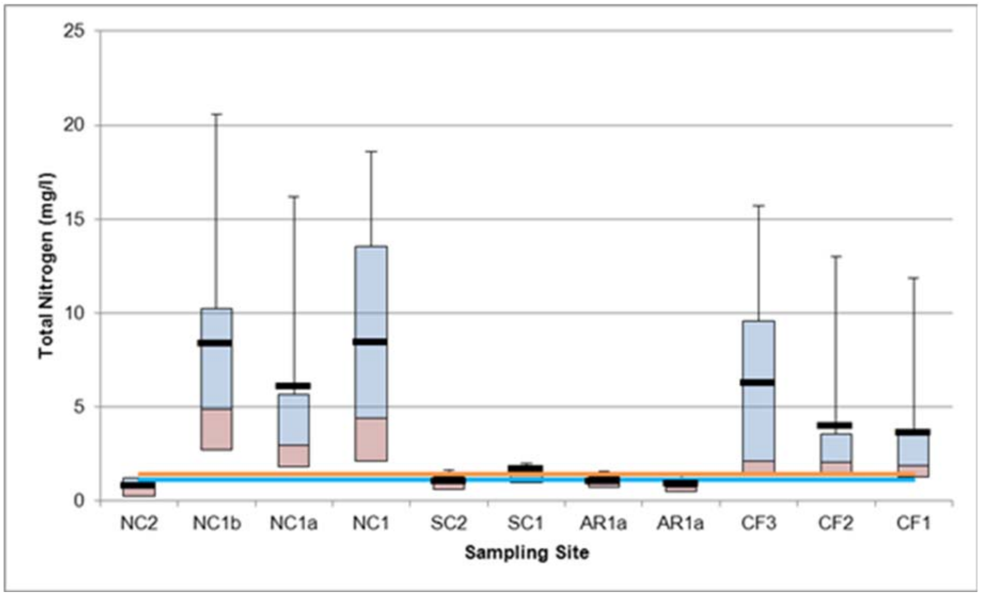


Figure 4.09-2 Curry's Fork Nitrogen Box Plots

Data results show a clear increase in nutrients downstream of NC2 in the North Curry's Fork subwatershed. These values are elevated through the North Curry's subwatershed and typically decline after the confluence of North and South Fork as flow moves downstream through the Curry's Fork main stem subwatershed.

South Curry's Fork and Asher's Run have considerably lower nutrient levels compared to North Curry's Fork and the Curry's Fork main stem subwatersheds, which can clearly be seen in Figures 4.09.1 and 4.09-2. Nitrogen levels for South Curry's Fork and Asher's Run were typically at or below the draft target values used. Phosphorus levels were slightly elevated above draft target values but that is partially due to lab analysis detection limits being higher than 0.1 mg/l. Phosphorus results in South Curry's Fork and Asher's Run were typically at the lowest detection limit. Because of these factors, nutrient levels were considered to be at appropriate levels; therefore potential pollutant sources and remediation measures were not evaluated for South Curry's Fork and Asher's Run.

4.10 NUTRIENT SUMMARY

As discussed in the previous section, sampling results indicate the downstream section of North Curry's Fork is the primary source of nutrients in the Curry's Fork watershed. Nutrient levels generally decreased downstream of NC1 through the Curry's Fork main stem, indicating the stream is recovering. Sampling results in Asher's Run and South Curry's Fork indicate nutrient levels that are mostly within the established draft nutrient target ranges. Remediation activities to reduce nutrient levels should focus on the downstream section of North Curry's Fork.

4.11 NUTRIENT POTENTIAL POLLUTANT SOURCES

Table 4.11-1 summarizes the probable pollutant sources in the North Curry's Fork subwatershed.

Location	Category	Pollutant Source
Upper Area (Low Priority Restoration / Protection)	More Probable Source	On-site wastewater systems in Crystal Lake subdivision Lawn fertilizers
	Less Probable Source	Pets Wildlife
Downstream Area (High Priority Restoration)	More Probable Source	Package treatment plant (Buckner–Permit No. KY0103110) Wastewater treatment plant (La Grange–Permit No. KY0020001)
	Less Probable Source	Wildlife Pets On-site wastewater systems

Table 4.11-1 North Curry's Fork Potential Nutrient Sources

The two more probable nutrient sources in the downstream area of North Curry's Fork subwatershed were the La Grange wastewater treatment plant (WWTP) and the Buckner WWTP. A review of both plants' DMR data showed they were in compliance with meeting their permitted nutrient effluent limits during the sampling period. Though both plants were in compliance with their permits, effluents still contributed to the subwatershed and the cumulative impact can affect water quality. After extensive deliberation, assessement and evaluation by the TC, the plants were determined to be the more probable source of nutrients in the subwatershed.

The more probable nutrient source for the Curry's Fork main stem is upstream contributions from the North Curry's Fork subwatershed. Nutrient levels typically decline moving downstream through the Curry's Fork main stem subwatershed, indicating no additional significant nutrient sources. No other nutrient sources were identified for the Curry's Fork main stem subwatershed.

4.12 DISSOLVED OXYGEN DATA RESULTS

Sufficient levels of DO are necessary to support healthy aquatic life. When DO concentrations drop below the allowable criteria, aquatic life is stressed and in extreme situations may lead to the death of certain organisms because of the lack of oxygen.

Table 4.12-1 summarizes the DO data collected in the Curry's Fork watershed. For detailed sampling information, refer to the Curry's Fork WDQR in Appendix D. Refer to Figure 3.02-1 for the location of the DO sampling sites.

Subwatershed	Site ID	Minimum	Maximum	Average	Number of Samples	Percent Less Than 5 mg/l	Percent Less Than 4 mg/l
North Curry's	NC2	4.46	14.50	8.01	16	6%	0%
	NC1b	6.88	8.12	7.47	9	0%	0%
	NC1a	3.90	9.30	7.69	16	6%	6%
	NC1	4.20	12.60	7.56	29	3%	0%
South Curry's	SC2	1.55	10.30	6.40	28	21%	11%
	SC1	2.80	10.50	7.46	25	12%	12%
Asher's Run	AR1a	2.90	10.30	7.31	17	6%	6%
	AR1	4.60	10.30	7.66	27	7%	0%
Curry's Fork Main Stem	CF3	3.90	15.60	8.34	28	7%	4%
	CF2	3.30	10.10	7.22	30	17%	10%
	CF1	3.76	11.05	7.31	31	10%	6%

Table 4.12-1 Curry's Fork DO Data Summary

South Curry's Fork yielded the lowest DO measurements compared to the other subwatersheds. Curry's Fork main stem typically yielded the next lowest DO measurements but the WQDAT agreed this was likely because of low DO influence from South Curry's Fork. DO levels in North Curry's Fork and Asher's Run were good compared to South Curry's and Curry's Fork main stem. NC2, NC1a, AR1a, and AR1 only had one DO sample each below WQS listed in Subsection 4.03 and all DO samples at NC1b were within acceptable ranges. Therefore, South Curry's Fork was identified as a priority area for low DO pollutant source identification and remediation measures.

4.13 DISSOLVED OXYGEN POTENTIAL POLLUTANT SOURCES

Field investigations during water quality sampling indicate the source of DO impairment in the South Curry's Fork is attributed to a number of physical habitat and land use features. An analysis of the nutrient data showed relatively low levels and the field habitat assessments also did not indicate the presence of nuisance algae blooms. The physical habitat and land use features that may be contributing to low DO levels in South Curry's Fork are:

- Lack of canopy cover
- Lack of riparian vegetation
- High degree of corridor development
- Stream channel straightening
- Stream channel alteration

These factors impact DO for a number of reasons. A reduction in canopy cover causes stream temperatures to rise because of increased exposure to sunlight. Temperature inversely controls the solubility of oxygen in water; therefore, when stream temperature is higher, oxygen is less soluble and DO decreases. Reduction in aquatic plants also decreases DO in water as photosynthesis is one of the main ways oxygen enters water. Sampling data indicated SC2 had the second highest average stream temperature exceeded only by NC2. Temperatures at NC2 were expected to be the highest because of the sampling location, which was on a concrete pad outfall from Crystal Lake. Although temperatures were higher at NC2, DO results were lower at SC2.

Figures 4.13-1 and 4.13-2 show DO levels in South Curry's Fork at the time of day they were taken. The lowest DO values tended to occur during the warmer parts of the day when stream temperature would be expected to be higher.

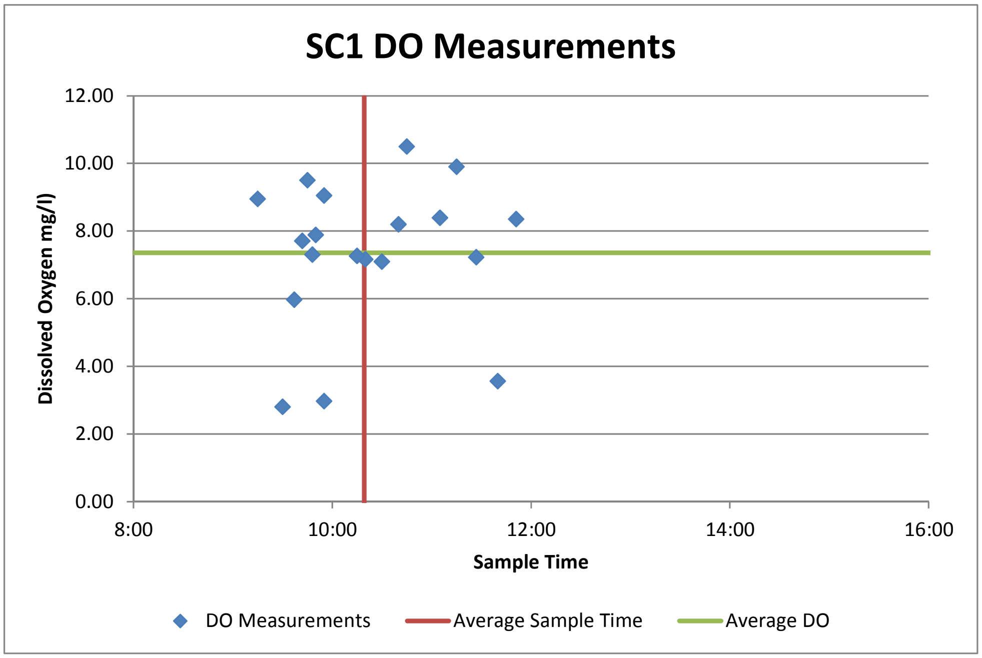


Figure 4.13-1 SC1 DO Measurements vs. Sample Time

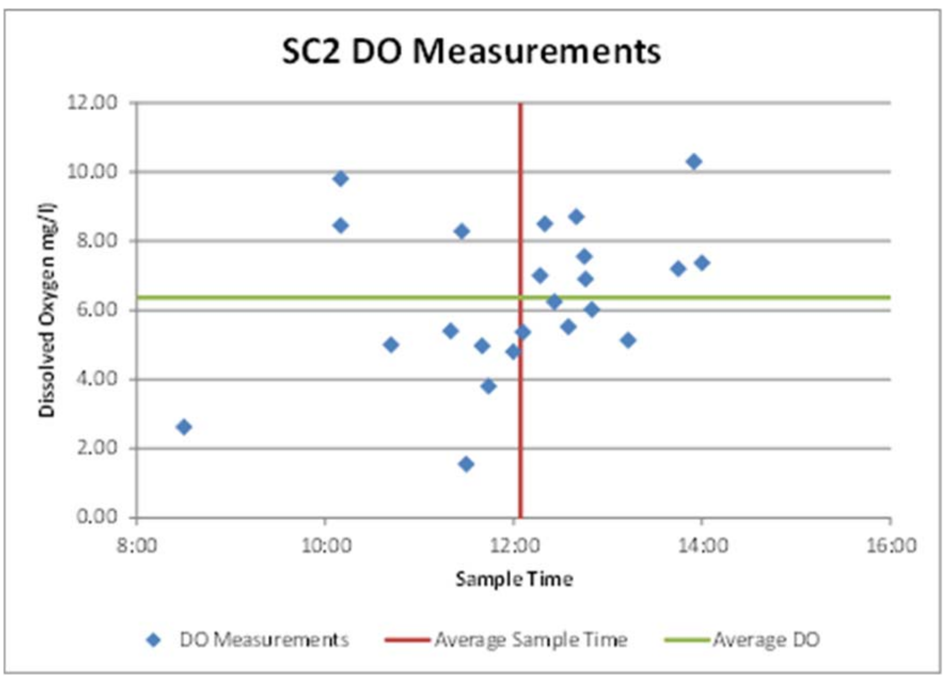


Figure 4.13-2 SC2 DO Measurements vs. Sample Time

Stream channel alterations and straightening reduce the riffle/pool frequencies. Riffles often cause water flow to become turbulent, which promotes oxygen dissolving in water. Additionally, stream channel straightening often results in streams becoming disconnected from their groundwater flows and thus, negatively affecting stream recharge, stream flows, and DO levels.

The introduction of organic wastes such as improperly treated sewage or animal manure to streams can lower DO by increasing the biological oxygen demand (BOD). The wastes are decomposed by microorganisms that delete oxygen in the stream, and the increase in organic matter increases the amount oxygen consumed in the stream. South Curry's Fork has several PTPs that discharge to the streams, but the facilities have been meeting their effluent limits and do not appear to be a source of low DO in the subwatershed.

4.14 SEDIMENT/SILTATION AND GEOMORPHIC ASSESSMENT RESULTS

The following tables, figures, and discussions are taken and summarized from the WQDR in Appendix D.

Siltation, or sedimentation, is one of the most common causes of stream impairment in the Commonwealth and within the United States. Siltation affects aquatic communities by choking spawning gravels, impairing food sources, and reducing habitat complexity. Sediment impairment can be the product of several factors, including sediment supply in excess of transport capacity, inadequate filtering by floodplains, and uniform in-channel deposition promoted by incision and entrenched channels.

The goal of the sediment assessment was to assess and quantify water pollutant loads being contributed from different sources within the watershed. The three objectives of the sediment assessment were to calculate loads of fine sediment from each subwatershed, evaluate the relative contributions of different sediment sources, and interpret the possible links between sediment production and WAH impairment.

A. Fine Sediment Yield

Fine sediment yield is the mass of sediment leaving a watershed over a specific period of time. Both suspended sediment and turbidity were assessed and monitored for this project. A suspended sediment concentration/turbidity relationship was developed to better utilize the much larger turbidity data set. Turbidity was plotted against stream flow discharge for individual storm events to determine whether sediment fluxes are coming from local sources or being carried from distant upstream sources. The vast majority of storm events indicates a dominance of local sources as sediment concentrations are higher before the flood peak. When comparing winter and summer storm events, the data suggests that local sediment sources are more important when ice-related weathering processes, specifically freeze-thaw, are active on the stream banks.

Total sediment loads for all subwatersheds from January through December 2009 are shown in Table 4.14-1.

Subwatershed	Drainage Area (sq mi)	Total Load (tons/yr)	Total Yield (tons/yr/sq mi)
Curry's Fork Main Stem	5.3	21,275	4,037
North Curry's Fork	10	17,100	1,703
South Curry's Fork	9.2	38,410	4,175
Asher's Run	3.3	4,998	1,506

Table 4.14-1 Curry's Fork Sediment Yield

The total sediment loads for all subwatersheds from January through December 2009 showed the greatest total load was from the South Curry's Fork subwatershed. The yields, normalized by area, however, show the main stem Curry's Fork subwatershed contributed a similar amount of sediment as South Curry's Fork.

B. Sediment Production

The major sources of fine sediment that were selected for measurement in each subwatershed were the contributions from stream bank erosion, unmapped headwater channels, and upland surface erosion.

1. Stream Bank Erosion

Annual erosion rates were determined by installing erosion pins in eroding banks. A total of 86 erosion pin measurements were made in all subwatersheds at a total of 29 sites. Table 4.14-2 summarizes the mass of sediment produced by bank erosion.

Subwatershed	Mass (tons/yr)	Unit Rate (tons/mi/yr)	Channel Length (mi)
Asher's Run	**923.6**	**35.7**	**25.8**
Main Stem	720.6	147.9	4.9
Blue Line Tributaries	83.1	11.2	7.4
Unmapped Tributaries	119.9	8.9	13.5
Curry's Fork	**1612.8**	**35.6**	**45.4**
Main Stem (downstream)	730.2	322.5	2.3
Main Stem (upstream)	470.0	185.6	2.5
Blue Line Tributaries	163.3	12.9	12.6
Unmapped Tributaries	249.3	8.9	27.9
North Curry's Fork	**1491.8**	**18.7**	**79.9**
Main Stem (downstream)	361.6	257.4	1.4
Main Stem (upstream)	381.4	94.7	4
Blue Line Tributaries	331.6	12.8	26
Unmapped Tributaries	417.2	8.6	48.5
South Curry's Fork	**1770.3**	**23.0**	**76.9**
Main Stem (downstream)	576.3	195.6	2.95
Main Stem (upstream)	521.0	152.9	3.41
Blue Line Tributaries	239.4	10.9	21.9
Unmapped Tributaries	433.6	8.9	48.6

Table 4.14-2 Sediment Produced by Bank Erosion

The highest rates of sediment production because of bank erosion occurred in the lower reach of the Curry's Fork main stem. The primary reason for the sediment production in the lower reaches is the very high banks, which average over 9 feet; bank heights of 12 feet were not uncommon. Photographs depicting high banks are included in the WQDR in Appendix D.

2. Stream Bank Erosion Priority Areas

Given the high variability of erosion rates, general trends were difficult to discern, but one clear temporal pattern was evident from field observations: weathering of the banks during winter months loosened large amounts of sediment that could be entrained by subsequent flows. The bank material composition in Curry's Fork watershed (primarily silt and clay) is particularly susceptible to freeze-thaw weathering, suggesting this is a long-term contributing factor of bank erosion.

Removal of the high banks through stream restoration would remove a significant source of sediment but would be expensive because of the large amount of earthmoving. If a demand for the soil could be identified, cost would be reduced considerably. A similar situation of high banks and high sediment production was found in the lower reaches of North Curry's Fork in the downstream section after diverging from I-71. Stream restoration projects could significantly reduce sediment production in this area.

The lowest rates of sediment production from a main stem were measured at NC1b, which runs between the south and northbound lanes of I-71. The banks at NC1b are relatively low, are not eroding for a high percentage of their length, and are well vegetated; this is an area suitable for protection rather than restoration. The North Curry's Fork subwatershed was the only subwatershed where the main stem contributed (in the area within I-71) less than half of the sediment production from bank erosion. Many tributaries flow through a culvert under the north- or southbound lanes of I-71, which would make a sensible site for a sediment trapping BMP because of the backwater from the culvert and the presence of a stable grade control.

The main stem of Asher's Run has lower banks and a smaller drainage area than the main stem in the other subwatersheds, but the sediment production rate was still relatively high, especially near the confluence with Curry's Fork. The downstream reaches of Asher's Run have higher banks than upstream reaches, so from a sediment production standpoint, they would be the best places to focus on stream restoration efforts.

This pattern of higher banks near the confluence with a larger stream reach was found in all subwatersheds and is more dramatic when the drainage areas confluencing streams are very different (e.g., where Asher's Run confluences with Curry's Fork). Sites near confluences are often sampling sites, and the original determination of Curry's Fork as impaired was based on biological sampling near the confluence with Floyds Fork.

3. Upland Surface Erosion

Soil erosion models are a widely used method of estimating upland erosion rates because instrumenting every hillslope and valley in a watershed is time- and cost-prohibitive. Use of soil erosion models without field measurements, however, is subject to great uncertainty and may produce results contrary to observed conditions. For this project, field measurements at a number of ponds were made to obtain local sediment loads. These were coupled with a geo-spatial water erosion prediction project model (GeoWEPP) to cover as much of the watershed as possible. Additional measurements at pond sites were used to assess the accuracy of the modeling efforts to ensure that the results were sensible and realistic.

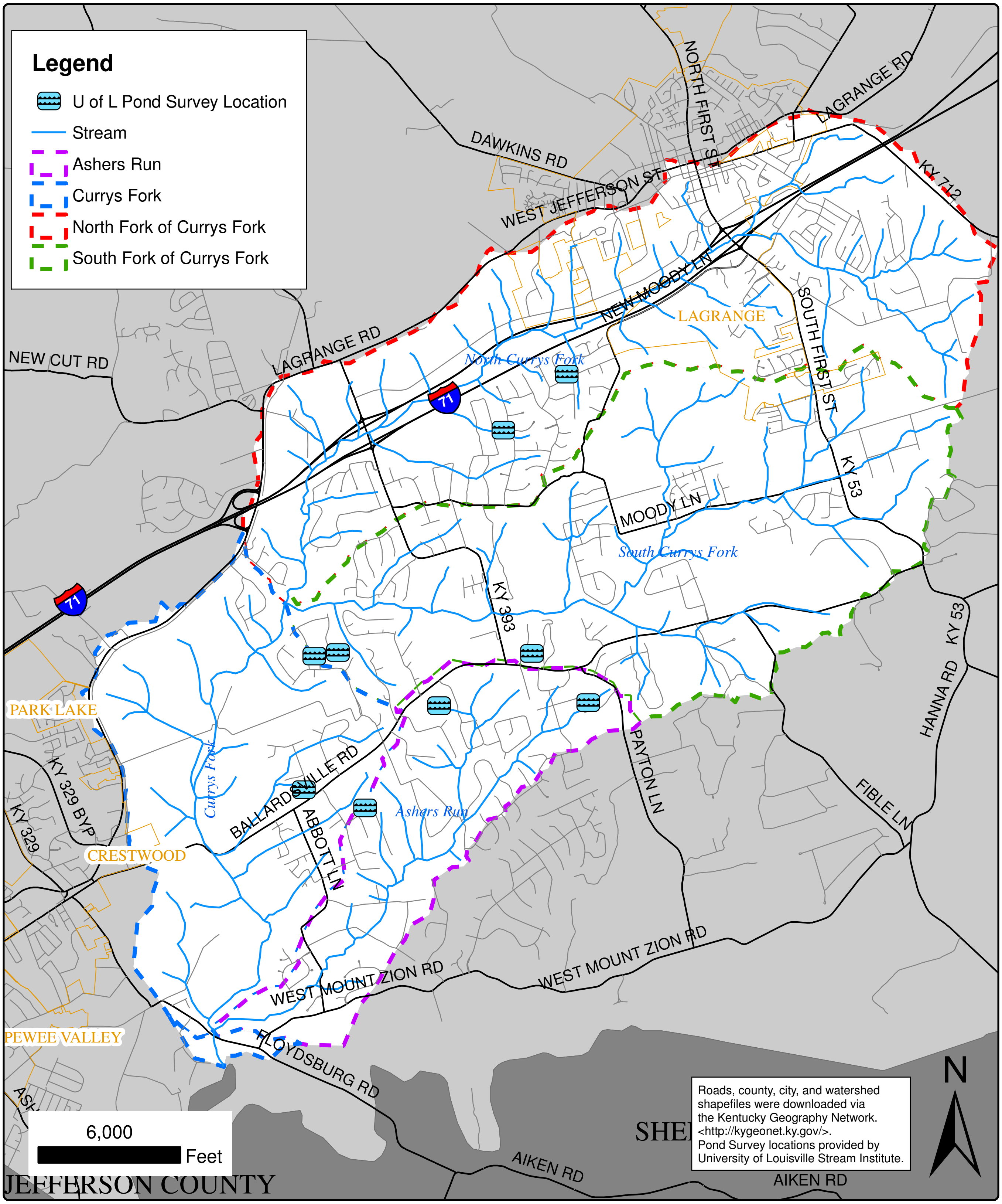
In the Curry's Fork watershed, many headwater channels not shown as blue line streams on United States Geological Survey (USGS) topographic maps are deeply incised gullies. Estimating the sediment production contribution from bank erosion requires an estimate of the extent of these unmapped channels. Channel networks were defined using standard GIS routines to determine the drainage area, or flow accumulation area, at which channel heads occur. Sediment production from unmapped channels as estimated, along with the length of the eroding bank. Bank heights were mapped in the field, and the erosion rate was estimated from erosion pin measurements.

Tables 4.14-3 and 4.14-4 show the results of the pond surveys and GeoWEPP modeling conducted by the UL Stream Institute, respectively. Figures 4.14-1 and 4.14-2 show the location of the pond surveys and the results of the GeoWEPP modeling, respectively.

Pond ID	Drainage Area (acres)	Date Built / Cleaned	Sediment Volume (ft^3)	Hillside Erosion Rate (tons/acre/yr)	Subwatershed
Cooper	4.0	1981*	29,277.45	0.33	South Curry's
Diebel	5.6	1959-1961	49,714.29	0.67	Asher's Run
Ennes	3.1	1981*	36,771.84	0.74	North Curry's
Forrest	4.6	1981*	34,943.13	0.62	North Curry's
Ghad2	13.1	1981	69,390.00	0.36	Asher's Run
Lanham	7.0	1993	21,852.45	0.38	Asher's Run
Northwood	5.5	1983	47,162.79	1.09	Asher's Run
Seymour	2.5	1995	15,133.23	0.66	Curry's Fork Main Stem
Yates	8.2	1979	29,679.48	0.19	South Curry's
Young	6.4	1981	22,062.51	0.15	South Curry's

*Date estimated from USGS Topographical quadrangles and KYTC aerial photo graphs

Table 4.14-3 Pond Survey Results

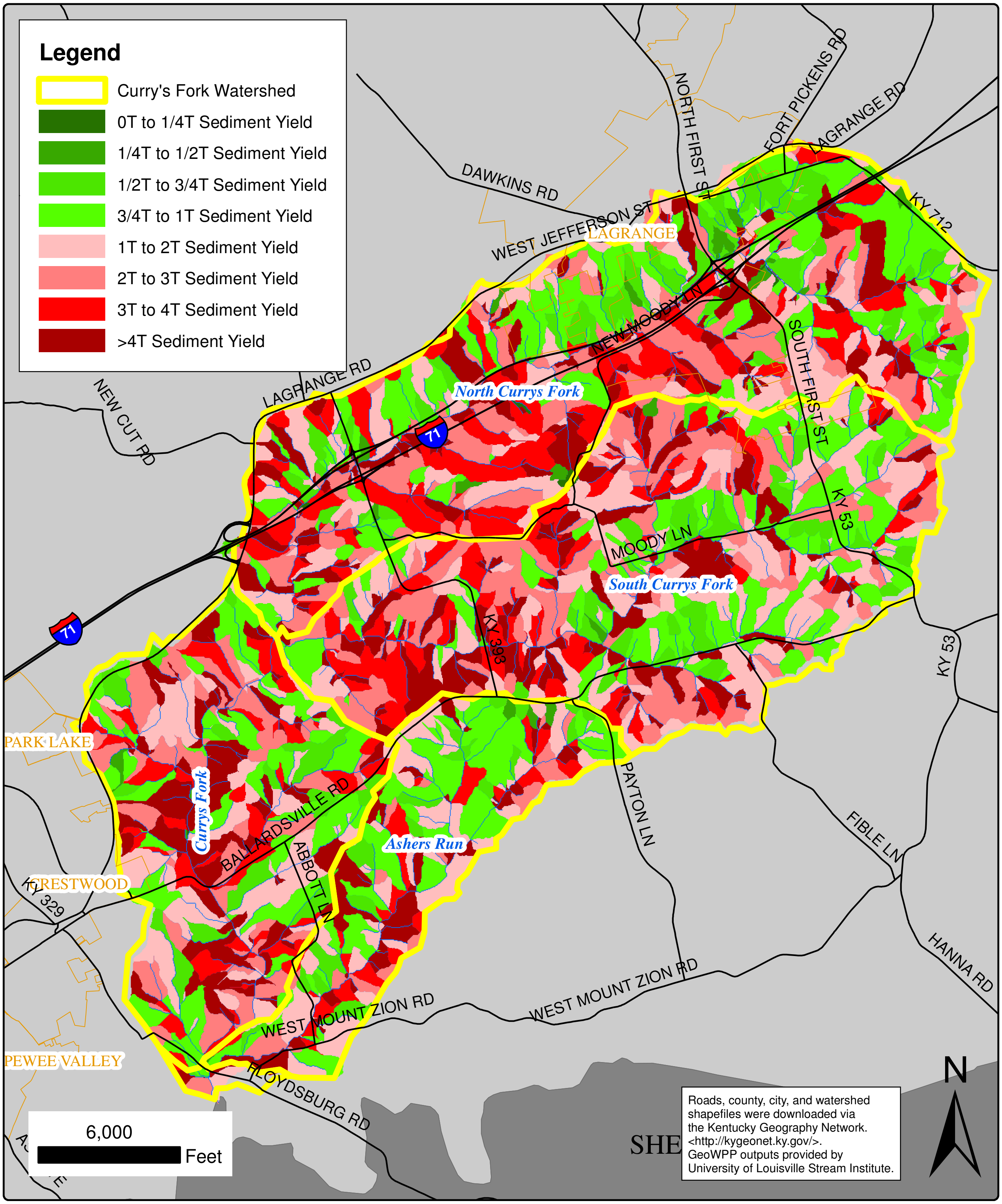


UNIVERSITY OF LOUISVILLE
POND SURVEY LOCATIONS

CURRY'S FORK WATERSHED PLAN
OLDHAM COUNTY FISCAL COURT
OLDHAM COUNTY, KENTUCKY

STRAND ASSOCIATES, INC.® ENGINEERS

FIGURE 4.14-1
5994.100



GEOWEPP MODEL RESULTS

CURRY'S FORK WATERSHED PLAN
OLDHAM COUNTY FISCAL COURT
OLDHAM COUNTY, KENTUCKY

STRAND ASSOCIATES, INC.® ENGINEERS

FIGURE 4.14-2
5994.100

Subwatershed	Soil Loss (tons/yr)	Sediment Deposition (tons/yr)	Sediment Yield (tons/acre/yr)
Asher's Run	3,601	192	2.19
Curry's Fork Main Stem	15,449	954	5.65
North Curry's	15,894	418	3.26
South Curry's	12,129	512	2.56

Table 4.14-4 GeoWEPP Output

Overall, the GeoWEPP model performed well, with predicted sediment mass being the same order of magnitude as that in measured pond surveys. Although erosion rates calculated in the model may have some errors, no evidence was found of systematic bias that might indicate whether sediment mass calculations were too low or too high.

4. Upland Surface Erosion Priority Areas

Curry's Fork main stem had the highest upland erosion rates per unit area based on GeoWEPP model estimations and Asher's Run had the lowest. No clear patterns were identified in or between subwatersheds based on erosion rates, which is indicative of the lack of variation in topography, geography, and land use. Curry's Fork main stem also had the highest proportion of sediment deposition because of the main stem's wide floodplain and long hillslopes with deposition zones at the base of the slope.

The mass of sediment deposited was relatively insignificant in each subwatershed, varying from 2.6 percent to 6.1 percent of the total mass of sediment eroded. The Curry's Fork main stem subwatershed had the highest proportion of sediment deposition because of the mainstem's wide floodplain and long hillslopes with deposition zones at the base of the slope. Based on a comparison of bank erosion and upland erosion, the upland areas appear to offer the greatest opportunity to reduce overall loads. The output from the GeoWEPP model estimated that more sediment was produced from hill slope erosion than from bank erosion in all four subwatersheds. However, sediment production from upland surface erosion occurs over a large area, making implementation of sediment reducing BMPs difficult. Also, if streambank erosion is converted into a per unit area rate using floodplain width, both upland surface erosion and bank erosion are of similar magnitude.

A different approach to reducing sediment would be to focus on the delivery of sediment from upland surface erosion to downstream waters rather than reduce the soil loss directly. Legacy impacts to the streams of the Eastern United States are well documented and have resulted in widespread incision of stream channels and their tributaries. In the headwaters, this incision propagates upslope, extending the drainage network. One consequence of this drainage expansion is that natural sediment storage zones could be effective in reducing the delivery of NPS to downstream waters.

C. Geomorphic Assessment

Sediment production and deposition are complex processes that are based on local morphology and the recent history and water and sediment delivery to particular reach. A geomorphic assessment of Curry's Fork was undertaken to identify some of the local morphological controls on sediment erosion and deposition and to investigate how these controls influence the physical habitat.

The geomorphic assessment for Curry's Fork included a desk-based GIS analysis and supplemental field investigations. An array of parameters as measured through the GIS analysis (sinuosity, valley width, stream width, and riparian corridor width) and others were observed through field investigations and aerial imagery (dams and weirs, bridges and culverts, floodplain development, bank armoring, berms and roads, and channel pattern). The presence or absence of each of these ten parameters was recorded in spreadsheet format for each reach. (Refer to the WQDR for additional details). Field investigations also included additional habitat observations and assessments for specific stream functions for each subwatershed.

The focus of the geomorphic assessment was the main stem of each subwatershed. A total of eight reaches of the main stem blue line streams in all four subwatersheds as selected for the field geomorphic assessment. The length of the assessment reach was typically between 1,400 feet and 3,000 feet to include representative variability in morphology and habitat function.

Various functions that contribute to physical habitat were assessed in each reach. Structural habitat and indicators of processes directly driving physical morphology were documented regularly, as were hydrologic/hydraulic habitat and indicators of processes related to flow interaction with physical morphological boundary conditions. The grade control in each reach was also recorded as this determines the potential for each reach to degrade.

Numeric results (e.g., riparian corridor width) from the GIS data collected were plotted over topographic base maps to visualize the spatial distribution of each parameter. For nonnumeric results, the percentage of total stream length with and without each feature was calculated. The data from the field assessment was collated in a spreadsheet and plotted in GIS to visually identify patterns in physical habitat function parameters.

1. North Curry's Fork Field Investigations

North Curry's Fork can be organized into three distinct groups of reaches: those downstream of I-71, those between I-71, and those upstream of I-71. Downstream of I-71, the main stem and its tributaries are entrenched, incised to bedrock, and lacking in habitat variability. Reaches of the main stem downstream of I-71 could potentially be very good for stream restoration projects because the valley is wide relative to the stream width, and residential encroachment is limited. A significant reduction in sediment loading to the stream could be expected if the long stretches of eroding banks were restored. The tributaries to the main stem downstream of I-71 were reasonably contrained by development and would provide logistical challenges to stream restoration. However, most of the tributaries do have good riparian buffers that should be preserved.

The reaches between north and southbound lanes of I-71 offer insight into the potential of Curry's Fork with no floodplain development, no removal of large woody material, and no bridge crossings or culverts to locally limit lateral migration. The channel is gradually increasing sinuosity after it was straightened in several reaches and has a wide riparian corridor. Eroding banks are common and provide good habitat, but because the banks are low, the mass of sediment supplied by the channel is low. The habitat in these reaches is the most varied in the subwatershed, if not all of Curry's Fork, with well-developed riffles and pools, and a well-connected floodplain. This reach also did not appear to dry out during summer months, although this may be related to the effluent from WWTPs. Future changes in WWTP effluent discharge quantities and locations may affect the availability of low flow.

The reaches upstream of I-71 are dominated by L and N Lake to the north of I-71 and Crystal Lake to the south. Above the lakes are minor headwaters that were not extensively investigated because of their low potential for remediation and small impact on the watershed.

2. South Curry's Fork Field Investigations

South Fork can be organized into two groups of reaches: those downstream of SC2 and those upstream of SC2. Reaches downstream of SC2 have residential development or are immediately adjacent to a subdivision, whereas reaches upstream of SC2 have less residential impact but have agricultural land occupying most of the valley flat, with only isolated houses. The riparian corridor downstream of SC2 is generally wide, although it is not continuous; upstream of SC2, the riparian corridor is very narrow and limited in extent.

Lower reaches of the main stem have good habitat, especially in anabranched reaches, except near the confluence with North Curry's Fork, where very high banks and a flat bedrock bed were evidence of incision and lack of habitat. The anabranched reaches coincided with reaches with large woody debris both from fallen trees and small jams in the channel. In the anabrached reaches, a lower floodplain or bar deposits were acting to trap sediment and, presumably, nutrients and contaminants associated with fine sediment. These sections had diverse physical habitat with riffles, pools, runs, and backwater areas. In contrast, the single-thread sections had limited riffle and pool development, less available cover, and little evidence of interaction between channel and floodplain. Anabranched reaches also have more eroding banks, so the net storage and sources of sediment are difficult to determine; scientific research on anabranched channels in incised systems is particularly lacking and would provide useful information for their role in affecting NPS pollution loads.

Stream restoration projects in the single thread main stem reaches would have the main benefit of reducing sediment supply by reducing the bank height and increasing the connectivity between floodplain and main channel. One main stem reach adjacent to Centerfield Elementary School could provide a suitable site for improving stream function and provide a demonstration of the improvements that could be made in physical habitat in these stream reaches. Most of the tributaries to these reaches of South Fork are extensively developed to the extent that stream restoration potential is limited, although channel improvements may be possible close to the confluence with the main stem.

The habitat in the upper reaches of South Fork showed the most consistent siltation of all reaches assessed in the Curry's Fork watershed. None of these reaches met the target condition for any of the assessed functions. These reaches also had the least extensive riparian corridor of all assessed reaches. Moreover, the quality of the riparian corridor is generally poor, with a significant percentage of invasive species such as osage orange. One cause of the suspended sediment deposition in the upper reaches of South Fork was sediment delivery from the tributaries during low flow periods. Siltation may be caused not by high loads of sediment but by relatively small amounts delivered when the flow in the channel is insufficient to influx. Restoration will locally reduce the input of fine sediment from these side channels when the flow in the main channel is low. The other potential source for fine sediment is the agricultural land use upstream, but results from GeoWEPP and field observations suggest that sediment production from these fields is relatively low.

3. Asher's Run Investigations

Asher's Run can be classified into three groups of reaches: those reaches in the immediate vicinity of Curry's Fork main stem, those reaches upstream of this confluence but downstream of Camden Lane, and those reaches upstream of Camden Lane. Reaches downstream of Camden Lane generally have a good riparian buffer and limited development, whereas reaches upstream have a less extensive riparian buffer and more direct channel impacts from development.

In the stream reaches immediately upstream of the confluence with the main stem of Curry's Fork, the influence of the larger stream is clear: banks are high and signs of frequent overbank flooding because of backwater effects are evident. Both banks in these reaches are eroding, so the local sediment production is relatively high, although for a short distance. Above the influence of the main stem, the bank height decreases, the amount of coarse sediment deposition increases, and the variability in physical habitat improves. There are alternating single-thread and anabranched reaches up to Camden Lane bridge. The anabranched reaches have a lot of available cover, varied substrate, and varied flow conditions.

Asher's Run upstream of Camden Lane is straighter, less forested, and has fewer anabranched reaches than downstream. Some reaches show signs of floodplain modification, whereas in others the stream itself has been modified. Although a stream restoration project in this group of reaches may be beneficial in terms of improving physical habitat, a number of constraints from adjacent roads and residential development would limit the ability to enact major changes in floodplain configuration. An alternative strategy would be to focus restoration efforts on the lower reaches of Asher's Run, where fewer landowners and more valley width would facilitate restoration work, and treatment of upstream water quality during low flow could be incorporated into the project design.

4. Curry's Fork Main Stem Field Investigations

The main stem of Curry's Fork can be classified into two main groups of reaches: those influenced by Floyds Fork and those upstream of the backwater influence. The main stem near the confluence with Floyds Fork has very high banks, and as a result of this entrenchment, little course sediment is deposited, limiting potential for bar or riffle formation. Some pea gravel is typically present, but this sediment is frequently mobilized and hence poor habitat for many benthic organisms that require a stable substrate. Improving habitat function in this downstream reach would involve a considerable amount of earthmoving to reduce entrenchment and improve floodplain-channel interaction. The floodplain of the downstream-most reach was inundated during the study period but only when Floyds Fork was also in flood and causing backwater. Away from the backwater influence of Floyds Fork, the stream reaches have lower banks, more stable substrate, and more connectivity with the floodplain. The channel configuration is relatively consistent up to the confluence of the North and South Fork with alternating single-thread and anabranched reaches. The single-thread channels have higher banks and are generally eroding on one bank. The anabranched reaches have a mixture of eroding and depositing regions. The anabranched reaches are the results of local erosion of the floodplain because of fallen woody debris and are typically three channels or less. The impact of these multiple channels on the storage of NPS pollutants has received limited scientific study but would be valuable information, especially for stream restoration design. Field observations suggest that these anabranched reaches could be very useful for providing diverse habitat and storing sediment and associated pollutants.

D. General Habitat Findings

Although each subwatershed had particular reaches that both met and did not meet target functions, higher-quality reaches shared similar characterisitics throughout the Curry's Fork watershed: the reaches that met the target functions had lower banks, more floodplain accessibility, greater groundwater connection, and more diverse morphology, and they were typically located away from the valley walls. Field investigations throughout the watershed at different times of the year also suggest that the presence or absence of low-flow habitat is significantly variable in the watershed. Many reaches in Asher's Run, South Fork, and North Fork were observed to dry out, whereas others maintained at least some standing water throughout the year. The main stem typically did not dry out except in isolated circumstances. Low or absent base flow has indirect impacts on aquatic communities through secondary effects such as elevated temperatures, decreased DO, elevated biochemical oxygen demand (BOD), and increased concentrations of contaminants and nutrients because of lack of mixing and dilution. Hence, impacts on the quantity of water during summer months will also impact water quality.

4.15 SEDIMENT/SILTATION AND GEOMORPHIC SUMMARY

To help develop effective watershed-scale management strategies for reducing NPS pollution, a study was conducted focusing on fine sediment loads and geomorphology, specifically relating to physical habitat functions. Annual loads of fine sediment in each of Curry's Fork's four major subwatersheds were measured, the contribution from bank erosion and upland surface erosion was measured, and the physical habitat functions were assessed in representative reaches of each subwatershed.

The highest subwatershed sediment loads were measured in South Curry's Fork and the lowest loads were measured in Asher's Run. The highest rates of sediment production from bank erosion were measured in the lower reaches of Curry's Fork main stem close to the confluence with Floyds Fork. Although the highest sediment production from upland surface erosion was predicted to be Curry's Fork main stem based on the GeoWEPP model results, no clear patterns were identified in or between subwatersheds based on erosion rates, which is indicative of the lack of variation in topography, geography, and land use.

The vast majority of stream reaches in all subwatersheds were incised to bedrock, at least in pools, had a dearth of instream cover/submerged structures, and showed signs of channel straightening. Stream restoration projects to improve surface-groundwater connectivity, increase habitat diversity, reduce shear stress, reduce bank erosion, and create floodplain wetlands could be implemented in most stream reaches, with the exception of the reach of North Curry's Fork between the divided interstate. Specific restoration and protection solutions based on this data are presented in Section 5.

For all subwatersheds, the mass of sediment from upland surface erosion was greater than from bank erosion. This difference was due to the much smaller area occupied by stream channels. When normalized by floodplain width, sediment production from bank erosion is greater than or similar to that from upland surface erosion. Importantly, sediment produced by bank erosion goes straight into the channel, whereas sediment produced by upland erosion may deposit at the base of the hill slope, deposit on the floodplain of receiving stream, or may be washed through the watershed without interacting with the channel bed.

4.16 BIOLOGICAL AND PHYSICAL HABITAT METRICS ANALYSIS

The following tables, figures, and discussions are taken and summarized from the WQDR in Appendix D.

Four stream reaches within Curry's Fork watershed were sampled for aquatic macroinvertebrates, fish, and physical habitat during the summer of 2007. Additionally, two locations in the Curry's Fork watershed were sampled for mussels as part of a larger KDOW sampling event in the Floyds Fork watershed during the summer and fall of 2003. Refer to Figure 3.05-1 for the biological monitoring locations. According to KDOW guidance, Asher's Run is considered a headwater stream (<5 mi^2 watershed), and the other streams are considered wadable (>5 mi^2 watershed).

For the aquatic macroinvertebrates, fish, and physical habitat assessments, the goal was to identify potential stressors to the sampled biological communities. Multiple metrics and multivariate tests were performed to achieve these results. Results were evaluated using KDOW *Standard Methods for Assessing Biological Integrity of Surface Waters in Kentuck*y (KDOW 2002) and supplements with multivariate community assessment. Habitat assessment field data sheets, physicochemical results, macroinvertebrate sampling results and fish sampling results are provided in the WQDR Appendix D.

Macroinvertebrate communities for each stream were evaluated through calculation of the MBI, as well as other metrics including functional feeding group abundances and community similarity between stations. The 2008 edition of KDOW Standard Methods for Assessing Biological Integrity of Surface Waters in Kentucky was used for calculations as it became available after the survey (KDOW 2008)

Tables 4.16-1, 4.16-2, and 4.16-3 show the physical habitat, macroinvertebrate, and fish assessment results collected at the four assessment sites in Curry's Fork. Table 4.16-4 summarizes the biological and physical habitat metrics calculated by Third Rock.

RBP Habitat Parameter	Sampling Site			
	NC1	SC1	AR1	CF2
Epifaunal Substrate / Available Cover	8	7	12	10
Embeddedness	17	15	13	18
Velocity / Depth Regime	13	8	13	8
Sediment Deposition	14	6	9	11
Channel Flow Status	13	16	9	16
Channel Alteration	16	16	14	17
Frequency of Riffles (or Bends)	9	17	15	16
Bank Stability (Left Bank)	3	8	7	8
Bank Stability (Right Bank)	3	7	7	9
Vegetative Protection (Left Bank)	2	8	5	8
Vegetative Protection (Right Bank)	2	8	5	8
Riparian Vegetative Zone Width (Left Bank)	2	10	2	10
Riparian Vegetative Zone Width (Right Bank)	2	10	2	2
Total Score	**104**	**136**	**113**	**141**

Table 4.16-1 Physical Habitat Assessment Results

Site	Taxa Richness (+)	EPT Richness (+)	MBHI (-)	%EPT (+)	% Mayflies (+)	% Midges and Worms (-)	% Clingers (+)	MBI Score (+)	MBI Rating
NC1	29	6	6.11	28.4	7.2	13.1	73.1	56.9	Fair
SC1	38	8	6.08	7.9	3.6	39.6	44.2	44.4	Fair
AR1	27	3	5.99	7	6.7	13.5	42.2	37.8	Poor
CF2	41	11	5.44	20.4	5.3	3.9	86.6	63.9	Good

Note: (+) or (-) indicates if metric will increase (+) or decrease (-) with improving water quality.

Table 4.16-2 Macroinvertebrate Core Metric Results

Site	Native Species Richness (+)	Darter, Madtom, Sculpin Richness (+)	% Facultative Headwater Individuals (-)	% Tolerant Individuals (-)	Intolerant Species Richness (+)	% Insectivore Individuals (+)	Simple Lithophile Richness (+)	IBI Score (+)	IBI Rating
NC1*	0 (5)	0 (3)	0 (77)	0 (50)	0 (0)	0 (50)	0 (2)	0 (24)	Very Poor (Poor)
SC1	8	2	81	86	0	14	1	32	Fair
AR1	0	0	0	0	0	0	0	0	Very Poor
CF2	11	2	85	70	0	29	2	28	Poor

Notes: (+) or (-) indicates if metric will increase (+) or decrease (-) with improving water quality.
* NC1 only had 30 individuals encountered during the fish survey. According to KDOW protocols if fewer than 50 individuals are collected then metrics are scored as zero. Numbers in () are actual values collected.

Table 4.16-3 Fish Core Metric Results

Site	Subwatershed	RBP (Physical Habitat)		MBI (Macroinvertebrate Analysis)		IBI (Fish Analysis)	
		Score	Rating	Score	Rating	Score	Rating
NC1	North Curry's	104	Not Supporting	56.9	Fair	0 (24)	Very Poor
SC1	South Curry's	136	Not Supporting	44.4	Fair	32	Fair
AR1	Asher's Run	113	Not Supporting	37.8	Poor	0	Very Poor
CF2	Curry's Fork Main Stem	141	Partially Supporting	63.9	Good	28	Poor

Note: RBP = Rapid Bioassessment Protocols; MBI = Macroinvertebrate Biotic Index; IBI = Index of Biotic Integrity

Table 4.16-4 Biological and Physical Habitat Data Summary

EPT richness and mayfly-stonefly-caddisfly richness are known to increase with improving water quality and with habitat diversity/suitability. Curry's Fork main stem at CF2 and South Curry's Fork at SC1 had the largest taxa richness and USEPA scores of all stations sampled. Physical stream integrity was found to correlate with these results as embeddedness was low, riffles were frequent, banks were stable, and riparian vegetation protection at the samples sites were good with these two locations. The physical characteristics for CF2 and SC1 could contribute to increased richness scores because of the availability of different habitat niches. At Asher's Run (AR1) and North Curry's Fork (NC1), the nonsupportive total habitat scores are closely associated with the low taxa and EPT richness.

Modified EPT abundance ranged from 7 percent (Asher's Run) to 28.4 percent (North Curry's Fork). Curry's Fork main stem and North Curry's Fork had higher EPT abundances than the other stations with 20.4 and 28.4 percent, respectively. While North Curry's Fork had a higher USEPA abundance score, most of the EPT individuals were fairly common or tolerate species. Many physical habitat parameters (i.e., frequency of riffles, bank stability, vegetative protection) scored within the marginal or poor categories for North Curry's Fork. Therefore, the EPT abundance score for North Curry's Fork may be a result of the presence of common EPT species rather than improved habitat availability.

Midges and aquatic worms are generally pollution tolerant organisms, and their abundance should increase with decreasing water quality conditions. Midges and worms were fairly abundant at South Curry's Fork comprising 39.6 percent of the community. Conversely, midges and worms represent a much smaller percentage of the macroinvertebrate community at the other stations.

Clingers are organisms that require hard, silt-free substrates to "cling" to. A decline in clingers could indicate sedimentation of substrates or unstable substrates. Lower clinger abundances at the Asher's Run and South Curry's Fork location, coupled with suboptimal embeddedness scores, indicate unstable substrates may be a concern.

Macroinvertebrate functional feeding group information can provide insight into the balance of feeding strategies and trophic dynamics within the benthic community. Table 4.16-5 shows the percent functional feeding group at each assessed sampling site. If food dynamics (and/or physical habitat) are not stable within a stream, an imbalance in functional feeding groups may occur, indicating a stressed community. Generalist taxa such as collector-gathers or collector-filterers are often more dominant in impaired streams. South Curry's Fork and Asher's Run had the highest percentage of collector-gatherer tax. However, Asher's Run had the lowest collector-filterer percent taxa among all the stations assessed. It is important to note that filter feeders are sensitive to low flow conditions, which may occur in Asher's Run since it is a headwater stream.

Functional Feeding Group*	Station (% Functional Feeding Group)			
	CF2	**NC1**	**SC1**	**AR1**
Predator	4.9	13.4	4.1	1.3
Collector-Gatherer	9.8	16.4	34.1	35.4
Shredder	2.5	0.7	0.2	0.0
Scraper	21.1	25.8	28.6	55.4
Collector-Filterer	61.7	43.7	32.9	7.8

* No piercers were collected in samples.

Table 4.16-5 Percent Functional Feeding Groups

Macroinvertebrate data from the four sites was compared through multivariate ordination to the measured environmental variables to determine potential correlations that exhibited ecological significance. Only two variables were found to be significantly correlated with the marcoinvertebrate communities: watershed size and stream flow. It appears from the association that the larger the watershed and the greater the flow, the greater the diversity and abundance of taxa collected. The sites having less flow and smaller watersheds had poorer MBI scores.

Fish communities for each station were evaluated through calculation of the IBI, as well as community similarity between stations. Refer to Table 4.16-3. South Curry's Fork had a rating of "Fair" and Curry's Fork main stem had a "Poor" rating. Asher's Run had no fish; it is a headwater stream that is either too intermittent or too impaired to support a fish community. North Curry's Fork had insufficient numbers of fish collected (only 30 individuals collected) for the fish community analysis to be meaningful. Thus, only two of the four stations resulted in usable fish community data information.

In 2003, the KDOW conducted a mussel survey in the Floyds Fork watershed of which Curry's Fork is a tributary. As part of this mussel survey, two sampling stations were established in the Curry's Fork watershed, one on the main stem of Curry's Fork and one on North Curry's Fork. Mussel data was collected utilizing timed, visual-based, qualitative searches at each sampling locations. The results of the mussel survey in the Curry's Fork watershed are described in the Table 4.16-6.

Species	Station # 21 Curry's Fork	Station # 22 North Curry's Fork
Actinonaias ligamentina, Mucket–A	0.5WD	
Alasmidonta viridis, Slippershell–C	0.5WD	
Lampsilis siliquoidea, Fatmucket–A	3LV8.5WD	1LV8.5WD
Pyganodon grandis, Giant Floater–A	3.5WD	1LV3WD
Toxolasma parvus, Lilliput–O	0.5WD	3.5WD

Note: A = Abundant (found in > 10 survey stations); C = Common (found in 6 to 10 of survey stations); O = Occasional (found in 2 to 5 survey stations); LV = Live specmimen; WD = Weathered, dry valve

Table 4.16-6 2003 Kentucky Division of Water Mussel Survey Results

The following summarizes the discussions from the Curry's Fork Biological Data Assessment by Third Rock and KDOW. Please refer to the WQDR for additional information.

A. North Curry's Fork

RBP score indicated a poor physical habitat with a rating of "Not Supporting," but there was a fair embeddedness score. Cover was typically poor as was bank stability and vegetative protection. Shading was less than optimal, and there was a chlorine odor noted during the assessment, indicating a treated water source nearby. Bedrock was the dominant substrate and therefore available in-stream cover was lacking.

NC1 had the highest percentage of EPT of 28.4 percent with 6 EPT taxa, which resulted in a "Fair" MBI rating.

Low fish numbers were found in the stream, which resulted in a "Very Poor" IBI rating. As indicated in Table 4.08-4, NC1 only had 30 individuals encountered during the fish survey. According to KDOW protocols, if fewer than 50 individuals are collected, metrics are scored as zero. Numbers in "()" are actual values collected.

The following is an excerpt from the 2003 KDOW Qualitative Mussel Survey summarizing the findings at Station #22 that is located within the North Curry's Fork subwatershed.

> "Station #22 – North Fork Curry's Fork
>
> On August 14th, only three native mussel species were found at this North Fork Curry's Fork station (*Lampsilis siliquoidea, Pyganodon grandis* and *Toxolasma parvus*). Live specimens of *Lampsilis siliquoidea* and *Pyganodon grandis* were recorded. As with other stations in this survey, *Lampsilis siliquoidea* was the most abundant species at this location with one live specimen and eight and a half weathered valves observed."

Mussel survey results show similar results to the biological, habitat, and geomorphic assessments indicating the middle section of North Curry's Fork between I-71 is generally in better condition than the downstream portion where the biological and habitat assessments were performed. Nine of the 23 sites surveyed had no live specimens; it is a good indicator that two live specimens were found at Station #22.

B. South Curry's Fork

SC1 had an RBP rating of "Not Supporting." SC1 had low embeddedness with frequent riffles and good riparian protection. SC1 had a bedrock-dominated substrate. Overall, available instream cover was lacking and the velocity/depth regime was poor as well. Sediment deposition was prevalent. Bank stability was typically poor although the vegetative protection and riparian zone widths were fair. This could indicate excessive flows from the upstream areas.

SC1 has a "Fair" MBI rating that was due to the moderate taxa richness and large abundance of midges and worms. The mayfly abundance was also the lowest at this site.

SC1 yielded the highest IBI rating of "Fair." SC1 had similar fish results to CF2 but because of its smaller drainage area, the resulting IBI rating was considered "Fair" instead of "Poor."

C. Asher's Run

Physical habitat results yielded a RBP rating of "Not Supporting" for AR1. Low RBP scores were primarily in sediment deposition, channel flow, bank stability, vegetative protection, and riparian zone widths categories. The stream typically had good canopy cover and riffle/run/pool ratios.

AR1 had an MBI rating of "Poor" because of the low taxa richness, low EPT taxa, and abundance, although the abundance of midges and worms was not too large.

No fish were found at AR1 during the assessment, which resulted in a "Very Poor" IBI rating. Asher's Run is a headwater stream that is either too intermittent or too impaired to support a fish community.

D. Curry's Fork Main Stem

CF2 had the best RBP rating of any assessment location with a RBP rating of "Partially Supporting." This was a result of good channel flow status, minimal channel alteration, and good bank stability and vegetative protection on both stream banks.

CF2 also had the best MBI rating of any assessment location with a MBI rating of "Good." The data showed high taxa richness and a fair number of EPT taxa with a low percentage of midges and worms.

The fish assessment results in a "Poor" IBI rating for CF2. This was mainly a result of an abundance of tolerant individuals, absence of intolerant taxa, and low darter-madtom-sculpin richness.

The following is an excerpt from the 2003 KDOW Qualitative Mussel Survey summarizing the findings at Station #21 that is located within the Curry's Fork main stem subwatershed.

> "Station #21 – Curry's Fork
>
> In Curry's Fork on August 18th, five native species were identified (*Actinonaias ligamentina, Alasmidonta viridis, Lampsilis siliquoidea, Pyganodon grandis* and *Toxolasma parvus*). Three live specimens of *Lampsilis siliquoidea* were observed during the survey and this species was the most abundant taxa with an additional eight and a half weathered valves recorded."

As discussed for North Curry's Fork, 9 of the 23 sampling sites yielded no live specimens. Station #21 had three live specimens and numerous weathered valves. This is a good indication the biological and physical habitats are still functioning and can be improved upon.

4.17 BIOLOGICAL AND PHYSICAL HABITAT PRIORITY AREAS

The analysis of the biological samples yielded results indicative of moderate impairment. It appears the found impairments could be more indicative of a lack of available habitat (including stream flow) and substrate than altered water chemistry.

In the macroinvertebrate and fish metric analyses, the calculated metrics generally indicated that some type of physical impairment was affecting the stream communities at all stations. Indications of community impacts pertaining to watershed size and stream permanence were observed with the function feeding group analysis. Fish data also indicated that stream permanence affected the present communities, though the correlation was not as apparent as with the macroinvertebrates. The results from the multivariate analysis of the macroinvertebrate and environmental data further supported this evidence through correlation between watershed size/stream flow and macroinvertebrate community diversity.

supported this evidence through correlation between watershed size/stream flow and macroinvertebrate community diversity.

With regard to flow in streams, an adequate hydrologic continuum is important for a diversity of aquatic species. The physical degradation of the sampled stream reaches from Curry's Fork did not exhibit a diversity of habitat, as bedrock was the common substrate found. As observed in the field, stream flow permanency was intermittent in the smaller streams of Curry's Fork during drier conditions. It is therefore believed that within Curry's Fork watershed, the primary stressor to the biological communities is a combination of a lack of flow and habitat cover. In the case of Curry's Fork, many stream channels are incised to bedrock, which offers little habitat for macroinvertebrates and fish.

According to the contractors for the biological and physical habitat assessments, remediation efforts should focus on a reduction of surface runoff through BMPs that promote infiltration. Focused efforts for stream restoration are recommended in conjunction with infiltration BMPs.

The biological and physical habitat data corresponded with the geomorphological data assessments performed by the UL. After reviewing all the biological and habitat data, the WQDAT concluded that South Curry's Fork subwatershed was the highest priority subwatershed for restoration efforts, and Curry's Fork main stem subwatershed was the highest priority subwatershed of protection efforts.

4.18 SUBWATERSHED SUMMARIES

Table 4.18-1 summarizes the final subwatershed bacteria priority area designations. Table 4.18-2 summarizes the nutrient and DO priority areas. Table 4.18-3 summarizes the biological and physical habitat parameters for each subwatershed. Table 4.18-4 summarizes the geomorphology results for each subwatershed.

Subwatershed	Section	Bacteria Priority	
		Restoration	Protection
North Curry's Fork	Upper	Medium	-
	Lower	Medium	-
South Curry's Fork	Upper	Medium	-
	Lower	Medium	-
Asher's Run	Upper	High	-
	Lower	-	High
Curry's Fork - Main Stem	Main Stem	-	High

Table 4.18-1 Bacteria Priority Area Subwatershed Summary

Subwatershed	Section	DO Priority	Nutrients Priority
North Curry's Fork	Upper	Low	Low
	Lower	Low	High
South Curry's Fork	Upper	High	Low
	Lower	High	Low
Asher's Run	Upper	Low	Low
	Lower	Low	Low
Curry's Fork - Main Stem	Main Stem	Medium	Medium

Table 4.18-2 Nutrient Subwatershed Summary

Subwatershed	Biological Habitat Assessments		Physical Habitat RBP Score
	MBI	IBI	
North Curry's Fork	Fair	Very Poor	Not Supporting
South Curry's Fork	Fair	Fair	Not Supporting
Asher's Run	Poor	Very Poor	Not Supporting
Curry's Fork–Main Stem	Good	Poor	Partially Supporting

Table 4.18-3 Biological and Physical Habitat Subwatershed Summary

Subwatershed	Stream Bank Erosion			Fine Sediment Yield		Upland Erosion	
	Downstream Confluence	Main Stem Downstream	Main Stem Upstream	Total	Per Area Basis	Total	Per Area Basis
North Curry's Fork	High	High	Low	Medium	Low	High	Medium
South Curry's Fork	High	Medium	High	High	High	High	Low
Asher's Run	High	Low	-	Low	Low	Low	Low
Curry's Fork–Main Stem	High	High	High	High	High	High	High

Table 4.18-4 Geomorphology Subwatershed Results Summary