Eagle Creek Straightpipe Abatement and Education Project

Northern Kentucky Independent
District Health Department
and
Commonwealth of Kentucky
Environmental and Energy Cabinet
Department for Environmental Protection
Kentucky Division of Water

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Project begin date May 1, 2005 to project end date December 31, 2010.

Prepared by:

Environmental Health and Safety Division
Northern Kentucky Independent District Health Department

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A. Acknowledgments

Grant County Fiscal Court, Office of the Judge Executive, Darrell Link, Judge Executive; Kentucky Water Resources Research Institute (KWRRI), Malissa McAlister, KY River Basin Coordinator; Kentucky Waterways Alliance (KWA), Hilary Lambert, Past Associate Director; Kentucky River Water Watch (KRWW), Rob Ziemba, Past Chair, John Webb, Current Chair; Community Enrichment Through the Arts (CETA), Amy Roe, Past Chair; Natural Resources Conservation Service, Grant County Conservation District, John Rankin, Past Education Coordinator; Reb Stacey Woodland and Wildlife Center, Reb and Bill Stacey, Owners; Northern KY Water District, Mary Carol Wagner, Laboratory Mgr.; Ed Thompson, District Conservationist; Grant County Cooperative Extension Service, Chris Ammerman, Agriculture Agent. Special thanks to Dr. Lindell Ormsbee of KWRRI for much guidance and forbearance.

B. Table of Contents

C. Executive Summary

Financial summary

Total Project Expense: Cash $265,000
Federal Agency Contributions: Cash $159,000
State & Private Contributions: Cash $106,000
TOTAL FUNDING **$265,000**
EXPENDITURES
Expenditures of EPA Funds: $159,000
Other Expenditures: $106,000
TOTAL EXPENDITURES **$265,000**

Background

As the Kentucky Watershed Management Framework, developed in 1997, was implemented, the lower section of Eagle Creek was identified as one of the three highest priority watersheds in the Kentucky River Basin. This led to a mobilization plan being developed by the Kentucky River Basin Management Team where stakeholders identified the major concerns and contributed to plans to manage these concerns. Because of our background in onsite wastewater regulation, Northern Kentucky Health Department (NKHD) agreed to lead a partnership of several agencies, groups and individuals for this EPA §319(h) grant, and also to serve as fiscal agent.

Objectives

The NKHD practices its mission of *"Linking People with Resources to Promote, Achieve, and Maintain a Healthier Community."* By participating in stakeholder-identified regional efforts to clean up Eagle Creek through monetary and educational resources, NKHD and our project partners contributed to these objectives:

- Reducing pathogen of Eagle Creek by reducing pathogens in Tenmile Creek subwatershed
- Enhance community involvement in watershed protection.
- Demonstrate how education and implementation of BMPs in a small stream watershed can lead to improvement in a larger stream.

Accomplished

This partnership was able to:

- Facilitate funding of repair or replacement of 34 problem septic systems in the Tenmile Creek region
- Educate many landowners, citizens and school children through various outreach methods about the importance of protecting our Commonwealth water resources with
    - proper septic system repair and maintenance
    - prevention of silt entering creeks from farming and construction
    - appreciation of the beauty and recreation value of the region's streams
- Collect water quality data for six years at five sites - three within the Tenmile Creek area served by the §319(h) grant, one upstream of the project area in Eagle Creek, and one downstream of the project area in Eagle Creek.

Lessons Learned

- In this project, reputable early adopters and local Certified Onsite Installers were important to ensuring participation in the Onsite Wastewater Incentive Grant (OWIG).
- Flexibility in planning was valuable, allowing the project to adapt to more successful methods of outreach when low participation plagued early efforts.
- Monitoring results showed aberrant patterns that were not apparent until final data analysis was performed at the end of the project. Systematic review of data quality early in the project could have prevented such problems.
- Our experiences through mid-project combined with a published Watershed Based Plan allowed us to continue to fund monitoring and septic repairs and replacements in this same project area through 2012 through a related but separate EPA 319(h) grant.

Results

Serious problems with data analysis put final monitoring data analysis in question. Analysis of results, however points to statistically significant improvement in water quality since the beginning of the project.

Conclusions

Despite the challenges that were encountered during this project, thousands of people were exposed to watershed issues in Grant County, 34 families have new septic system repairs or replacements, and as a result a significant amount of sewage is not discharging directly into the streams of this watershed.

D. Introduction & Background

A 12.9-mile segment of Eagle Creek, extending from the mouth of Tenmile Creek downstream to the mouth of Two Mile Creek, was determined as not supporting its designated warm water use of primary contact recreation (swimming) due to pathogen impairment. Thus, this segment was placed on the 1998 303(d) list for Total Maximum Daily Load (TMDL) development. Kentucky Department for Environmental Protection Division of Water (KDOW), 1998 TMDL development for Eagle Creek was contracted to the Kentucky Water Resources Research Institute (KWRRI), and the first phase of its development began in March of 2002.

The purpose of this project is to specifically address nonpoint source issues within the Tenmile Creek in order to reduce impairments in the Tenmile subwatershed and to reduce its effect on Eagle Creek in a highly impaired section downstream from the mouth of Tenmile Creek.

Tenmile Creek is a fifth order stream that joins with Eagle Creek near the town of Folsom. Arnolds Creek is a major tributary of Tenmile Creek. Sampling results from the TMDL development process suggests that these tributaries contributed to the overall pathogen contamination of Eagle Creek. (KWRRI, 2004) In both 2006 and 2008, this stretch was 303[d] listed for partial support for primary contact recreation. (KDOW, 2006, KDOW 2008)

The goal of this project is to advance the Kentucky Nonpoint Source Management Program's mandate to protect surface waters of Kentucky, and to further the goals of the Kentucky Watershed Management Framework, specifically goals of the Kentucky River Basin Management Plan, by using an approach that addresses several different types of nonpoint source pollution affecting the Tenmile Creek Watershed, as well as addressing community attitudes.

The objective of this project is put into action NKHD's mission of *"Linking People with Resources to Promote, Achieve, and Maintain a Healthier Community."* This partnership of many dedicated grant partners and NKHD has worked together to:

- Reduce pathogen of Eagle Creek by reducing pathogens in Tenmile Creek subwatershed
- Enhance community involvement in watershed protection.
- Demonstrate how education and implementation of BMPs in a small stream watershed can lead to improvement in a larger stream.

E. Materials & Methods

a. BMP Implementation. Supporting materials can be found in Appendix C. BMP Implementation Plan and its appendix can be found in Appendix C.1

i. A description of the project area.

This project specifically addresses nonpoint source issues within the Tenmile Creek subwatershed of Eagle Creek, the majority of which is located within Grant County. Tenmile Creek is a fifth order stream that empties into the Eagle Creek near the town of Folsom. Among the creeks that feed it are Kittle Run, Bullock Run, Sulphur Lick Branch, North Fork, Little Tenmile Creek, Flat Creek, Napoleon Branch, and Arnolds Creek, which is a major tributary that enters near the stream mouth.

The Tenmile Creek subwatershed occupies northwestern Grant County and adjacent corners of Gallatin, Boone, and Kenton Counties. The land is in the hills of the bluegrass subregion of the Bluegrass physiographic region, characterized by hilly terrain, very rapid surface runoff, and slow groundwater drainage. The subwatershed lies above interbedded limestone and shale (>20% limestone, allowing groundwater flow where the clay content is low enough).

The Tenmile Creek subwatershed encompasses approximately 68 square miles, and contains approximately 64 stream miles. Land in the watershed is about 60% agricultural, 30% rural and wooded, and 10% residential or commercial. (KRRWI, 2002)

There are five water monitoring sample sites associated with this project. Three are within the Tenmile Creek area served by the §319(h) grant, one upstream of the project area in Eagle Creek, and one downstream of the project area in Eagle Creek. See Appendix C, map Figure 1 for subwatershed map with sampling locations. The Best Management Practice implementation in this area has been repairs to failing or inadequate septic systems or full system installations to replace straightpipes. In the course of this project 34 septic system installations or repairs have been performed in this watershed. See Figures 2 and 3 for map and subwatershed map with BMP implementation locations.

See Appendix C, table 1 for details on these BMP installations.

ii. A description of all methods used to obtain the results for this project

The Onsite Wastewater Incentive Grant Program was designed through knowledge gained in development and implementation of an existing grant project administered in 2004 by Northern Kentucky Independent District Health Department. This incentive grant funded repair or replacement of 34 problem septic systems in the Tenmile Basin.

NKHD did outreach to advertise the Onsite Wastewater Incentive Grant Program using several methods. Following approval of the BMP plan, but prior to the beginning of the grant program, the NKHD developed articles for a local newspaper concerning onsite wastewater issues, targeting local homeowners, emphasizing the importance and practical benefits of maintaining a healthy onsite sewage system. All articles and radio ads were approved by KDOW prior to their publication. Radio and Cable interviews also advertised the program and the underlying need to correct nonpoint source problems. According to an email by Rosetta Fackler from 8/8/06, interviews were not required to have pre-approval. The talking points for these interviews followed our approved website fact sheet, and are included. Beginning in 7/06, newspaper articles began to inform citizens about nonpoint source issues as well as advertise for the grant program. A radio advertisement ran through the month of March 2007 on WNKR radio. The ad encouraged participation in the Onsite Wastewater Incentive Program. All Certified Septic System Installers who were certified by the NKHD were sent mailers explaining the grant. Residents in the Tenmile Basin were sent a direct mailing with information about the grant program, application information, and contact numbers. Residents who lived close to streams were sent mailers explaining the grant. Any Tenmile Basin resident who was placed under notice to abate a sewage nuisance through NKHD's existing nuisance program was automatically given an application. See Appendix D for figures and tables. See Appendix E for newspaper articles, copy for radio ads.

Applications were screened for eligibility to determine if they were located in the Tenmile Basin and then scored based on: watershed impact and public health potential impact. A NKHD Onsite Inspector visited the site of the proposed repair/installation area and performed necessary soil and site evaluations. A report was sent to the applicant with necessary project modifications. The homeowner was responsible for obtaining two bids from Certified Septic Installers. After a permit was obtained and when weather and soil conditions were conducive, the septic system was installed and was inspected by the Onsite Inspector. Only when all inspections were completed and approved were the funds authorized to be disbursed directly to the Certified Septic Installer. Information pertaining to the application was recorded and tracked on an existing database and includes special components of this grant, such as grant application number, significant dates, type of work done, overall cost of project, GPS coordinates, cost of system disbursed, and load reduction calculations. See Appendix C for detailed summary of systems installed and maps: Figures 2 and 3 for subwatershed map with BMP implementation locations. See table 1 for details on these BMP installations. All BMP related figures and tables can be found in Appendix C

iii. A description of any specialized materials that were used in the collection of data for this project. Supporting materials can be found in Appendix C1.

Data were collected for this part of the project by several means, using the protocol developed for this project, figure C1. Information about applicants was provided by them on applications. See figure C2. Site visits and inspections by a trained Health Environmentalist were used to collect data about applicants' properties; these data were used to rank the level of NPS impact on nearby streams using a predetermined ranking scale, figure C3. Location data were collected using Global Position Satellite (GPS) units, such as

Garmin ETrex Legend, or Trimble GeoExplorer3C unit. Demographic and geospatial data, such as parcels close to target streams and the associated owner name and address, were collected using ESRI ArcMap 9.3.1. and state and locally obtained metadata. All geospatial data used was consistent with Federal Geographic Data Committee (FGDC) endorsed standards. Information on federal endorsed standards can be obtained from the web site www.fgdc.gov under the topics of "standards" and "Standard Documents by Sponsoring Agencies.

b. Education and outreach

i. A description of the project area. Supporting materials can be found in Appendix D.

It was determined at the beginning of this project that educational efforts should not be limited to the Tenmile Creek subwatershed. As such, most efforts were focused towards Grant County, but presentations and events were also held in Boone and Kenton Counties.

ii. A description of all methods used to obtain the results for your project.

1. Milestone 3. Social marketing research began February 2006. To gather information from the community to guide our efforts in this grant and to foster more protective community attitudes, two focus group sessions were held on 3/20/06 and 4/10/06. To publicize the focus group sessions, postcards were sent to all residents of the project area. See Figure 4. Also, an interview was granted to a local cable television program, "Raising Grant County" on 3/16/06. See Figure 5.

   As interested people responded, a telephone interview confirmed they were in the target group of landowners in the watershed, verified their availability, and asked a few demographic questions. See Figure 6. Upon arrival to the focus groups, participants were asked to fill out a registration form. See Figure 7. The group facilitator read the "Focus Group Introduction" (figure 8) and the focus group questions (figure 9). A tape recording was utilized to capture the discussions. The group facilitator was chosen from the Community Health Promotion division of the Health Department, who had previously worked on several social marketing projects, to eliminate potential bias. During the questions and discussions, three NKHD personnel took notes, and these were used to corroborate the answers and discussions.

   Once the focus group sessions were completed, the tapes were transcribed by a paid third party transcription company. The transcriptions were then summarized by the facilitator, and the results were compiled. Comments from the registration questionnaire were also compiled. See figures 10 and 11. An executive summary (figure 12) was drawn from these compilations, as well as a list of educational ideas (figure 13), and these were used to guide the educational efforts of the project. For instance, since a large percentage said they trusted information coming from Co-operative Extension Agents and Natural Resource Conservation Specialists, This project partnered with Grant County Extension agent and the regional Conservationist for one of the workshops on soil erosion prevention.

   The citizen participation level was disappointingly low during the focus groups and subsequent events. The 3/20/06 and the 4/10/06 focus group had 5 and 8 participants, respectively. Due to the low participation levels, it was felt that the before and after surveys would not return useful information, and were not used for the workshops and field days. This campaign aimed to "evaluate attitudes prior to the installation of abatement measures and educational events, and … provide input and focus during the project, and … provide a way of measuring the impact of educational events on the attitudes and behaviors." Because of very limited participation, though, enough data could not be generated to draw valid conclusions. In spite of this potentially bleak situation, however, a sense of attitudes prior to the education and implementation portions of the grant was gained allowing some ideas to be gleaned and these were used to guide and focus education outreach efforts.
2. Milestone 6. Five media interviews were performed: cable interview given to Williamstown Local Cable on 3/16/06, WNKR radio interview 8/9/06, cable interview given to Williamstown Local Cable on 8/10/06. WNKU radio interview on 9/6/06. Williamstown Local Cable on 4/30/08. See figures 14, 15, 16, 17, and 18. All of these interviews highlighted the problem of nonpoint-source pollution and

encouraged citizen participation to create long term solutions. The interviewee addressed many of the concerns raised in the focus groups after the first interview, which was in part an advertisement for the first focus group.

3. Milestone 8. Six approved newspaper articles were published July 2006, August 2006 April 2007, May 2007, June 2007, and July 2007. See Figures 19-24. These articles were to inform the public about nonpoint-source issues as they relate to Grant County and the Eagle Creek watershed. Radio ad ran during the month of March 2007 to promote the Onsite Wastewater Incentive Grant, see figure 25 for the copy and on the CD, figure 26 for the recording.
4. Milestone 9. Approved website material was published to web in March 2007. See figure 27. In addition to informing the public about nonpoint-source issues, especially as they relate to Grant County and the Eagle Creek watershed, this site links to KRWW water quality database, so all the monitoring data collected for this project are available to the public.
5. Milestone 10. Grant County Fair display was approved in July 2006 and used in Aug 2006. Display highlighted the top three things people can do to restore Eagle Creek: learning about Grant County Streams, preventing nonpoint source pollution through household hazardous waste and pesticide removal programs, and correcting septic problems. See figure 28.
6. Milestone 13. NKHD collaborated with a local arts organization in Grant County, Community Enrichment through the Arts (CETA) to hold an art contest promoting appreciation of water and streams in Grant County. The theme of the contest was “Grant County People and Water”. CETA holds an Autumn Arts Festival in Grant County. In June 2006, a proposal was sent to CETA outlining the possibility for a collaborative effort. See figure 29. CETA responded with interest, and a meeting was held on 7/28/06. See figure 30 for the meeting agenda form that was very useful for planning this event. The planning group for the art contest consisted of 3 members of CETA, one member of the Grant County Solid Waste Board, one member of Grant County Cooperative Extension Service, and one NKHD employee. A planning sheet (figure 31) was used to determine the details of the contest in that meeting, subsequent emails, and phone calls.

   Contest format consisted of six categories of media, and six age groups. An artwork release form contained contest information as well as permission to take photos of and use their artwork for this project. See figure 32.

   Project outreach was accomplished through various means. The Extension agent worked with the school Family Resources and Youth Services personnel to distribute flyers, figure 33, in the schools. The local newspaper, Grant County News ran an ad for the Festival, which featured information about the contest. Copy of this ad was not able to be obtained. The editor of the newspaper also conducted a radio program on the local radio station, WNKR, and held an interview about the contest. See figure 15. Williamstown Cable conducted an interview, figure 16, in which the contest was featured.

   In order to tie the contest with nonpoint source themes, the fair display from milestone 10 was set up in the artwork display area at this event. Artwork was required to be submitted and judged prior to event to allow for their display. Judging was completed by an art teacher from a neighboring county.

   Cash prizes were funded by the Eagle Creek Watershed Council. Each category/age group combination awarded the amounts of $5 for 3rd place, $10 for 2nd place, and $15 for 1st place, with a bonus prize of $5 for Best in Show. CETA also provided ribbons for 1st, 2nd, and 3rd place and honorable mention. For the awards ceremony, CETA invited Rodger Bingham, known as “Kentucky Joe”, to be the presenter. He is a Grant County native who appeared on a season of the popular television program Survivor. See Figure 34 for power point summary of contest.
7. Milestone 16 and milestone 35a. NKHD collaborated in 2008 with Rebecca Hutchinson, 7th grade teacher at Grant County Middle School for several events involving school children. She had an innovative grant through UK to teach in-depth real world science to 7th grade students. Her project focused on the ecology of invasives as they affect our local ecosystems, with some emphasis on technology. Three events were held as a result of this collaboration: an in-class interactive discussion combined with a field trip in the spring; a second field trip the following fall; and a two-day field trip with several different presenters and

stations exploring a variety of topics relating to environmental education, with NKHD's portion focusing on nonpoint source interactions.

The first two were approved as a field day for milestone 16. On 3/26/08, an in-class interactive discussion explored nonpoint source pollution and how it related to water quality parameters like D.O., pH etc. This discussion was correlated with KERA core content **SC-07-4.7.1**, as will be discussed in the results section. The class was set up with a smart-board system so the presentation used (Figure 35) could link directly with a website that discussed the effects of each type of pollutant on each parameter. A strong emphasis was placed on real world science, and discussion of how these study topics were used for this grant project. They were shown monitoring data, and how this data demonstrated the principles they were studying. This led to a discussion of data-to-action: how a Citizen Water Quality volunteer, using data collected from the local environment, resulted in grant money being available to Grant County to correct NPS problems. See Figure 40 for KERA core content **SC-07-4.7.1**.

The field trip was intended to follow the classroom portion but rain caused it to be rescheduled on 5/30/09. In the field portion physical chemistry and biological assessment were reviewed. See figure 36.

Milestone 35a, the two day field trip was organized by the teacher Mrs. Hutchinson along with her grant partners from UK, and was held on 9/21/08 and 9/22/08. NKHD's part was to be one of many stations. The description of the approved presentation:

"The content I will include will address NPS by discussing how watersheds are affected by the movement of water through soil. I will do core samples to show the soil morphology, structure and texture of the soils. I will talk about the importance of septic systems using the appropriate soil and how septic contamination can result in inappropriate soils being used. I'll address setbacks and the importance of keeping the proper distance with sewage from stream banks. I will also address how oils and other household chemical wastes can percolate through soil into groundwater and ultimately into watersheds. I will address how these pollutants can affect ecosystems. There will be no printed materials associated with my station. The Core Content most closely associated with this topic is SC-07-4.7.1."

8. Milestone 17, PowerPoint for Boone Extension approved, presented Aug 2006. See figure 37.
9. Milestone 19, Feb 2007, Silt and erosion prevention workshop help at Grant County Library with help from Agents from NRCS and Grant County Cooperative extension focusing on how Farm Bill funds can help with erosion methods and proven successful silt/erosion control methods employed in Grant County. See figure 38.
10. Milestone 20, Held Agricultural Silt workshop with Chris Ammerman, Grant Co. Ag Ext. Agent as part of the GC Cattlemen's Association. Watershed general info, specific Grant County info, update on grant and proven successful silt/erosion control methods employed in Grant County. Approved March 2008, held April 2008 Used same presentation as 2/2007.
11. Milestone 21, Presentation for National Association of Retired Federal Workers approved in Feb 2007 and presented in March 2007. Adapted presentation from Commonwealth Watershed Education Program. See figure 39
12. Milestone 22, Presentation to Grant County Kiwanis Club May 2007: no material to be approved, just a status report on the grant and how to apply for the Onsite Wastewater Incentive Grant.
13. Milestone 24, Grant Senior Fair display approved July 2006, attended 9/20/07. Used same display approved for and used at Grant County Fair in August 2006 .
14. Milestone 29, Grant County Outdoor Family Appreciation field day was held on 9/19/08 at a lakeside park in Dry Ridge. Game Warden Charlie Phillips and KDFWR educator Vikki Rawe volunteered. Eagle Creek Watershed Council provided prizes for Raffle for family fishing gear.
15. Milestone 30, Participate in WaterIfic water education event for 6th Graders, May 2007. No material to approve, lecture about septic systems, drinking water, preventing non-point source pollution, collaborated with Eagle Creek Watershed Council to bring Grant County Students on field trip as reward for selected students interested in ecology. See Figure 40 for KERA core content **SC-06-4.7.1**.

16. Milestone 31, Presentation to Grant County Conservation District July 2007: no material to be approved, just a status report on the grant and water quality in Grant County. Former GCCD employee, John Rankin had volunteered for this grant's monitoring in 2004 and 2005. GCCD Board asked for update.
17. Milestone 32, Grant County MapQuest: Participated in Grant County Parks and Recreation Summer Camp with session based on "Race You to the Top of the Hill!" (Kentucky Environmental Education Council, 2005) which was approved in June 2005. Taught kids to read topographic maps emphasizing watersheds and NPS issues, then demonstrated with field trip to Eagle Creek at Reb Stacey Woodland Wildlife Center. NKHD was one of 4 stations, seined macroinvertebrates, identified them and talked about NPS as it related to their ecology. 150 students participated from several grades as a summer enrichment program. See power point figure 41 and map packet figure 42.
18. Milestone 34, 5-08 Held Construction Silt Workshop with Sean Blake, program Manager for SD1 Plan Review and Development Group focused on cost effective tools for erosion and sediment control; local permitting, enforcement efforts, and responsibilities; and distribution of KDOW/Tetra Tech ESC field Guides. Part of Northern Kentucky Building Inspectors Association meeting. Used CWEP "pre-approved" growth readiness presentation. See figure 43.
19. Milestone 35a, see milestone 16 for Grant County Middle School 2 day field trip
20. Milestone 35b, Presentation to Northern Kentucky University group of Biology students: no material to be approved. Gave a status report on the grant, possible opportunities to participate with any remaining educational efforts, and an overview on regional efforts for improving water quality.
21. Milestone 35c, Presentation of material previously approved for milestone 32, slightly modified for the summer enrichment program at Burlington Elementary School in Boone County Kentucky. Taught students to read topographic maps emphasizing watersheds and NPS issues. See Figure 44.

iii. **A description of any specialized materials that were used in the collection of data for the project.** Questionnaires were used in the initial social marketing focus groups. These attempted to illuminate barriers to environmentally friendly behaviors. See figures 4-13 in Appendix D for these materials.
An Event Journal was used during the project to collect information about each event such as venue effectiveness, presenter effectiveness, ideas for similar events, numbers of participants, analysis of event, etc. See figure 45 in appendix D for this document.

c. Monitoring

i. A description of the project area.

This project specifically addresses nonpoint source issues within the Tenmile Creek subwatershed of Eagle Creek, the majority of which is located within Grant County. Tenmile Creek is a fifth order stream that empties into the Eagle Creek near the town of Folsom. Among the creeks that feed it are Kittle Run, Bullock Run, Sulphur Lick Branch, North Fork, Little Tenmile Creek, Flat Creek, Napoleon Branch, and Arnolds Creek which is a major tributary that enters near the stream mouth.

The Tenmile Creek subwatershed occupies northwestern Grant County and adjacent corners of Gallatin, Boone, and Kenton Counties. The land is in the hills of the bluegrass subregion of the Bluegrass physiographic region, characterized by hilly terrain, very rapid surface runoff, and slow groundwater drainage. The subwatershed lies above interbedded limestone and shale (>20% limestone, allowing groundwater flow where the clay content is low enough).

The Tenmile Creek subwatershed encompasses approximately 68 square miles, and contains approximately 64 stream miles. Land in the watershed is about 60% agricultural, 30% rural and wooded, and 10% residential or commercial. (KRRWI, 2002)

There are five water monitoring sample sites associated with this project. Three are within the Tenmile Creek Subwatershed, one is in Eagle Creek upstream from the mouth of Tenmile, and one is in Eagle Creek below the downstream of Tenmile. See Appendix C, map Figure 1 for subwatershed map with sampling locations.

ii. A description of all methods used to obtain the results for this project. Supporting materials may be found in Appendix E.

Monitoring methodology was adapted from the QAPP for the 2002 KWRRI TMDL study, and followed its methodology as closely as possible to enable KWRRI to incorporate this data into the TMDL if so desired. (Ormsbee and Brion, 2002). Surveying methodology was adapted from the US Forest Service book “Stream Channel Reference Sites: An Illustrated Field Guide to Field Technique” (Harrelson, Rawlins and Potyondy, 1994).

In addition, data were collected for the sampling season 2004 as a part of a focus study funded by KRWW in partnership with KWRRI and the Northern Kentucky Water District. As much as possible, the Tenmile Creek Focus Study data were collected using techniques developed from QAPP and SOP for the KWRRI 2002 Eagle Creek TMDL study in order to be compatible with data to be recorded later for this project. Although these data were collected before the QAPP for this project was approved, they are included nonetheless for the value they may provide. They were collected to provide a bridge between TMDL data which were collected at several of the same sites and this project. In addition, data were collected and recorded in a manner that would facilitate their inclusion in KRWW volunteer water quality data, permitting them to be published on public websites and conferences along with KRWW data. See table 2.

The following methodology is from the QAPP for this project which was approved March 31, 2005. Data parameters for flow rate, dissolved oxygen, pH, temperature, and fecal coliform numbers were collected twice a month per sample site during the 6 month recreation season of May through October from May 2005 to October 2009 in each of five sample sites in the Tenmile Creek Basin, and in Eagle Creek above and below the mouth of Tenmile Creek. A sample was taken at each sample site from which analysis was performed for fecal coliform, for E. coli, total coliform and atypical coliform. Sample locations were selected through segmentation of the watershed into incremental units and local knowledge gained through Health Department experience in the field. Sampling was done at five sites, numbered K318 in Eagle Creek above the mouth of Tenmile Creek, K328 in Eagle Creek below the mouth of Tenmile Creek, K321 in Tenmile Creek about ¼ mile upstream from the mouth, K319 in Arnolds Creek about ½ mile upstream from its mouth into Tenmile Creek, and K327 Tenmile Creek about ¼ mile above the mouth of Arnolds Creek. These sites were chosen to represent locations where the effects of BMP implementation can be measured independently of the effects of other creeks The sampling sites were correlated with map coordinates obtained by using a Trimble GeoExplorer3C Global Position Satellite (GPS) instrument and ESRI ArcMap and are identified by these coordinates, standard KRWW sampling site code numbers, and other identifying features that are logged into the record for reporting purposes so that others may identify these locations. All GIS data created are consistent with Federal Geographic Data Committee endorsed standards.

Samplers collected samples for bacteria using the following methodology: the sampler entered the stream and traveled upstream into an area upstream from disturbance from wading, and in the midstream portion of the stream when safe enough to do so. He then faced upstream and allowed any disturbed sediment flow away. When waters were dangerously high, samples were taken from the edge of the stream in an area with unobstructed flow and without eddies. Sampling containers were kept closed until they were to be filled.

Just before samples were taken, hands were thoroughly cleansed with waterless germicidal hand sanitizer. Sterile, unrinsed, sealed containers with flip caps were opened underwater at mid-depth with the open end facing upstream. The cap was opened slightly while pushing the bottle upstream. When capped bottles were used, the sterile, unrinsed, sealed bottle was carefully opened just prior to plunging the bottle vertically into the water with an upstream scooping motion until the bottle was nearly filled. Overfilling of bottles was avoided. At least ½” headspace was left in the bottle for mixing purposes. The opened mouth of the container was at all times upstream of the sample collector, sampling apparatus and any disturbed sediments. After filling, the cap was replaced immediately and attached firmly.

When duplicate samples were taken, at a predetermined site both flip cap bottles were opened underwater simultaneously side by side and filled in the manner described above. When capped bottles were used, both bottles were opened within seconds of each other and plunged in the water simultaneously side by side in the manner described above. Field blanks were prepared by first thoroughly cleansing hands with waterless germicidal hand sanitizer and then filling a sample container with distilled water from a freshly opened bottle. This was done at one of the sample sites, prior to going to the creek for the remaining samples.

Sample bottles were immediately chilled on wet ice in an ice chest at 1° to 4° C. using a cooler that had been sanitized with alcohol before sampling. Chain of custody documentation was completed and duplicated in the field for record keeping and data gathering purposes. Chain of custody forms were submitted with each sample event and are on record at the lab. All microbiological samples were delivered for analysis within 6 hours of sampling to the Northern Kentucky Water District Water Quality Laboratory for immediate analysis for fecal coliform, E. coli, total coliform and atypical coliform using SM9222B. (American Public Health Association. 1989). Data from analysis were recorded onto excel sheets by lab techs and emailed to the Health Department. This workbook also contained the monitoring schedule for each year. Each year of sampling prior to the beginning of sampling, the lab was sent a new template with schedule. See table 3.

Using the same collection methodology for coliform samples, a sample for turbidity was collected at the same time at each site. These samples were collected in 50 ml conical screw top sample bottles. Samples were not refrigerated, but were kept in a clean plastic bag. Upon return to the office, the turbidity samples were analyzed at the Health Department using a Hach 2100P turbidimeter following standards of calibration and directions supplied by the manufacturer.

Field chemical and physical measurements will be taken in the following manner: Oakton pH/DO300 dissolved oxygen and pH testing instrument was calibrated in the field on the day of sampling, both before and after sampling. Calibration events were logged on the chain of custody sheets. Measurements were taken at the same stream locations and within a short time of the samples being collected. Probes were placed in water upstream of sampling zone, and in an area if running current where possible. Measurements were recorded. Note: Several times in 2005, the DO/pH probes malfunctioned, and as a result were sent back to the manufacturer for repair. A set of spare probes were purchased and used during this time. As a result of the malfunctions, sampling events on 9/8/05, 9/21/05 and 10/18/05 have no measurements for these parameters. Dissolved Oxygen, pH and temperature were read and recorded into a Dell Axim PDA device in an excel spreadsheet in the field. See table 4.

Stage was read by using a Crain 16' fiberglass measuring rod (Model 90343) marked in feet and tenths. The bottom of the measuring rod was placed precisely at water line, and the height difference between the waterline and the benchmark for each site using a Suunto clinometer (model PM-5/360 PC). Measurements were recorded into the PDA in an excel spreadsheet in the field. See table 4.

With regards to measuring discharge, for many sampling events, stretching a tape across the stream was not possible due to dangerously high water, so the flow measuring strategy evolved to an approach that was practical for all sampling events and likely to be at least as accurate as the "orange float" method. A "Flowatch" flowmeter was initially purchased for this project and used from 5/21/04 through 5/1/06. Due to problems discussed below (in section F.d.i. Quality Assurance Project Plan quality control checks), a different flow meter was purchased. From 5/15/06 onward, a Global Flow Velocity Probe (model FP-101) was used for current measurement. The instrument features real-time averaging, so following directions provided; probe was placed into water and slowly lowered straight down until bottom was hit, then raised to surface at same rate. This was repeated when possible across the stream in 3 to 10 equidistant increments. When water was high, probe shaft was extended to maximum length of 6.5', probe was placed into water and slowly lowered straight down until bottom was hit, then raised to surface at same rate, as far out as was safe to be in the water, and procedure repeated in 3 to 5 equidistant increments back towards shore. Flow rate measurements in feet per second were recorded into the PDA excel spreadsheet in the field. Previously recorded cross sectional data were used to calculate cubic feet per second or cfs after returning from the field. Cross sectional data were measured at least twice per sampling season. At benchmarks established for this project, a tape was stretched across the stream bed. Using the Crain 16' fiberglass measuring rod along with a CTS/Berger model LMH laser site level and receiver, the contour of the stream bed and both shores as well as the benchmarks for each site were measured and recorded in field notebooks following the Harrelson et al 1994 methodology. See figure 46. All field data books are available for review upon request. All cross sectional data were transferred to Excel workbooks to be used to calculate cfs discharge for each site for each sampling event. These were added as worksheets within each year's data workbook. Their tabs are labeled by site number, e.g.318. Once the second survey was completed, the cross sectional data were added to the same tab and henceforth those cross sectional data were used to calculate cfs. See table 5.

All measurements in field recorded onto the PDA were also copied onto two copies of the chain of custody form. One copy was kept for internal files and one copy was submitted to the lab with the samples. After returning from the field, data were transferred from the PDA to the desk computer to Excel spread sheets.

At the completion of each season, data were compiled and sent to KDOW and to KRWW. The NKHD website maintained a link to the KRWW data in order to facilitate public access to these data throughout the project. See http://www.nkyhealth.org/mx/hm.asp?id=eaglecreekmonitoring.

iii. A description of any specialized materials that were used in the collection of data for the project.

A standard operating procedure was developed that guided data collection efforts as described above. This was adapted from the QAPP for a UK research project in the same watershed area as this project. (Ormsbee and Brion, 2002). Information from Harrelson, et al (1994) was incorporated into it. It was designed so anyone with basic training in water monitoring could pick it up, read it and be able to collect, protect and transfer the samples properly with the proper chain of custody to produce valid data. It was also designed to be congruent with the 2004 TMDL project so the data could also be incorporated into that project. See figure 47. The Tenmile creek focus study used KRWW chain of custody sheets. See figure 48.

The PDA field excel is table 4. This was used to record data at the sample sites. At the office, data was uploaded to a desktop computer and saved into excel files in the folder for each year's monitoring.

The chain of custody used for 2005 through 2009 is table 5. All completed chains of custody for this project have been scanned and are available for viewing upon request. To collect data in the field for surveying cross-sectional profiles of streams, a field notebook was developed and employed. The Publisher file with instructions and the graphed pages is figure 49. Examples of its use: figures 46 and 50. To schedule sampling, a form was designed that contained projected sampling dates, as well as randomly generated duplicate and blank numbers. See table 6.

Demographic and geospatial data, such as sampling sites, streams targeted for outreach efforts and system installations were collected using ESRI ArcMap 9.3.1. and state and locally obtained metadata. All geospatial data used was consistent with Federal Geographic Data Committee (FGDC) endorsed standards. Information on federal endorsed standards can be obtained from the web site www.fgdc.gov under the topics of “standards” and “Standard Documents by Sponsoring Agencies. See figures 51 and 52 for examples of maps that were created using this software.

F. Results & Discussion

a. BMP Implementation.

During the implementation phase of this project, 34 septic systems were funded for repair or replacement. See Figure 52 for a map showing locations of these installations. Details for these systems are in Appendix C table 1. Types of systems: All but three had installed new 1500 gallon 2-compartment septic tanks. Four dwellings had tanks that were suitable for continued use. All thirty-four had installed some amount of leach lines, of two types, chambers or conventional pipe and gravel laterals. The four with conventional rock laterals all had 324 linear feet of lateral line installed. Those with chamber laterals had from 100 feet to 320 feet of lateral line installed. Of the 34, only two required the leach field to be located at a higher elevation than the tanks, thus requiring an additional tank and an effluent pump. Six systems required significant amounts of backfill soil to be brought in. According to KWRRI (2004) models, efficiency of septic repairs and replacements is near 100%.

b. Education and outreach

For this project, the intended audiences for education and outreach were homeowners and landowners in the OWIG target area of the Tenmile Creek subwatershed, farmers and landowners in Grant County, schoolchildren in Grant County and the general public throughout our four county health district.

Early in the project social marketing focus groups were conducted and it was found that, even though cash incentives were offered for participation, such low participation prevented good data collection. After sparse turnout at the first several events coupled with our focus study experience, it was decided to measure success by numbers of people exposed to the materials rather than by pre- and post-event testing. There was concern that results would be skewed by events with low participation.

Eight events were targeted for school age children. Two events were held as summer enrichment programs, with varying ages of children in attendance. This made assigning KERA content problematic. However, it followed closely the content for the other six events.

Four of the six events involved one teacher and her Seventh Graders. KERA content discussed can be found in Appendix D, figure 40. In the spring lecture, 150 students were taught real world examples of how water quality monitoring can generate data that can be used to correct environmental problems, as this grant project has done. Of those 150 participants, 40 students attended a spring field trip to learn about water sampling methodologies, as wells as macro-invertebrate assessment. In the fall, a new class of students went on a field trip where the Health Department manned one of eight booths. This material could be incorporated into the State Program of Studies. Core content SC-07-4.7.1 was covered with 300 students over the course of two days. The Station presented by the Health Department addressed the role of soils in nonpoint source pollution.

NKHD's Environmental Health & Safety Division participates annually in an environmental education event called "WaterIfic" held at Sanitation District 1 in Northern Kentucky, at their Public Service Park. With respect to this grant, in 2007 and 2008, 360 and 230 students respectively were given an interactive lecture how water is an integral part of our daily lives by discussing private drinking water sources and private sewage disposal systems. This material could be incorporated into the State Program of Studies. Core content can be found in Appendix D, figure 40.

In August 2006, approved material was displayed the Grant County fair disseminating information about the program. Approximately 1000 people attended the fair that day. An estimated 100 interacted with the booth. In August, a presentation was held for Boone County Extension emphasizing nonpoint source pollution with 12 people in attendance. In September 2006, an art contest was held for kids and adults. There were 21 entries, and 19 prize winners. In February 2007, a silt workshop was held at the Gant County Library with only one person attending. In March and July 2007, presentations were given to National Association of Retired Federal Workers Boone and Kenton county chapters, with 30 and 20 attendees respectively. In July 2007 NKHD participated in Grant County Parks and Recreation Summer Camp where 150 students were taught how to read topography maps and then demonstrated their new skill during a field trip to Reb Stacey's Woodland Wildlife Center. In July 2007, presented grant and water quality status to Grant County Conservation Board, seven members present. In September 2007, NKHD attended the Grant County Senior Fair with the watershed education booth. About 500 people attended, and around 40 stopped by the booth. In April 2008, NKHD participated in the Grant County Cattlemen's Association monthly meeting and presented along with the Grant County Extension Agent on agricultural silt prevention with 20 members were present. In May 2008, NKHD and Northern Kentucky Area Planning co-hosted a construction silt and sediment workshop for builders, inspectors and code officials with 230 people attended. In September 2008, the Grant County Family Appreciation field day was held at a small lake in Dry Ridge, KY.

c. Monitoring Results

See Appendix F Table 7 for data analysis worksheets charts and Table 8 for all project monitoring data.

Statistical Analysis of 0511 Eagle and Tenmile Creek Pathogen Data 2004 – 2009 performed by Kentucky Water Resource Research Institute

Dr. Lindell Ormsbee, Director
Ben Albritton, Scientist I
2/11/2011

Tenmile Creek, located primarily within Grant County, is a major tributary of Eagle Creek. The confluence of the two is near the town of Folsom. Arnolds Creek is a major tributary of Tenmile Creek that enters 3 miles above the stream mouth (see Figure F.c. 1).

The 12.9-mile segment between river miles 14.4 and 27.3 of Eagle Creek was placed on the 1998 303(d) list for pathogen Total Maximum Daily Load (TMDL) development. Independent sampling results from both the TMDL development process and from Kentucky River Watershed Watch volunteer sampling suggest that Arnolds Creek and Tenmile Creek are contributing to the overall pathogen contamination of Eagle Creek. The 2008 Integrated Report to Congress on Water Quality in Kentucky (305[b] and 303[d] reports) list Tenmile Creek in partial support for fecal coliform. Contamination issues include the use of septic straight pipes, the failure of septic systems, and runoff from farms.

In order to test this hypothesis, water samples were collected at five sites during the recreational period between May and October from 2004 through 2009. The sites are: K318 in Eagle Creek above the mouth of Tenmile Creek, K328 in Eagle Creek below the mouth of Tenmile Creek, K321 in Tenmile Creek about ¼ mile upstream from the mouth, K319 in Arnolds Creek about ½ mile upstream from its mouth into Tenmile Creek, and K327 Tenmile Creek about ¼ mile above the mouth of Arnolds Creek (see Figure F.c. 1).

These sites were chosen because they represent locations where the effects of Best Management Practice (BMP) implementation can be measured independently of the effects of the other creeks. Additionally, sample sites were chosen to be congruent with data collection begun in 2003 and 2004 for KWRRI's TMDL development and for the KWRRI study "Diagnostic Watershed Model of Pathogen Speciation and Mitigation." Two of these sites overlap with TMDL and DWMPSM sample sites where data were collected March 2002 to August 2002 and May 2003 to August 2003. Site K318=S6 in the TMDL, and K321=T6. Site numbers used are in the same format used by Kentucky River Watershed Watch (KRWW), to facilitate use of volunteer data in this project and to facilitate sharing this data with the public domain through KRWW.

Project work in Tenmile Creek (including Arnold's Creek) consisting of the repair of failing septic systems and the replacement of straight pipes with septic systems was begun in May 2006 and concluded in August 2008. Installment or repairs were done for residences located in areas directly affecting sites K319, K321, and K327. (See Figures F.c.2 and F.c.3) No work was documented for residences located in the area affecting site K318; and although site K328 is fed by flow passing through all of the other four sites, no work was done for residences located in an area which would have affected only site K328. Tables F.c.1 and F.c.2 show the dates of work done for residences upstream of sites K319 and K327 respectively, and the percent of water quality samples collected prior to that date. Table F.c. 3 shows the same information for residence work done upstream of site K321 but downstream of sites K319 and K327.

In order to assess the efficacy of the project work in remediating the contamination issues, KWRRI performed statistical tests on the water quality sample data. To this end, the data were first divided into two time-groups: the first group consisted of samples taken in 2004 through 2006 and the second group consisted of samples taken in 2007 through 2009. Secondly, each time-group was split into two subgroups based on flow conditions. Based on examination of the data collected, it was deemed that the most reliable indicator of flow conditions would be the USGS recorded flows at the Glencoe station (USGS 03291500). Data from this station from 12-1-1988 to 2-1-2011 was used to produce a flow duration curve shown as Figure F.c. 2. Flows with a probability of exceedance greater than 70% were placed into the low flow category called “dry.” The other flows were placed into the higher flow category called “wet.” Also, the time-groups were compared as a whole and in these cases, the category is referred to as “All.”

If the project work has been effective in mitigating pathogen contamination, improvement should be observed in the form of lower bacteria counts in the streams that are statistically significant. Tables F.c. 4 through F.c. 8 show measures of central tendency for all the water quality data at each of the sampling sites. Geomeans were calculated for fecal coliform, E. coli, total coliform, and atypical coliform data, while arithmetic means were calculated for the atypical to total coliform ratios (AC/TC). The order of tables will then on follow a hydrologic order: K327, K319, K321, K318, K328.

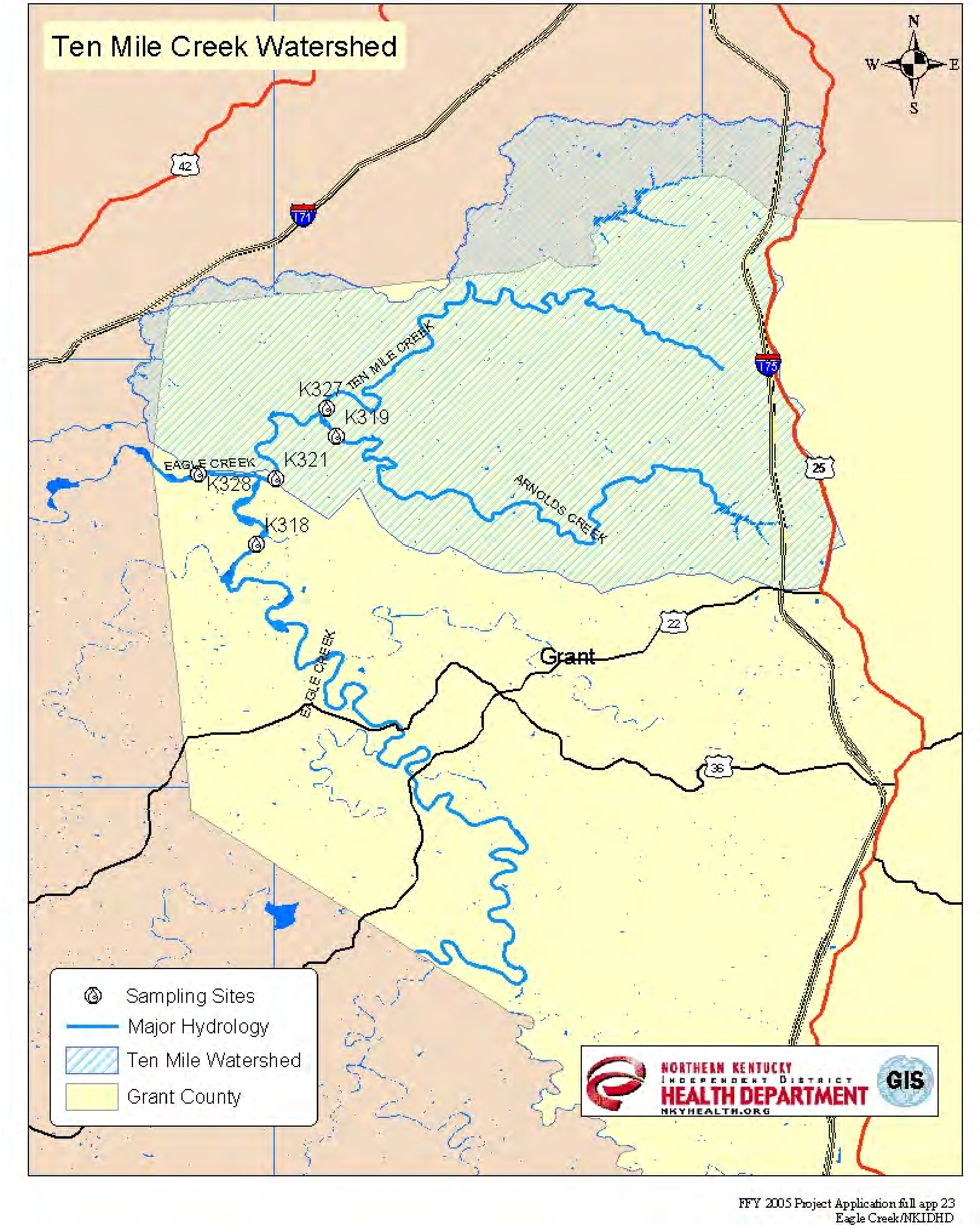

Figure F.c. 1a. Water Quality Sampling Site Locations 2004-2009 (NKIDHD, 2005).

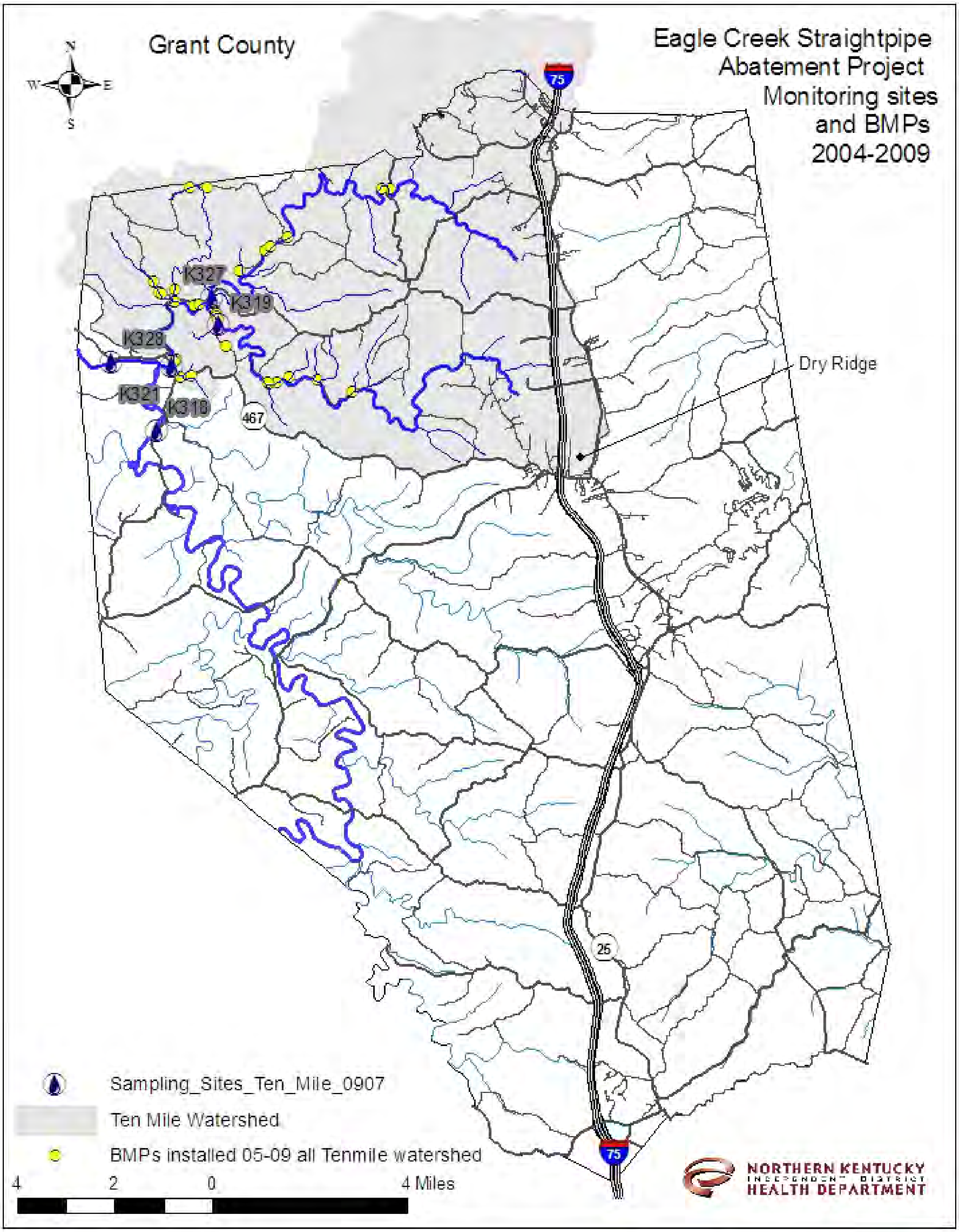

Figure F.c. 1b. BMPs and Sample Site Locations 2004-2009 (NKIDHD, 2005).

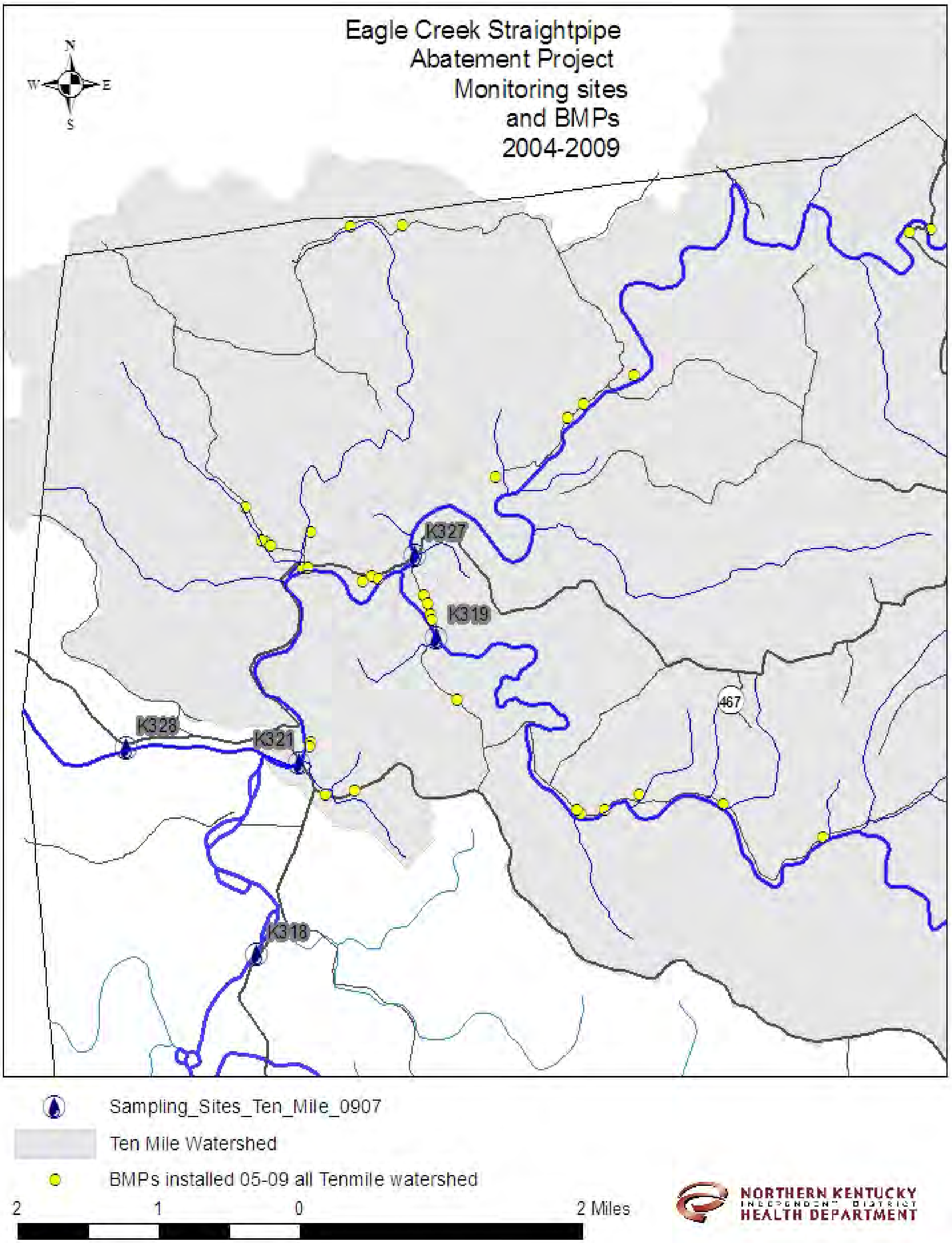

Figure F.c. 1c. Close-up BMPs and Sample Site Locations 2004-2009 (NKIDHD, 2005).

Table F.c. 1. K319 Associated Project Work.

Date of Installation/Repair Directly Affecting K319	**Number of Water Quality Samples Taken Prior to Installation/Repair**	**Total Number of Water Quality Samples Taken at K319**	**Percent of Water Quality Samples Collected Prior to Installation/Repair**
11/14/2006	35	71	49%
5/15/2007	36	71	51%
5/31/2007	37	71	52%
6/5/2007	38	71	54%
8/10/2007	41	71	58%
9/12/2007	43	70	61%
8/1/2008	53	71	75%

Table F.c. 2. K327 Associated Project Work.

Date of installation/repair directly affecting K327	**Number of water quality samples taken prior to installation/repair**	**Total number of water quality samples taken at K327**	**Percent of water quality samples collected prior to installation/repair**
6/5/2007	38	71	54%
10/5/2007	46	71	65%
10/5/2007	46	71	65%
10/5/2007	46	71	65%
10/31/2007	47	71	66%
11/1/2007	47	71	66%

Table F.c. 3. K321 Associated Project Work.

Date of Installation/Repair Directly Affecting K321	Number of Water Quality Samples Taken Prior to Installation/Repair	Total Number of Water Quality Samples Taken at K321	Percent of Water Quality Samples Collected Prior to Installation/Repair
4/25/2006	23	70	33%
10/13/2006	33	70	47%
10/25/2006	34	70	49%
11/13/2006	34	70	49%
11/13/2006	34	70	49%
11/14/2006	34	70	49%
5/15/2007	35	70	50%
5/15/2007	35	70	50%
5/23/2007	36	70	51%
7/13/2007	39	70	56%
7/31/2007	40	70	57%
7/31/2007	40	70	57%
8/14/2007	40	70	57%
8/14/2007	40	70	57%
9/12/2007	42	70	60%
9/12/2007	42	70	60%
11/2/2007	46	70	66%
7/25/2008	52	70	74%
7/25/2008	52	70	74%
8/1/2008	52	70	74%
8/1/2008	52	70	74%

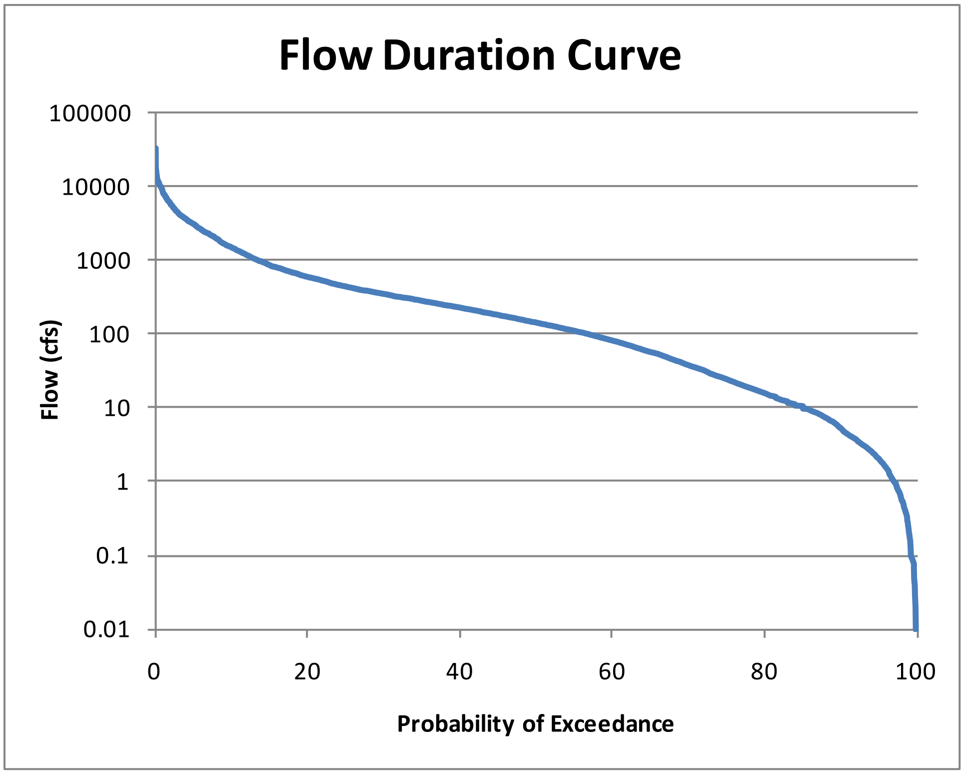

Figure F.c. 2. Flow Duration Curve for USGS Glencoe Station

Table F.c. 4. Central Tendency Measures of Data for Site K327.

	Geomean FC	Geomean EC	Geomean TC	Geomean AC	Mean AC/TC
Wet 04-06	274	253	2961	30105	19.9
Dry 04-06	90	83	1591	20864	17.9
All 04-06	164	152	2191	25202	18.9
Wet 07-09	175	139	15644	44532	3.8
Dry 07-09	30	58	7329	44283	8.0
All 07-09	69	88	10485	44400	6.0

Table F.c. 5. Central Tendency Measures of Data for Site K319.

	Geomean FC	Geomean EC	Geomean TC	Geomean AC	Mean AC/TC
Wet 04-06	319	302	4220	36064	14.1
Dry 04-06	55	50	1645	23882	19.3
All 04-06	143	133	2673	29531	16.6
Wet 07-09	156	146	6598	33995	7.1
Dry 07-09	74	89	6719	47338	8.6
All 07-09	105	112	6661	40486	7.9

Table F.c. 6. Central Tendency Measures of Data for Site K321.

	Geomean FC	Geomean EC	Geomean TC	Geomean AC	Mean AC/TC
Wet 04-06	370	348	5494	36098	10.4
Dry 04-06	43	42	1002	24418	35.2
All 04-06	144	136	2475	30054	22.0
Wet 07-09	221	203	8428	49043	8.0
Dry 07-09	35	48	3996	31475	9.4
All 07-09	84	95	5684	38808	8.7

]

Table F.c. 7. Central Tendency Measures of Data for Site K318.

	Geomean FC	Geomean EC	Geomean TC	Geomean AC	Mean AC/TC
Wet 04-06	301	296	3425	29638	17.0
Dry 04-06	31	31	618	12508	26.3
All 04-06	107	106	1454	19253	21.7
Wet 07-09	162	137	9749	32531	4.2
Dry 07-09	23	32	5272	29300	7.3
All 07-09	56	62	6983	30735	5.9

Table F.c. 8. Central Tendency Measures of Data for Site K328.

	Geomean FC	Geomean EC	Geomean TC	Geomean AC	Mean AC/TC
Wet 04-06	480	462	5797	45469	15.2
Dry 04-06	43	41	856	16807	23.6
All 04-06	168	161	2443	29008	19.0
Wet 07-09	230	198	19609	52292	3.8
Dry 07-09	28	33	3992	28542	8.4
All 07-09	76	77	8465	37989	6.2

2.0 Kentucky Water Quality Standards

The water quality standard for pathogens is tied to a specific designated use, Primary Contact Recreation (PCR), which is enforced from May 1 through October 31. For this designated use, The Water Quality Criterion (WQC) in 401 KAR 5:031 Section 7 (1)(a) states that:

[The] Fecal coliform content or Escherichia coli content shall not exceed 200 colonies per 100 ml or 130 colonies per 100 ml respectively as a geometric mean based on not less than five (5) samples taken during a thirty (30) day period. Content also shall not exceed 400 colonies per 100 ml in twenty (20) percent or more of all samples taken during a thirty (30) day period for fecal coliform or 240 colonies per 100 ml for Escherichia coli. These limits shall be applicable during the recreation season of May 1 through October 31.

2.1 Compliance with Chronic Standards

Chronic standards are enforced through the geometric mean values as specified in the Kentucky Water Quality Standards. Although the sampling in this study did not technically meet the frequency requirement for this type of analysis (i.e. five or more samples per month), the standard can still be evaluated using the geomeans of the subsets of data.

A few things are apparent from an examination of the geomeans in Tables F.c.4 through F.c.8. It is noted that all stations violated both the fecal coliform chronic standard (200 cfu/100 ml) and the E. coli chronic standard (130 cfu/100 ml) for wet conditions in the 2004-2006 time period. In the 2007-2009 time period, under wet conditions, all sites still violated the E. coli chronic standard, but a great improvement seems to have happened so that they only just barely surpass the standard. For example, site K327 went from 253 down to 139 and site K318 went from 296 down to 137. In the 2007-2009 time period, under wet conditions, two sites still violated the fecal coliform chronic standard, but also just barely after a large improvement: site K321 went from 370 down to 221 and site K328 went from 480 down to 230. No site's dry conditions geomean violated either the fecal coliform or E. coli standards during either time period. Overall, the geomeans of both fecal coliform and E. coli decreased appreciably from all 2004-2006 to all 2007-2009 for all five sites.

2.2 Compliance with Acute Standards

Acute standards are enforced through maximum values based on a maximum prescribed percent of exceedance (i.e. 20%) as prescribed in the Kentucky Water Quality Standards. A summary of the sample results relating to the acute standards for both fecal coliform and E coli are provided in Tables F.c.9 through F.c.13 below. As can be seen from tables, all stations violated both the fecal coliform acute standard (20% or more >400 cfu/100 ml) and the E. coli acute standard (20% or more >240 cfu/100 ml) for wet conditions in the 2004-2006 time period. For the 2007-2009 time period, under wet conditions, four out of five sites violated the E. coli acute standard and three out of five sites violated the fecal coliform acute standard. Under dry conditions, only one violation was present: site K321 in the time period 2007-2009 for E. coli. Overall, the percent of samples above the acute limits of both fecal coliform and E. coli decreased appreciably from all 2004-2006 to all 2007-2009 for all five sites.

Table F.c.9. Percent of Samples Above Acute Limit for Site K327.

	FC > 400	EC > 240
Wet 04-06	31.6	36.8
Dry 04-06	12.5	12.5
All 04-06	22.9	25.7
Wet 07-09	29.4	29.4
Dry 07-09	5.3	10.5
All 07-09	16.7	19.4

Table F.c.10. Percent of Samples Above Acute Limit for Site K319.

	FC > 400	EC > 240
Wet 04-06	31.6	42.1
Dry 04-06	12.5	12.5
All 04-06	22.9	28.6
Wet 07-09	11.8	17.6
Dry 07-09	15.8	15.8
All 07-09	13.9	16.7

Table F.c.11. Percent of Samples Above Acute Limit for Site K321.

	FC > 400	EC > 240
Wet 04-06	36.8	47.4
Dry 04-06	6.7	6.7
All 04-06	23.5	29.4
Wet 07-09	23.5	35.3
Dry 07-09	15.8	21.1
All 07-09	19.4	27.8

Table F.c.12. Percent of Samples Above Acute Limit for Site K318.

	FC > 400	EC > 240
Wet 04-06	36.8	42.1
Dry 04-06	0.0	0.0
All 04-06	20.0	22.9
Wet 07-09	18.8	25.0
Dry 07-09	0.0	0.0
All 07-09	8.6	11.4

Table F.c.13. Percent of Samples Above Acute Limit for Site K328.

	FC > 400	EC > 240
Wet 04-06	38.9	61.1
Dry 04-06	7.1	14.3
All 04-06	25.0	40.6
Wet 07-09	29.4	35.3
Dry 07-09	0.0	10.5
All 07-09	13.9	22.2

3.0 Statistical T-Tests

While the potential improvement of water quality over time in response to a particular management action (e.g. installation of new sewers, etc.) may be indicated by a decrease in the measures of a particular pollutant (e.g. fecal coliform counts, E coli counts), there always remains the possibility that the observed "improvement" may be simply due to randomness in the data. That is, that although the data may show improvement, the improvement may in fact not be real and may not be in response to a particular management action. One way to provide some quantifiable measure of assurance of such conclusions is through the use of some type of statistical analysis where a measure of probability can be assigned or associated with the particular conclusion (i.e. the water quality is improving). When comparing the differences between two data sets (e.g. 2004-2006 and 2007-2008), a special statistical test called a t-test is frequently used. Technically, there are two types of t-tests: one in which we test if the means of two data sets are different regardless of which direction that difference lies (i.e. a two tailed test), and the other is one in which we test if the means of two data sets are different in a specified direction (i.e. a one tailed test). A one tailed t-test is appropriate for the analysis of the data under this study because where pathogen abatement projects have been extensively implemented, it is reasonable to believe that if there has been a change in the water quality, it would be a change of improvement. That is, the geomeans of bacteria counts for the period after these projects (2007-2009) would be less than the geomeans of bacteria counts for the period before them (2004-2006), if any intrinsic difference in the watershed system had indeed occurred.

Because bacteria counts can have very large ranges of values that are usually not normally distributed, such data are frequently first transformed using a logarithmic transformation. Table F.c.14 through F.c.18 indicate the direction of the change between the measures of central tendency of the subsets of data (2004-2006 set versus 2007-2009 set) and show the p-values resulting from Microsoft Excel's T-Test function on the subsets of data. For coliform data, a decrease in geomeans is indicated as "GOOD" and an increase is indicated as "BAD." It is the opposite for AC/TC ratios. A decrease in arithmetic means is indicated as "BAD" because that means that loads are fresher and are dumped more directly into the stream. P-values are between 0 and 1 because they are probabilities. The lower the p-value, the more confidence we can have that the observed change indicates an intrinsic change in the watershed system and is not just the result of random sampling on an intrinsically unchanged system. P-values < 0.10 indicate a 90% confidence level and this is usually the most relaxed level used to determine statistical significance; p-values < 0.05 indicate a 95% confidence level, and p-values < 0.01 indicate a 99% confidence level.

Table F.c.14. Change and Significance Between 2004-2006 and 2007-2009 for site K327.

	FC	EC	TC	AC	AC/TC
Wet Change	GOOD	GOOD	BAD	BAD	BAD
Wet Significance	0.203767	0.163168	0.002217	0.111122	0.017362
Dry Change	GOOD	GOOD	BAD	BAD	BAD
Dry Significance	0.034103	0.180715	0.000019	0.002233	0.009171
All Change	GOOD	GOOD	BAD	BAD	BAD
All Significance	0.025035	0.072476	0.000004	0.003047	0.001425

Table F.c.15. Change and Significance Between 2004-2006 and 2007-2009 for site K319.

	FC	EC	TC	AC	AC/TC
Wet Change	GOOD	GOOD	BAD	GOOD	BAD
Wet Significance	0.085325	0.082573	0.192578	0.435292	0.026752
Dry Change	BAD	BAD	BAD	BAD	BAD
Dry Significance	0.336309	0.175541	0.000438	0.015192	0.010103
All Change	GOOD	GOOD	BAD	BAD	BAD
All Significance	0.252599	0.346581	0.003385	0.091873	0.001158

Table F.c.16. Change and Significance Between 2004-2006 and 2007-2009 for site K321.

	FC	EC	TC	AC	AC/TC
Wet Change	GOOD	GOOD	BAD	BAD	BAD
Wet Significance	0.180942	0.168211	0.187214	0.192875	0.199657
Dry Change	GOOD	BAD	BAD	BAD	BAD
Dry Significance	0.373109	0.391285	0.000010	0.190315	0.011109
All Change	GOOD	GOOD	BAD	BAD	BAD
All Significance	0.134529	0.204112	0.006294	0.134564	0.009043

Table F.c.17. Change and Significance Between 2004-2006 and 2007-2009 for site K318.

	FC	EC	TC	AC	AC/TC
Wet Change	GOOD	GOOD	BAD	BAD	BAD
Wet Significance	0.122301	0.067840	0.037271	0.393872	0.024172
Dry Change	GOOD	BAD	BAD	BAD	BAD
Dry Significance	0.242716	0.467803	0.0000004	0.001214	0.000460
All Change	GOOD	GOOD	BAD	BAD	BAD
All Significance	0.069893	0.080646	0.000040	0.020258	0.000130

Table 18. Change and Significance Between 2004-2006 and 2007-2009 for site K328.

	FC	EC	TC	AC	AC/TC
Wet Change	GOOD	GOOD	BAD	BAD	BAD
Wet Significance	0.076563	0.049392	0.014272	0.335598	0.019199
Dry Change	GOOD	GOOD	BAD	BAD	BAD
Dry Significance	0.222845	0.332578	0.0000003	0.005323	0.002169
All Change	GOOD	GOOD	BAD	BAD	BAD
All Significance	0.044916	0.049418	0.000614	0.112557	0.000462

3.1 T-Tests for Fecal Coliform and E. coli Data.

As mentioned previously, the geomeans between all 2004-2006 data and all 2007-2009 data improved for all sites. Now we can look more closely at that improvement. We see that three of the five sites improved with statistical significance meeting a 90% or higher confidence level, for both fecal coliform and E. coli.

If we look at the wet flow conditions, we noted previously that all sites had improved geomeans. Only two of the five sites had fecal coliform improvements with statistical significance meeting a 90% or higher confidence level. Three of the five sites had E. coli improvements with statistical significance meeting a 90% or higher confidence level.

If we look at dry flow conditions, none of the changes, fecal coliform or E. coli, for any of the sites showed statistical significance except one time: site K327 for fecal coliform. This means that all the other times the change, whether “good” or “bad”, was likely the result of random fluctuations in measurements of a system that was as a statistical population, constant.

3.2 T-Tests for Total Coliform, Atypical Coliform, and AC/TC Ratio.

The TC and AC geomeans between all 2004-2006 data and all 2007-2009 data increased for all sites. We see that for AC, three of the five sites increased with statistical significance meeting a 90% or higher confidence level. For TC, all five sites increased with statistical significance meeting a 99% or higher confidence level.

If we look at the wet flow conditions, TC and AC increased for all sites. However, none of the AC increases were statistically significant, but three of the five TC increases were statistically significant with a 95% or higher confidence level.

If we look at dry flow conditions, again TC and AC increased for all sites. The statistical significance measure of this increase is very strong. All five TC increases had statistical significance meeting a 99.9% or higher confidence level, and four of the five AC increases were statistically significant with a 95% or higher confidence level.

The AC/TC ratio decreased (got more problematic) for all five sites overall and for both wet and dry cases. The statistical significance measure of this change is also very strong. All five of the decreases in the overall and the dry case were statistically significant with a 99% or higher confidence level. Four of the five decreases in the wet case were statistically significant with a 95% or higher confidence level.

4.0 Cumulative Relative Frequency Plots

In addition to looking at either the geomeans of the data or the frequency of exceedance for one particular threshold value (i.e. 400 cfu/100 ml for fecal coliform and 240 c/100 ml for E coli), one can gain a better appreciation for the variation (or improvement) at a particular site over the entire range of data through the development of cumulative relative frequency plots for the companion data sets. Refer to the horizontal axis of each plot for the frequency bins employed for the particular water quality parameter. Improvement in the water quality associated with a particular station will be evidenced by an increase in the frequency of occurrences of observations at the lower end of the frequency plots. This will correspond to the occurrence of higher histogram bars earlier (farther left) in the plot. This will be opposite for AC/TC ratios.

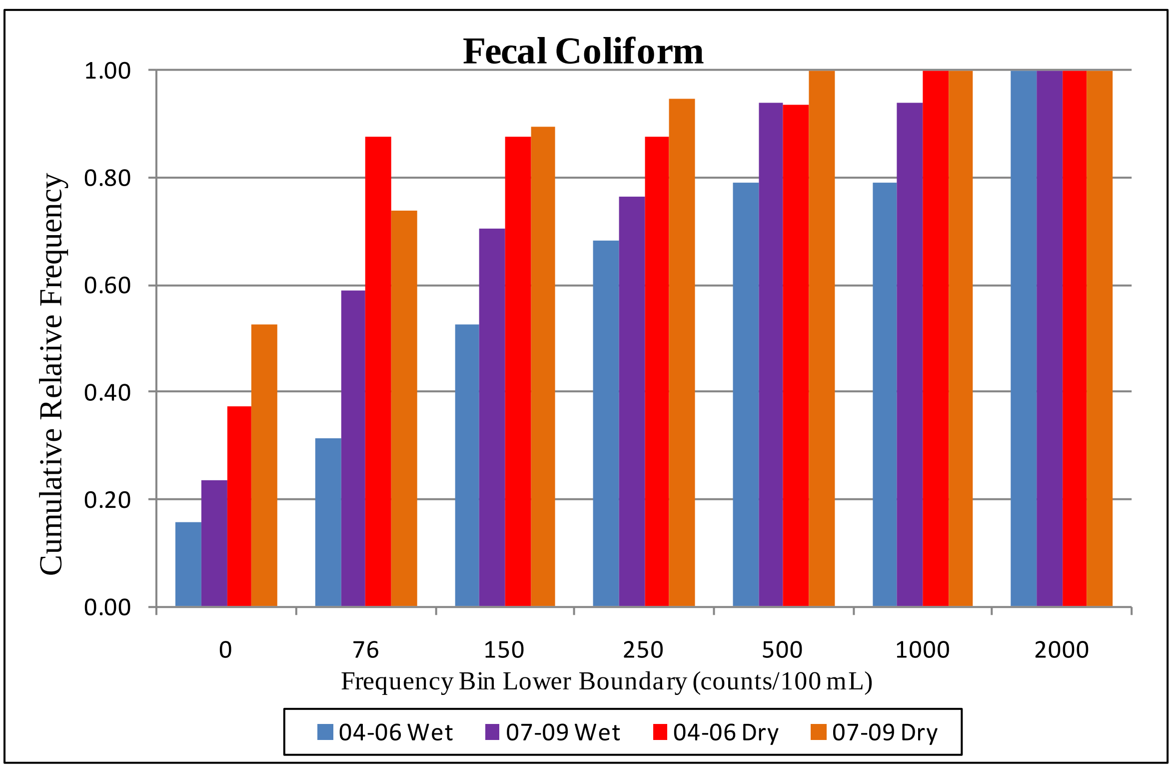

Figure F.c. 3. Cumulative Relative Frequency for Fecal Coliform for K327.

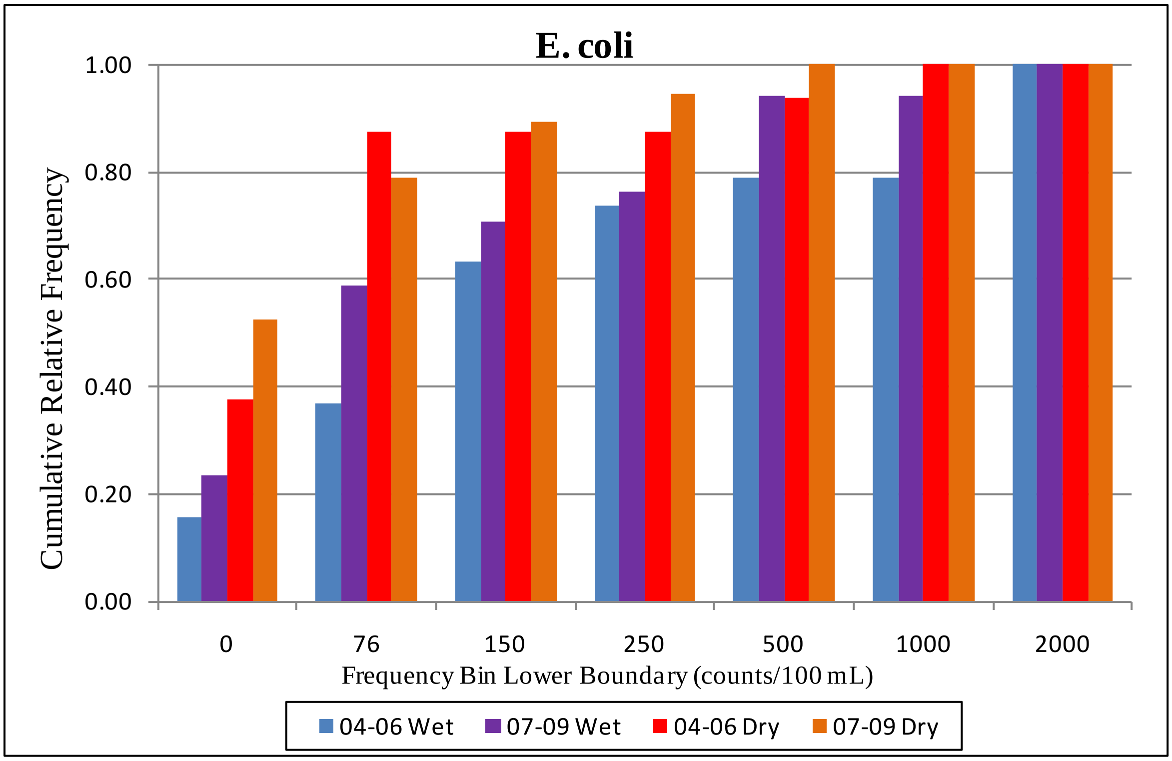

Figure F.c. 4. Cumulative Relative Frequency for E. coli for K327.

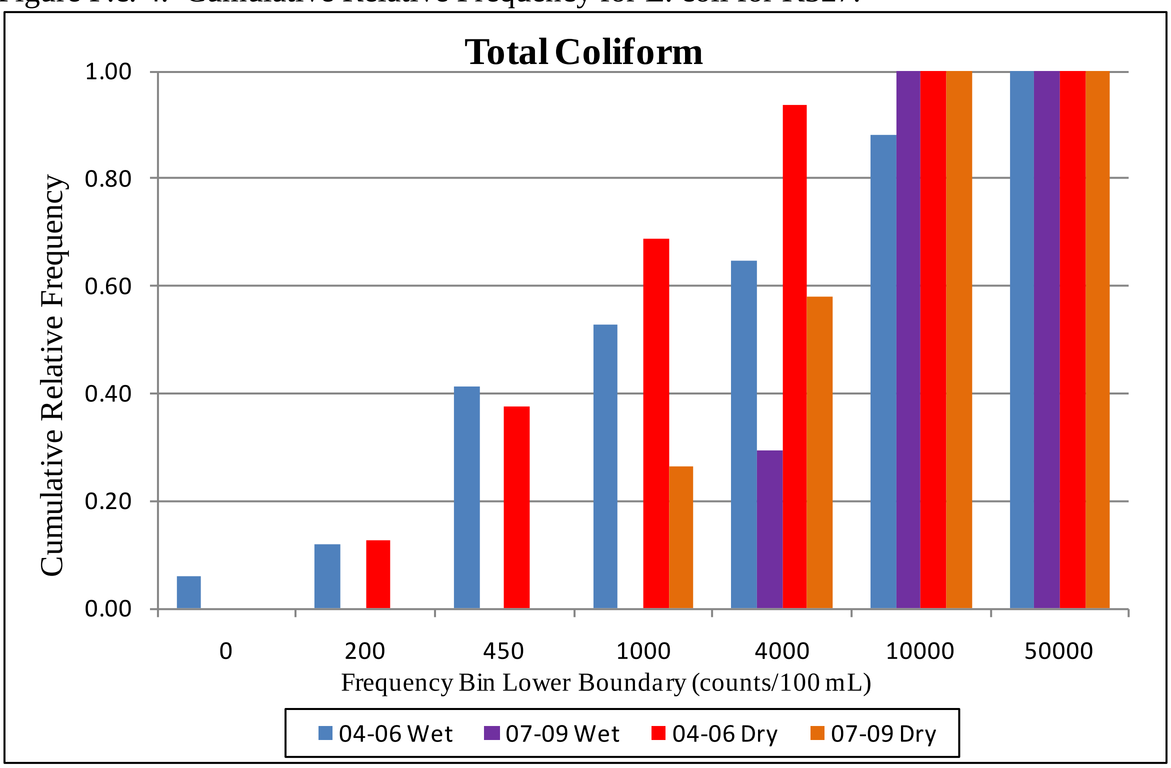

Figure F.c. 5. Cumulative Relative Frequency for Total Coliform for K327.

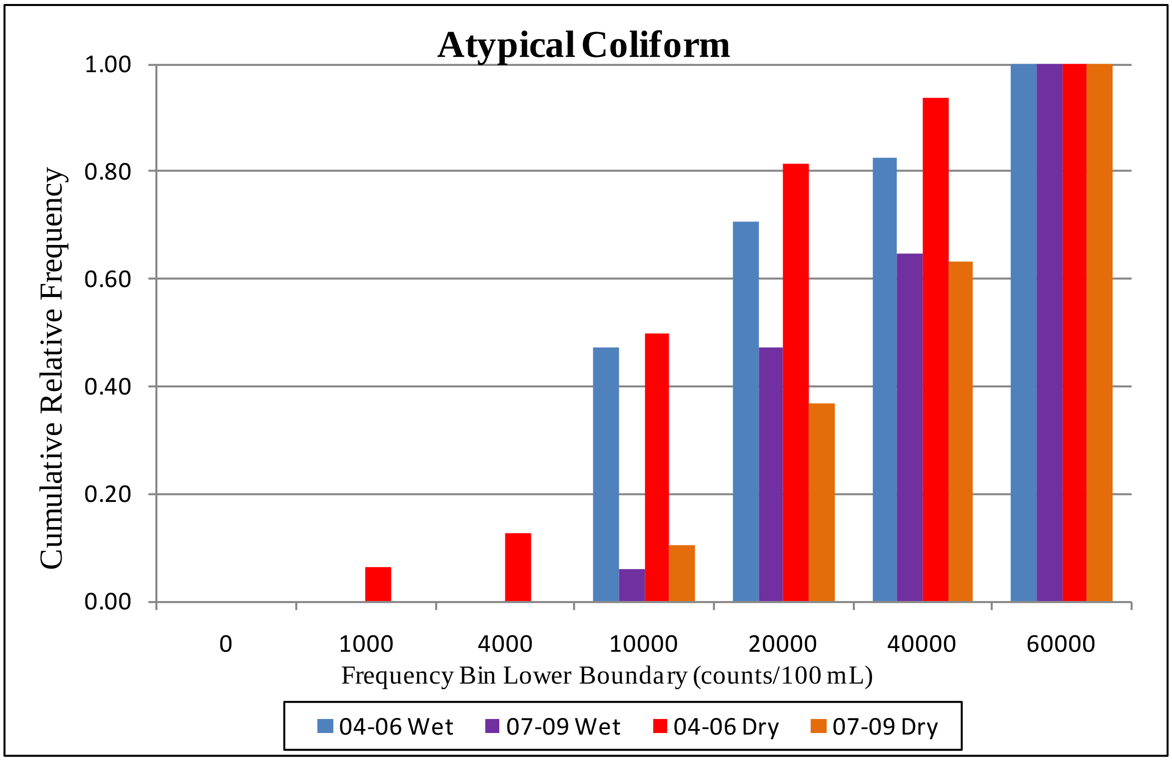

Figure F.c. 6. Cumulative Relative Frequency for Atypical Coliform for K327.

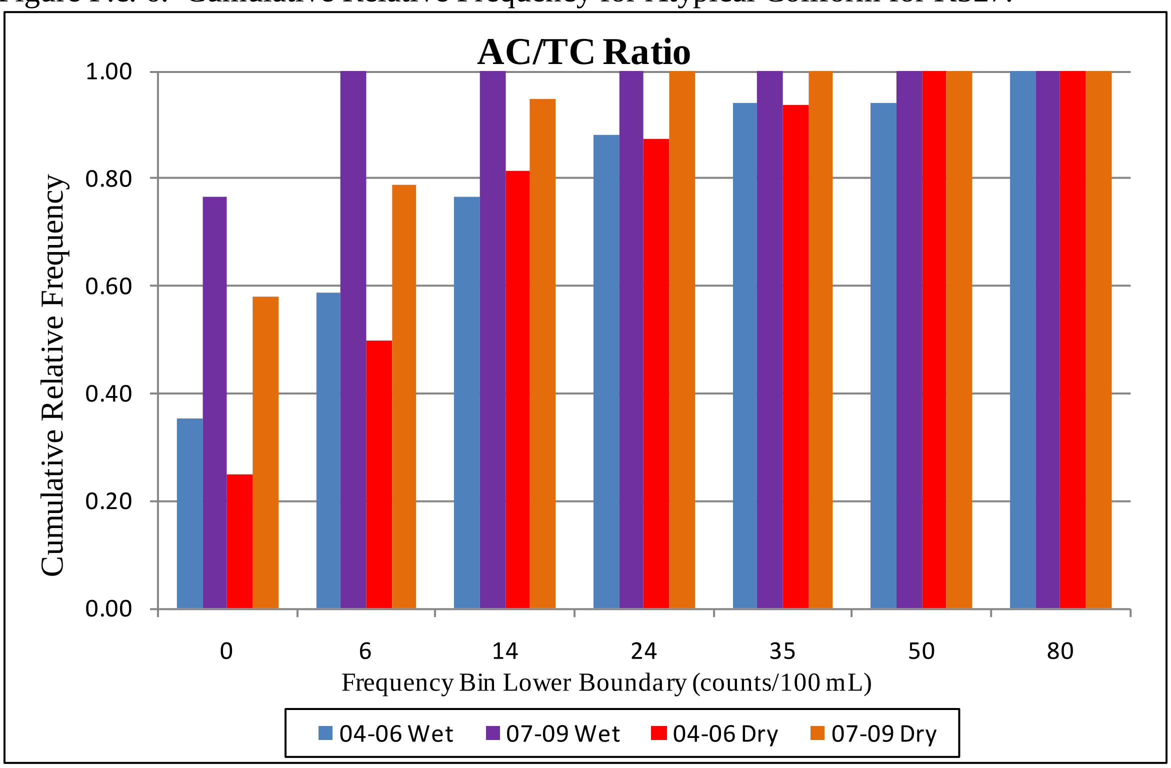

Figure F.c. 7. Cumulative Relative Frequency for AC/TC for K327.

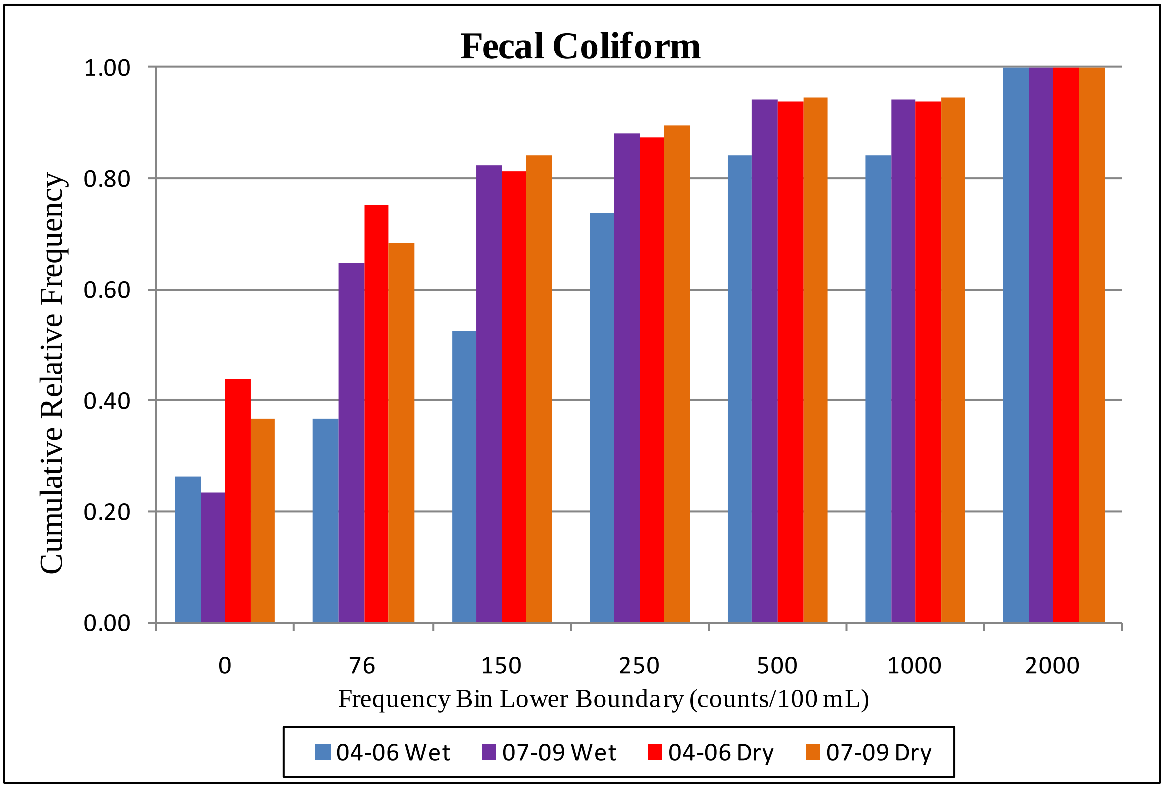

Figure F.c. 8. Cumulative Relative Frequency for Fecal Coliform for K319.

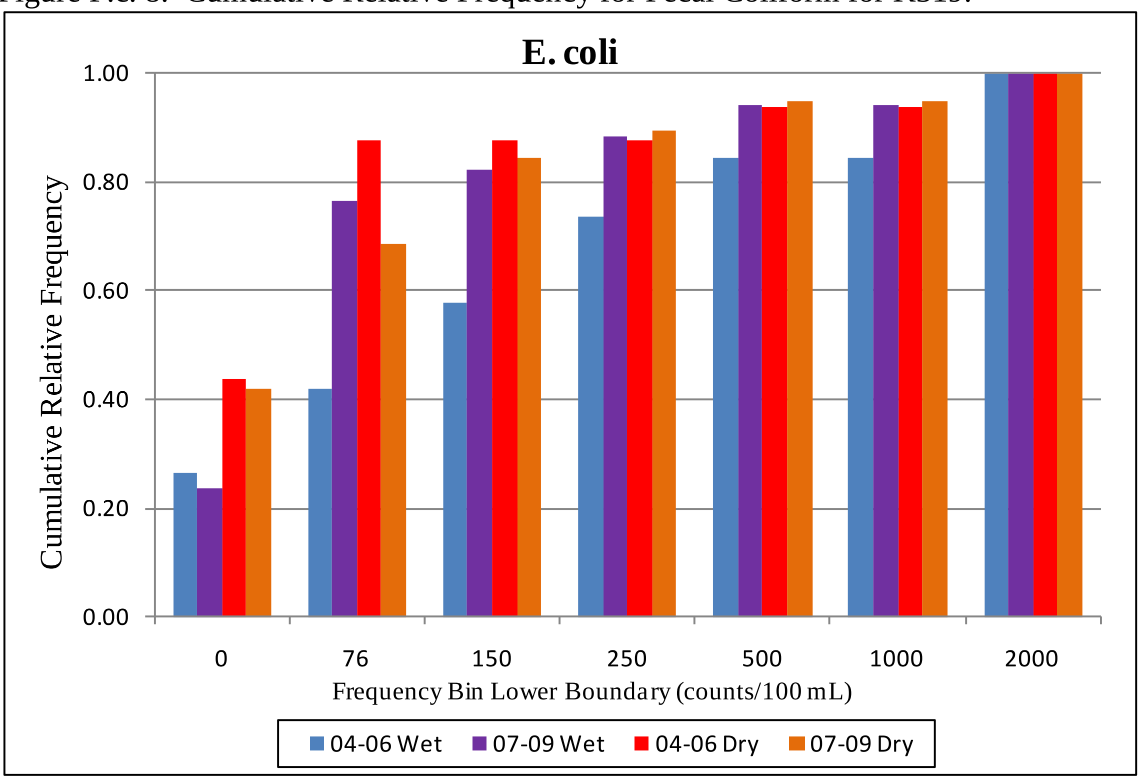

Figure F.c. 9. Cumulative Relative Frequency for E. coli for K319.

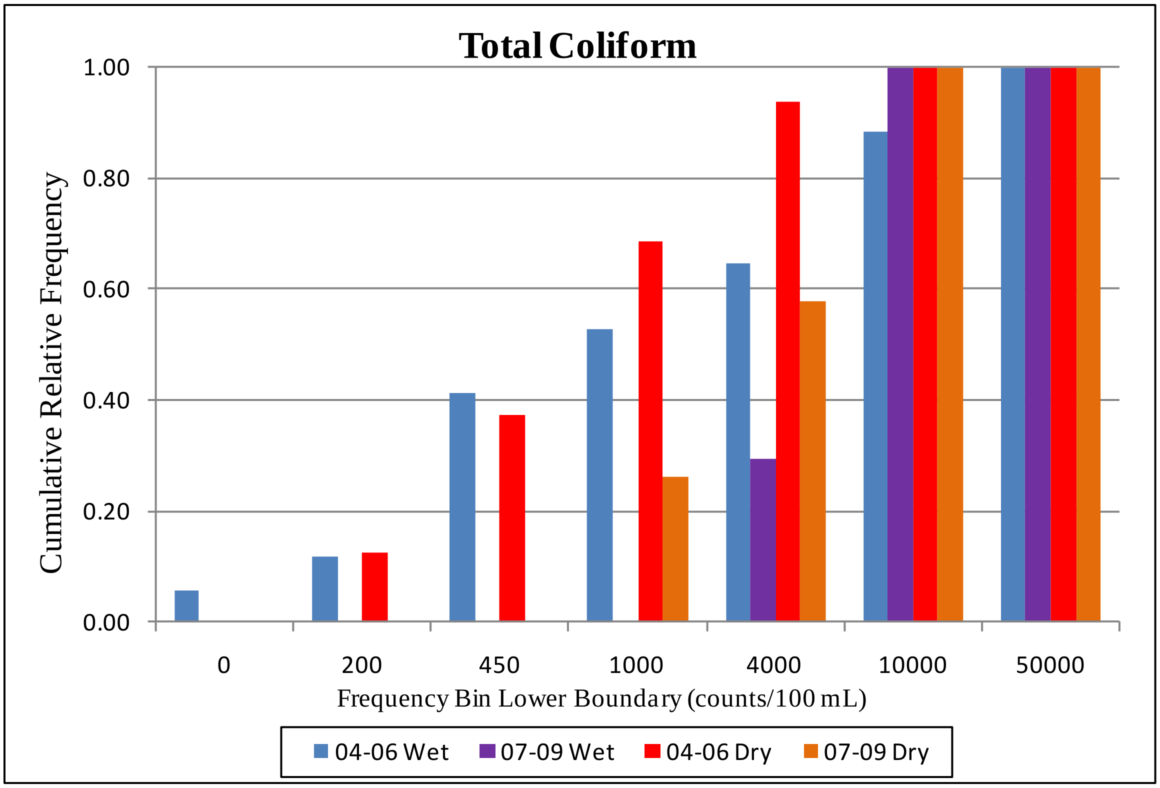

Figure F.c. 10. Cumulative Relative Frequency for Total Coliform for K319.

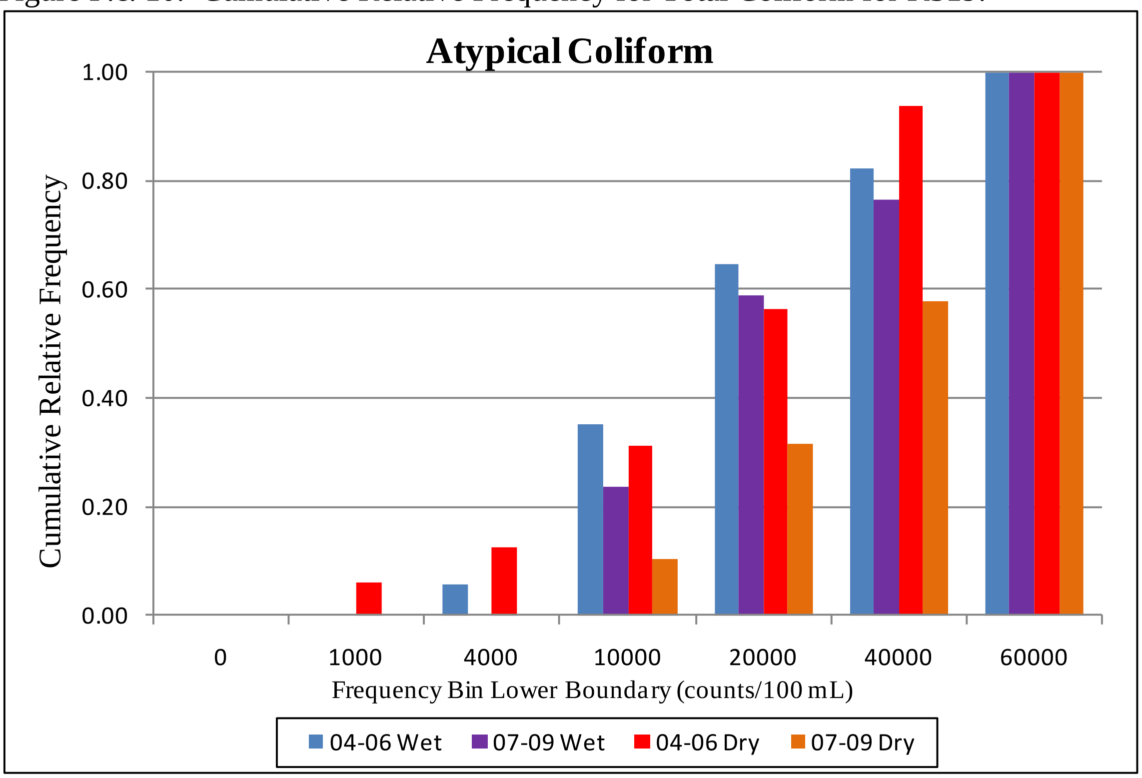

Figure F.c. 11. Cumulative Relative Frequency for Atypical Coliform for K319.

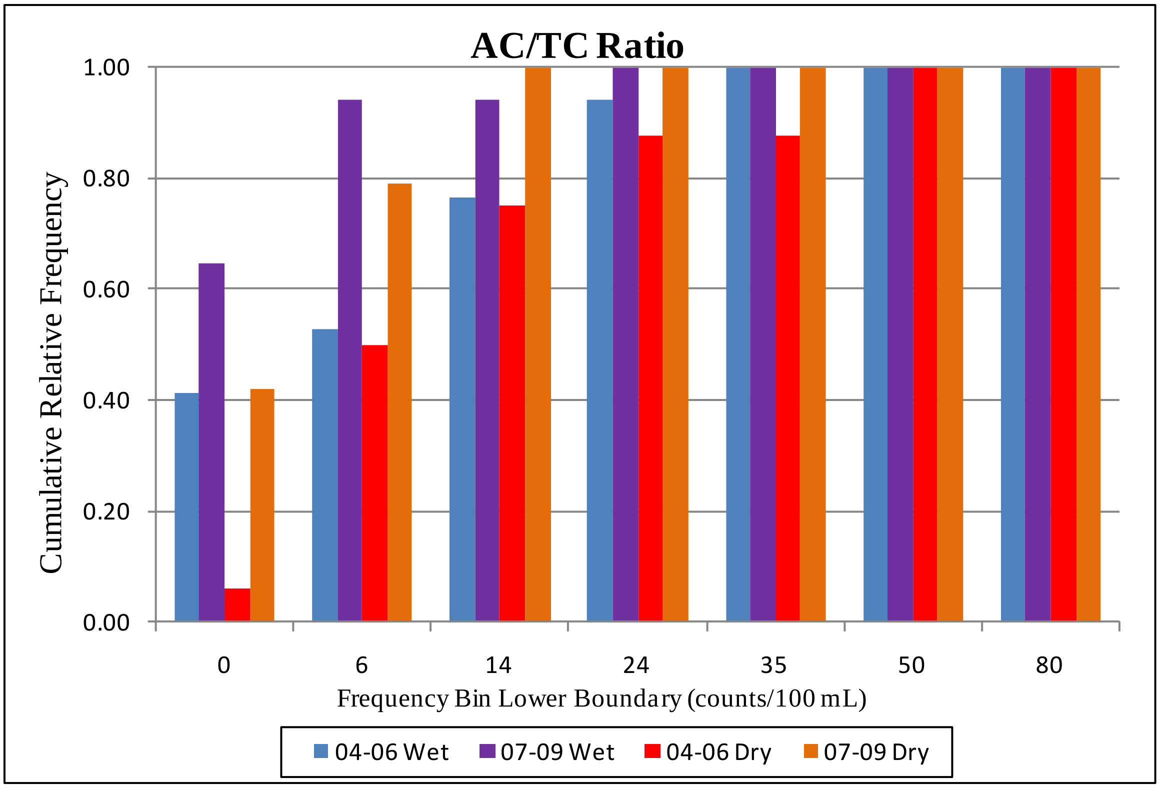

Figure F.c. 12. Cumulative Relative Frequency for AC/TC for K319.

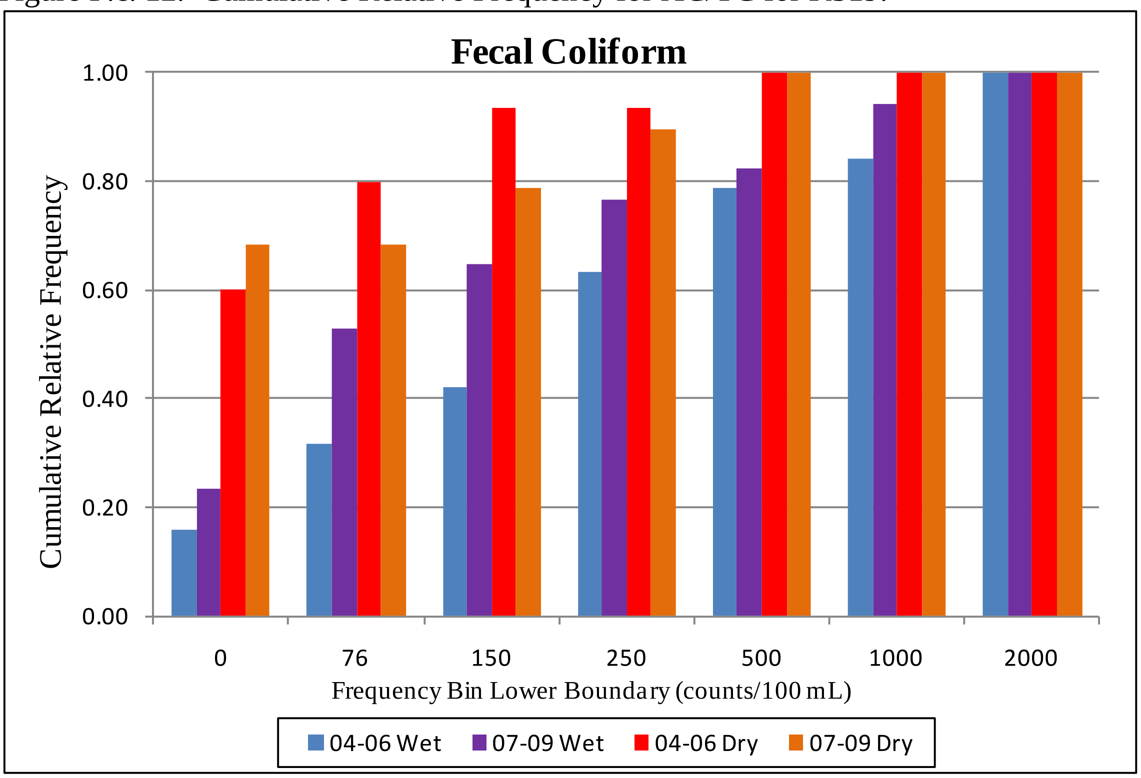

Figure F.c. 13. Cumulative Relative Frequency for Fecal Coliform for K321.

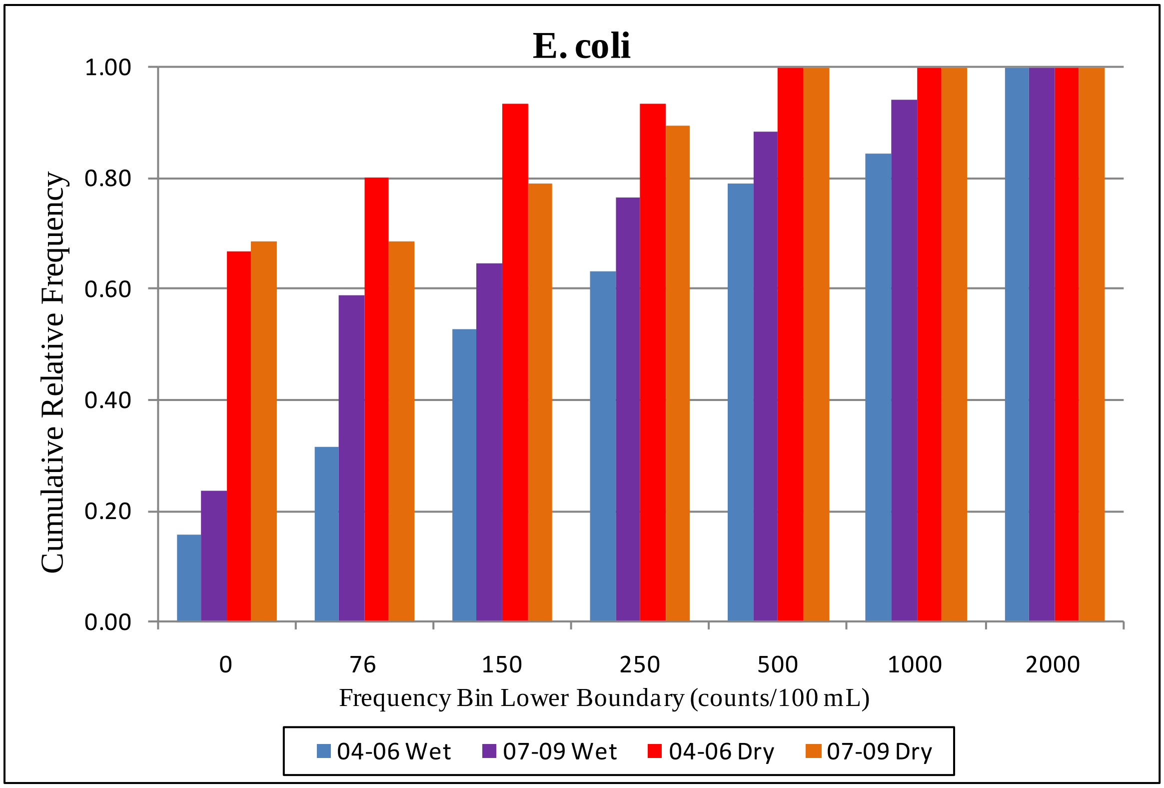

Figure F.c. 14. Cumulative Relative Frequency for E. coli for K321.

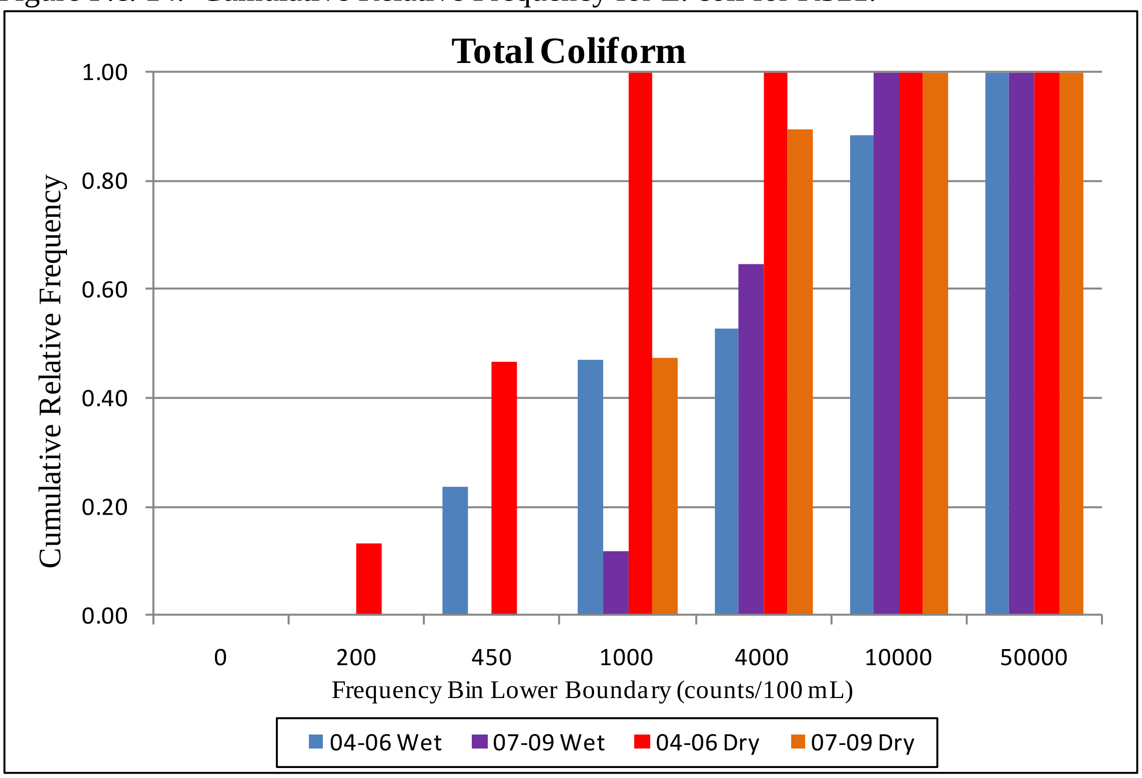

Figure F.c. 15. Cumulative Relative Frequency for Total Coliform for K321.

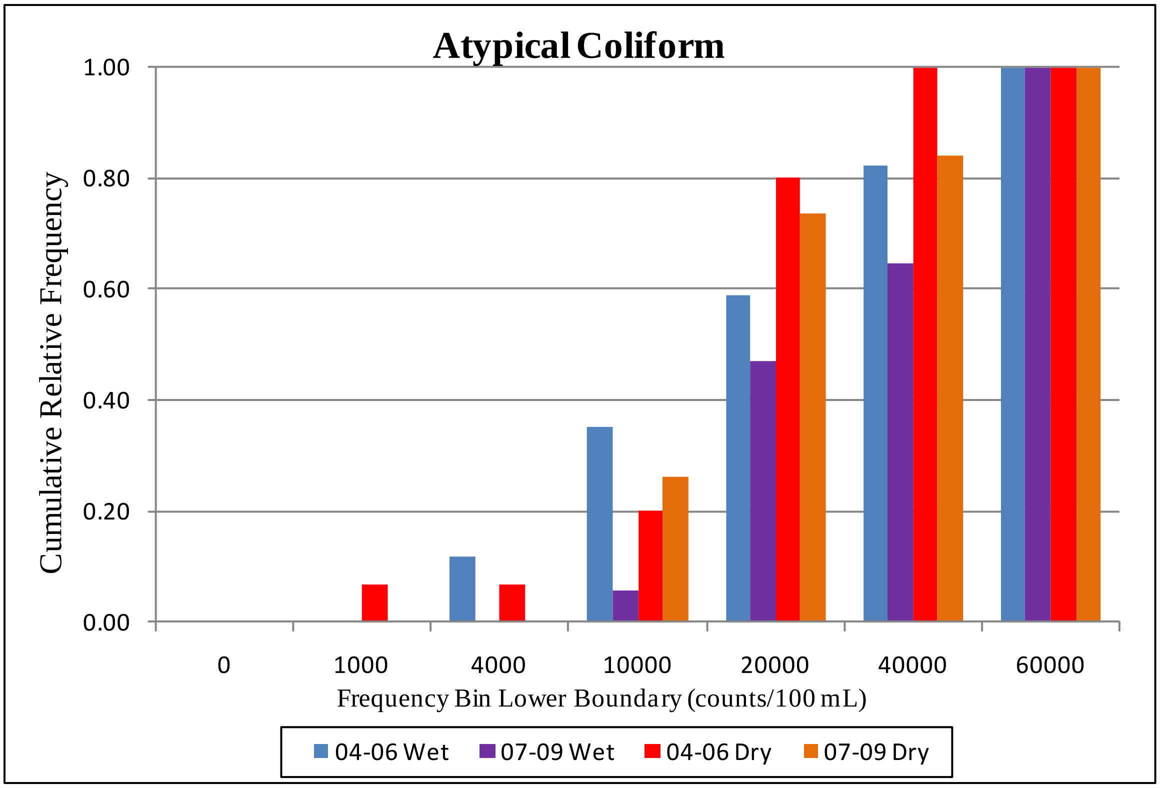

Figure F.c. 16. Cumulative Relative Frequency for Atypical Coliform for K321.

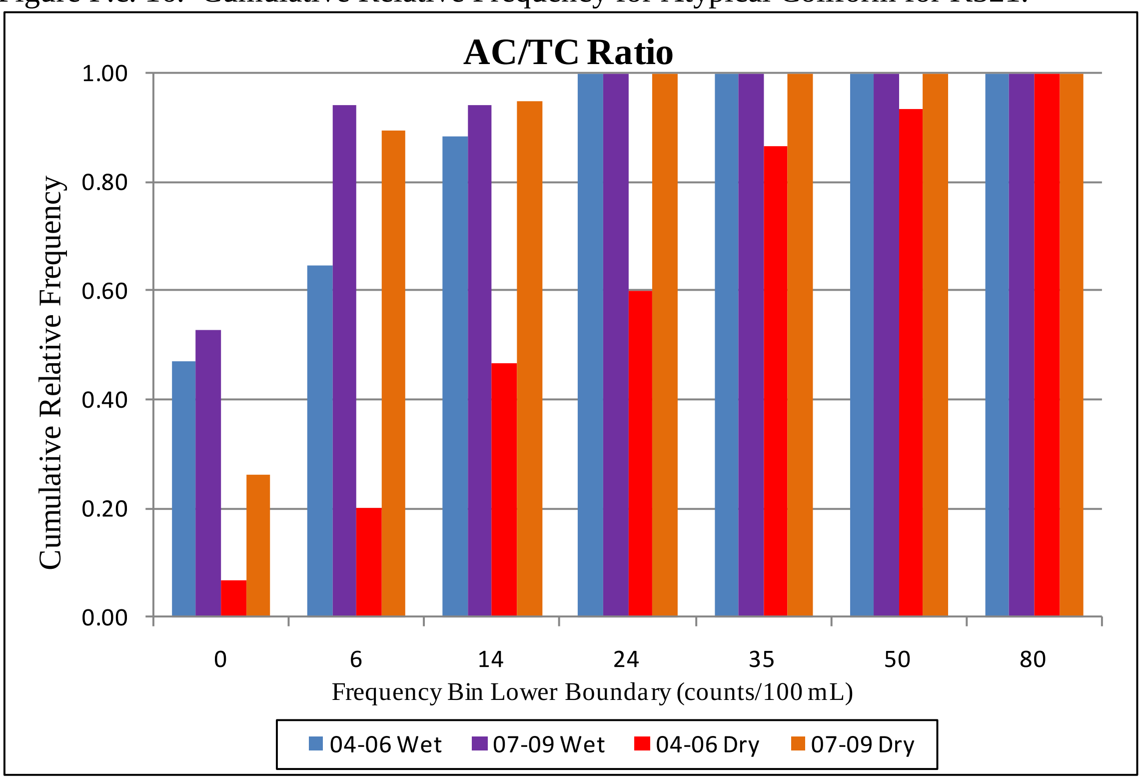

Figure F.c. 17. Cumulative Relative Frequency for AC/TC for K321.

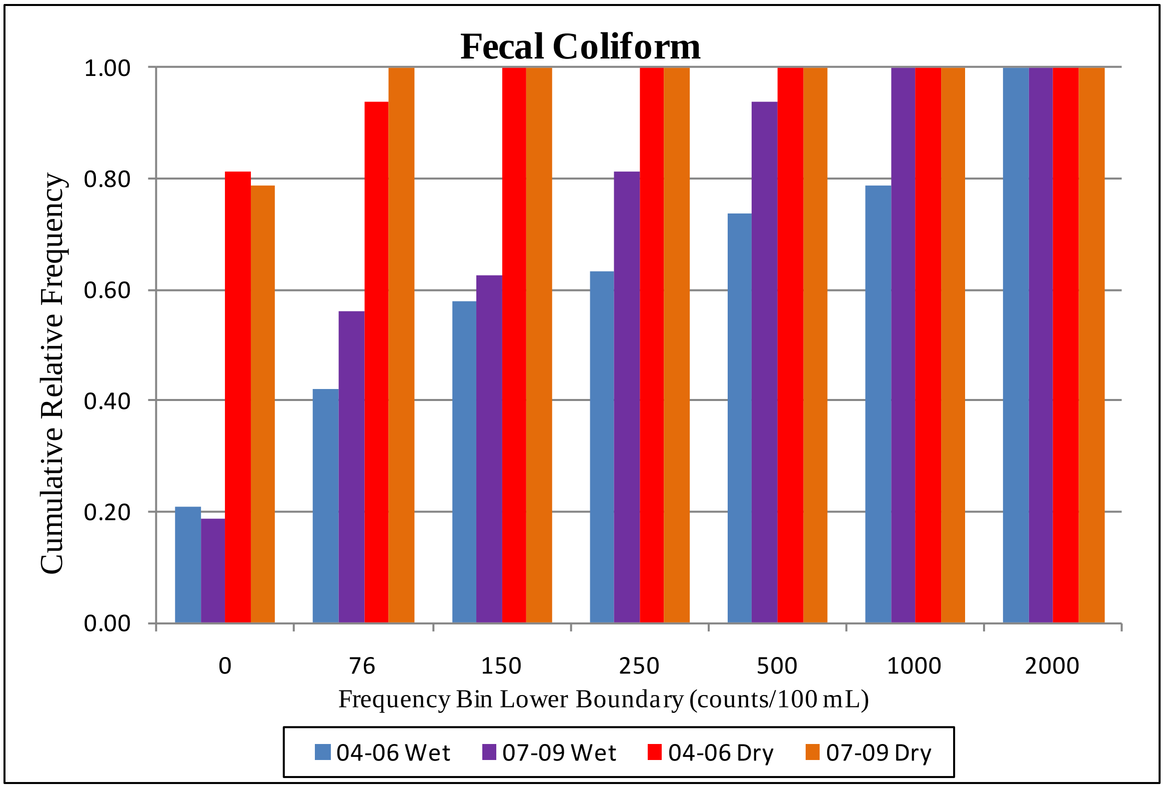

Figure F.c. 18. Cumulative Relative Frequency for Fecal Coliform for K318.

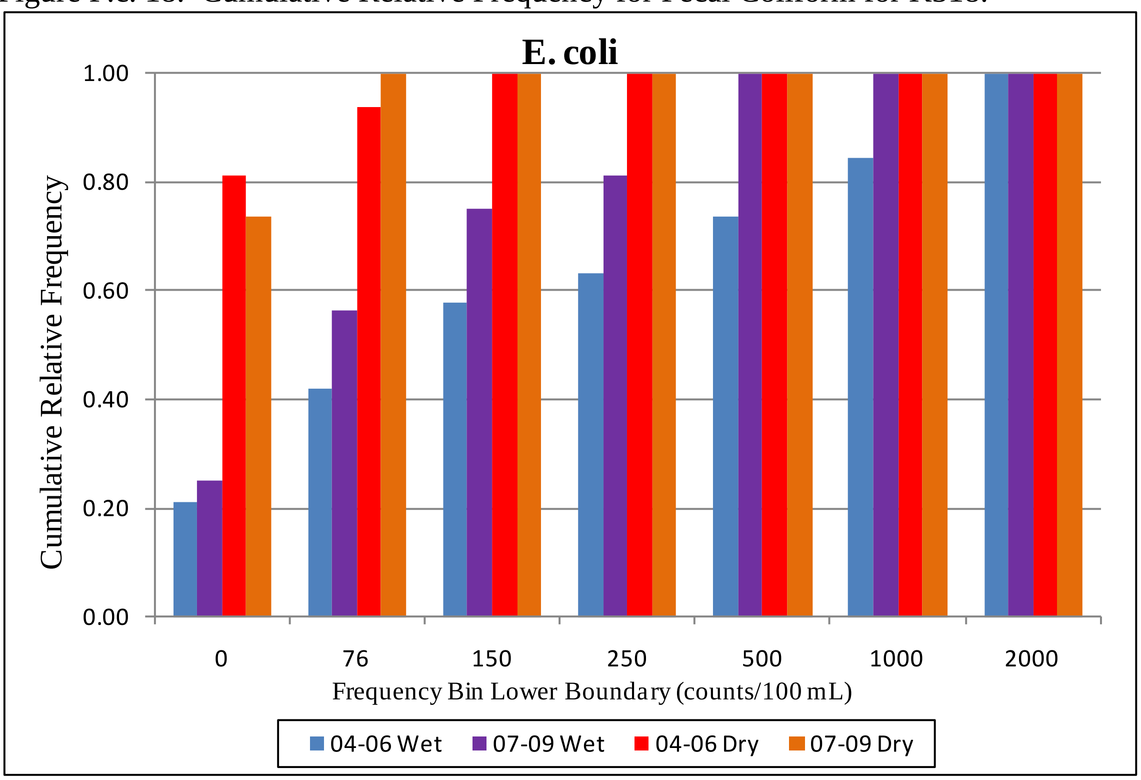

Figure F.c. 19. Cumulative Relative Frequency for E. coli for K318.

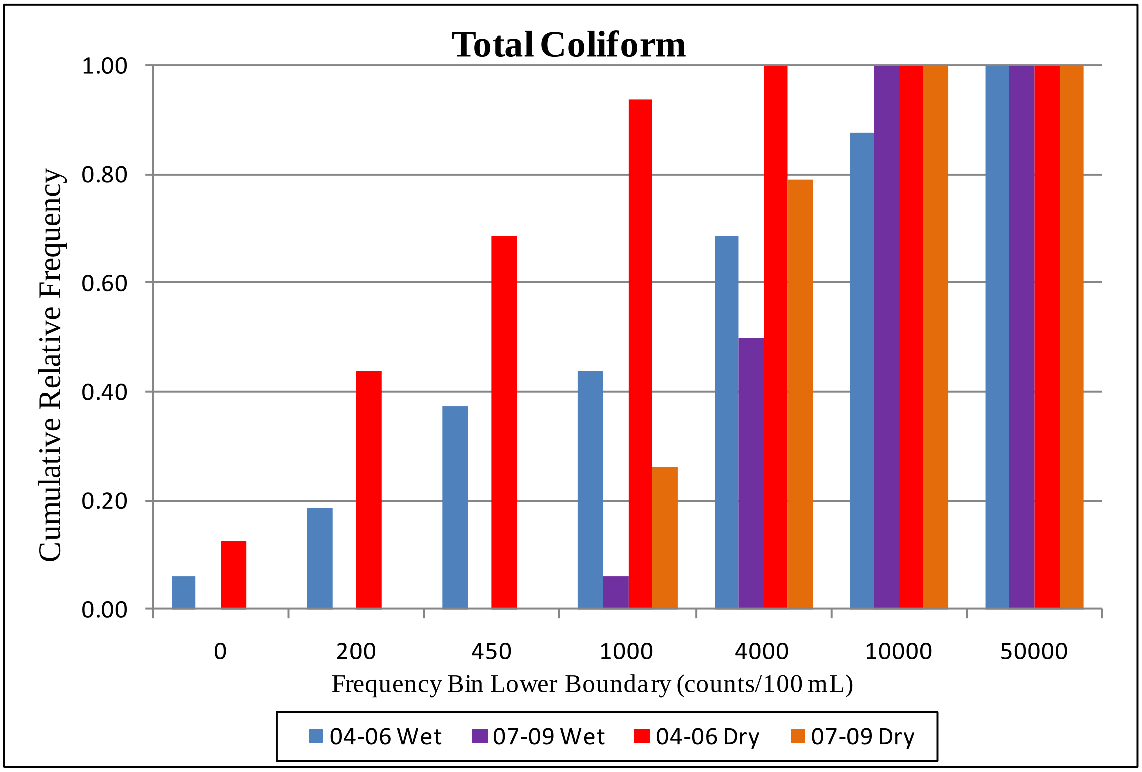

Figure F.c. 20. Cumulative Relative Frequency for Total Coliform for K318.

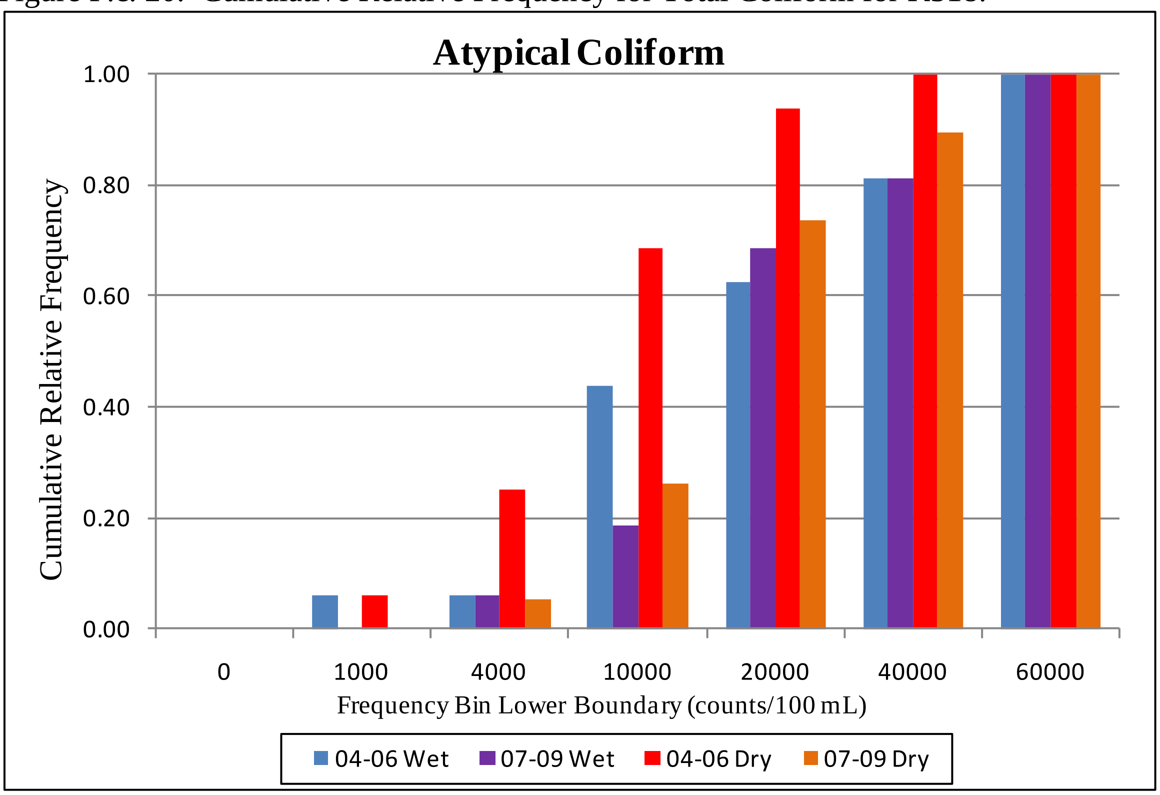

Figure F.c. 21. Cumulative Relative Frequency for Atypical Coliform for K318.

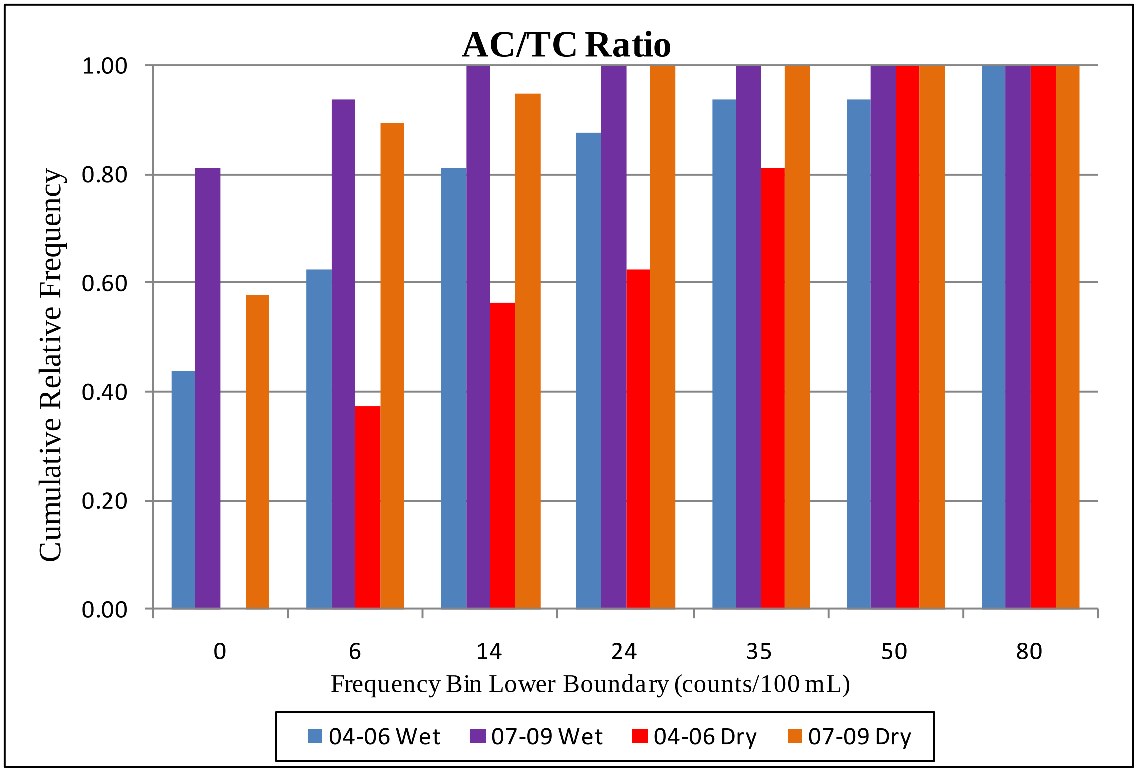

Figure F.c. 22. Cumulative Relative Frequency for AC/TC for K318.

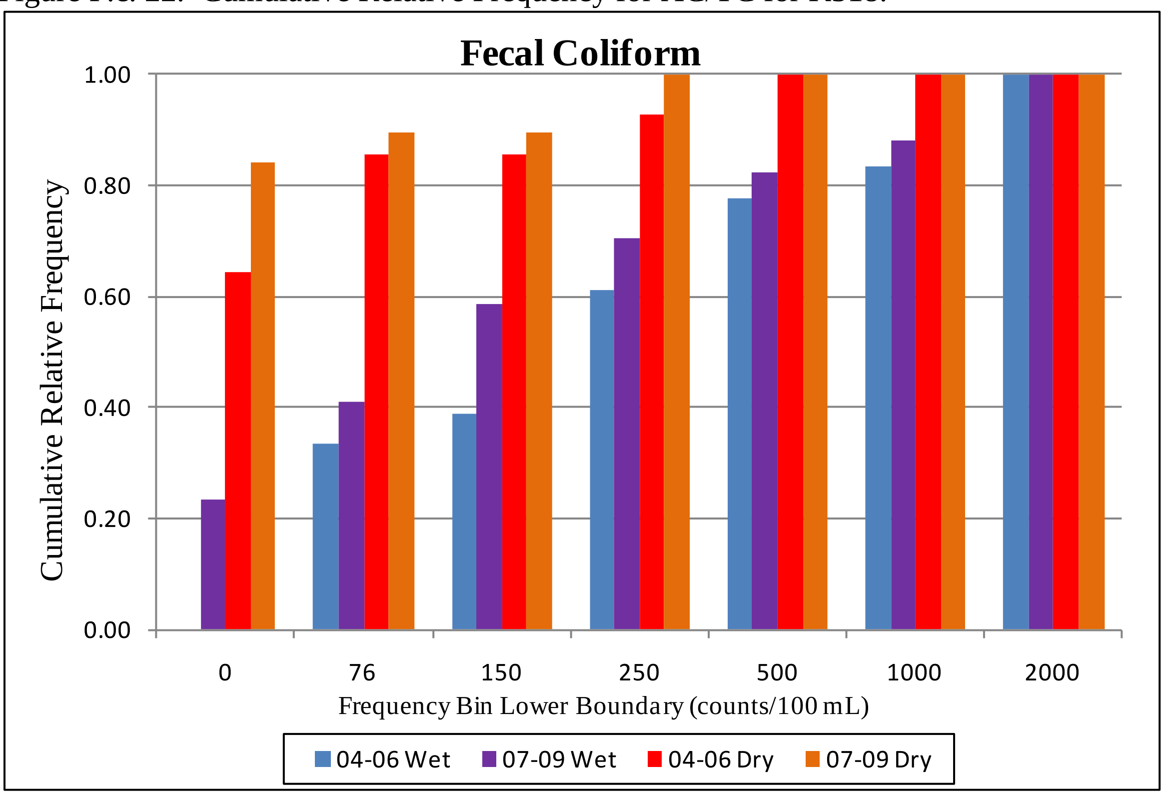

Figure F.c. 23. Cumulative Relative Frequency for Fecal Coliform for K328.

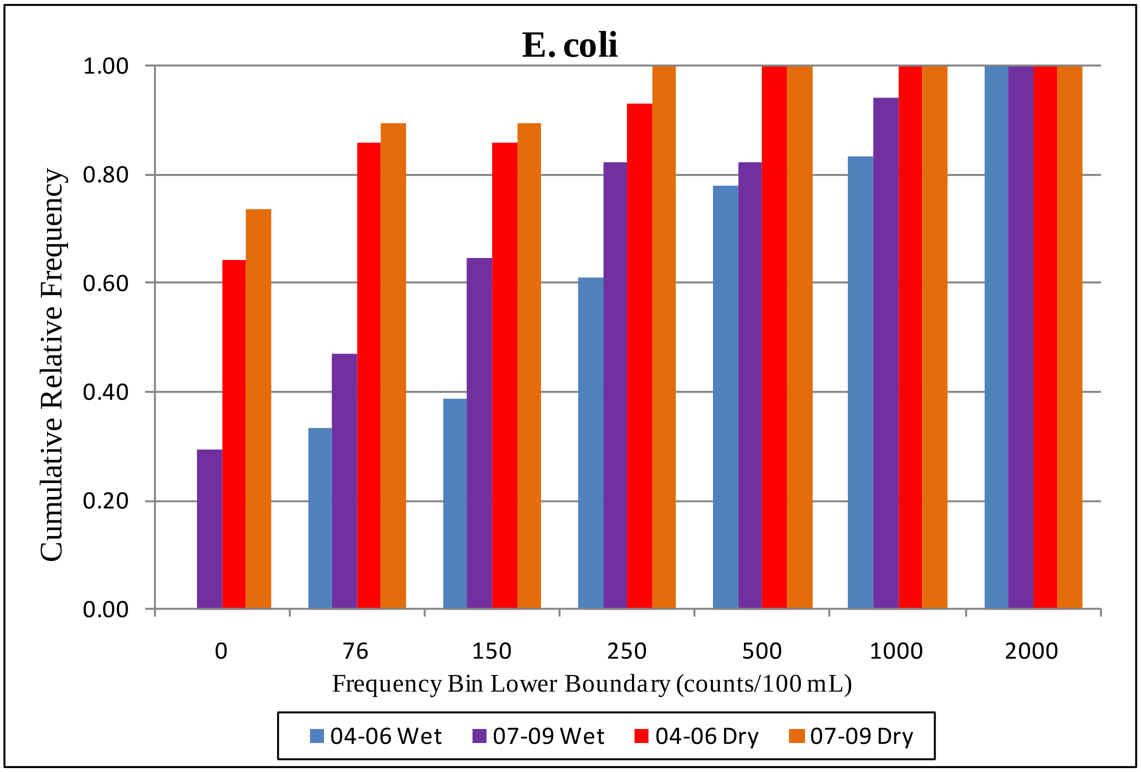

Figure F.c. 24. Cumulative Relative Frequency for E. coli for K328.

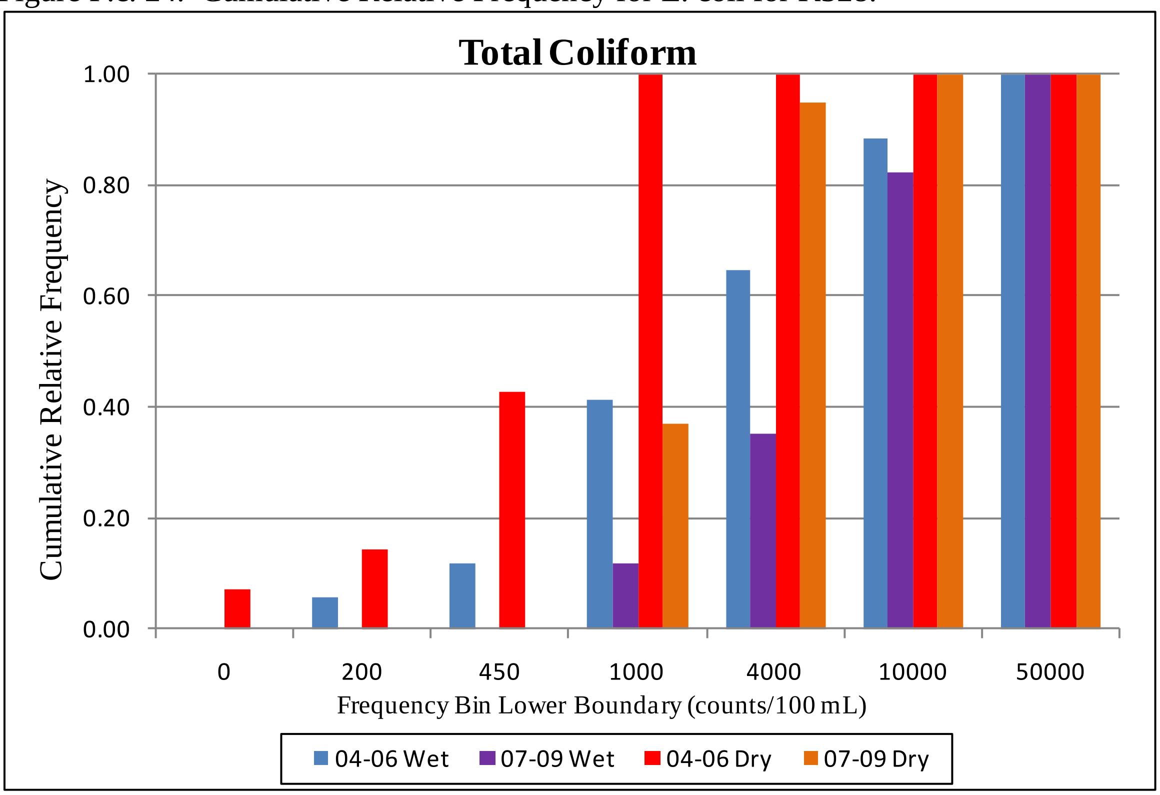

Figure F.c. 25. Cumulative Relative Frequency for Total Coliform for K328.

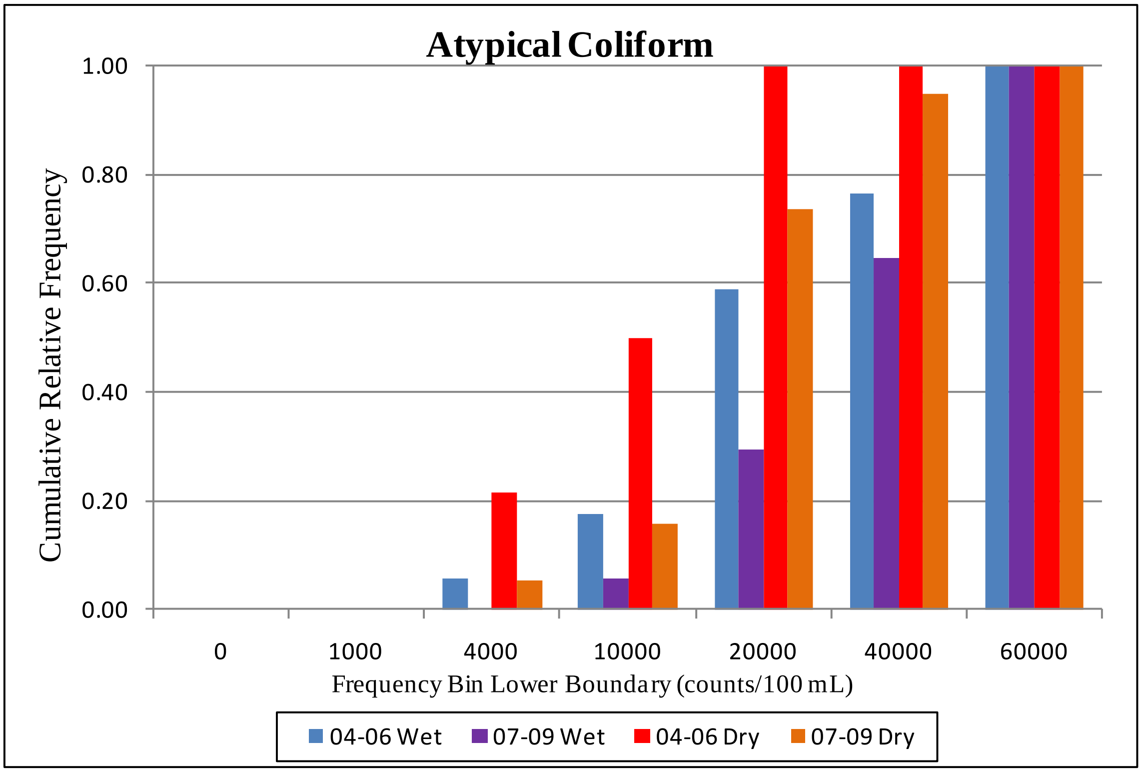

Figure F.c. 26. Cumulative Relative Frequency for Atypical Coliform for K328.

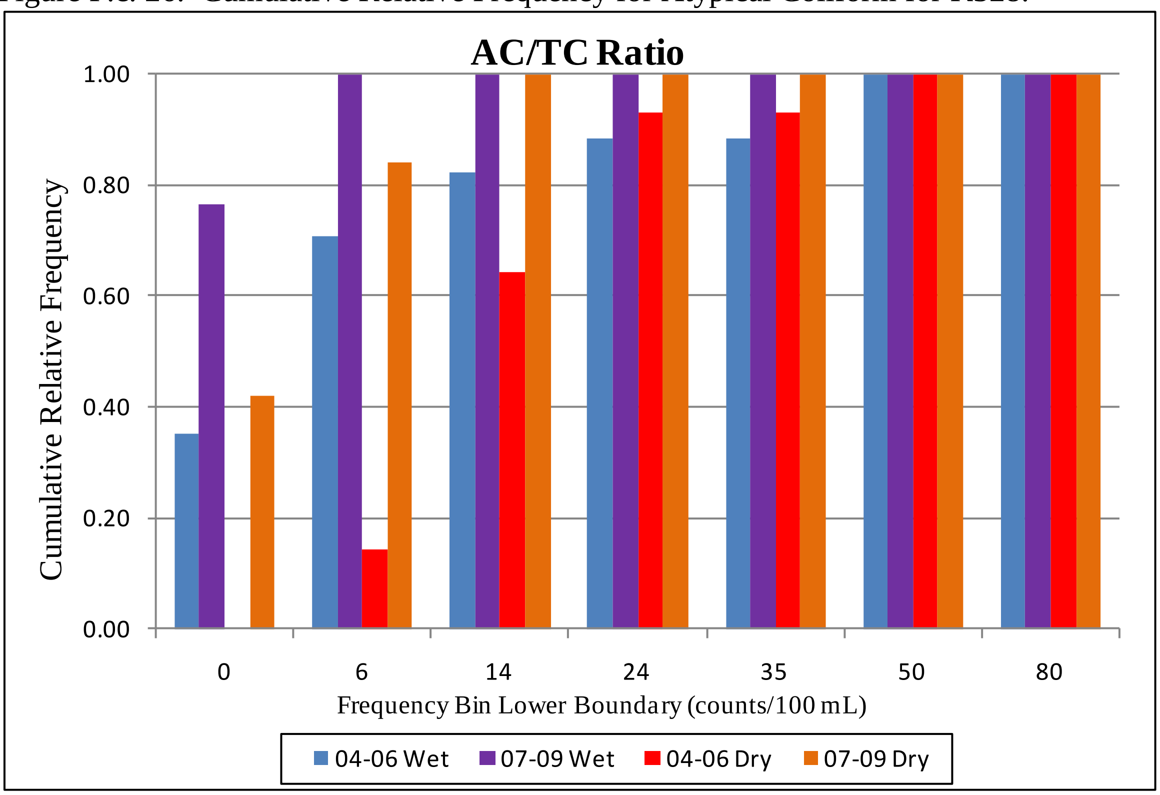

Figure F.c. 27. Cumulative Relative Frequency for AC/TC for K328.

5.0 Analysis and Conclusions

The picture given by the Fecal Coliform and E. coli data is one of improvement from the 2004-2006 years to the 2007-2009 years. When looking at pathogen pollution in a watershed, you must consider the amount of loading, the source, and the age of the loads. While the TC and AC values have increased from the 2004-2006 years to the 2007-2009 years, TC and AC are not necessarily indicators of how much fecal load is being put into the watershed because both TC and AC grow and multiply in the environment. FC and EC, since they do not multiply the way TC and AC do in the environment, are better indicators of the amount of loading. Water quality standards in Kentucky are also based on FC and EC. However, what the increase in TC and AC can indicate is that for some reason they are able to grow and multiply better in the 2007-2009 environment than in the 2004-2006 environment. There could be an increase in nutrients in the stream. The AC/TC ratio is most directly an indicator of the age of a fecal load, and in conjunction with other information and consequent deductions can be helpful in identifying sources of fecal loading. If a fecal load is deposited on a landscape and remains there for many days before being washed into a stream, then it will result in a higher AC/TC ratio than if the fecal load was directly deposited in the stream. For direct and fresh deposits in the stream, the AC/TC ratio is in the range of the averages computed for the sites over the 2007-2009 years. What this can mean is that even if a net decrease in the amount of load has been achieved, the load that is present is a direct and fresh load. Figure F.c.28 through F.c.30 show the geometric means of Fecal Coliform across the watershed in a spatial graph. The Fecal Coliform can indicate the amount of loading. Figure F.c.31 through F.c.33 show the average AC/TC across the watershed in a spatial graph. It is important to note that in Figure F.c.28 and F.c.31, Tenmile Creek is an input between K318 and K328; in Figure F.c.29 and F.c.32, Arnolds Creek is an input between K327 and K321 and upstream Eagle Creek is an input between K321 and K328; and in Figure F.c.30 and F.c.33, upstream Tenmile Creek is an input between K319 and K321 and upstream Eagle Creek is an input between K321 and K328. The graphs allow the tracking of parameters with flow in a continuous downstream path.

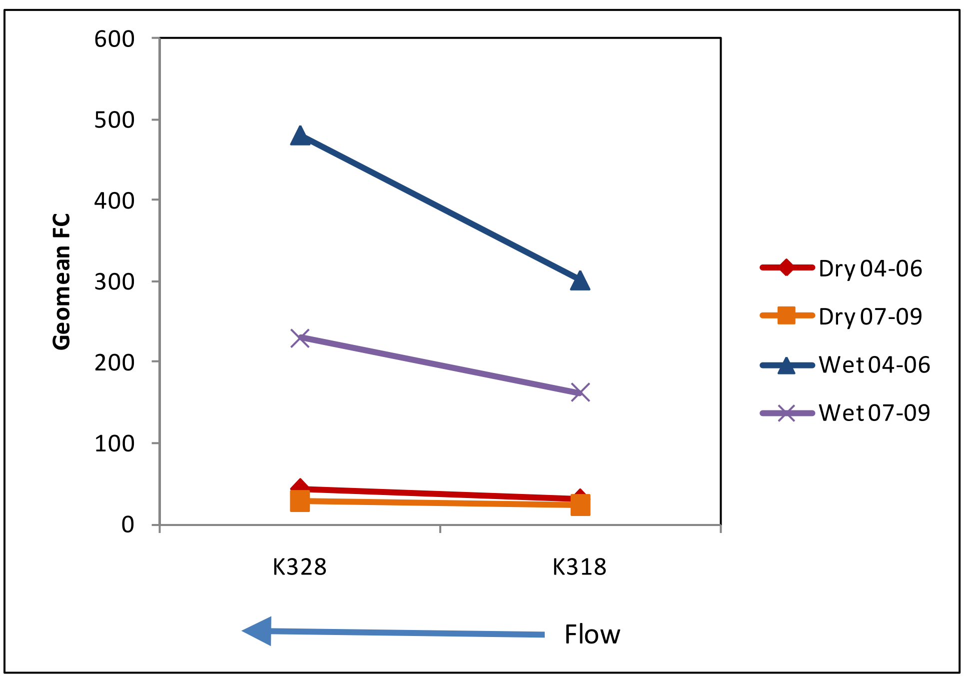

Figure F.c. 28

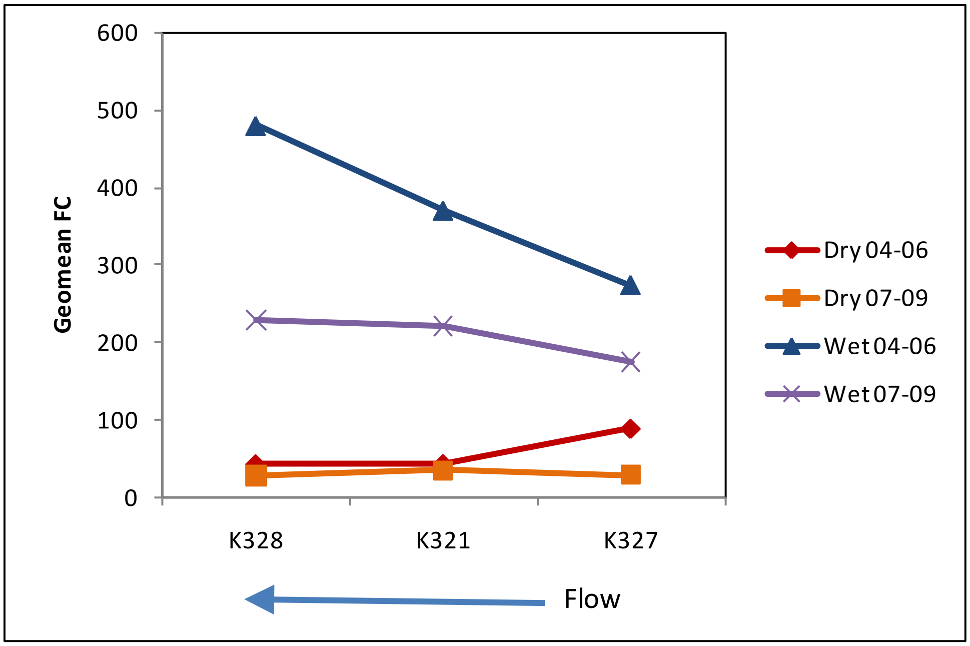

Figure F.c. 29

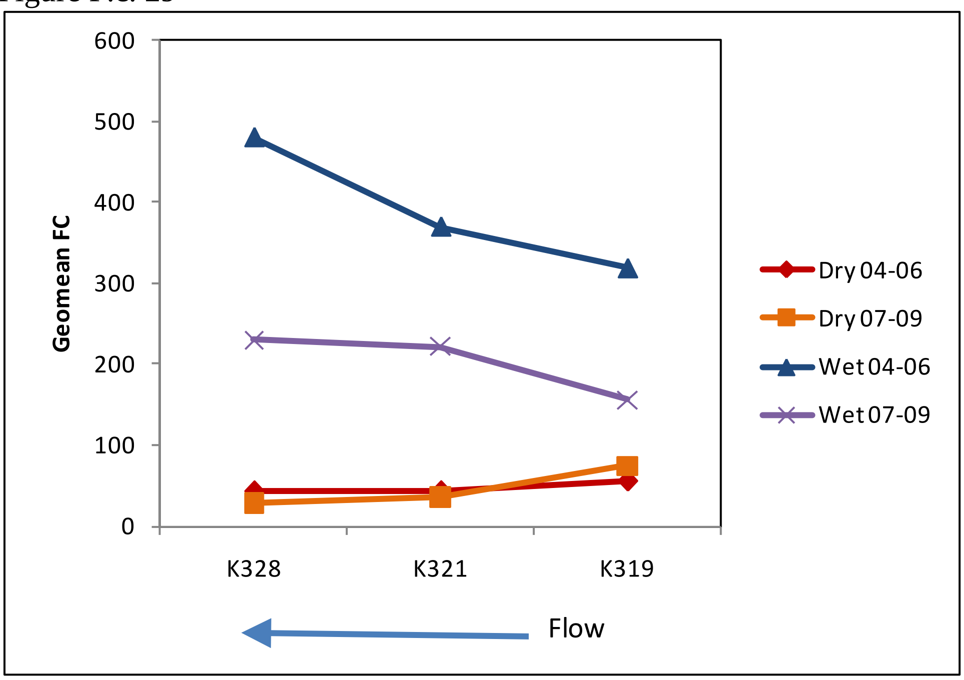

Figure F.c. 30

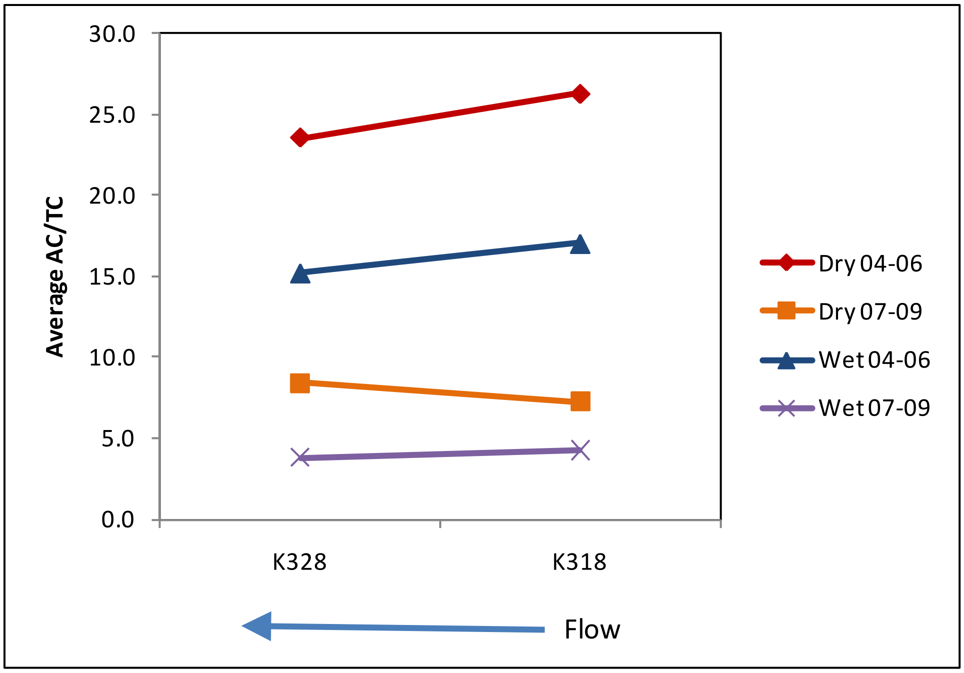

Figure F.c. 31

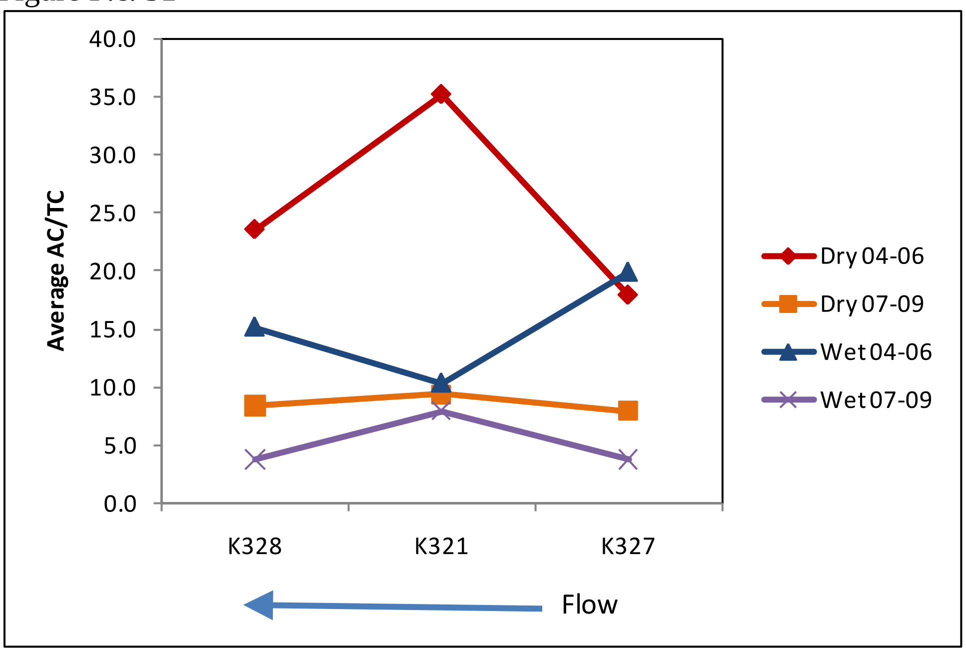

Figure F.c. 32

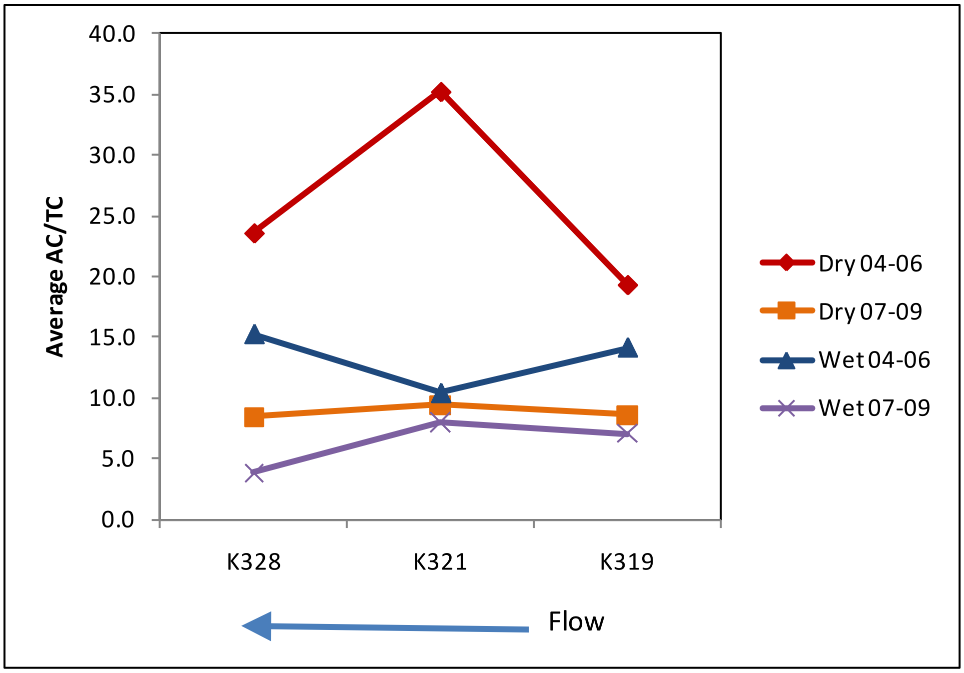

Figure F.c. 33

There are many possibilities for analyzing the data and results contained within this report. The reader who wishes to obtain insight into possible clues or factors within this watershed is encouraged to pursue further analysis. Examples include:

1) Looking at Figure F.c.28 and F.c.31 for effects of Tenmile Creek on the water quality in Eagle Creek. For instance, in Figure F.c. 28 the sharp incline (from right to left) for wet conditions in the 04-06 years indicates that Tenmile Creek was an input of extra fecal load to Eagle Creek; however, it can be seen that for wet conditions in the 07-09 years, the slope is not nearly as steep. It can also be observed that for dry conditions, the lines are very nearly horizontal for all years, which indicates that Tenmile Creek had little impact on the water quality of Eagle Creek during dry conditions. Because different sources affect water quality depending on high runoff/flow or low flow conditions, supportable conjectures can be made regarding the nature of fecal pollution in the Tenmile Creek watershed.

2) Examine Figure F.c. 32. The following picture of the 04-06 years is theoretically supportable. Because AC/TC ratios increase from K327 down to K321 with dry conditions and decrease with wet conditions, we conjecture that the main problem between K327 and K321 is with failing septic systems and not straight pipes. And the opposite occurs between K321 and K328, so that between these two points we conjecture that the main problem is with straight pipes and not failing septic systems.

3) Spatial graphs can be used in conjunction with statistical significance results. Examine Figure F.c. 29 for wet conditions. We observe that for both 04-06 and 07-09 years there is an increase from K327 downstream to K321, but while the 04-06 loads continue to climb even higher downstream to K328, the line is horizontal for the 07-09 years. This suggests that the most significant improvement really occurred between K321 and K328 even though the starting point at K327 is lower for the 07-09 years than the starting point at K327 for the 04-06 years. And when we look at statistical significance results, it tells us that that lower starting point could be just chance because the wet improvement at K327 for Fecal Coliform is not statistically significant. However, the wet improvement at K328 for Fecal Coliform is statistically significant.

6.0 Data Limitations

Data for the year 2004 was obtained from Kentucky River Watershed Watch (KRWW) volunteers and was not collected under the grant for this project. However, KRWW volunteers all become certified samplers through a training workshop for correct sampling protocol.

Questions have arisen regarding the validity of the project's lab data. Specifically, Fecal Coliform counts and E. coli counts are very close to one other to a remarkable degree. When E. coli values are plotted against Fecal Coliform values, there is a linear trend with an R^2 of 0.994. An attempt was made to screen Fecal Coliform and E. coli values, where one or the other, but not both, were kept based on lab methodology. However, the screening resulted in having mostly all Fecal Coliform data for the years before repair and mitigation work and only E. coli data for the years after the repair and mitigation work. This was not conducive to being able to use the data for the purposes of any analysis. Still, based on Fecal Coliform values, 94% of the E. coli values fall within the 90% confidence interval of expected E. coli values based on a regression relationship between Fecal Coliform and E. coli for the Kentucky River Basin from "Relationship Between Fecal Coliform and E Coli within the Kentucky River Basin" by Madhu Akasapu and Lindell Ormsbee. This means that all the data fall within ranges we expect them too. However, the fact that within that range they are so very close to each other at all times is remarkable.

The lab did not follow good standard protocol for plate counts and dilutions. Dilutions were not adequate in many cases and counts excessively high above what can reliably be counted on one plate were frequently recorded as data. AC/TC ratios are especially vulnerable to using correct dilutions and using reliable counting ranges. All suggestions made in this report based on AC/TC ratios (and other data) have to be made assuming the data is good data, otherwise no analysis can proceed. However, the sensitivity of AC/TC ratio deduction validity to correct lab protocol, especially with dilutions and reliable count ranges, should be noted. Because such high counts on one plate are not reliable, large variations could be within the data causing phenomenon that may not be representative of the real system, affecting both geomeans and statistical significances. However, these data could not be all discarded because then what would be left would have no use for analysis either.

The USGS gaging station at Glencoe was used for determining flow conditions because the field flow data accompanying the sample data did not seem possible in many cases based on which sites were upstream and which were downstream and compared to the flow at the USGS Glencoe station just four miles away from K328 without any major tributaries in between, and which in terms of additional watershed area, is only a small fractional increase over the watershed area of K328. One other thing should be noted about the analysis in the report based on the division of "dry" and "low" flows. Apparently there was a drought in 2007, and as a consequence, the Dry 2007-2009 data set consists of about 50% of data points from 2007. Therefore the Dry 2007-2009 data set is over-represented by 2007 data. This is important because the majority of the repair and mitigation work was done in 2007. So even though this year gets put into the "after repairs" set, it had projects ongoing throughout that year. This means that the Wet 2007-2009 has almost all 2008 and 2009 data, which in terms of time, had the most benefit from all the repairs and mitigation work done in the watershed. Consequently, this may be the reason there is such a pronounced and statistically significant improvement for the Wet conditions and not for the Dry conditions.

The duplicates showed satisfactory precision based on a simple log deviation from each other. The four parameters obtained from the lab had duplicates that were 94%, 94%, 94%, and 97% within a 90% confidence interval for FC, EC, TC, and AC respectively. Therefore the duplicates were good. It was questioned if they were too good. The duplicates were done in a manner which ensured that they were blind to the lab. The fact that a few of them perfectly match as is the case for 1620 and 1620 can be explained by the following: an examination throughout all the years of data show that for the great majority of the sampling events, values returned for several of the sites for a given sampling event were very close to each other and there are several cases where two sites had the same value. A simple calculation of combinations and probability shows that there is a good chance that the duplicates might meet a 90% confidence interval regardless of any special precision attributable to the lab on duplicates themselves and that it is probable a couple of the 34 duplicates would indeed match exactly.

The blanks were very good. Almost all blanks were zero value for the parameter. The couple of times a blank had a numeric value recorded were only a less than number and the magnitude of that upper limit was based on the dilution. *~End of KWRRI statistical analysis~*

i. Discussion of data problems

During the statistical analysis that was performed by KWRRI in February 2010, problems with data came to light. The analyst with Kentucky Water Resources Research Institute recognized patterns within the data that raised red flags. When he and the director of KWRRI examined them more fully, these red flags were found to be indicative of several troubling problems with the monitoring data for this project.

- When the IDEXX method was used, the counts of the small and large cells did not appear to match the values for the total coliform and the E. coli counts that would be derived from the chart published for this methodology.
- Inconsistencies with decimal places as relates to dilutions used became apparent
- It does not appear the lab used multiple dilutions for analyses throughout the project as would be standard operating procedure for the methods used.
- Counts of bacterial colonies on media plates often appeared to be in excess of what would be considered good laboratory practice for the methods used.
- Duplicate pair values were exceptionally close in value
- When compared with a study of fecal coliform vs., E. coli values in four states, an anomalous correlation was found to exist between fecal coliform and E. coli values throughout the project, whether membrane filtration methodology was used for both pathogen analyses, or even if IDEXX colilert methodology was used for the E. coli and membrane filtration methodology was used for fecal coliform.

Additional problems with the project were revealed:

- These data were submitted at the end of each sampling season to both KDOW and to KWRRI with the request that the data be reviewed to see if everything appeared valid.
- In 2008 KWRRI's Kentucky River Basin Coordinator discovered that the E. coli values looked strangely correlated with fecal coliform values. When asked about the similarities, the lab's answer was that fecal and E. coli values tend to be close. The matter was not pursued further by NKHD, KWRRI or KDOW.

These problems were investigated in several ways throughout 2010. First, lab personnel were asked detailed questions by email and phone interview about the methodologies with all raw data requested and provided. Second, arrangements were made to visit the lab with samples over the course of two days to observe the process of analyzing samples. Third, the data problems were brought to the attention of KDOW, and as a result, the Certification Program Manager with KDOW's Drinking Water Branch performed an audit on 8/10/10.

The results of these investigations revealed the following:

- Values not matching IDEXX method: This is adequately explained by rounding errors, and was observed by both NKHD and KDOW. NKWD has provided all data for the project without rounding, and with the correct values for IDEXX based analyses.

- Values that don't appear to match the dilutions used: NKWD has provided all data for the project without rounding, and with proper dilutions, which were sometimes incorrect on the first set of raw data sheets.
- High colony counts for method used: NKWD lab tech explained that if numbers of colonies were high, rather than return a value of “too numerous to count”, he tried to provide a number, even if it was in excess of what is normally considered countable
- KDOW audit noted that only one dilution was used, instead of three as is good laboratory practice.
- KDOW audit revealed that raw data was not kept on bench sheets for this project as is standard operating procedure for the methods practiced, and was only kept as excel spreadsheets.
- Exceptionally close duplicate pair values: no adequate explanation by any of the investigations.
- Anomalous correlation between fecal coliform and E. coli values: no adequate explanation by any of the investigations.

In light of the unanswered questions, it must be concluded, that this data cannot be unequivocally be considered to be valid. As the statistical analysis has shown, however, there is value in the examining the data and the trends it appears to show, as long as there are firm qualifications as to the validity of the data.

d. Quality Assurance Project Plan quality control checks

Data pertaining to analysis of duplicates and blanks can be found in Appendix F, Table 7. The following quality control checks were performed:

i. Quality Control for flow calculations will be by periodical re-evaluation of cross sectional area of each sample site as well as comparison to continuous USGS stream gauge measurements. The stream gauge number is 03291500, and is located in Eagle Creek, near the town of Glencoe in Gallatin County, Kentucky. Sample sites were surveyed twice a year during the sampling season in order to determine accurate cross sectional area. Calculated flow values for the lower Eagle Creek sample site, K328 and USGS gage station flow values should agree within 10%. Discussion: During the 2005 sampling season, it was found that the “Flowatch” flowmeter originally purchased for this project did not function at low flow situations. A new “GEO Flow” probe was purchased and was used from the second sampling event of 2006 onward. However, a chance was missed to ensure the accuracy of this device. Because a plan to check flow data against the Glencoe gage during the project either was neither required nor voluntarily performed, this quality check was not performed until the final analysis. At that point it was too late to make any adjustments in data collection. Collected data did not fall within the acceptable range – only 10.9% of measurements throughout the project were within 10% of values for the Glencoe continuous USGS stream gage. As a result, during the statistical analysis of the monitoring data, the decision was made to use data from the Glencoe continuous USGS stream gage rather than the project flow data.

ii. Field blanks are intended to be free of analytes of interest. Blank samples are analyzed to test for bias that could result from contamination of environmental samples by the analytes of interest during any stage of sample collection, processing and analysis. A field blank is prepared in the field and used to demonstrate that: (1) sample collection and processing have not resulted in contamination and (2) sample handling and transport have not introduced contamination. Two samples out of 18 had indications of bacterial contamination. Discussion: The first event on 9/5/06 was determined to be most likely the result of re-using a bottle of distilled water. A gallon bottle of distilled water was bought and stored in the vehicle, and re-used at the next sampling event. After that time, new distilled water was purchased for every sampling event. The second event on 5/13/09 was possibly the result of aerosolized stream water landing the mouth of the field blank bottle as it was being filled. This sample was prepared at K327 at 7:40 AM. At this time of day, this location tends to be foggy. The creeks were running somewhat high on this day, and it is possible that aerosolized water from a riffle area near the sampling site mingled with the fog and landed in the bottle as it was being prepared. Results and discussion of field blanks can be found above in the Statistical Analysis in section F.c.i. Field blanks were kept blind for the lab by giving them a unique identifier not connected with the original sample and keeping out time and other potential identifiers.

iii. Duplicate samples are two or more samples collected and processed such that the samples are considered identical in composition. Concurrent duplicates are multiple (usually 2) samples collected from the environment as close as practical to the same location and time. These duplicates are used to assess variability introduced by sample collection, processing and analysis. To prevent bias, several measures were taken throughout the project to ensure the duplicates were blind: randomly generated site number, no physical data included that would compare with the physical data collected for the other of the pair, not mentioning sample sites or other info when dropping off samples, and not including time of collection that could be compared. Results and discussion of duplicate samples can be found above in the Statistical Analysis in section F.c.i. Duplicates were kept blind for the lab by giving them a unique identifier not connected with the original sample and keeping out time and other potential identifiers.

G. Conclusions

The NKHD practices its mission of *"Linking People with Resources to Promote, Achieve, and Maintain a Healthier Community."* In order to do this we practice the Ten Essential Public Health Services.

1. **Monitor** health status to identify and solve community health problems.
2. **Diagnose and investigate** health problems and health hazards in the community.
3. **Inform, educate**, and empower people about health issues.
4. **Mobilize** community partnerships and action to identify and solve health problems.
5. **Develop policies and plans** that support individual and community health efforts.
6. **Enforce** laws and regulations that protect health and ensure safety.
7. **Link** people to needed personal health services and assure the provision of health care when otherwise unavailable.
8. **Assure** competent public and personal health care workforce.
9. **Evaluate** effectiveness, accessibility, and quality of personal and population-based health services.
10. **Research** for new insights and innovative solutions to health problems.

This project demonstrated services 2, 3, 4 and 6 in the following ways. By gaining intimate knowledge of Grant County through the practice of (# 6) enforcing onsite wastewater laws and regulations, NKHD was able to diagnose and investigate (#2) wastewater health hazards. After mobilizing community partners (#4) who were able to help identify problems and advance solutions, this project was able to (#3) inform, educate, and empower people to learn about the effects of sewage pollution, to repair problems, and to discover the value of learning about nature in order to foster a sense of protectiveness and stewardship.

By participating in stakeholder-identified regional efforts to clean up Eagle Creek through monetary and educational resources, NKHD and our project partners addressed these objectives from Sections 16 and 21:

- **Produce and disseminate a comprehensive Watershed Based Plan for the Eagle Creek Watershed.**

This project produced the first Watershed Based Plan in Kentucky as now required by EPA for all section 319(h) grants. Because of this WBP, NKHD was able to continue abatements of septic systems in the target subwatershed in a second 319(h) grant which was awarded in 2009.

Several lessons were learned during the writing of this plan, such as working through the complexities of meeting the nine criteria required of such a plan, finding accurate and timely sources of data supporting each criterion, and assembling this mass of information in a comprehensive and usable document. The experiences brought to light in writing this WBP were shared in October 2005 with a coalition of groups led by Kentucky Waterways Alliance (2010) which influenced the development of a **Watershed Planning Guidebook for Kentucky Communities.** This guidebook helps groups through the challenges of writing a WBP.

This grant was written without knowledge that the WBP requirement would be added during the MOA phase. It was apparent that for subsequent projects a WBP would be a vital first step. In the time since, it has been observed through other projects in the region that the WBP is often, but not always, combined with a measure of implementation if it is produced through an EPA 319(h) grant

- **Reducing pathogen impairment of Eagle Creek by reducing pathogens in Tenmile Creek.**

The Onsite Wastewater Incentive Grant Proposal (OWIGP) was successful in funding repairs of 34 high impact problem septic systems. The level of success achieved was due in part to several outreach efforts. Newspaper articles, radio interviews, cable television interviews and a month long radio ad campaign got the word out about the program. At first there was low interest, but after the participation in the program by some "early adopters" it was apparent we had "buy-in" from the community. At project's end we had several requests for repair that were not able to fund. Good participation meant funding the abatement of problem septic systems with highest ranked impact on water quality, and thus maximizing the reduction of pathogens in this subwatershed.

The target goal of 40 septic systems repaired or replaced was closely matched by the actual installation of 34 system repairs. Several systems required pumping to higher elevations than the septic tank or required the addition of large amounts of topsoil to effectively cover new lateral fields. Many more systems than anticipated required new septic tanks. As such, we did not meet the target goal. However, all the funds allocated for installations were spent.

The following is an example of a before and after system. Photos were scanned from Polaroids. All photos taken are available for viewing upon request.

Lessons learned for this objective were …

- Identify influential people in the region who can endorse the program and are willing to help get the word out.

Monitoring results

Although statistical analysis showed the likelihood of improvement when several statistical tools were applied to the data, there remain several unanswered questions about the quality of the data even after a year of investigation. In short, which data were faulty remains unclear. For instance, fecal coliform and E. coli values were repeatedly seen throughout the project to have a nearly one-to-one value. No matter how high or low, the E. coli had nearly identical values to fecal coliforms. This trend was observed whether membrane filtration methodology was used for both pathogen analyses, or if IDEXX colilert methodology was used for the E. coli and membrane filtration methodology was used for fecal coliform. Akasapu and Ormsbee (2011) assert that the models of the relationship of E. coli to fecal coliform values based on many years data for four states predicts that E. coli should always be less than fecal coliform, since E. coli are a subset of fecal coliform bacteria. For lower counts, it is possible for values to be similar, but for values of fecal coliform greater than 100 cfu, the E. coli counts should be much less and this was not the case in our data. See Table 8 (all project monitoring data) in Appendix F.

It is particularly troublesome that this trend occurred throughout the project in spite of differing methodologies. And even though data was submitted and requested to be reviewed every year, this problem was only recognized as serious during the final data analysis. In addition, an intensive review of the lab and other investigation did not shed any light on the source of this error.

However, no matter what the perceived or observed failings of project partners, it remains first and foremost the responsibility of NKHD to ensure the quality of the data by becoming knowledgeable and being diligent to recognize a problem when it arises or is pointed out, then assiduously pursuing it to a satisfactory resolution.

However, it is worthwhile to point out that the statistic analysis definitely shows statistically significant improvement for both fecal and for E. coli data.

Lessons learned for this objective were …

- Regarding monitoring, many new safeguards have already been put into place for the next phase of this project, consisting of a two year monitoring program combined with funding for around 20 additional septic repair/replacements within the watershed based plan for this Tenmile Creek subwatershed. Some examples of the safeguards are,
  - detailed contracts with labs specifying SOPs and practices to be used
  - early data and quality control review
  - randomized date for additional data and quality control review
  - procedures to investigate quickly anomalous data and sources of error
  - field splits in which two labs will analyze two aliquots of the same sample water. The main lab will know two field splits will be performed per monitoring season, but will be kept blind as to the exact date.

- **Enhance community involvement in watershed protection.**

Outreach events held for this effort were designed to educate the community about watershed issues ranging from sewage and onsite waste water to animal manure and siltation of streams.

Displays at county fairs and festivals, streamside and lakeside field days for both children and adults, and silt prevention workshops, as well as numerous presentations succeeded in exposing over 2000 people to watershed issues that face this county and this region. Although sign in sheets have not been located for this project (following the problems with the social marketing campaign, their use was sporadic), numbers of participants were recorded for each event, and are contained in the Event Journal, Appendix D figure 45. Appendix D also contains all the outreach materials developed for this program. Specifically for this objective, there were 6 newspaper articles published in the Grant County News and a radio advertisement heard for the entire month of March 2007 Williamstown radio station WNKR (Appendix D, figures 19-26).

Low participation plagued our outreach efforts, especially the social marketing piece. In spite of sending postcards to all area residents, being interviewed on local cable television, and offering participants reimbursement for attending focus groups, we still had very low numbers. The 3/20/06 focus group had 5 participants, and the 4/10/06 focus group had 8 participants. Due to low participation, it was determined that the surveys would not return useful information, so the before and after surveys were not used for the workshops and field days.

This campaign aimed to "evaluate attitudes prior to the installation of abatement measures and educational events, and … provide input and focus during the project, and … provide a way of measuring the impact of educational events on the attitudes and behaviors." Because of very limited participation, though, enough data could not be generated to draw valid conclusions. In spite of this potentially bleak situation, however, a sense of attitudes prior to the education and implementation portions of the grant was gained allowing some ideas to be gleaned and these were used to guide and focus education outreach efforts.

Kentucky River Watershed Watch was alone among the project partners to see any kind of increase in participation, and of the nine members added in the Northern Kentucky area during this project, only three have stayed active, and these three did not join as a result of the Eagle Creek Straightpipe Abatement and Education Project.

Low participation also in workshops led to changes in the way these were marketed. Initially flyers were passed out and word of mouth used. It was determined that combining these outreach efforts with existing meeting of groups likely to be interested in the subject matter allowed us to present to captive audiences. One field day was changed to allow more interaction with students involved with an innovative middle school science grant. The other was a fishing event aimed at families, which also suffered low participation, but it was rewarding to see families that did attend get high impact attention. In this case, because of the low participation rate, all the families that attended were able to win very nice prizes that had been funded by the Eagle Creek Watershed Council, and were able to get close attention by the event presenters. So in a sense, we didn't have impact on a lot of people, but we had a lot of impact on a few.

Lessons we learned for this objective were:

- The right partnerships can make a big difference. Combining our efforts with a teachers innovative science grant allowed good, concentrated and targeted efforts to educate kids who were interested and active participants, which advanced both the schools objectives, as well as this objective to enhance community involvement in watershed protection. By fostering a spirit of stewardship in these kids, we hope to create a community mindset where making good environmental decisions will be easier than making bad ones.
- Captive audiences with similar interests were a good way to get a message to a target group
- Social marketing won't work well with low participation. A pre-study is needed if social marketing is to be used.

Indeed, these lessons were incorporated into the second phase of this project, were we were funded through a separate EPA 319 (h) grant in 2009 to install 20 more systems. Because of the difficulties with low participation rates, it was felt that concentrating on installations of repairs and monitoring were better uses of money, so this 2009 grant design reflected these lessons.

- **Develop demonstration of how environmental education efforts and improvements to water quality of Tenmile Creek can reduce nonpoint source pollution in Eagle Creek and lead to increase in community involvement in watershed protection.**

During the project, the Event report and journal were combined into one. Information on venue effectiveness, presenter information, displayer information, analysis of event and ideas for similar events were kept for each event. Flexibility was incorporated into planning and wherever possible, lessons from one event were applied to the next. One example is the lone participant of the 2/28/07 workshop on sediment, silt and erosion prevention leading to a change where the same presentation was given to the Grant County Cattlemen's association on 4/7/08. In collaboration with our presenting partner, material was offered to this audience that was known to be of interest to this particular group, and being part of an existing meeting, it was delightful to have an audience that was 2000% larger than the 2/28/07 event (20 participants instead of 1).

Outreach materials distributed to the community consisted of 6 newspaper articles published in the Grant County News and a radio advertisement heard for the entire month of March 2007 Williamstown radio station WNKR (Appendix D, figures 19-26). Appendix D contains all other outreach materials produced for this grant, such as interview fact sheets, website content, presentations, PowerPoint with summary of fair displays, materials used in classes, etc.

Lessons learned for this objective were:

- The demonstration aspect is perhaps the most difficult part of this grant. The challenges of the outreach program mean that attitudes could not be measured quantifiably. The problems that occurred during monitoring meant that the overall improvement, though statistically significant, was clouded with unanswered questions about data validity.

- It is not practical to offer this final report as a comprehensive guidebook for others who want to apply for EPA 319 grants, especially in view of the fact that ours had the first Watershed Based Plan in KY. This WBP proved to be very difficult to produce with nothing to go by for local guidance. The KWA guide to WBPs is a more efficient tool than materials that could be developed as a result of this grant.

- The demonstration of the Onsite Wastewater Incentive grant has indeed been valuable. The Banklick Watershed Council has drawn heavily on our experiences in implementing a sewage abatement grant. The Onsite Wastewater Incentive grant application, evaluation, ranking forms, and protocols were shared with BWC, and BWC has integrated them into their BMP implementation plan with very few changes. Our experiences have allowed community involvement in watershed protection to increase in our region by helping provide readymade materials that were put into use immediately, as well as outreach materials such as newspaper articles which are planned to be published in county newspapers.

Overall conclusions:

Although outreach was disappointing, there were some encouraging developments. Newspaper articles which had been published in the Grant County newspaper were shared with another 319(h) project. The outreach efforts did succeed in exposing more than 2000 people to watershed issues, some in a very high impact way, like the families whose kids caught their first fish ever during one event. And in an interview with a local game warden, Officer Charlie Phillips, he said in spite of a decline in the last ten years in the number of hunting and fishing licenses, there have been increases in recreational boating, archery licenses, fishing licenses, and horse trail riding.

Monitoring results were particularly troublesome, because such a long period of collecting data was followed by the anguish of finding that the data were questionable. This could have been prevented by different quality control methods and more diligence during the project as to what the results *mean* and what they *indicate*. However, it has been pointed out that this large data set does have some value. There are indicators that show that fecal coliform and E. coli values are within the ranges of what are expected, and that overall, there is statistically significant improvement in both fecal coliform and E. coli values between all 2004-2006 data and all 2007-2009 data.

The Onsite Wastewater Incentive Grant was really the highlight of this grant. It allowed 34 problem septic systems to be corrected in a long term way, effectively and permanently eliminating large amounts of sewage that had been flowing into Tenmile Creek and ultimately into Eagle Creek. In spite of difficulties with monitoring, it is certainly an accomplishment that large amounts of sewage are now contained and treated by natural soil processes instead of fouling these streams. When figures developed for load reduction estimates for this project are used, it can be seen that an estimated 5200 gallons per day of untreated sewage is not entering Eagle Creek. That amounts to almost 2 million gallons per year.

The work done in developing this Wastewater Incentive Grant has proven valuable to taxpayers already in the sense that both outreach materials and forms like protocol, ranking scales, etc have been shared with another similar project in our region. The Banklick Watershed Council has incorporated many elements from our Best Management Practices Implementation Plan into their own, and is in the process of using it for a straightpipe abatement and repair project in our region. Because NKHD sits on the BWC board as advisors, it has been rewarding to be able to use our experiences and observations, our achievements and challenges to help them during the writing of their grant, and currently in the implementation of septic related objectives.

Further, the lessons learned have been vigorously applied to the related phase of this project. As we near sampling season 2011 for the 0907 grant, we rest in the assurance that quality control checks and balances, improved communications, specific contracts and standard operating procedures, as well as the battle-scarred and painstaking knowledge borne of this difficult journey will result in a bright and shiny data set worthy of any hydrologist's scrutiny.

Learned

Overall, in this project several things were learned:

- Reputable early adopters and local Certified Onsite Installers were important to ensuring participation in the Onsite Wastewater Incentive Grant (OWIG).

- Flexibility in planning was valuable, allowing the project to adapt to more successful methods of outreach when low participation plagued early efforts

- Monitoring results showed aberrant patterns that were not apparent until final data analysis was performed at the end of the project. Systematic review of data quality early in the project could have prevented such problems.

- Our experiences through mid-project combined with a published Watershed Based Plan allowed us to continue to fund monitoring and septic repairs and replacements in this same project area through 2012 through a related but separate EPA 319(h) grant.

Ultimately we have been able to demonstrate that through a project like this, thousands of citizens can learn about watersheds, and millions of gallons of untreated sewage can be eliminated from the waters of the commonwealth.

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I. Appendices

Appendix A.

Financial and Administrative Closeout

Appendix B.

QAPP for Water Monitoring

Appendix C.

BMP Implementation Plan and Materials

Appendix D.

Education Outreach Materials

Appendix E.

Materials Relating to Monitoring

Appendix F.

Materials Relating to Results