Water Quality Report

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Abstract
Water quality studies involved regular testing of physical chemistry parameters and pathogen indicators. Four three-point transects were set (using GPS and GIS technologies) across in specific places in pools 2 and 3 of the Ohio River. These sites were sampled over a six week period in dry weather conditions. Single point sampling sites were also placed at the mouths of all streams. The field sampling and the results do not reflect the PA DEP or US EPA water quality sampling criteria, which would require 5 samples in 30 days averaging both wet and dry weather conditions. A minimal wet weather study was also conducted.

Rivers in Dry Weather: Our sampling indicates that dry weather water quality conditions in the Ohio River Pools 2 and the upper section of Pool 3 meet our target water quality standard for recreational use most of the time. The exception is Mile Point 11.9, left bank descending, by the Sewickley Bridge.

Rivers in Wet Weather: Our data suggest that the Pittsburgh Pool and Ohio River Pool 2 are impacted by fecal contamination the days following a wet weather event. This is based on minimal wet weather events and further studies are suggested.

Tributary Streams: Our study shows that during dry weather, fecal coliform concentrations vary among the tributary streams studied. Three streams had geometric means for fecal coliform greater than 1,000 CFU/100ml. Chemical and field tests indicate most parameters are within an expected range for this region and within state water quality standards.

Comparitive conclusion: Our study indicates that during dry weather most of our sampling sites along the Ohio River are below our target number for fecal coliform, indicating little fecal contamination. The majority of the tributary streams sampled have fecal coliform concentrations lower than 300 CFU/100ml and E. coli concentrations lower than 200 CFU/100ml. Wet weather river water quality is impacted by fecal pollution in both the Pittsburgh Pool and Ohio River Pool 2. The project recommends future studies to determine the sources of the fecal pollution utilizing molecular and biochemical methods.

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I. Introduction

The 3 Rivers 2nd Nature water quality study is a strategic program developed by the STUDIO for Creative Inquiry, in partnership with 3 Rivers Wet Weather Inc. (3RWW), ALCOSAN, and the Allegheny County Health Department (ACHD). It is intended to reveal patterns and relationships between water quality, public use, and the functioning ecosystems of our urban river systems. The project provides a relatively short-term, low-budget, strategic survey of water quality over a broad geographic area. This project began in 2000 in the Pittsburgh Pool. In 2003, Year 4, the project focused on the Ohio River from the Edgeworth Lock and Dam to the edges of Allegheny County.

Urban rivers have been used as a source for municipal water supply and as a sink for sewage and industrial wastes. Over the last century the rivers have been redesigned as regional infrastructure to accommodate shipping and other commercial purposes. This view of the rivers as a raw material for industry and as an alternating source of water and sink for municipal wastes has displaced their value as a natural resource and an important amenity among the general public. However, the emphasis is beginning to shift from industrial-commercial uses of the rivers to public access, recreational uses and the combined aesthetic and economic values which stem from natural urban amenities. To facilitate this change, the larger 3 Rivers 2nd Nature program seeks to illustrate opportunities such as intact habitats, increased biodiversity, good water quality, and easy public access. By also recognizing current constraints, such as sewer infrastructure problems and habitat loss, the program hopes to initiate a public dialogue that will help solve these problems. This work will begin to fill the information gaps that limit our ability to discuss these issues.

This method and process are informed by a group of interdisciplinary advisors, public health officials, engineers and biologists from academia, regulatory, state and federal agencies. They provide expert guidance throughout the study.

Goals and Objectives

The goal of the water quality program is to reveal the dynamic nature of water quality in our region. We seek to define water quality in the context of increased public access to the rivers and tributary streams of Allegheny County. This project constitutes the initial attempt to establish a protocol that can be used by other agencies and organizations to develop a regional water quality baseline. This baseline will be used to make more informed decisions and for comparisons to future water quality changes. It is not intended to determine regulatory compliance with water quality standards or provide data for future modeling of the river systems.

The objective of dry weather sampling is to understand how clean the water is in terms of pathogen indicators and to assess quality of the water over a broad sampling area. This sampling program provides an initial indication of the recreation and public access potential of Allegheny County's surface waters.

The objective of wet weather sampling is to understand how contaminated the water becomes in terms of pathogen indicators when it is raining, how quickly the water quality return to dry weather conditions, and how consistent these changes are over a wide sampling area.

We seek to answer the following questions about surface water quality in relationship to the region's rivers and tributary streams in a variety of weather conditions:

Rivers
Multiple site sampling, analysis and comparison of water quality, in both dry and wet weather conditions.

Dry Weather
1. What is the dry weather water quality and are there spatial variations in quality?
2. Are there water quality problems indicated at points of public access?
3. Are there specific areas that warrant further study? Why?

Wet Weather
1. What is the wet weather water quality and are there spatial variations?
2. Do the water quality spatial relationships change during a rainfall?
3. Are there space and time differences in returning to dry weather conditions?
4. Are there specific areas that warrant further study? Why?

Because this study is concerned with public use issues, the rivers were monitored for bacteria that indicate the presence of fecal matter as well as basic field parameters such as temperature, pH, and dissolved oxygen. Additional chemical and physical analyses were outside the main public health objective of this study:

Tributary Streams: Single site sampling and analysis of water quality in dry weather conditions.
1. What is the dry weather water quality and how does it vary among the streams?
2. Do the streams affect the water quality of the main stem rivers?
3. Are there water quality problems at points of public access?
4. Does each tributary have the minimum conditions to support aquatic life?
5. Do these tributary streams warrant further study? Why?

In order to develop an initial understanding of the water quality for tributary streams and determine if they have the basic conditions to support aquatic life, the project advisors recommended additional chemical and physical analyses. They also recommended a biological study of the rivers, which began in 2001. A team of biologists with the U.S. Army Corp of Engineers have matched this study stream by stream (Koryak & Stafford, 2001, 2002, and 2003).

Public Access Overview:

There are a variety of forms of public access. In 1996, Terrestrial Environmental Specialists Inc. et. al. was commissioned to assess recreation along the three rivers in Pittsburgh. Public access was defined as formal public parks, commercial marinas, and fishing access. In the Riverbank Conditions component of this study, an increase in marinas on the rivers was documented, as well as a vast number of informal public access points that are favorite sites for fishing, sunning, and other leisure activities.

In the context of water recreational activities, the focus is generally on access to the main stem rivers. However, it is important to note that there is more potential for informal access along our region's tributary streams than rivers. In the 3 Rivers 2nd Nature study area, tributary streams wind through many neighborhoods, dozens of communities and a significant number of public parks as illustrated in the project's Geographical Information System.

II. Materials and Methods

Sampling was conducted from a 16' aluminum boat with a jet propulsion system. This sampling platform allowed the project team to move safely into shallow creeks and tributary streams as well as approach near shore structures in shallow water.

The dry weather sampling was limited to Pool 2 and portions of Pool 3 on the Ohio River. Pool 2 is delineated by Emsworth Locks and Dam at Mile Point 6.2 to Dashield Locks and Dam at Mile Point 13.3. The Pool 3 study area is delimited by Dashield Locks and Dam to the Allegheny County line at Mile Point 15.5.

The wet weather sampling included areas in Pools 2 of the Ohio River as well as areas of the Pittsburgh Pool.

SEE ATTACHED MAPS FOR OVERVIEW OF SITES

Dry Weather Sampling Program

Sampling Schedule

Sampling occurred from the period of June through November during dry weather when public recreation is at its greatest and the best opportunity exists to provide baseline recreational use conditions of the river systems. Dry weather conditions are defined as a minimum of 72 hours after the last rainfall.

One river system was sampled one to two days per week (weather permitting), resulting in no more than 24 samples per test run (ACHD laboratory limit). This included river sampling points as well as tributary streams. Weekly sampling occurred Monday through Thursday within the dry weather criteria.

Weather Conflicts

The planned schedule for 2003 of 6 sampling events per pool from June to September was not possible due to the frequent wet weather events that occurred throughout the summer. The sampling protocol required that there be no rain for 3 days or 72 hours prior to sampling and that sampling occur on Monday through Thursday (due to laboratory restrictions). This limited sampling to only 5 events in Pool 2 and 4 in Pool 3. Sampling occurred into early November. Despite limited sampling opportunities, it is important that the protocol remain unchanged so that data comparisons can be made for over the 4 years of the study.

River Monitoring

Sample sites were chosen based on the relationship between public access and inflow points into the main stem rivers (see Table 1 below). Tributary streams, culverted tributaries, and combined sewer overflow structures were considered inflow points. (A detailed analysis of mixing zones and hydraulic function is beyond the scope of this investigation.)

Cross sections were established at four points within each pool of the Ohio River in Year 4 study area. Cross-sectional samples were taken at three points across the river (50-100' from the left descending bank, midstream and 50-100' from the right descending bank) at approximately 12 to 18 inches below the surface. This depth was selected based on our interest in public recreation. (Swimmers and recreational users are primarily in contact with the surface of the water.)

TABLE 1: Selected River Monitoring Sites in the Ohio River Pools 2 and 3.

Ohio River Pool	Mile Point	Site Description
2	8.0	Below Emsworth Lock and Dam
2	10.1	Below Neville Island
2	11.9	Sewickley Bridge
2	12.9	Above Dashields Lock and Dam
3	13.7	Below Dashields Lock and Dam
3	15.6	Allegheny County Line

River Monitoring Parameters

The parameters in Table 2 were selected to determine the public health aspects of recreational uses of the rivers. See Appendix A for the Pennsylvania water quality criteria and descriptions of the additional field parameters selected. Sampling protocols followed

TABLE 2: Selected Parameters for Rivers and Tributary Streams in the Ohio River Study Area (methods taken from APHA et al., 1992 except as noted)

Parameter	Justification	Field/Lab	Method
pH	Important for aquatic life	Field Test	4500-H B
Temperature	Important for aquatic life	Field Test	2550 B
Conductivity	Important for aquatic life	Field Test	2510 B
DO	Important for aquatic life	Field Test	4500-O G
Total Coliform	Data gathered as part of *E. coli*	ALCOSAN Lab	Idexx
E. coli	Indicator species of mammalian fecal	ALCOSAN Lab	Idexx
Enterococci	Indicator species of mammalian fecal	ALCOSAN Lab	Idexx
Fecal Coliform	Indicator for fecal contamination	Allegheny Co. Lab	9220 D

Standard Methods (APHA et al. (1992) Sec. 9060). Total coliform, E. coli, and enterococci followed defined substrate method (Idexx Laboratories, Westbrook, ME).

Tributary Stream Monitoring

Tributary streams that flow into the Ohio River were investigated in this survey (see Table 3). One sample site per tributary stream was selected at the lower end of the stream above the mouth to the river. These sites were selected to assure that no backflow from the rivers were affecting the samples. This was determined by the first stream riffle, based on access by foot or by boat. Cross-sections were not established in the tributary streams because the widths of the streams were less than 15 feet.

TABLE 3: Selected Tributary Monitoring Sites in the Ohio River Study Area

Tributary	Pool
Toms Run	2
Kilbuck Run	2
Montour Run	2
Moon Run	2
McCabe Run	2
Thorn Run	2
Narrows Run	2
Hays Run	2
Little Sewickley Run	3
Flaugherty Run	3
Big Sewickley Creek	3

TABLE 4: Additional Parameters for Tributary Streams in the Ohio River Study Area

Parameter	Justification	Field/Lab	Method
TDS	Toxic to aquatic life	ACHD Lab	2540 C
Ammonia	Toxic to aquatic life	ACHD Lab	4500-NH_3 F
Hardness	Indication of metals availability	ACHD Lab	2340 C
Alkalinity	Indicator of acid mine drainage	ACHD Lab	2320 B
Iron	Indicator of acid mine drainage	ACHD Lab	3500-Fe B
Al*	Indicator of acid mine drainage	ACHD Lab	3500-Al B
Cu**	Toxic to aquatic life – synergistic effect with zinc	ACHD Lab	3500-Cu B
Zinc**	Toxic to aquatic life – synergistic effect with copper	ACHD Lab	3500-Zn B

(methods taken from APHA et al., 1992)
*Dependent of pH value. If above 8.0 or below 3.0, sample will be analyzed for Al
**Dependent on analysis of upstream NPDES discharges.

Tributary Monitoring Parameters

Tributary stream parameters included those in Table 2 as well as additional chemical and physical parameters listed in Table 4. (See Appendix A for parameter descriptions.) Due to laboratory restrictions, only 3 samples per stream were taken, instead of the planned 6.

Wet Weather Sampling Program

Wet weather sampling focused on bacteriological analyses and basic field parameters (Table 2) limited to no more than 24 samples per testing-run. In 2001, the Allegheny County Health Department requested concurrent sampling for wet weather in the Pittsburgh Pool as well as in the study areas so that an overview of upstream/downstream relationships can be developed. The Three Riverskeeper provided the boat for the concurrent work in the Pittsburgh Pool. The sites for wet weather sampling are as follows:

Pittsburgh Pool – The last transects on the Monongahela and Allegheny Rivers above the confluence of the three rivers, Mile Points 0.23 and 0.18, respectively. Two sites on the Ohio River, upstream of Brunot's Island and upstream of Neville Island at Mile Point 6.2.

Ohio River – Pool 2, Mile Points 10.1, 11.9, and 12.9 (downstream of Neville Island).

SEE ATTACHED MAPS FOR OVERVIEW OF WET WEATHER SITES

A wet weather event (rain storm) was defined as occurring after a period of 72 hours since the previous rainfall, as recommended by USEPA (1992) for storm water sampling. ALCOSAN combined sewer overflow data, weather forecasts, and rainfall data provided the best indicator of broad-scale regional rainfall and wet weather impacts in the Ohio River basin. The ALCOSAN wet well and interceptor systems (upstream of the Ohio River study area) have been modeled to determine when overflows are occurring. This is based on the water flowing through the plant and wet well levels. This is the same indicator used by the Allegheny County Health Department's Regional River Water Advisory Program. Sampling occurred 12-24 hours after a rain event and for 2 days afterward. Rain gauge data are averaged from county-wide gauges of the 3 Rivers Wet Weather, Inc. calibrated rain gauge system.

Geographical Information System Mapping

Geographic Information Systems (GIS) have become an increasingly necessary component of analysis and decision making processes. GIS serve as a powerful tool in portraying data or a database spatially. In addition to the powerful querying capabilities, GIS displays information in the form of a map, a graph, or a report. GIS is continually enhanced by technological advancements, as well as peripheral device improvements (e.g. global positioning system technology).

GIS has been instituted in almost all aspects of 3 Rivers 2nd Nature project. The water quality team established procedural protocols and designated test sites. A Global Positioning System (GPS) was used for the initial site identification. The GPS was also used to navigate back to these sites for sampling. (Accuracy is within 30 feet.) These sites included river transects consisting of 3 points, designated stream test sites, and wet weather protocol. Each site was given a specific name, which will link the spatial location of the site and the data collected.

After the data collection process, the data was arranged in a relational database (Microsoft Access) compatible with ESRI ArcView 3.2 software. This allows the GIS software to connect to the database, enabling it to access existing tables and queries, as well as create its own using SQL (a database query language). This method allows the data to be maintained in a widely known format (Microsoft Access), allows for the storing of data in a common location (a database,) and allows for a streamlined database design. GIS served as a powerful tool for visualization with regard to the analysis of the river transects. By using thematic mapping, variations in parameter test values become more apparent. This can be seen in the GIS maps supplemental to the Water Quality Report.

III. Pathogenic Indicators

Water quality indicators like fecal coliform and *E. coli* indicate the presence of fecal matter in the watershed. Although fecal coliform and *E. coli* themselves do not cause sickness, they indicate the presence of other organisms that may cause gastrointestinal illness (APHA, et. al, 1992). The source of the fecal matter cannot be determined using routine laboratory analysis. Sources could include humans and other mammals such as raccoons, rabbits, or deer, or domesticated animals such as dogs and cats. Therefore, the methodology utilized here cannot determine if the fecal matter is from humans and occurring as a result of an aged and leaking sewer system, septic system, an improper connection of a sanitary sewer to a storm sewer, or combined or separate sanitary sewer overflows.

As stated above, the goal of this study was not to determine regulatory compliance. Therefore, the protocol does not meet the sampling requirements in the regulatory standards, stated below (5 samples per site per month). However, by sampling over a five-month period instead of one month, we were able to obtain a broader view of water quality in the Allegheny River during the recreational season. The regulatory standards will be used as a benchmark for indicating relative water quality.

Fecal Coliform

The Ohio River Valley Water Sanitation Commission (ORSANCO) has set fecal coliform standards for the water-contact recreational season from May to October. At a given site, fecal coliform data are not to exceed 400 Colony Forming Units (CFU) per 100ml in more than 10% of the samples during a month. The monthly geometric mean is not to exceed 200 CFU/100ml, based on no less than 5 samples per month. (ORSANCO Pollution Control Standards for Discharges to the Ohio River, 1997 Revision).

During the swimming season (May 1 through September 30), the Pennsylvania Department of Environmental Protection has set a maximum fecal coliform level at a geometric mean of 200 CFU/100ml, based on five consecutive samples, with each sample collected on different days in one month. For the remainder of the year, the maximum fecal coliform level is set as a geometric mean of 2,000 CFU/100ml, based on five consecutive samples collected on different days. (25 PA Code § 93.7)

Keeping with the intent of using the standards as a benchmark for our data, we consider 200 CFU/100ml as our target for fecal coliform in recreational waters.

E. coli

ORSANCO has developed a recreational standard for *Escherichia coli (E. coli)* in the Ohio River basin of 240 CFU/100ml for any single sample and 130 CFU/100ml as a monthly geometric mean, based on no less than 5 samples per month. (ORSANCO Pollution Control Standards for discharges to the Ohio River, 1997 Revision.) *E. coli* is being recommended by the U.S. Environmental Protection Agency (USEPA, 1999b) as an indicator organism to replace fecal coliform. However, the Pennsylvania Department of Environmental Protection has not yet adopted this recommendation.

Keeping with the intent of using the standards as a benchmark for our data, we consider 130 CFU/100ml to be an acceptable target for *E. coli*.

Historical Overview of Pathogenic Indicators

Enumeration of water quality indicator bacteria has always been a critical part of any water quality evaluation. The fecal coliform standard was first proposed in 1968 by the National Technical Advisory Committee of the Department of the Interior and was based on studies conducted at 4 different sites in the 1940's and 1950's (NTAC, 1968). At that time, total coliform was used as the indicator bacteria. Families at each beach site were asked to record their swimming activities and illnesses on a daily basis. From this study, it was determined that swimmers who swam in water with a median coliform density of 2,300 CFU/100ml had a higher rate of gastrointestinal illness when compared to the expected rate for the total study population. The coliform water quality index was translated into a fecal coliform index in the mid-1960's. It was determined that about 18% of the coliforms were found to be fecal coliform. Based on this ratio, 400 fecal coliforms per 100 ml would relate to statistically significant swimming-associated gastrointestinal illness. Since this was an unacceptable risk, the index was cut in half to 200 CFU/100ml, with no more than 10% of the samples above 400 CFU/100ml. The USEPA recommended this criterion again in 1976, despite criticisms of the study design and data sets. The fecal coliform indicator was also faulted because at least one member of the fecal coliform group has a non-fecal source. (USEPA, 1986)

The USEPA undertook further studies to address these concerns. In 1986, the USEPA recommended new standards for bacteriological water quality criteria based on *E. coli* for freshwater since it is the most fecal specific of the coliform indicators. The USEPA has reinforced this recommendation in its Action Plan for Beaches and Recreational Waters (1999b). Their goal is for all states to change their criteria from fecal coliform to *E. coli* or enterococci. At the time of this report, only one third of all states have adopted the new standards. This may be due to the uncertainty that states have for the applicability of the new standards and a reluctance to abandon the decades of data gathered for fecal coliform. Likewise, state governments might be concerned that a change in regulations could put into question previous public health conditions at local beaches or that large-scale, expensive wastewater infrastructure projects with goals based on existing criteria would need to be revised. (Isaac, et al, 2000)

Fecal coliform is the main water quality indicator used in Pennsylvania and a significant body of historical data exists for the region's rivers. However, the project recognizes the eventual shift from fecal coliform to *E. coli* or enterococci and therefore, selected *E. coli*, enterococci, and fecal coliform as indicator organisms for this study.

IV. Results of 2003 Ohio River Sampling

On the following pages you will find the results for our survey. The first two sections describe dry weather results for the two pools of the Ohio River. For each of the pools, graphs describe results for fecal coliform and *E. coli* sampling in dry weather and a table describes additional tributary stream data.

The third section describes fecal coliform and *E. coli* data for the Ohio River from the Pittsburgh Pool, sampled in 2000 to the Allegheny County line.

The fourth section describes wet weather results. Graphs illustrate water quality during rain events for fecal coliform and *E. coli*.

Geometric mean averages are used for fecal coliform and *E. coli* in this study to compare with the USEPA and PADEP standards that are based on geometric means. According to Standard Methods, APHA et. al., 1992, the best estimate of central tendency of log-normal data is the geometric mean. The geometric means are typically used in bacteriological data because bacteria reproduce geometrically and react to a range of environmental factors. Changes in temperature, for instance, can result in significant variance in potential numbers of colonies from the time the sample is first taken to the time that the laboratory analyzes the water. The geometric mean is intended to balance out this factor. Some researchers have debated the use of geometric means in environmental samples because it may underestimate the true mean value by downplaying the large values. They argue for use of the arithmetic mean as a more accurate measure of central tendency (Parkhurst, 1998). Although we use geometric means in this report, in Appendix B raw data can be found along with arithmetic means.

Ohio River – Pool 2

The Ohio River was divided into two sections for study. In Pool 2, the river was sampled at four transects and at the major tributary streams. Pool 2 was delineated by the Emsworth Locks and Dam at Mile Point 6.2 and the Dashields Lock and Dam at Mile Point 13.5. Due to the unusually wet recreational season of 2003, only 5 (instead of the planned 6) dry weather sampling events occurred from July 2 to October 1.

Figure 1 shows the geometric means of the fecal coliform data for Pool 2 in the Ohio River. Since our sampling scheme did not permit sampling to occur in a 30 day period and due to the wet weather in 2003, the data in Figure 1 do not conform to the recreational standards set by the PADEP and ORSANCO. However, the standards are used in this instance as a benchmark to indicate relative water quality. With this in mind, the Ohio River sites (indicated by Mile Points) except Mile Point 11.9 left bank are well within the geometric mean standard of 200 CFU/100ml. MP 11.9 left bank exceeds this benchmark, with a maximum result of 1800 CFU/100ml.

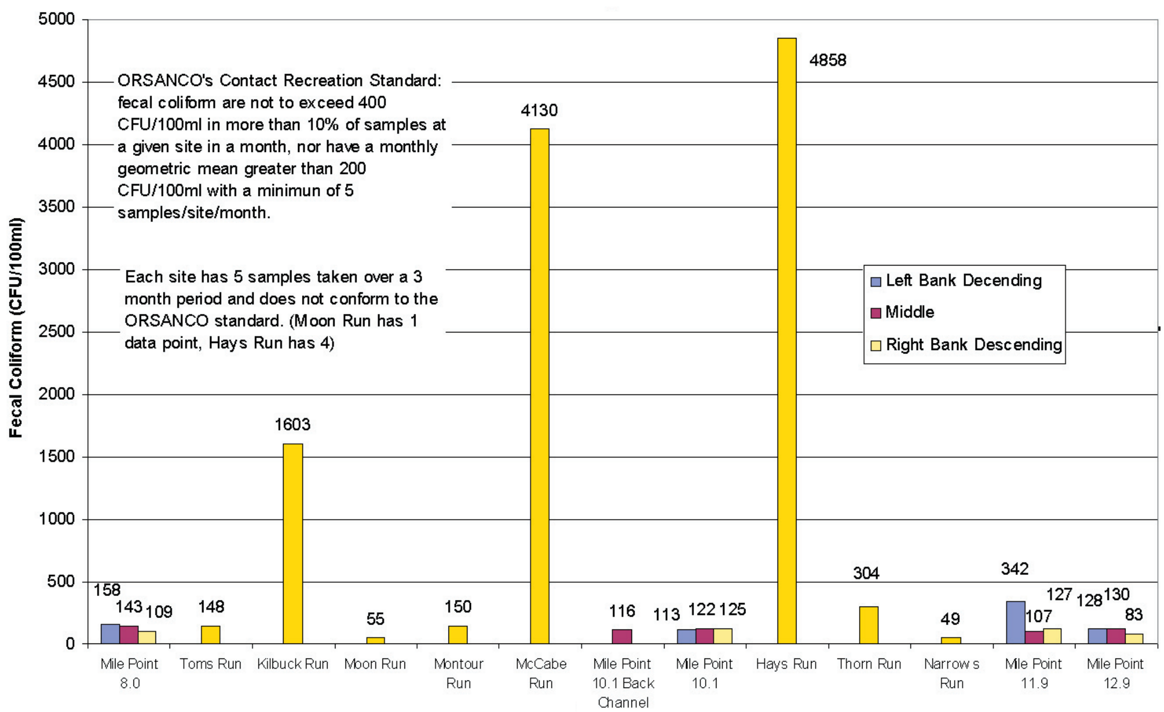


Figure 1.

Geometric Means of fecal coliform data for Pool 2 on the Ohio River from Emsworth Lock & Dam to Dashields Lock & Dam in dry weather, 2003 recreational season

Four of the tributary streams sampled were within the 200 CFU/100ml benchmark: Toms Run, Moon Run, Montour Run, and Narrows Run. Four tributary streams fall outside the 200 CFU/100ml geometric mean benchmark: Hays Run, McCabe Run, Kilbuck Run, and Thorn Run, at 4858, 4130, 1603, and 304 CFU/100ml respectively.

All the data for fecal coliform is included in Appendix B. The data taken during the sampling run of September 10, 2003 showed, in general, the highest fecal coliform results of any of the sampling runs. The river transect sites ranged from 305 to 670 CFU/100ml. Most of the stream data for September 10 was also higher than the other sampling runs. Most notable are McCabe Run at 158,000 and Kilbuck Run at 12,900 CFU/100ml. Results ranged from 24,000 to 113 for the other sampling runs for McCabe Run. Kilbuck Run data ranged from 2,310 to 385 for the other runs. The 3 Rivers Wet Weather, Inc., calibrated rain gauge system shows no rainfall at its 34 gauges throughout the county for 5 days prior to the sampling event on September 10. However, the gauges recorded an average of 3.4 inches of rain from August 26 to September 4. These heavy rains may explain the higher river results due to the residual effects of the combined sewer overflows from the Allegheny County Sanitary Authority. It is unclear if the streams were impacted on September 10 from this rainfall that occurred 6 days prior.

McCabe Run also registered Dissolved Oxygen results on September 10th, ranging from 2.6 to 5.23 mg/L. Temperature and pH were within acceptable limits. No odors were detected during the sampling runs.

Hays Run ranged from 3500 to 7800 CFU/100ml for all 4 sampling runs. No sample was taken on August 20, 2003 due to the difficulty in sampling the stream from the river.

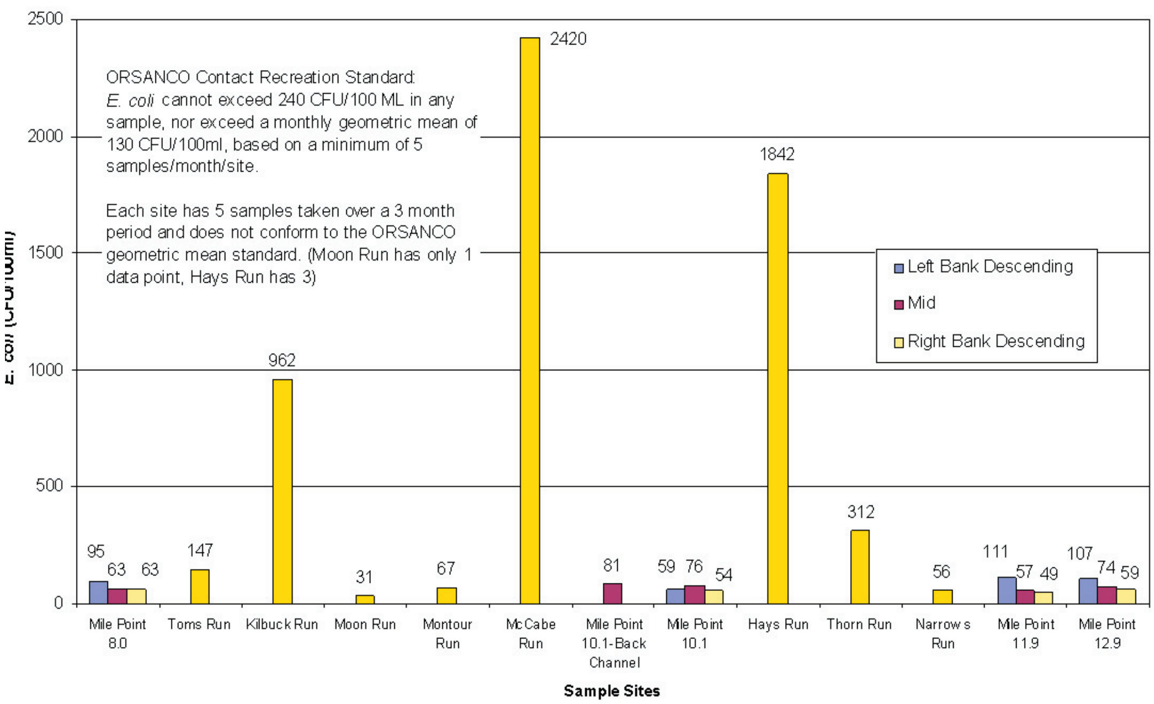


Figure 2.

Geometric means of E. coli data for Pool 2 of the Ohio River from Emsworth Lock & Dam to Dashields Lock & Dam in dry weather, 2003 recreational season

Figure 2 illustrates the *E. coli* data for Pool 2 of the Ohio River. The data in Figure 1 do not conform to the recreational standards set by ORSANCO, due to the wet weather in 2003 and the fact that our sampling scheme did not permit sampling to occur in a 30 day period. However, the standards are used in this instance as a benchmark to indicate relative water quality. With this in mind, the Ohio River sites (indicated by Mile Points) are within the geometric mean standard of 130 CFU/100ml. Appendix B contains all of the data for *E. coli*. Only 2 river sites, Mile Points 11.9 left descending bank, and 12.9 left descending bank, have individual data points exceeding the 240 CFU/100ml maximum, ranging from 326 to 613 CFU/100ml. Both sites had these high results occurring on July 31 and October 1, 2003.

The *E. coli* results for September 10th sampling run are not the highest as it is for the fecal coliform results for that day. Another sampling event on July 31 recorded the highest results for *E. coli*. According to the 3RWW rain gauges, an average of 0.26 inches of rain fell 4 days prior to the sampling event, possibly affecting the *E. coli* results in the river that ranged from 101 to 570 CFU/100ml.

Like the fecal coliform results, Kilbuck, McCabe, and Hays Runs had the highest *E. coli* results of the 8 tributaries. Kilbuck Run's maximum *E. coli* result occurred on September 10 at 1986 CFU/100ml.

McCabe Run's results for E. coli were all above the 2419 CFU/100ml upper detection limit. Hays Run had one data point above this limit. The two other data points for Hays were above 1000 CFU/100ml.

Additional Parameters
Tributary streams were sampled for the additional parameters of hardness, iron, ammonia, alkalinity, and total dissolved solids (TDS). Each stream was sampled 3 times for these parameters due to laboratory restrictions. Montour and Moon Runs had fewer samples due to difficulty sampling these streams from the river.

Table 5 contains average results of these parameters plus field parameters. All of the data can be found in Appendix B. McCabe Run's average dissolved oxygen (DO) is below the PADEP's water quality criteria minimum of 4.0 mg/L for warm water fisheries (Appendix A). Montour and Moon Runs both exceeded the TDS water quality criteria of a maximum 750 mg/L. Kilbuck Run, a designated cold water fishery, exceeded the maximum temperature criteria for CWF on 2 occasions. Ammonia concentrations are elevated for a number of the streams, with McCabe Run with the highest concentration of 0.391 mg/l.

Table 5. Average results from dry weather events for tributary streams for Pool 2 of the Ohio River from July to October, 2003.

	Temp* C	pH* SU	DO* Mg/L	Conductivity*	Hardness** Mg/L	Iron** Mg/L	Ammonia** Mg/L	Alkalinity** Mg/L	TDS** Mg/L
Toms Run	16.28	8.33	8.76	595	148	0.183	0.074	124	406
Kilbuck Run	17.93	8.29	8.68	902	176	0.160	0.1861	152	579
Hays Run	15.59	8.00	8.03	665	152	0.041	0.084	103	444
Moon Run	11.57	8.22	8.41	1320	277	0.017	0.0146	97	855
Montour Run	18.52	7.94	7.74	1267	215	0.129	0.090	126	828
McCabe Run	17.44	7.84	3.76	921	163	0.568	0.391	140	580
Thorn Run	18.06	8.28	8.63	670	155	0.165	0.0926	120	466
Narrows Run	17.90	7.91	9.15	1155	221	0.576	0.0758	130	753

*3 data points, except for Montour with 2 and Moon with 1
**5 data points except for Hays and Thorn Runs with 4 and Moon Run with 1

Ohio River – Pool 3

The Ohio River was sampled in Pool 3 at 2 river transects and 3 tributary streams. Our sampling was delineated by the Dashields Lock and Dam at Mile Point 13.5 and the Allegheny County line at Mile Point 15.5. Sampling occurred only 4 times (instead of the planned 6 events) from October 8 to November 3 in dry weather due to frequent wet weather events.

Figure 3 shows the geometric means of the fecal coliform data for Pool 2 in the Ohio River. Since sampling occurred only 4 times in a 30-day period due to the wet weather in 2003, the data in Figure 3 do not conform to the recreational standards set by the PADEP and ORSANCO. However, the standards are used in this instance as a benchmark to indicate relative water quality.

All of the geometric means for the Ohio River sites (indicated by Mile Points) and Little Sewickley Creek were below the 200 CFU/100ml benchmark. Geometric means for Flaugherty Run and Big Sewickley Creek were under 300 CFU/100ml. All of the data is shown in Appendix B. The maximum sample in Pool 3 is 3,000 CFU/100ml, taken at Flaugherty Run. Big Sewickley Creek

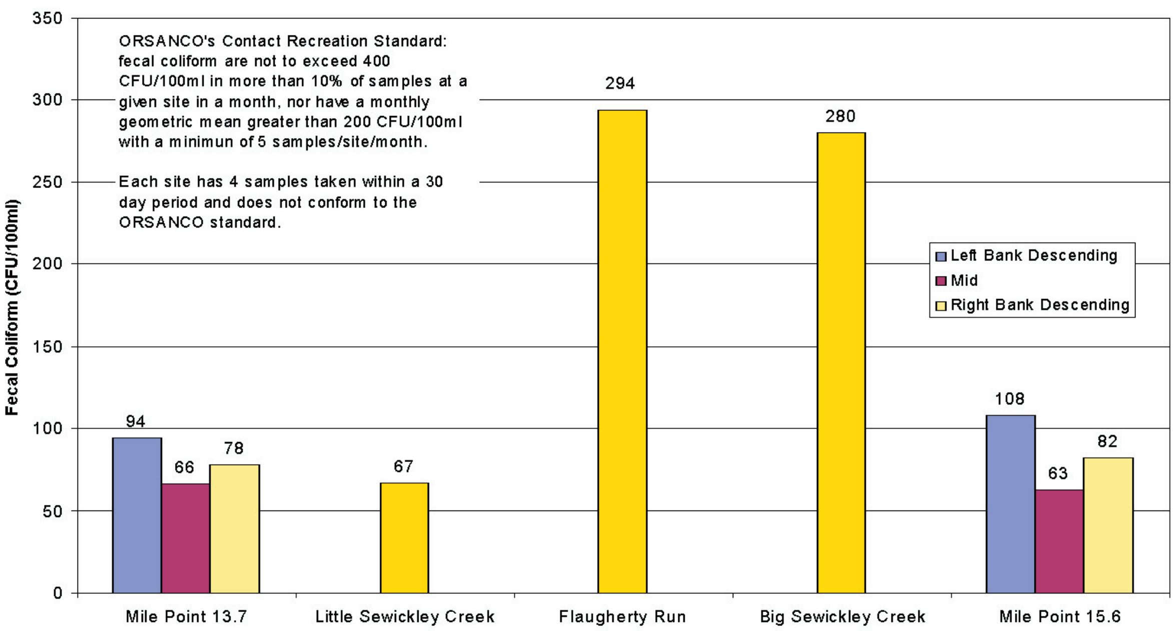


Figure 3.

Geometric Means of fecal coliform data for Pool 3 on the Ohio River from Emsworth Lock & Dam to Dashields Lock & Dam in dry weather, 2003 recreational season

ranged from 160 to 405 CFU/100ml. None of the individual river data points were above 200 CFU/100ml.

As described in Figure 4, the geometric means for the Ohio River sites, indicated by Mile Points, and Little Sewickley Creek were below the 130 CFU/100ml benchmark. Flaugherty Run and Big Sewickley Creek geometric means were above this benchmark for *E. coli*, similar to the fecal coliform results. The raw data are shown in Appendix B. Neither Little Sewickley Creek nor any of the river sites were above the 240 CFU/100ml maximum for any one sample. One sample for Flaugherty Run was above the 2419 CFU/100ml upper detection limit. Big Sewickley Creek samples ranged from 272-1203 CFU/100ml. The maximum samples for Flaugherty Run and Big Sewickley Creek occurred on the same day, October 9, 2004. The maximum fecal coliform results for these two streams also occurred on Oct. 9.

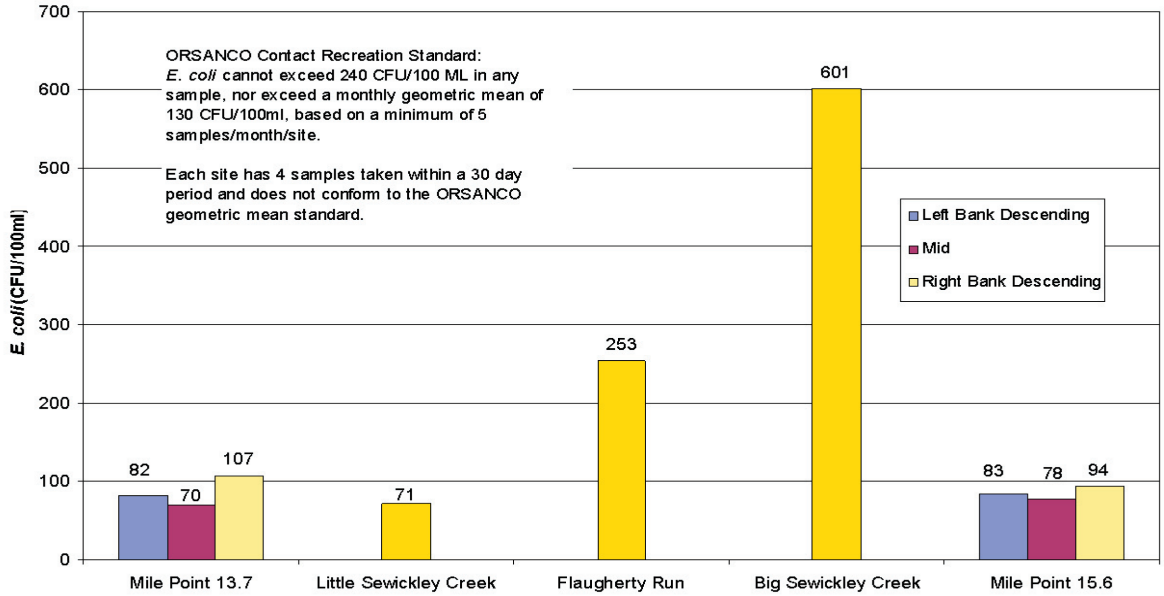


Figure 4.

Geometric Means of E. coli data for Pool 3 on the Ohio River from Emsworth Lock & Dam to Dashields Lock & Dam in dry weather, 2003 recreational season

Additional Parameters:
Tributary streams were sampled for the additional parameters of hardness, iron, ammonia, alkalinity, and total dissolved solids (TDS). Streams were sampled only 2 times for these parameters due to both laboratory restrictions and weather conflicts.

Table 6 contains average results of these parameters plus field parameters. All of the data can be found in Appendix B. Most of the parameters for the streams are within PADEP water quality criteria found in Appendix A. Big Sewickley Creek had an elevated Ammonia concentration of 0.139 mg/L.

Wet Weather

Three wet weather events were sampled in 2003 during the months of May and June. Sites in the Pittsburgh Pool consist of a transect on the Allegheny River above the confluence with the Monongahela River, one on the Monongahela River above the confluence with the Allegheny, and 2 transects along the Ohio River below the confluence of the Allegheny and Mon Rivers. The Ohio River Pool 2 wet weather sites consist of transects at Mile Points 10.1, 11.9, and 12.9. Sampling was conducted for 3 days following a rain event.

Table 6. Average results from dry weather events for tributary streams, Pool 3 of the Ohio River (Oct - Nov, 2003)

	Temp* C	pH* SU	DO* Mg/L	Conductivity*	Hardness** Mg/L	Iron** Mg/L	Ammonia** Mg/L	Alkalinity** Mg/L	TDS** Mg/L
Little Sewickley Creek	10.64	8.97	9.14	546	108	0.0376	0.0449	101	349
Flaugherty Run	11.97	8.58	7.73	817	171	0.0279	0.0502	134	531
Big Sewickley Creek	11.10	8.85	8.74	624	115	0.1394	0.0406	109	396

*4 data points, **2 data points

Many of the wet weather days coincided with small watercraft advisories due to the high flows and rough conditions in the rivers. This prohibited the sampling team from attaining complete sets of sampling data for two of the three events. Below are the data in graph form for 2 of the 3 wet weather events. The June 4 event is incomplete and shown only in Appendix B.

On May 13 and 14, *E. coli* data was collected for most of the sites in the Pittsburgh Pool and the Ohio River Pool 2 (Figure 5). An average total of 0.25 inches of rain fell across Allegheny County prior to sampling, according to the historical rain gauge data found at the 3 Rivers Wet Weather, Inc. website. Rain totals were calculated for each of the 34 rain gauges across the county. An average was then calculated for those meters that registered rain data.

As Figure 5 indicates, no Ohio River sites in the Pittsburgh Pool were sampled on May 13. Only Ohio River Mile Point 10.1 in Pool 2 was sampled on both days. This was due to the rough conditions of the rivers in May. However, the data indicate that E. coli concentrations at the river sites are much higher than dry weather conditions (2001 Report) for both the Pittsburgh Pool and Pool 2, and that the E. coli concentrations decrease in the subsequent days. This is also evident in the June 23-25 wet weather sampling event described below in Figures 6 and 7.
All of the wet weather sites were sampled during the wet weather event of June 23 to 25 in Figures 6 and 7. Within 24-48 hours of sampling, an average of 0.62 inches of rain fell across Allegheny County, according to the 3 Rivers Wet Weather Inc., rain gauge system. Rain began at 4:00 pm on June 20 and ended at 1 pm on June 21. This is approximately 42 hours prior to sampling. The data show that fecal coliform and *E. coli* concentrations were above 600 CFU/100ml during the first 2 days of sampling. The third day, all sites fell below 400 CFU/100ml for both pathogen indicators.

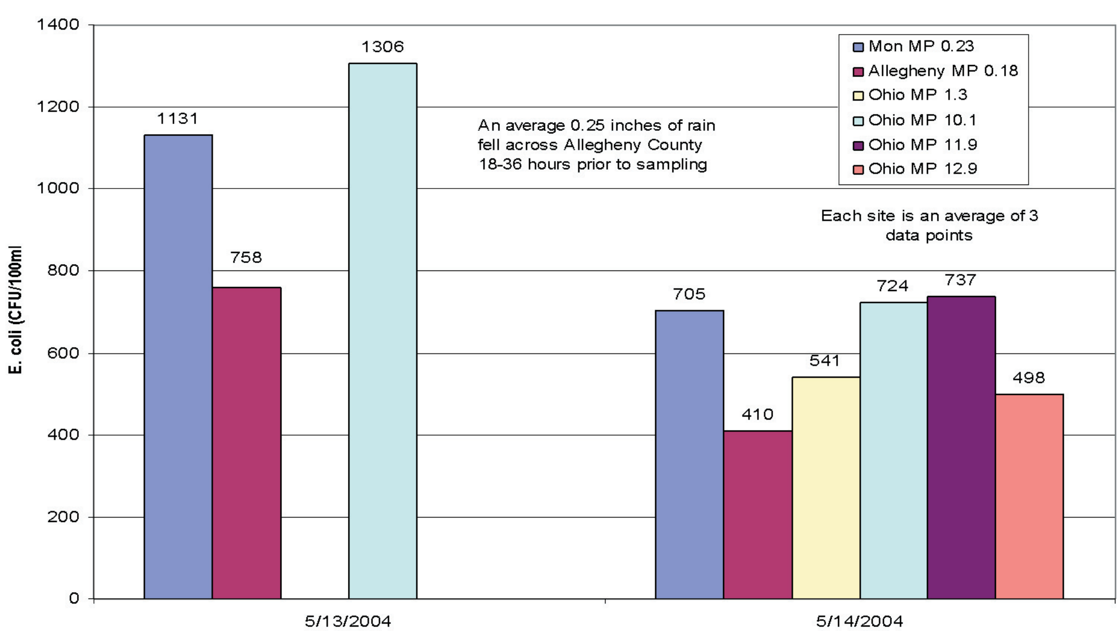


Figure 5.

Average E. coli Data for Select Sites along the Allegheny, Monongahela, and Ohio Rivers following a Wet Weather Event in May 2003

OhIo River Dry Weather Comparisons

Figures 8 and 9 illustrate fecal coliform and *E. coli* data, respectively, for the Ohio River from the confluence with the Allegheny and Monongahela Rivers in downtown Pittsburgh to the Allegheny County line. This section of river is 15 miles long flowing through mostly urban and suburban areas. In Figure 8, most of the sites are below the 200 CFU/100ml benchmark, except for the left bank of Mile Point 0.8 and 11.9. The maximum result for Mile Point 0.8, left bank was 2,300

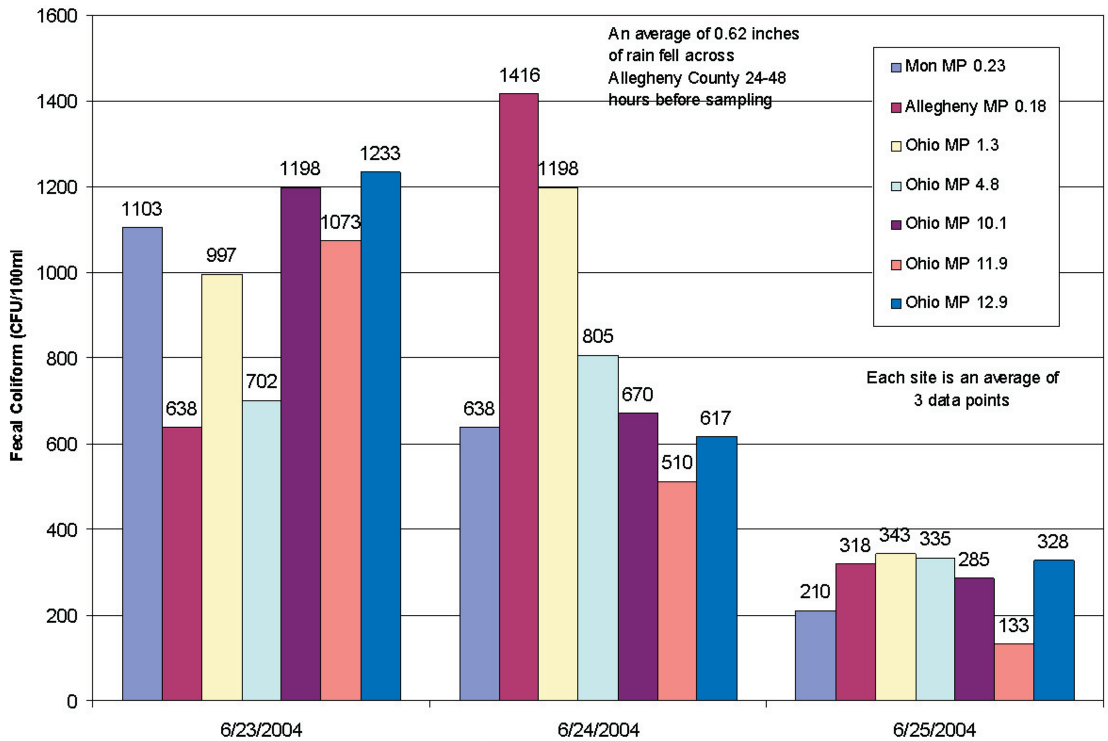


Figure 6.

Average Fecal Coliform Data for Select Sites along Allegheny, Monongahela, and Ohio RIvers following a Wet Weather Event in June 2003

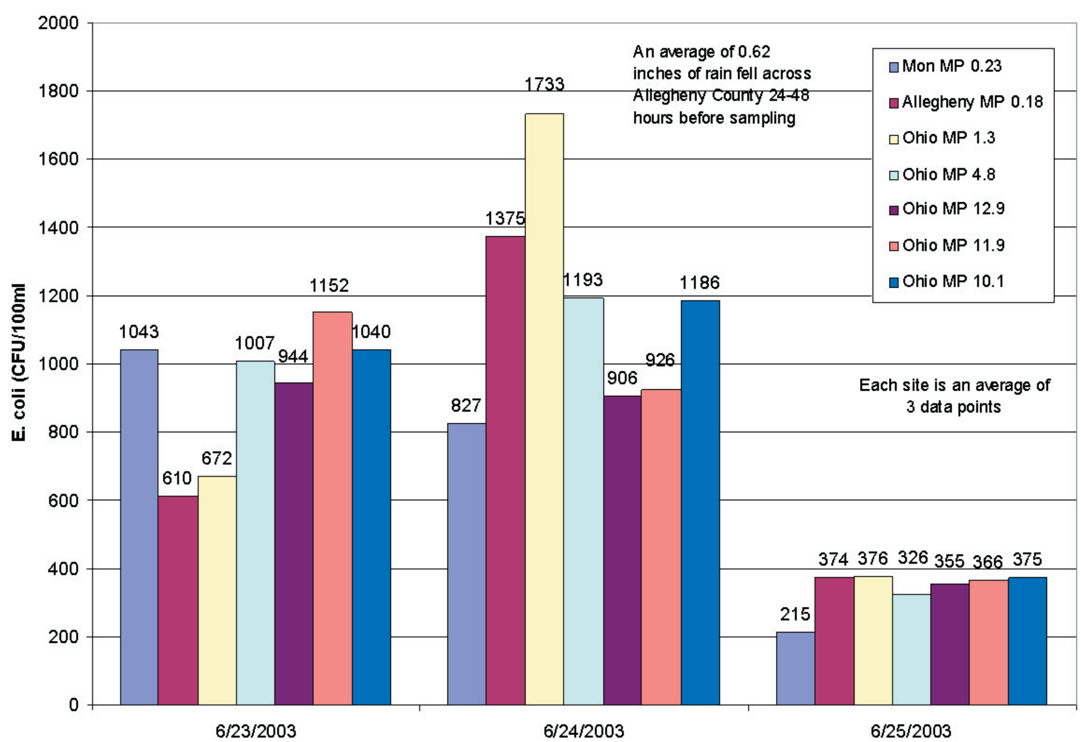


Figure 7.

Average E. coli Data for Select Sites along Allegheny, Monongahela, and Ohio RIvers following a Wet Weather Event in June 2003

CFU/100ml. The Monongahela River comprises this left bank side of the Ohio River as well as Saw Mill Run at Mile Point 0.8 below the West End Bridge. Saw Mill Run also had a maximum result of 14,000 CFU/100ml on the same day as the maximum fecal coliform result for MP 0.8. This also occurred at Mile Point 2.7 left bank, downstream of Chartiers Creek. Both Mile Point 2.7 and Chartiers Creek had maximum concentrations of fecal coliform on the same day, 2,900 and 575 CFU/100ml respectively. However, there is no obvious source of fecal coliform for Mile Point 11.9, which had a maximum result of 1,800 CFU/100ml on July 31, 2004. *E. coli* results indicate a similar pattern as fecal coliform.

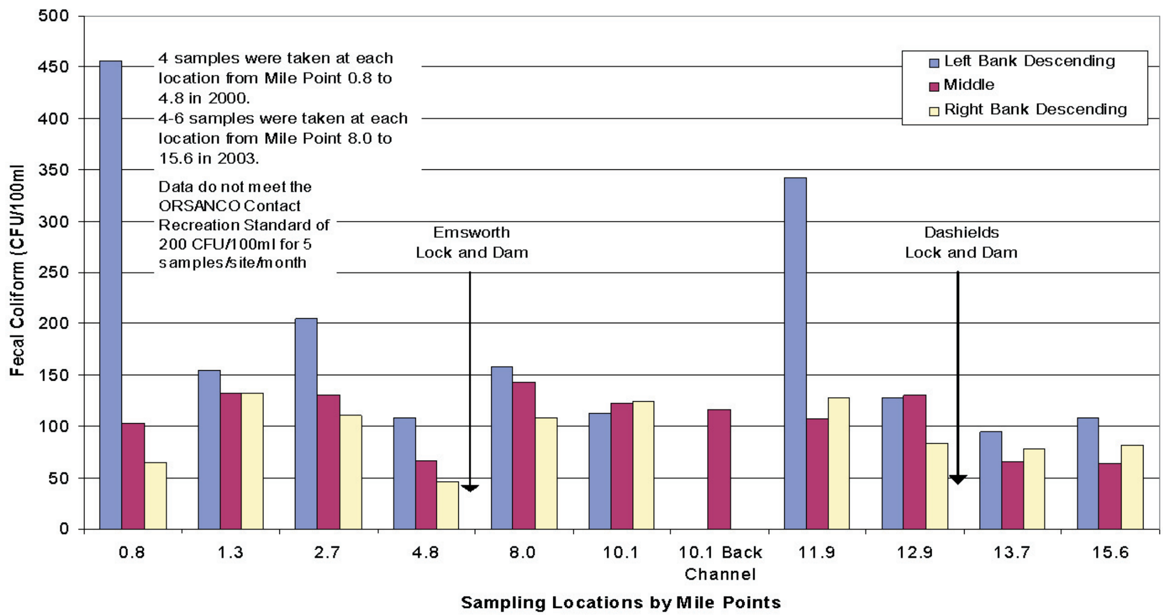


Figure 8.

Geometric Mean of Fecal Coliform Data for the Ohio RIver from the Confluence of the Allegheny and Monongahela Rivers to the Allegheny Co. Line in Dry Weather 2000 & 2003 Recreational Seasons

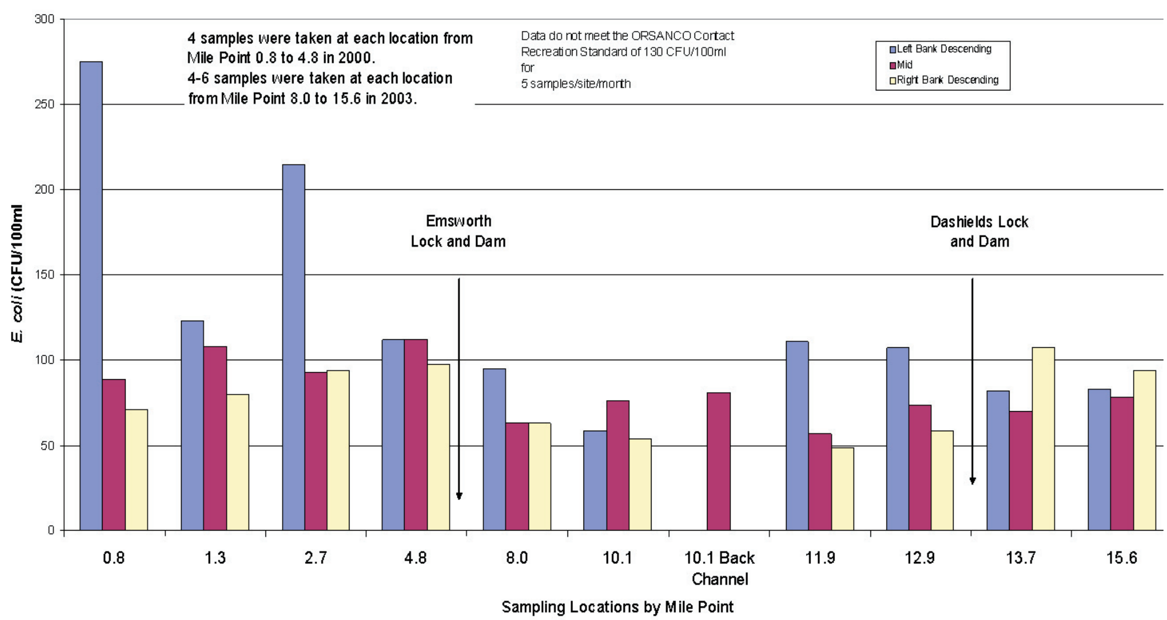


Figure 9.

Geometric Mean of E. coli Data for the Ohio River from the Confluence of the Allegheny and Monongahela Rivers to the Allegheny Co. Line in Dry Weather 2000 & 2003 Recreational Seasons

V. Water Quality Conclusions

This survey was developed to begin to understand the patterns and relationships between water quality, public use, and functioning ecosystems in our urban river system.

The project data indicate that fecal pollution impacts several of the Pools 2 and 3 Ohio River tributary streams in dry weather. This is a primary area for further study because the number of stream miles is four times the number of river miles. Streams frequently run through parks and neighborhoods.

For the most part, the dry weather conditions of the rivers are within the 200 CFU/100ml fecal coliform benchmark used in this study. Wet weather data indicate that the Ohio River Pool 2 is impacted by fecal pollution during a rain storm, as is the Pittsburgh Pool.

More sampling in both the rivers and tributary streams is needed to further define the relationship between water quality issues and public recreation opportunities. From a public health perspective, determining the sources of fecal contamination in the tributary streams should be a priority. Once sources have been identified, it is important to stop the contamination or reduce its impact. It is also important to determine the ecological health of the upper reaches of the tributary streams in full studies of the major watersheds. This will help us understand the full potential of these tributary streams as assets to the community.

In the following pages, you will find a discussion of the water quality issues on the rivers in dry weather, wet weather, and the tributary streams.

Rivers: In Dry Weather

1. What is the water quality baseline and are there spatial variations in quality?

As Table 7 indicates, the Ohio River (calculating a geometric mean for all data for each pool) is within our specific target number for fecal coliform of 200 CFU/100ml. Despite this, Mile Point 11.9 left descending bank exceeds this geometric mean benchmark for fecal coliform at 342

Table 7: Fecal Coliform Results for Ohio River Samples for the 2003 Recreational Seasons in Dry Weather*

Ohio River Pools	Geometric Mean ** CFU/100ml
Pool 3 – MP 8.0-13.3	81
Pool 2 – MP 13.7-15.6	130
Pittsburgh Pool – MP -6.2***	119

*At least 3 days without rain or known combined sewer overflows.
**Geometric means are calculated from fecal coliform results from all sampling locations in each Pool
***Data from 2000 Recreational Season

CFU/100ml, with a maximum of 1,800. This site is at the downstream side of the Sewickley Bridge. The data at the mid point and left bank at this mile point are within the benchmark standards, indicating that the source of fecal contamination may lie along the left bank, between this site and Mile Point 10.1 upriver. Thorn Run and Narrows Run are on the left bank between MP 10.1 and 11.9, although the fecal coliform and E. coli results are not unusually high.

2. Are there water quality problems indicated at points of public access?

While there are several marinas and fishing spots along Pool 2 in the Ohio River, there is only public boat launch near Toms Run and Mile Point 8.0. In dry weather, MP 8.0 was below the 200 CFU/100ml benchmark. However, on the September 10 dry weather that preceded heavy rains, the fecal coliform concentrations were above 400 CFU/100ml. This site is below the Emsworth Lock and Dam, below the Pittsburgh Pool which is heavily influenced by combined sewer overflows.

In Pool 3, a public access boat ramp is located in Leetsdale, near Mile Point 15.6. This site had very low fecal coliform concentrations when sampled in dry weather. However, several fishermen and boaters at the site indicated a sewer outfall at the boat ramp would discharge during wet weather.

3. Are there specific areas that warrant further study? Why?

See Wet Weather section below.

Rivers: In Wet Weather

1. What is the wet weather water quality and are there spatial variations?

Wet weather sampling demonstrated that fecal coliform and E. coli concentrations are elevated in both the Pittsburgh Pool and Pool 2 several days following a rain storm. Pool 2 is downstream of the Pittsburgh Pool and 317 sewer overflows – 265 combined sewer overflows and 52 sanitary sewer overflows – in the Allegheny County Sanitary Authority's service area. According to 3 Rivers Wet Weather, Inc., just 1/10 of an inch of rain in Allegheny County can cause sewer overflows. This data suggests, as would be expected, that Pool 2 follows similar patterns of fecal pollution concentration as the Pittsburgh Pool in wet weather. And due to the extensive rain fall throughout the recreational season, many of the dry weather events sampled in 2003 were most likely influenced by previous wet weather and resulting sewer overflows.

2. Are there wet weather water quality problems at points of public access?

None of the sampling locations for wet weather were at points of public access. However, within the sampling area, there are public boat launches, private marinas, and fishing spots where fishermen wade into the river. Although the Allegheny County Health Department has a River Water Advisory Program to warn people of river contact after a rain storm, there is no notification or signage to indicate an ongoing advisory at these sites of access and recreation. Very few, if any, marinas were seen participating in the Advisory Program which encourages marinas to fly an orange “CSO” flag. Therefore, a day or more following a rain event, provided there was no small watercraft advisories, boaters and fisherman were seen using the river without caution.

3. Are there space and time differences regarding a return to dry weather conditions?

As stated above, Pool 2 has similar results are the Pittsburgh Pool in the days following a rain event. On the third day of sampling for the June event, June 25, all of the sites were below 400 CFU/100ml. More data is needed to fully understand the relationship of the down stream sections of Ohio River to the upstream section that are within the ALCOSAN service area and its 317 sewer overflows. USGS is also conducting a wet weather sampling program, with similar sampling locations. The results from this study should help further illuminate this question.

4. Are there specific areas that warrant further study? Why?

The major problem with using fecal coliform and E. coli as indicators of fecal pollution is that the conventional methods do not allow source determination. While it is assumed that the contribution of the detected fecal pollution is mostly from sewer overflows, it cannot be confirmed. Bacterial source tracking techniques using molecular and biochemical methods are being developed and used in watershed analysis to determine fecal sources such as human, dog, horse, or raccoon. These methods are outside the scope and budget of this project. However, with the municipalities within the ALCOSAN service area and ALCOSAN itself signing consent decrees with the US EPA to address the overflow problem, and with an estimated $3 billion dollar investment into these corrections, it is recommended that future studies use these new techniques. Understanding the contributions of fecal pollution from both animal and human sources would help determine effectiveness of future sewer overflow controls.

Tributary streams:

1. What is the water quality and how does it vary among the tributary streams?

Of the 8 tributary streams sampled in Pool 2, 3 streams have geometric means of fecal coliform above 1,000 CFU/100ml: Kilbuck, Hays and McCabe Runs. McCabe Run had a maximum fecal coliform concentration of 158,000 CFU/100ml. McCabe and Hays Runs are both small watersheds with little urbanization. Kilbuck Run is more urbanized and is designated by PADEP as a cold water fishery. On 2 occasions, temperature readings for Kilbuck Run were slightly above the specific water quality criteria for CWF. For McCabe Run, 3 out of 4 Dissolved Oxygen readings were below the 4.0 mg/L DO minimum for warm water fisheries.

In Pool 3, only Flaugherty Run had a fecal coliform sample above 1,000 CFU/100ml at 3,000, though the other 3 data points were below 250 CFU/100ml.

Ohio River Tributary Streams Pool 2

Most Impacted with Fecal Coliform (>4,000 CFU/100ml): McCabe Run, Hays Run

Least Impacted with Fecal Coliform (<200 CFU/100ml): Narrows Run, Moon Run, Montour Run, Toms Run

Ohio River Tributary Streams Pool 3
Most Impacted (>250 CFU/100ml): Big Sewickley Creek, Flaugherty Run
Least Impacted (<200 CFU/100ml): Little Sewickley Creek

Allegheny River Tributary Streams Pool 4
Buffalo Creek: 153 CFU/100ml

2. Do tributary streams impact the water quality of the main stem rivers?

Our study did not investigate the mixing zones of the tributary streams in the mainstem river. However, at our sampling locations, the data does not indicate that upstream tributary streams are affecting downstream sampling locations. The relatively small flows of the tributary streams compared to river and the relatively low fecal coliform concentrations on the majority of the streams would support this general conclusion.

3. Are there water quality problems indicated at points of public access?

Kilbuck Run empties into the Ohio River at a private marina. Three of the 3 samples at Kilbuck were above 1,000 CFU/100ml, with a maximum value of 12,900. McCabe and Hays Run are not located near marinas or boat docks.

4. Does each tributary stream have the minimum conditions to support aquatic life?

Most of the streams were within the PADEP's water quality criteria for the analyzed parameters for the designated uses (Appendix A). As stated above, Kilbuck Run exceeded the maximum temperature requirements for cold water fisheries for 2 of the 5 sampling events. Narrows and Montour Runs had several samples that exceeded the Total Dissolved Solid maximum of 750 mg/L.

Benthic macroinvertebrates are the insects and other invertebrates that live on the bottom of rivers and streams and serve as food sources for fish and birds. Monitoring these benthic communities reveals significant information about the biological health of streams. The results of the macroinvertebrate study performed as part of 3R2N will indicate in a more complete sense whether the tributary streams can sustain aquatic life (Koryak and Stafford).

5. Do these tributary streams warrant further study? Why?

A targeted pathogen study of the upper watersheds of streams with high fecal coliform and E. coli concentrations will better define the pollution issues. As stated above, bacterial source tracking using molecular and biochemical analysis will determine the sources of fecal pollution.

In Summation

Dry Weather

In 2003, the results indicate that dry weather water quality conditions in the Ohio River Pools 2 and the upper section of Pool 3 meet target water quality standard for recreational use most of the time. The exception is Mile Point 11.9 left descending bank.

From May 15 to September 30, the Allegheny County Health Department notifies the general public of health concerns during and after a rainfall through the River Water Advisory Program. In the 2003 recreational season, there were 29 of 138 days when it was considered safe for direct contact with river water by ACHD River Water Advisories. According to the advisories, it was considered safe to use our rivers for direct body contact only 21% of the time from May to September 30, 2003.

Wet Weather

Our data suggest that the Ohio River Pool 2 is impacted by wet weather as is the Pittsburgh Pool for several days following rain events.

Due to the heavy and frequent rains during the 2003 recreational season, there was a total of 109 of 138 days when it was unsafe (or 79% of the time) for direct contact with river water according to the river advisories. The first advisory issued in 2003 lasted 43 days from May 15 to June 27. There were 7 more advisories called for the 2003 recreational season.

Tributary Streams

Our study shows that during dry weather, fecal coliform concentrations vary among the tributary streams studied. Three streams had geometric means for fecal coliform greater than 1,000 CFU/100ml. Chemical and field tests indicate most parameters are within an expected range for this region and within state water quality standards.

Conclusion

Our study indicates that during dry weather most of our sampling sites along the Ohio River are below the study's target number for fecal coliform, indicating little fecal contamination. The majority of the tributary streams sampled have fecal coliform concentrations lower than 300 CFU/100ml and E. coli concentrations lower than 200 CFU/100ml. Wet weather river water quality is impacted by fecal pollution in both the Pittsburgh Pool and Ohio River Pool 2. The project recommends future studies to determine the sources of the fecal pollution utilizing molecular and biochemical methods.

This study and more information are available at **http://3r2n.cfa.cmu.edu/.**

VI. Comparison of Data: Phase 1- Phase 4

The same protocol was followed for each Phase in the 3 Rivers 2nd Nature project. (3R2N Water Quality Reports, 2000, 2001, & 2002.) Similar analysis was performed on each data set.

In 2000, Phase 1 focused on the Pittsburgh Pool from on the Allegheny River from Lock and Dam 2 (Highland Park) to the confluence of the Ohio River; on the Monongahela River from the Braddock Locks and Dam to the confluence of the Ohio River; and on the Ohio River from MP 0.8 to the Emsworth Lock and Dam.

In 2001, Phase 2 focused on the Monongahela River from the Braddock Lock and Dam to the Allegheny County line at MP 35.

In 2002, Phase 3 focused on the Allegheny River from Lock and Dam 2 to the Allegheny County line at MP 28.9.

In 2003, Phase 4 focused on the Ohio River from the Emsworth Lock and Dam to the Allegheny County line at MP 15.6.

Dry Weather River Data

The following graphs illustrate dry weather fecal coliform data for the Monongahela and Allegheny Rivers, respectively, from the Allegheny County line to the beginning of the Ohio River in downtown Pittsburgh.

Figure 10 shows the Monongahela River data taken from 3R2N Water Quality Report 2001. The data indicate that most river sites, especially in the section between Mile Point 35 and Mile Point 16.7, fall within the 200 CFU/100ml benchmark for fecal coliform for river recreation. Two sites, Mile Point 14.3 and 10.21 on the left descending bank, are well above this benchmark. Although the authors were unable to determine the source of fecal contamination, it was noted that major tributaries upstream of these sites may be impacting river flows. The mouth of the Youghiogheny River, with a fecal coliform geometric mean of 325 CFU/100ml, is approximately one mile upstream and on the same side of the river as Mile Point 14.3, right bank. The mouth of Turtle Creek, which has an geometric mean of 1,859 CFU/100ml in 2001, is approximately one mile upstream and on the same side of the river as Mile Point 10.21, right bank. These two tributary flows may be impacting the river before they are completely mixed with the river flows. There are several sites above the 200 CFU/100ml benchmark for fecal coliform but below 300 CFU/100ml. These sites are within the Mile Points 16.7 and 5.66.

Figure 11 shows the Allegheny River data taken from 3R2N Water Quality Report 2002 (note he different scales for fecal coliform for each figure). The geometric means of fecal coliform data of all sites but one are below the 200 CFU/100ml benchmark. Mile Points 28.9 and 26.9 and 24.2 mid and right bank sites in Pool 3 have the lowest geometric means – below 32 CFU/100ml. As the river flows into more urbanized areas, the geometric means tend to increase. The data for the one site above 200 (209 CFU/100ml, Mile Point 22.6, right descending bank) range from 5 to 600 CFU/100ml. Although this is lower than the 2 points in the Monongahela River mentioned above, it is noteworthy because it is adjacent to a PA Fish and Boat Commission public boat launch.

Figure 12 illustrates fecal coliform taken in 2000 and 2003 for the Ohio River from the confluence with the Allegheny and Monongahela Rivers in downtown Pittsburgh to the Allegheny County

Figure 10.

Geometric Mean of Fecal Coliform Data in the Monongahela RIver from the Allegheny County Line to the Conflkuence with the Allegheny River in Dry Weather 2000-2001 Recreational Seasons

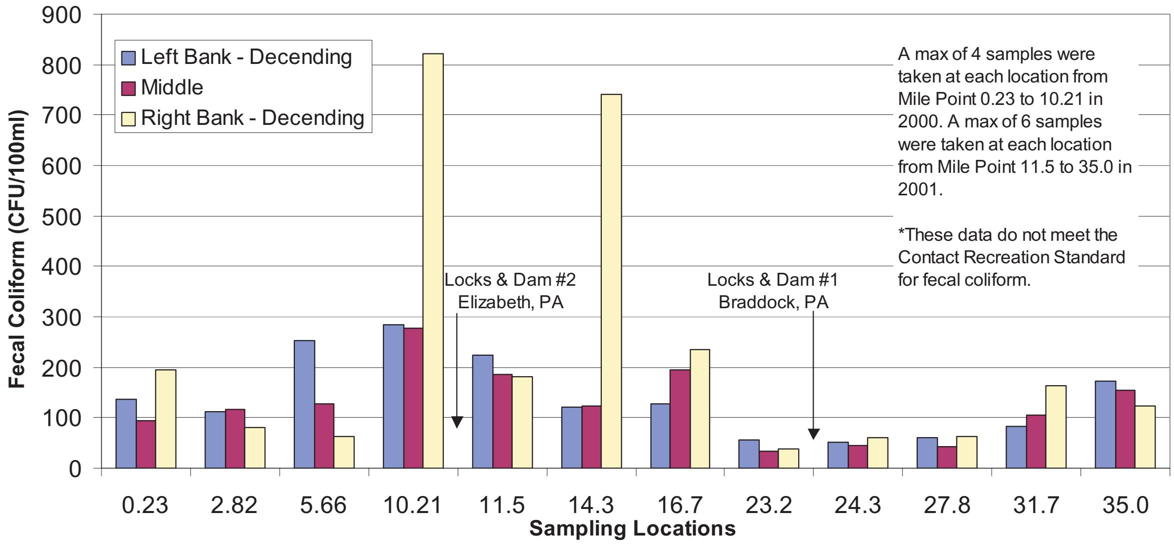
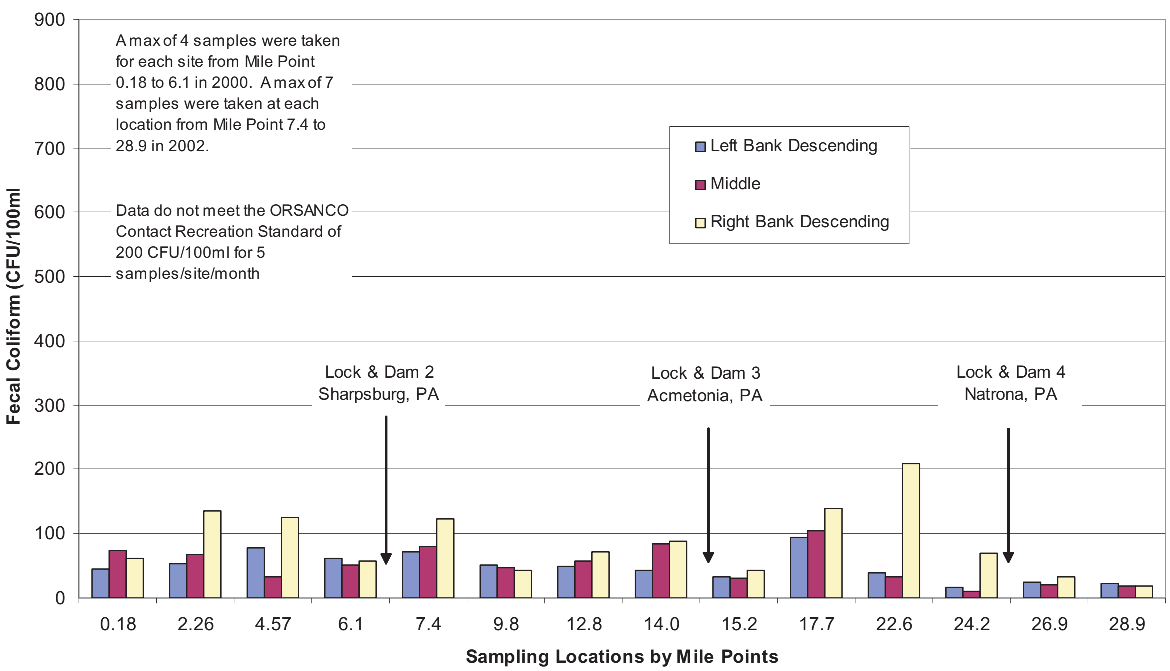


Figure 11.

Geometric Mean of Fecal Coliform Data for the Allegheny RIver from the Confluence with the Monogahela River to the Kiskiminetas River to in Dry Weather 2000-20012 Recreational Seasons



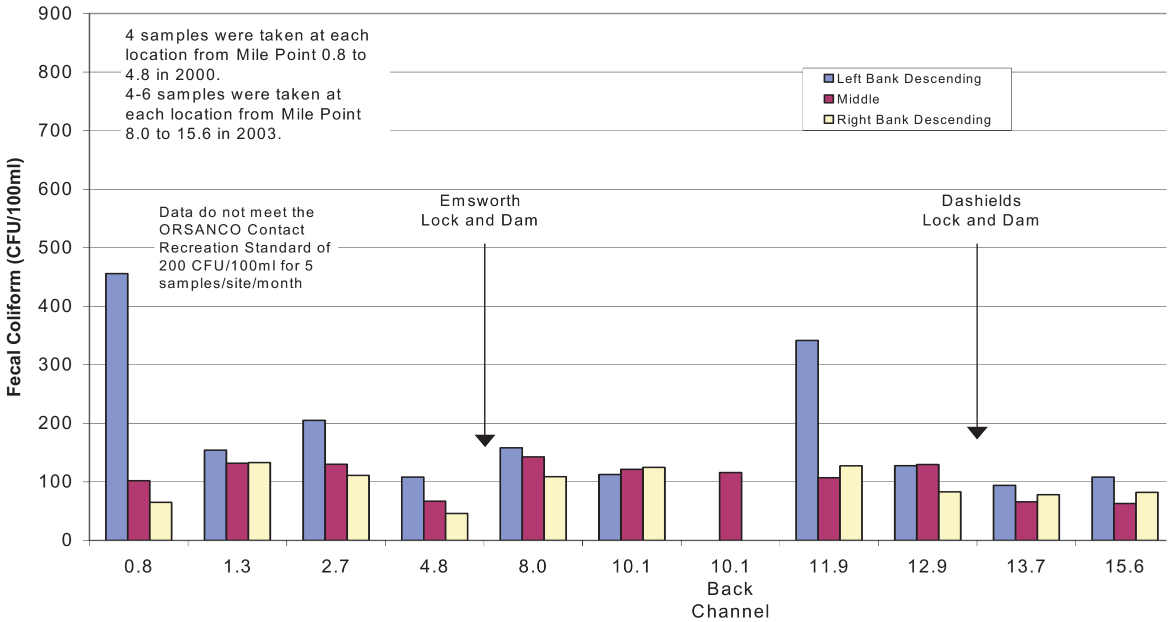


Figure 12.

Geometric Mean of Fecal Coliform Data for the Ohio RIver from the Confluence of the Allegheny and Monongahela Rivers to the Allegheny Co. Line in Dry Weather 2000-2001 Recreational Seasons

line. This section of river is 15 miles long flowing through mostly urban and suburban areas. Most of the sites are below the 200 CFU/100ml fecal coliform benchmark except for the left bank of Mile Point 0.8 and 11.9. The maximum result for Mile Point 0.8, left bank is 2,300 CFU/100ml. The Monongahela River comprises this left bank side of the Ohio River as well as Saw Mill Run at Mile Point 0.8 below the West End Bridge. Saw Mill Run also has a maximum result of 14,000 CFU/100ml on the same day as the maximum fecal coliform result for MP 0.8. This also occurrs at Mile Point 2.7 left bank, downstream of Chartiers Creek. Both Mile Point 2.7 and Chartiers Creek have maximum concentrations of fecal coliform on the same day, 2,900 and 575 CFU/100ml respectively. However, there is no obvious source of fecal coliform for Mile Point 11.9, which had a maximum fecal coliform result of 1,800 CFU/100ml on July 31, 2004.

Table 10 below illustrates all of the geometric means for each pool in each of the three rivers plus an overall geometric mean for each river system. The Allegheny River has the lowest geometric means of the 2 rivers. In general, the less urbanized Pools beyond the Pittsburgh Pool tend to have lower geometric means for fecal coliform.

Table 10: Geometric Means of Fecal Coliform Data for each River System taken from 2000 to 2003 recreational season in dry weather. (data taken from 3R2N Water Quality Reports 2000-2003)

	Allegheny River	**Monongahela River**	**Ohio River**
Pittsburgh Pool	65	119	119
Pool 1	64	150	130
Pool 2	49	83	81
Pool 3	22		
Overall Geometric Mean	47	135	121

Wet Weather River Data

Select sites from each of the river systems were sampled in wet weather. A wet weather event (rain storm) was defined as occurring after a period of 72 hours since the previous rainfall, as recommended by USEPA (1992) for storm water sampling. Sampling occurred 12-24 hours after a rain event, and for 2 days afterward. Because each rain event was variable, so that wet weather data cannot be directly compared, this section will not present data but will only refer to general trends. More detailed analysis for each river system can be found in the annual 3R2N reports. Each river system was sampled along with the Pittsburgh Pool. The Allegheny and Monongahela Rivers followed a similar trend that all Pools show elevated fecal coliform data the day following a rain event, with the Pittsburgh Pool having the highest concentrations 10-fold from dry weather concentrations. Outlying pools tend to have lower concentrations that the Pittsburgh Pool. All pools show decreased concentrations two to three days following wet weather. The exception is the Allegheny River Mile Point 22.6, right descending bank, which has an increased concentration of fecal coliform on the third day following the rain event. This is the same site that has elevated dry weather fecal coliform concentrations.

The Ohio River Pool 2 follows the general trend of the Pittsburgh Pool, with elevated fecal coliform data the day following a rain event, with subsequent days showing a decrease. Pool 3 of the Ohio River was not sampled.

The US Geological Survey, in conjunction with the Allegheny County Health Department conducted a similar wet weather study that started in 2002 and continued through 2003 and possibly into future years. This study had fixed sites along all three rivers that were sampled for fecal coliform, E. coli, and enterococci on the first, third and fifth days following a rain storm. The results of the study have not been released at the time of this report for a comparison with the 3R2N data.

The 3R2N wet weather data, though limited to 2-3 wet weather events in each river, with the Allegheny River having only one successful event, are not surprising. There are many sources of fecal coliform besides human waste, such as domestic livestock, pets, and wild mammals, yet the sheer number of combined and sanitary sewer overflows in the Allegheny County Sanitary Authority's service area (over 300 structures that overflow with as little as 1/10 inch of rain - http://3riverswetweather.org) as well as the many CSO's in small municipal systems throughout Allegheny County, would most likely contribute the highest amounts of fecal coliform pollution to the three rivers. Without a more sophisticated analysis such as molecular and biochemical methods that are being developed and used in watershed analysis, the exact sources of fecal coliform cannot be documented. With an estimated $3 billion dollar investment into these corrections, it is recommended that future studies use these new techniques. Understanding the contributions of fecal pollution from both animal and human sources would help determine effectiveness of future sewer overflow controls

Tributary Stream Data

Tributary streams to each river system were sampled in dry weather with access by boat. Each stream was sampled at a point closest to the confluence with the river above the first riffle poll, which was assumed to have no backflow from the river. At streams where the first riffle pool was not visible due to high flow, the boat was driven upstream ½ to one mile when possible or the sampling team walked up the stream bank for a sample. The data collected represent the first data taken on many streams. Streams were sampled 4-6 times within the dry weather recreational season, the same days as river sampling.

Figure 13 shows the fecal coliform data for all of the tributaries sampled in the Allegheny River watershed during the recreational seasons of 2000 and 2002. As shown, three tributaries in the Pittsburgh Pool (from MP 0 to Sharpsburg Lock and Dam #2) have fecal coliform concentrations above 5,000 CFU/100ml. Indian Creek in Pool 2, between Lock and Dams 2-3 is the most impacted with fecal coliform. This stream flows through a culvert in the town of New Kensington. Tributaries in Pool 3, between Locks and Dams 3, have fecal coliform concentrations below 1,000 CFU/100ml.

Many private marinas are located in the Allegheny River in the study area. The notable public access boat ramp (PA Fish and Boat Commission) is just upstream of Bull Run. The geometric mean of Bull Run fecal coliform data is 246 CFU/100ml, with a maximum of 1,400 CFU/100ml. The geometric mean of E. coli data (not shown) for Bull Run is 932 CFU/100ml, with a maximum of 2,419 CFU/100ml. Although the mixing zone for Bull Creek was not determined, these results may indicate that at the mouth of Bull Creek boaters and fishermen may encounter exposure to fecal contamination.

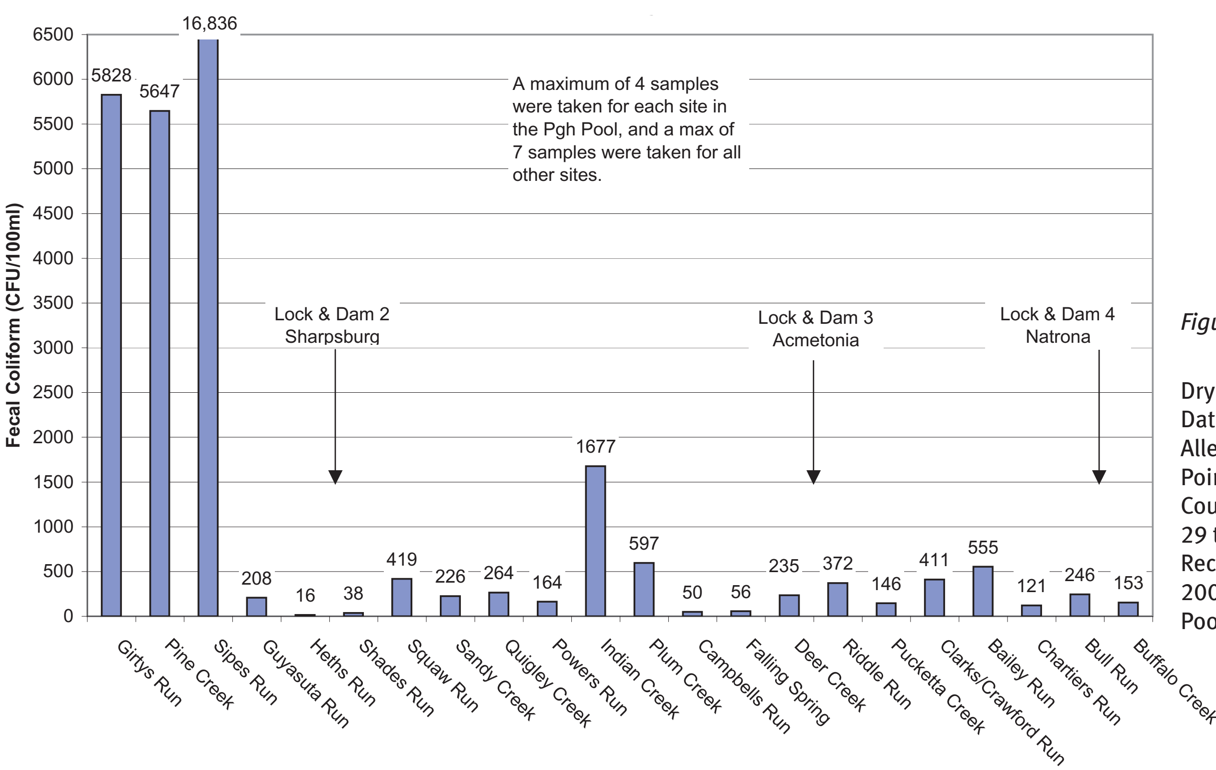


Figure 13.

Dry Weather Fecal Coliform Data for Triutaries of the Allegheny River from Mile Point 0 to the Allegheny County Line at Mile Point 29 taken during the Recreation Seasons fo 2000 & 2002: Pittsburgh Pool, Pool 2 & 3

Figure 14 illustrates the fecal coliform data for tributary streams sampled in the Monongahela River watershed in the recreational seasons of 2000 and 2001. As shown, 5 streams in the study area are above 5,000 CFU/100ml fecal coliform. These high concentrations of fecal coliform indicate a probable human source of contamination. Crooked Creek, with a geometric mean of 443,694 CFU/100ml, flows through a culvert in the town of McKeesport. Eight streams are above 1,000 CFU/100ml.

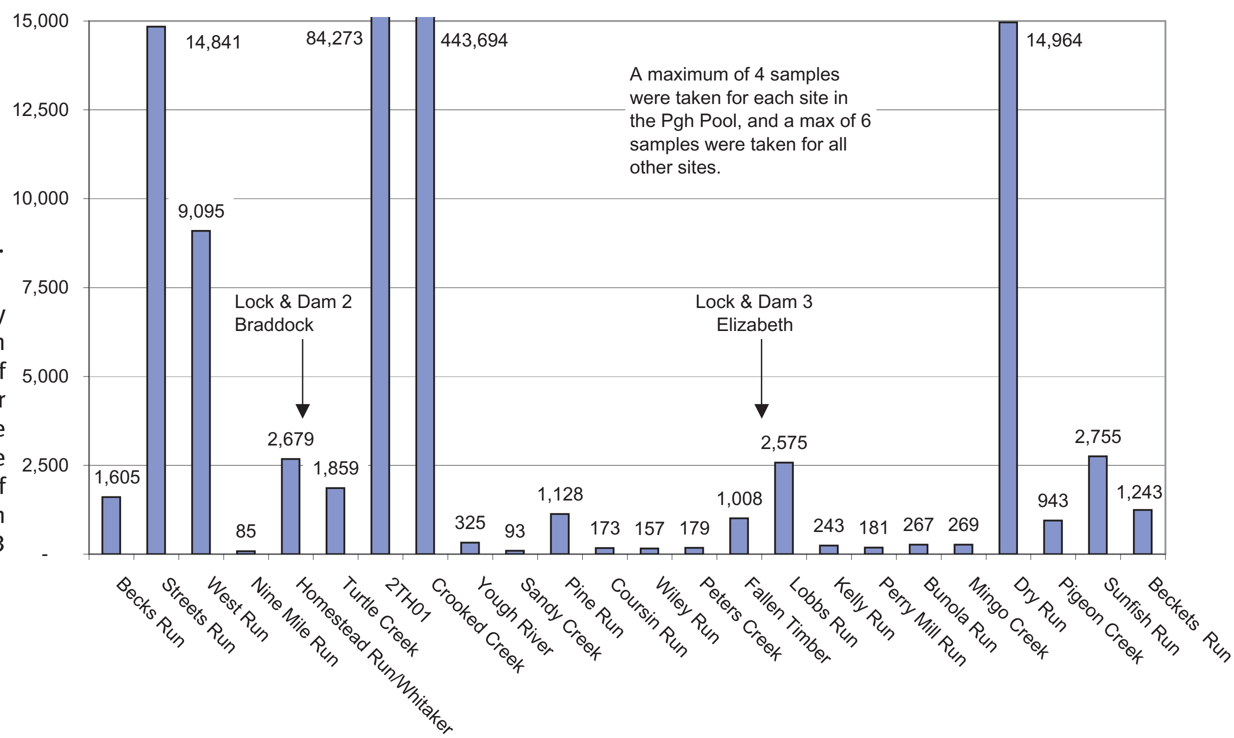
Figure 15 illustrates the fecal coliform data for tributary streams sampled in the Ohio River watershed in the recreational seasons of 2000 and 2003. The maximum concentration for any stream is 4,858 CFU/100ml (Hays Run in Pool 2). McCabe Run in Pool 2 has a concentration of 4,130 CFU/100ml. However, the Coraopolis Municipal Authority repaired its sewer line that runs along this stream after this sampling program concluded. Thus, the contamination of fecal coliform may be less than what was found in this study.
From the 59 streams sampled, the fecal coliform geometric mean results range from 16 in Heths Run in the Allegheny River, Pittsburgh Pool to 443,694 CFU/100ml in Crooked Run in the Monongahela River, Pool 2.

Figure 16 illustrates the distribution of concentrations of fecal coliform within the defined ranges. 32% or 19 streams have geometric means of fecal coliform below 200 CFU/100ml. Of the 20, only 2 streams are in the Pittsburgh Pool: Heths Run and Nine Mile Run in the Monongahela River. The other 18 streams are in outlying pools.

32% or 19 streams have geometric means for fecal coliform within 200 to 1000 CFU/100ml. with 2 in the Pittsburgh Pool: Guyasuta Run in the Allegheny River and Chartiers Creek in the Ohio River.

Figure 14.

Geometric Means of Dry Weather Fecal Coliform Data for Tributaries of the Monongahela River from Mile Point 0 to Mile Point 35 taken during the Recreational Seasons of 2000 & 2001: Pittsburgh Pool, Pools 2 & 3



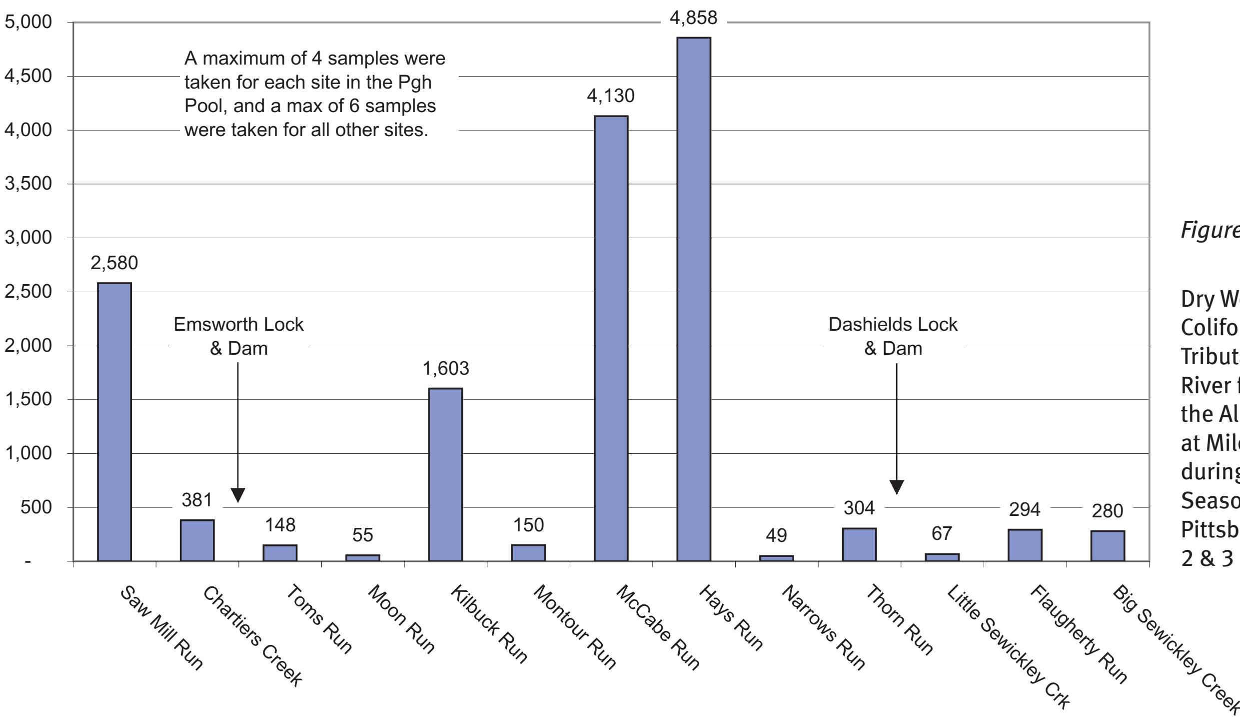


Figure 15.

Dry Weather Fecal Coliform Data for Tributaries of the Ohio River from Mile Point 0 to the Allegheny County Line at Mile Point 15.6 taken during the Recreational Seasons of 2000 & 2003: Pittsburgh Pool, Pools 2 & 3

27.1% or 16 streams have geometric means of 1001 to 10,000 CFU/100ml, with 5 in the Pittsburgh Pool.

8.5% or 5 streams are above 10,001 CFU/100ml with 4 in the Monongahela River watershed and one in the Allegheny River.

There is a similar distribution for E. coli results (not shown), however, many of the higher results are above the upper detection limit of 2,420 CFU/100ml.

In order to determine if there is a linear relationship between development and fecal coliform concentrations, the available percent impervious surface data was correlated to fecal coliform data. Impervious surface data was obtained from the GIS database and is the land in the watershed that contains buildings, pavement or other surface that does not allow water to penetrate into the ground. Because no data exists for watersheds outside Allegheny County or small first order streams in the GIS database, 42 of the 59 streams were used in calculating the correlation coefficient. The resulting correlation coefficient is 0.08. This would indicate that for this database, there is no linear

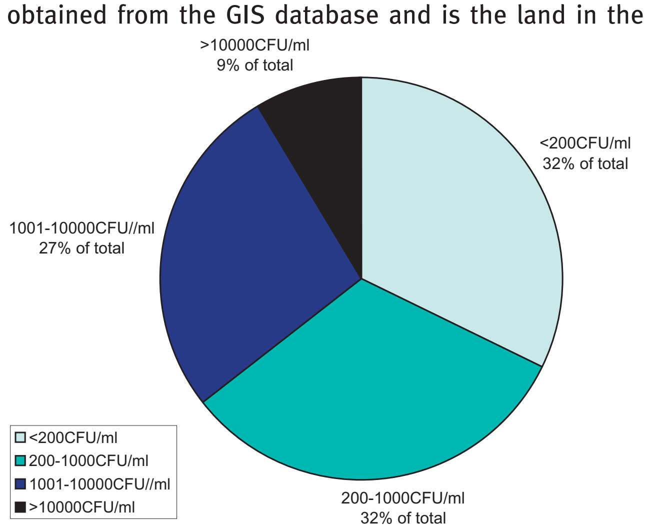


Figure 16.

Allegheny County streams with pathogen Impacts. Based on fecal geomean of all available data. Mix of first order and streams relationship between the level of development and dry weather fecal coliform concentrations. It may be that fecal coliform concentrations are more of a result of the condition of sewer lines than development.

Table 11 shows the geometric means of tributary stream data for each pool. The data indicates that streams in the Pittsburgh Pool has higher fecal coliform concentrations than outlying pools. The Monongahela River tributaries have higher fecal coliform concentrations than the other rivers systems.

Table 11: Geometric Means of Fecal Coliform Data for Tributary Streams Sampled in Each Pool of the Three Rivers in the Recreational Seasons of 2000-2003

	Allegheny River CFU/100ml	**Mon River CFU/100ml**	**Ohio River CFU/100ml**
Pgh Pool	1130	2181	991
Pool 2	200	1278	394
Pool 3	314	901	161
Pool 4	153		
Overall Geometric Mean	332	1253	348

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Appendix A

PA Water Qualiy Criteria,
Physical and Chemical Parameters

Warm Water Fisheries	(mg/L) unless noted	25 PA Code § 93.7, 93.9w
Alkalinity	20	Minimum allowable
Ammonia Nitrogen	site specific	Based on pH and Temp
Dissolved Iron	0.3	Max allowable
Dissolved Oxygen	4	Minimum allowable (5.0 mg/L min for WWF-High Quality)
Fecal coliform	200	CFU/100ML – Geometric mean for recreational season
Total Iron	1.5	30-Day ave
pH	6-9	S.U. – Range of allowable concentration
Temp	28.9-18.9	Celcius – Seasonal max from June 15-Oct 31
TDS	500	Monthly Average
	750	Max allowable
		Toms Run, Hays Run, Moon Run, McCabe Run, Thorn Run, Flaugherty Run

Trout Stocked	(mg/L) unless noted	25 PA Code § 93.7, 93.9w
Alkalinity	20	Minimum allowable
Ammonia Nitrogen	site specific	Based on pH and Temp
Dissolved Iron	0.3	Max allowable
DO	5	Min from Feb 15-July 31
DO	4	Min for remainder of year
Fecal	200	CFU/100ml – Geometric mean for recreational season
Total Iron	1.5	30-day ave
pH	6-9	S.U. – Range of allowable concentration
Temp	22.2-18.9	Celcius – Seasonal max from June 15-Oct 31
TDS	500	Monthly Average
	750	Max allowable
		Montour Run, Big Sewickley Creek
High Quality TSF		
DO	6	Min daily ave
	5	Min Little Sewickley Creek (all other parameters same as TSF)

Cold Water Fishery		
DO	Same as for HQ-TSF	
Temperature	17.8-10	Seasonal Max from June 15 to Oct 31
		Kilbuck Run (all other parameters same as TSF)

pH

The measurement of pH is one of the most important and frequently used tests in water chemistry. pH represents the effective concentration (activity) of hydrogen (H+) ions in water. The activity of hydrogen ions can be expressed most conveniently in logarithmic units. pH is defined as the negative logarithm of the activity of H+ ions:

$$pH = -\log[H^+]$$

As H+ increases, pH decreases. Since pH is on a log scale based on 10, the pH changes by 1 for every power of 10 change in $[H^+]$ (APHA et al, 1992). Several factors affect pH. Carbon dioxide (CO_2) enters water from a variety of sources, including the atmosphere, runoff from land, release from bacteria in the water and respiration by aquatic organisms. This dissolved CO_2 form a weak acid. Because plants take in CO_2 during the day and release it during the night, pH levels in water can change from day to night. Acidic and alkaline compounds can be released into water from different types of rock and soil. When calcite ($CaCO_3$) is present, carbonates (HCO_3, CO_3^{2-}) can be released, increasing the alkalinity of the water. Drainage from forests and marshes is often slightly acidic, due to the presence of organic acids produced from decaying vegetation. Mine drainage also be acidic. Air pollution can increase the concentrations of nitrogen oxides and sulfur dioxide in the air. These pollutants react in the atmosphere to form nitric and sulfuric acids. These acids can affect the pH of streams by combining with moisture in the air and falling to the earth as acid rain or snow.

Very high (greater than 9.5) or very low (less than 4.5) pH values are unsuitable for most aquatic life. Young fish and immature stages of aquatic insects are extremely sensitive to pH levels below 5 and may die at these low pH values. High pH levels (9-14) can harm fish by denaturing cellular membranes. Changes in pH can also affect aquatic life indirectly by altering other aspects of water chemistry. Low pH levels accelerate the release of metals from rocks or sediments in the stream. These metals can affect fish metabolism and the ability to take water in through the gills (Murphy, 2000).

DO

Dissolved Oxygen is a very important indicator of a water body's ability to support aquatic life. Fish breathe by absorbing dissolved oxygen through their gills. Oxygen enters the water from the atmosphere or by aquatic plant and algae photosynthesis. Oxygen is removed from the water by respiration and decomposition of organic matter.

Temperature affects DO concentrations. The colder the water, the more oxygen that will be dissolved in the water. Therefore, DO concentrations at one location are usually higher in the winter than the summer. During dry seasons, water levels decrease and the flow rate of a river slows. As the water moves slower, it mixes with less air and the DO concentrations decreases. (Murphy, 2000).

Photosynthesis affects DO concentrations. During photosynthesis, plants release oxygen into the water. In the absence of sunlight, plants respire and remove oxygen from the water. Bacteria and fungi also use oxygen as they decompose dead organic matter in the water. If many plants are present, the water can be supersaturated with DO during the day, as photosynthesis occurs. Concentrations of DO can decrease significantly during the night because of respiration. Anthropogenic inputs of organic waste can result in algal and microbial blooms, which may cause marked oxygen depletion, especially at night. Waters that contain toxic chemicals are often low in oxygen, which can influence contaminant toxicity. (Hoffman et. al., 1995)

Temperature

Temperature of water is very important factor for aquatic life. It controls the rate of metabolic and reproductive activities. Most fish are ectothermic, meaning the body temperature closely tracks the environmental temperature. The temperature tolerance zone varies greatly among species and, to a lesser degree, with age, physiological condition and temperature to which the fish has been acclimated. Sublethal exposure to toxic chemicals may reduce the upper lethal temperatures of fish, thereby constricting the tolerance zone. Futhermore, fish show reduced growth and impaired swimming ability when subjected to the extremes of their temperature tolerance zone. (Hoffman et al., 1995)

Temperature also affects the concentration of dissolved oxygen, as discussed above, and can influence the activity of bacteria and toxic chemicals in water. Toxicity of ammonia to fish is influenced greatly by pH and temperature as discussed below.

Riparian vegetation provides shade to the stream, preventing the sun from heating up the water. During dry season when there is less water in a stream, it flows more slowly, allowing the water to warm up more quickly. Industrial discharges and sewage effluents can also cause elevated temperatures in a stream or river.

Conductivity

Specific Conductance, SC, is a measure of the ability of water to conduct an electrical current. This ability depends on the presence of ions; on their total concentration, mobility, and valence, and on the temperature measurement. Ions come from the breakdown of compounds and conduct electricity because they are negatively or positively charged when dissolved in water. Therefore, specific conductance is an indirect measure of the presence of dissolved solids such as chloride, nitrate, sulfate, phosphate, sodium, magnesium, calcium, and iron and can be used as an indicator of water pollution. Solutions of most inorganic compounds are relatively good conductors. Molecules of organic compounds that do not dissociate in aqueous solution conduct a current very poorly. (APHA et al, 1992)

Some ions occur naturally when water flows over rock or soil containing calcite ($CaCO_3$), such as calcareous shales, calcium, and carbonate ions will dissolve into the water and increase SC.

Acid mine drainage may contribute iron, sulfate, copper, cadmium, arsenic and other ions if minerals containing these constituents are present and are exposed to air and water. Runnoff from farms can contain fertilizers, in which phosphate and nitrate are present. Runoff from roads can also carry salts and leaked automobile fluids that contribute ions to water. Although conductivity is not regulated, it is a good indicator of the amount of dissolved solids in water.

Total Dissolved Solids

Total Solids is a term applied to the material residue left in the vessel after evaporation of a sample and its subsequent drying in an oven at a defined temperature. Total solids includes Total Suspended Solids, the portion of the sample retained by a filter and Total Dissolved Solids, the portion of the sample that passes through the filter. (APHA et al., 1992) TDS is a measure of material dissolved in water such as carbonate, bicarbonate, chloride, sulfate, phosphate, nitrate, calcium, magnesium, sodium, organic ions and other ions. A certain level of these ions in water is necessary for aquatic life. Changes in TDS concentrations can be harmful because the density of the water determines the flow of water into and out of an organism's cells. However, if TDS concentrations are too high or too low, the growth of aquatic life can be limited, and death may occur. High concentrations of TDS may also reduce water clarity, contribute of a decrease of photosynthesis, combine with toxic compounds and heavy metals, and lead to an increase in water temperature (Murphy, 2000).

Dissolved solids can occur when water flows over rock or soil that release ions easily, as described above for specific conductance. Runnoff from streets containing salts, fertilizers, and other material can be washed into streams or rivers. Treated sewage effluents may also add dissolved solids to a body of water. As plants and animals decay, dissolved organic particles are released and can contribute to the TDS concentration.

Alkalinity

Alkalinity is the measure of the buffering capacity of water, or the capacity of bases to neutralize acids. Measuring alkalinity is important in determining a stream's ability to neutralize acidic pollution. Alkalinity does not refer to pH, but instead refers to the ability to resist change in pH. These buffering materials are primarily bicarbonate (HCO_3^-) and carbonate (CO_3^{2-}), and occasionally hydroxide (OH^-), borates, silicates, phosphates, ammonium, sulfides and organic ligands. As increasing amounts of acids are added to a water body, the pH of the water decreases, and the buffering capacity of the water is consumed. If natural buffering materials are present, pH will drop slowly to around 6; then a rapid pH drop occurs as the biocarbonate buffering capacity (HCO_3^- and CO_3^{2-}) is used up. At pH 5.5, only very weak buffering capacity remains, and the pH drops further with additional acid. A solution having a pH below 4.5 contains no alkalinity, because there are no HCO_3^- and CO_3^{2-} ions left (Murphy, 2000).

Alkalinity not only helps regulate the pH of a water body, but also the metal content. Biocarbonate and carbonate ions in water can remove toxic metals (such as lead, arsenic, and cadmium) by precipitating the metals out of solution.

Carbonates are added to a water system if the water passes through soil and rock that contain carbonate materials. Where limestone and sedimentary rocks and carbonate-rich soils are predominant, waters will often have high alkalinity. Treated sewage effluents can also add alkalinity to a stream. Levels of 20-200 mg/L are typical of fresh water. A total alkalinity of 100-200 mg/L will stabilize the pH level in a stream.

Ammonia

Nitrogen is required by all organisms for the basic processes of life to make proteins, to grow, and to reproduce. Nitrogen is very common and found in many forms in the environment. Inorganic forms include nitrate (NO_3), nitrite (NO_2), ammonia (NH_3) and nitrogen gas (N_2). Nitrogen is most abundant in the environment as N_2 gas. Nitrogen is continually recycled by plants and animals. This recycling is known as the nitrogen cycle. Most organisms can't use nitrogen in the gaseous form, and depend on other organisms to convert nitrogen gas to ammonia, nitrate, nitrite or amino acids.

When plants and animals die, proteins are broken down by bacteria to form ammonia. This process is called ammonification. Certain bacteria break ammonia down to nitrite then to nitrate. This conversion is called nitrification. Nitrates are then reduced to gaseous nitrogen.

Ammonia is the least stable form of nitrogen in water. Ammonia is easily transformed to nitrate in waters that contain oxygen and can be transformed to nitrogen gas in waters that are low in oxygen. Ammonia is found in water in two forms: as ammonium ions (NH_4^+) or as dissolved, un-ionized (no electrical charge) ammonia (NH_3). Total ammonia is the sum of both types. Ionized ammonia has little toxicity, whereas the un-ionized form is highly toxic. This may be because the un-ionized ammonia ion is a neutral ion and can diffuse more readily through epithelial membranes of aquatic organisms than the ionized ion (USEPA, 1999c).

The dominant form depends on the pH and temperature of water:

$$NH_3 + H_2O \quad NH_4^+ + OH^-$$

As the pH increases, H^+ concentration decreases and OH^- concentration increases, increasing the amount of NH_3, un-ionized ammonia. (USEPA, 1999c) At a constant temperature, a rise of one pH unit causes an approximate tenfold increase in the un-ionized form of ammonia. A 10ºC rise in temperature at any given pH results in a threefold increase in formation of un-ionized ammonia (Hoffman et al., 1995).

Ammonia can affect the early life stages of fish, by affecting hatching and growth rates of fish. It also can cause changes in tissues of gills, liver, and kidneys during structural development (Murphy, 2000). The effect of temperature and pH on the toxicity of ammonia is not well understood (Hoffman et al., 1995).

Anthropogenic sources of ammonia are treated sewage effluents, industrial discharges, fertilizer runnoff, and animal wastes. Pennsylvania's water quality criteria are based on the pH and temperature of a water body (25 PA Code § 93.7).

Hardness

Hardness is a measure of polyvalent cations (ions with a charge greater than +1) in water. Hardness generally represents the concentrations of calcium (Ca^{2+}) and Magnesium (Mg^{2+}) ions, because these are the most common polyvalent cations. Other ions, such as iron (Fe^{2+}) and manganese (Mn^{2+}) may also contribute to the hardness of water, but are generally present in much lower concentrations (APHA et al., 1992).

Hardness mitigates metals toxicity, because Ca^{2+} and Mg^{2+} help keep fish from absorbing metals such as lead, arsenic, and cadmium into their bloodstream through their gills. The greater the hardness, the harder it is for toxic metals to be absorbed through the gills (Murphy, 2000).

Soft waters are mainly derived from the drainage of igneous rocks, because these rocks don't weather very easily and so don't release many cations. Hard water is often derived from the drainage of calcareous (calcite-rich) sediments because calcite dissolves and releases the calcium. Mine drainage also contributes calcium, magnesium, iron, manganese and other ions if minerals containing these constituents are present and are exposed to air and water. Treated sewage effluents and industrial discharges may also contribute to the hardness of water (Murphy, 2000).

Because hardness varies greatly due to differences in geology, there aren't general standards for hardness. Hardness of water can naturally range from zero to hundreds of milligrams per liter.

Iron

Acid mine drainage comes from pyrite or iron sulfide, a mineral associated with coal mining. When pyrite is disturbed, as it is during coal mining or highway construction, it weathers and reacts with oxygen and water to cause high levels of iron, aluminum, and sulfate in runoff water. AMD is formed by a series of complex geo-chemical and microbial reactions that occur when water comes in contact with pyrite (iron disulfide minerals) in coal, refuse or the overburden of a mine operation. The resulting water is usually high in acidity and dissolved metals. The metals stay dissolved in solution until the pH raises to a level where precipitation occurs. The iron essentially clogs the gills of fish.

Appendix B

Fecal coliform and E. coli data

Ohio River Pool 2: fecal coliform dry weather data (CFU/100ml)

	7/2/2003	7/31/2003	8/20/2003	9/10/2003	10/1/2003	**Geometric Mean**	**Arithmetic Mean**
MP 8.0 Left	145	250	25	570	190	**158**	**236**
MP 8.0 Mid	85	185	40	700	135	**143**	**229**
MP 8.0 Right	65	165	20	490	145	**109**	**177**
MP 10.1 Channel	50	50	40	575	365	**116**	**216**
MP 10.1 Left	35	100	45	580	200	**113**	**192**
MP 10.1 Mid	100	230	20	525	110	**122**	**197**
MP 10.1 Right	25	225	100	345	155	**125**	**170**
MP 11.9 Left	40	1,800	200	660	490	**342**	**638**
MP 11.9 Mid	10	170	45	610	300	**107**	**227**
MP 11.9 Right	30	230	100	305	160	**127**	**165**
MP 12.9 Left	15	15	65	670	400	**83**	**233**
MP 12.9 Mid	30	125	75	465	280	**130**	**195**
MP 12.9 Right	40	180	25	430	440	**128**	**223**
Toms Run	140	170	125	685	35	**148**	**231**
Kilbuck Run	1,200	2,310	770	12,900	385	**1,603**	**3,513**
Hays Run	5,100	3,500		7,800	4,000	**4,858**	**5,100**
Moon Run					55	**55**	**55**
Montour Run	160	120	95	550	75	**150**	**200**
McCabe Run	7,900	355	113	158,000	24,000	**4,130**	**38,074**
Thorn Run	1,800	410	70	360	140	**304**	**556**
Narrows Run	35	70	40	595	5	**49**	**149**

Ohio River Pool 2: *E. coli* dry weather data (CFU/100ml)

	7/2/2003	7/31/2003	8/20/2003	9/10/2003	10/1/2003	**Geometric Mean**	**Arithmetic Mean**
MP 8.0 Left	43	326	41	135	98	**95**	**129**
MP 8.0 Mid	50	129	25	111	56	**63**	**74**
MP 8.0 Right	34	142	17	125	93	**63**	**82**
MP 10.1 Channel	22	178	31		361	**81**	**148**
MP 10.1 Left	26	178	21	80	91	**59**	**79**
MP 10.1 Mid	22	150	75	110	96	**76**	**91**
MP 10.1 Right	21	127	23	76	101	**54**	**70**
MP 11.9 Left	9	579	57	93	613	**111**	**270**
MP 11.9 Mid	10	143	24	142	120	**57**	**88**
MP 11.9 Right	18	206	23	35	93	**49**	**75**
MP 12.9 Left	24	326	50	86	416	**107**	**180**
MP 12.9 Mid	15	119	58	88	236	**74**	**103**
MP 12.9 Right	19	101	46	41	204	**59**	**82**
Toms Run	140	248	199	147	67	**147**	**160**
Kilbuck Run	1,203	613	866	1,986	649	**962**	**1,063**
Hays Run		1,986		1,300	2,420	**1,842**	**1,902**
Moon Run					31	**31**	**31**
Montour Run	88	67	41	93	62	**67**	**70**
McCabe Run	2,420	2,420	2,420	2,420	2,420	**2,420**	**2,420**
Thorn Run	2,419	517	72	172	192	**312**	**674**
Narrows Run	79	57	24	102	52	**56**	**63**

*2420 is upper detection limit

Ohio River Pool 3: fecal coliform dry weather data (CFU/100ml)

	10/8/2003	10/9/2003	10/21/2003	11/3/2002	Geometric Mean	Arithmetic Mean
MP 13.7 Left	80	105	140	65	**94**	**98**
MP 13.7 Mid	45	90	85	55	**66**	**69**
MP 13.7 Right	115	75	95	45	**78**	**83**
MP 15.6 Left	160	80	90	120	**108**	**113**
MP 15.6 Mid	45	40	120	75	**63**	**70**
MP 15.6 Right	80	80	95	75	**82**	**83**
Little Sewickley Creek	70	145	40	50	**67**	**76**
Flaugherty Run	120	3,000	90	230	**294**	**860**
Big Sewickley Creek	395	405	160	240	**280**	**300**

OhioRiver Pool 3: E. coli dry weather results (CFU/100ml)

	10/8/2003	10/9/2003	10/21/2003	11/3/2003	Geometric Mean	Arithmetic Mean
MP 13.7 Left	66	78	86	101	**82**	**83**
MP 13.7 Mid	52	57	98	82	**70**	**72**
MP 13.7 Right	135	99	128	78	**107**	**110**
MP 15.6 Left	74	73	80	108	**83**	**84**
MP 15.6 Mid	72	80	81	80	**78**	**78**
MP 15.6 Right	86	56	122	132	**94**	**99**
Little Sewickley Creek	44	115	48	102	**71**	**77**
Flaugherty Run	99	2,420	78	219	**253**	**704**
Big Sewickley Creek	408	1,203	272	980	**601**	**716**

*2,420 is upper detection limit

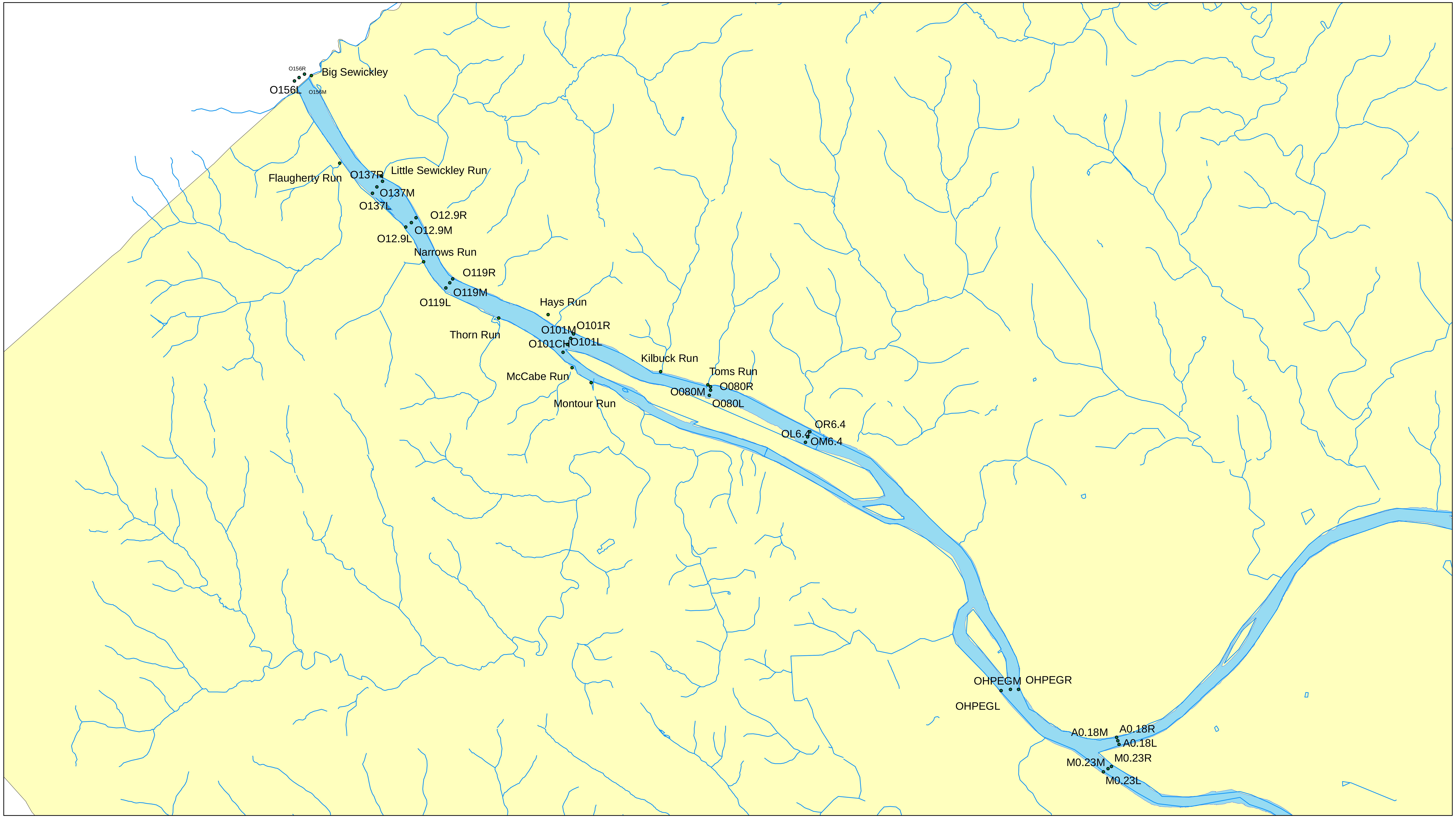
Wet Weather data for June 4, 2003 sampling event:

Mile Points	E. coli	Fecal Coliform
Mon River 0.23 Left	1203	1800
Mon River 0.23 Mid	1733	3080
Mon River 0.23 Right	2419	2400
Allegheny 0.18 Left	1046	1590
Allegheny 0.18 Mid	488	370
Allegheny 0.18 Right	1414	3080
Ohio Peg Left	1553	2800
Ohio Peg Mid	1553	2000
Ohio Peg Right	1046	815
Ohio NV Left	1733	2100
Ohio NV Mid	1203	1200
Ohio NV Right	1300	1000

		Hardness	Iron	Ammonia	Alkalinity	TDS		Temp	pH	DO	Conductivity
	Sample Date	Mg/L	Mg/L	Mg/L	Mg/L	Mg/L	Sample Date	C	SU	Mg/L	
Toms Run	10/1/2003	159	0.109	0.038	127	420	10/1/2003	11.32	8.17	9.26	682
	9/10/2003	154	0.406	0.0518	129	433	9/10/2003	16.81	8.35	9.65	617
	7/31/2003	132	0.0346	0.133	115	364	8/20/2003	18.3	8.83	8.43	604
	Average	**148**	**0.183**	**0.074**	**124**	**406**	7/31/2003	17.3	8.38	8.01	536
							7/2/2003	17.65	7.91	8.43	535
							Average	**16.28**	**8.33**	**8.76**	**595**
Kilbuck Run	10/1/2003	154	0.0393	0.0367	151	589	10/1/2003	12.34	8.14	8.71	996
	9/10/2003	197	0.4	0.0565	147	596	9/10/2003	18.66	8.36	7.74	926
	7/31/2003	178	0.041	0.465	159	553	8/20/2003	20.68	8.52	10.21	950
	Average	**176**	**0.160**	**0.186**	**152**	**579**	7/31/2003	18.66	8.22	8.42	861
							7/2/2003	19.31	8.23	8.34	777
							Average	**17.93**	**8.294**	**8.684**	**902**
Hays Run	10/1/2003	153	0.0405	0.0399	98	435	10/1/2003	11.53	7.82	9.09	717
	9/10/2003	161	0.0476	0.0608	111	478	9/10/2003	16.64	7.9	7.56	691
	7/31/2003	141	0.0362	0.151	99	420	7/31/2003	17.44	8.31	7.49	626
	Average	**152**	**0.0414**	**0.084**	**103**	**444**	7/2/2003	16.74	7.96	7.98	624
							Average	**15.59**	**8.00**	**8.03**	**665**
Narrows Run	10/1/2003	216	0.0676	0.0421	128	717	10/1/2003	11.67	8.24	9.47	1194
	9/10/2003	229	1.24	0.0644	138	787	9/10/2003	17.11	8.2	8.57	1148
	7/31/2003	218	0.419	0.121	125	754	8/20/2003	18.88	7.79	12.38	1167
	Average	**221**	**0.576**	**0.076**	**130**	**753**	7/31/2003	18.11	7.76	7.33	1110
							7/2/2003	23.71	7.58	8.01	
							Average	**17.90**	**7.91**	**9.15**	**1155**
Thorn Run	10/1/2003	153	0.153	0.054	110	443	10/1/2003	13.02	8.54	10.59	692
	9/10/2003	149	0.202	0.0947	117	487	9/10/2003	18.19	8.30	9.00	669
	7/31/2003	162	0.139	0.129	134	468	8/20/2003				
	Average	**155**	**0.165**	**0.093**	**120**	**466**	7/31/2003	20.49	8.45	8.33	669
							7/2/2003	20.53	7.84	6.6	650
							Average	**18.06**	**8.28**	**8.63**	**670**
McCabe Run	10/1/2003	159	0.0558	0.654	135	555	10/1/2003	13.55	8.08	5.23	934
	9/10/2003	166	0.207	0.268	147	595	9/10/2003	17.73	7.66	2.6	910
	7/31/2003	164	1.44	0.251	139	590	8/20/2003				
	Average	**163**	**0.568**	**0.391**	**140**	**580**	7/31/2003	19.07	7.93	3.74	910
							7/2/2003	19.39	7.7	3.46	928
							Average	**17.435**	**7.8425**	**3.7575**	**920.5**
Montour Run	10/1/2003	293	0.141	0.0153	130	821	10/1/2003	11.91	8.08	9.9	1248
	9/10/2003	136	0.117	0.165	121	835	9/10/2003	17.84	7.87	8.51	1275
	Average	**215**	**0.129**	**0.090**	**126**	**828**	8/20/2003	20.62	7.58	4.84	1347
							7/31/2003	21.22	8.28	8.84	1170
							7/2/2003	21.02	7.87	6.61	1295
							AVERAGE	**18.52**	**7.94**	**7.74**	**1267**
Moon Run	10/1/2003	277	0.017	0.0146	97	855	10/1/2003	11.57	8.22	8.41	1320

	Date	Temp C	pH SU	DO Mg/L	Conductivity	Hardness Mg/L	Iron Mg/L	Ammonia Mg/L	Alkalinity Mg/L	TDS Mg/L
Big Sewickley Creek	11/3/2003	12.44	9.16	9.6	575					
	10/21/2003	11.59	9.12	7.68	624	113	0.0818	0.034	111	382
	10/9/2003	10.84	8.86	8.75	649					
	10/8/2003	9.51	8.25	8.94	648	116	0.197	0.0472	107	409
	Average	**11.10**	**8.85**	**8.74**	**624**	**115**	**0.1394**	**0.0406**	**109**	**396**
Flaugherty Run	11/3/2003	12.23	9.1	7.87	791					
	10/21/2003	12.7	8.95	6.64	824	165	0.0305	0.0347	137	518
	10/9/2003	11.32	8.08	8.94	821					
	10/8/2003	11.61	8.17	7.46	832	176	0.0253	0.06565	131	544
	Average	**11.97**	**8.58**	**7.73**	**817**	**171**	**0.0279**	**0.0502**	**134**	**531**
Little Sewickley Creek	11/3/2003	11.71	9.56	8.56	526					
	10/21/2003	11.65	9.21	8.08	551	105	0.0338	0.0369	103	345
	10/9/2003	10.39	8.19	9.45	556					
	10/8/2003	8.82	8.93	10.48	552	110	0.0413	0.0529	98	352
	Average	**10.64**	**8.97**	**9.14**	**546**	**108**	**0.0376**	**0.0449**	**101**	**349**

Overview of Testing Sites



Author: Lena Andrews & Noel Hefele
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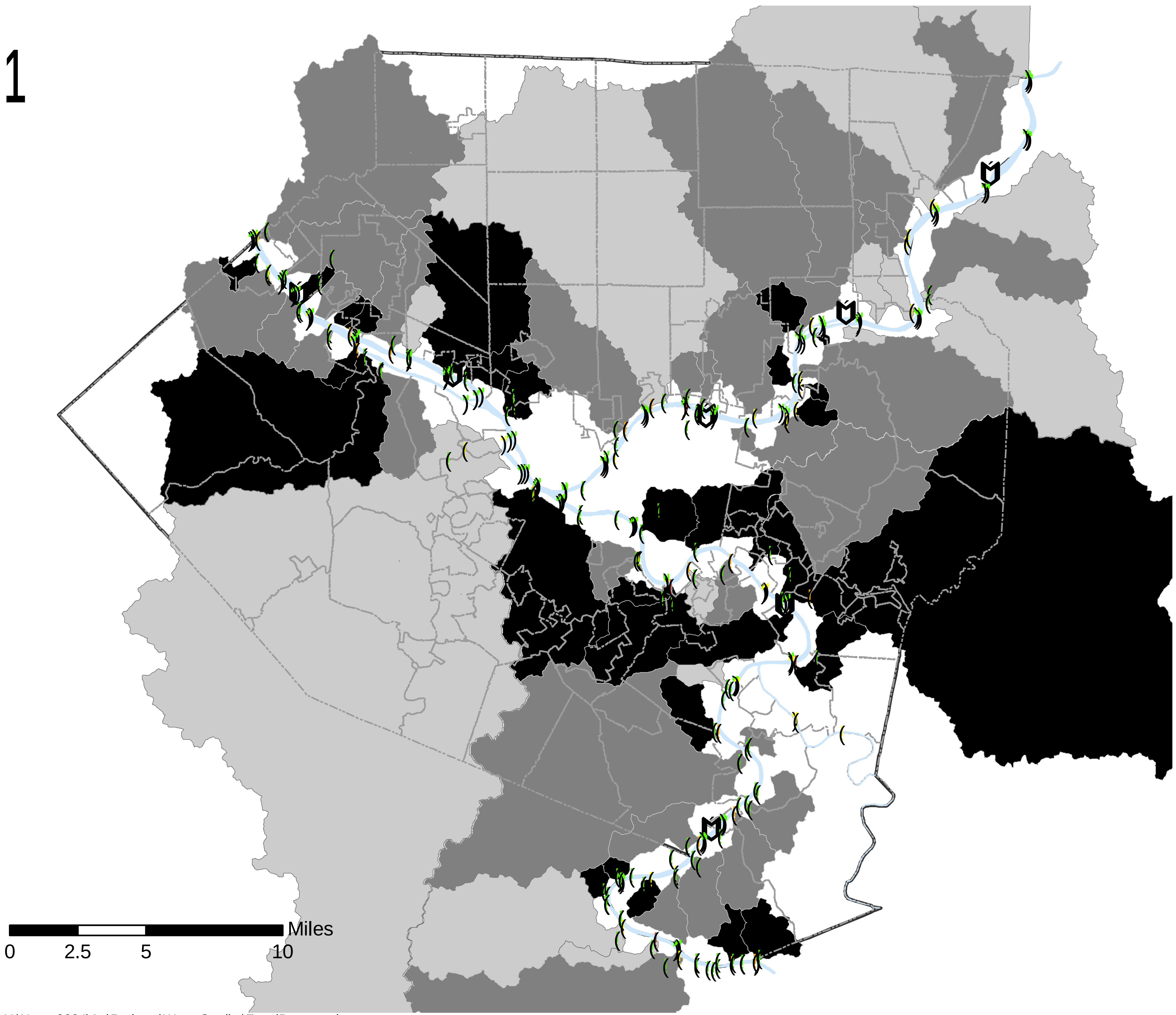

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Dry Weather Sites Fecal Coliform Geometric Mean and Invertebrate Condition Score

Legend

Invertebrate Condition Score

- 0 - 40
- 41 - 60
- 61 - 100

Lock and Dam

Municipal Boundaries

Streams

- Good (<200)
- Fair (200 - 1,000)
- Poor (1,000 - 10,000)
- Very Poor (>10,000)

Rivers

- Good (<200)
- Fair (200 - 1,000)
- Poor (1,000 - 10,000)
- Very Poor (>10,000)

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Author: An Lewis

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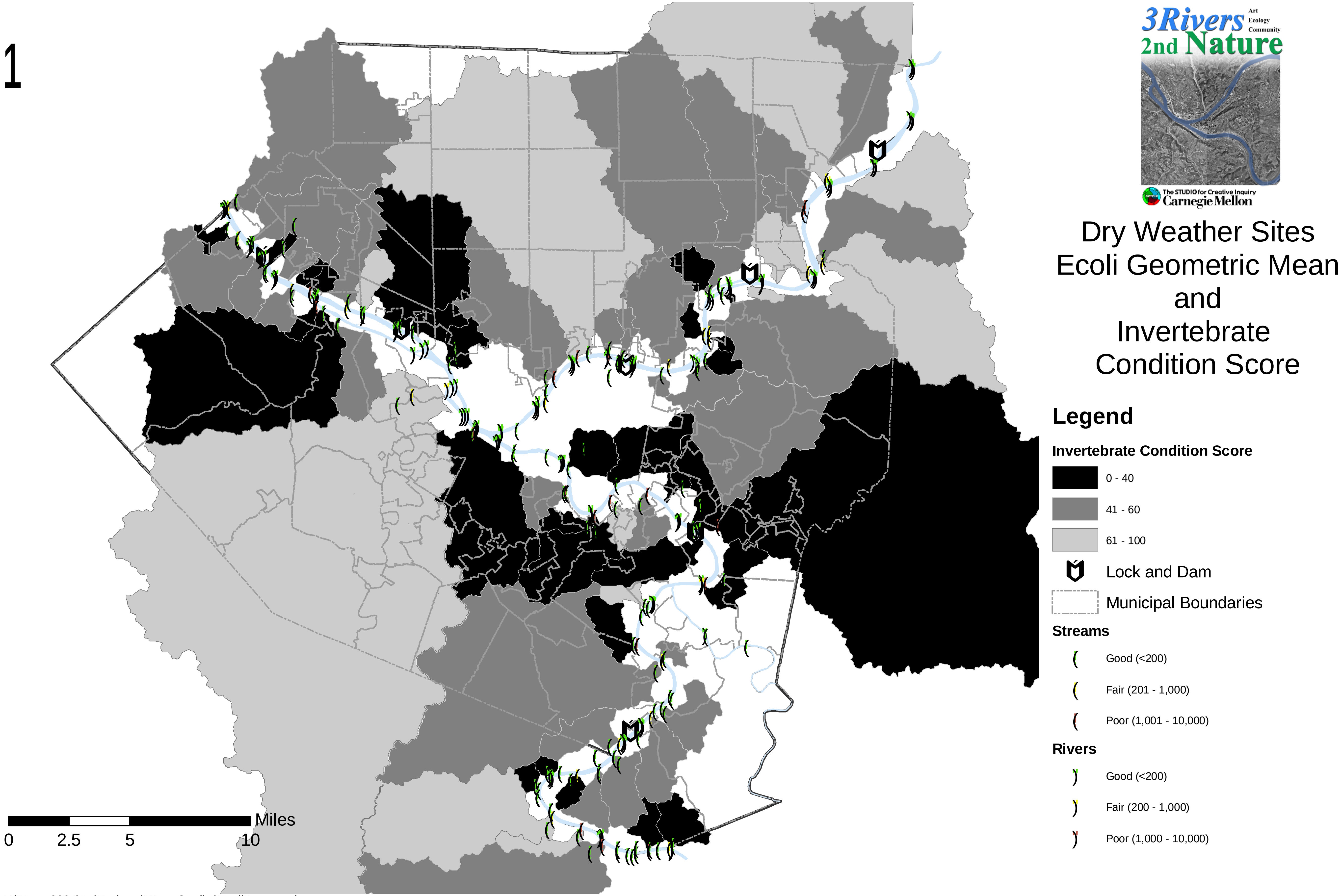

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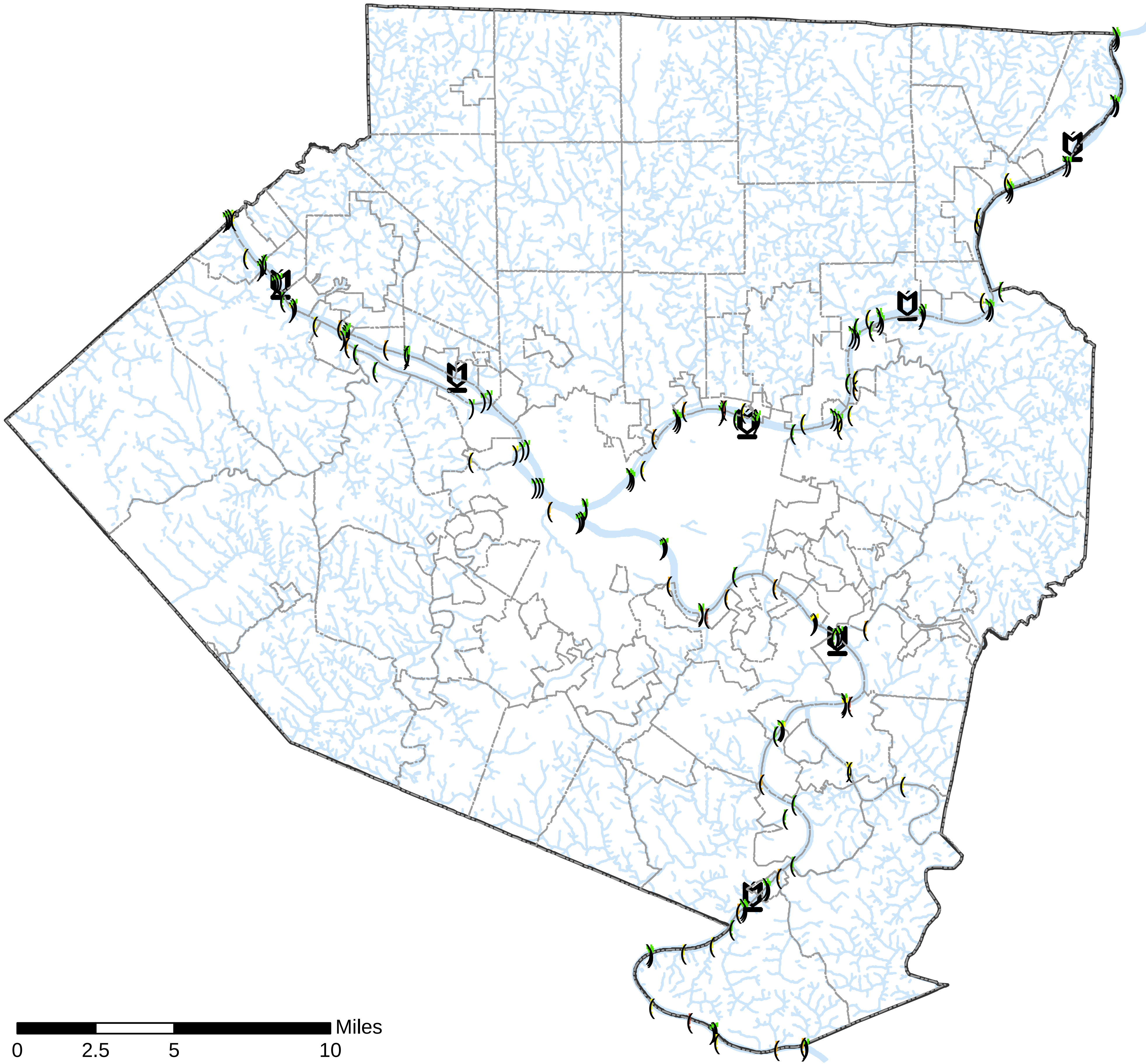
Author: An Lewis



Dry Weather Sites Fecal Coliform Geometric Mean

Legend

Lock and Dam

Hydrology

Municipal Boundaries

Streams

Good (<200)

Fair (200 - 1,000)

Poor (1,000 - 10,000)

Very Poor (>10,000)

Rivers

Good (<200)

Fair (200 - 1,000)

Poor (1,000 - 10,000)

Very Poor (>10,000)

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Author: An Lewis

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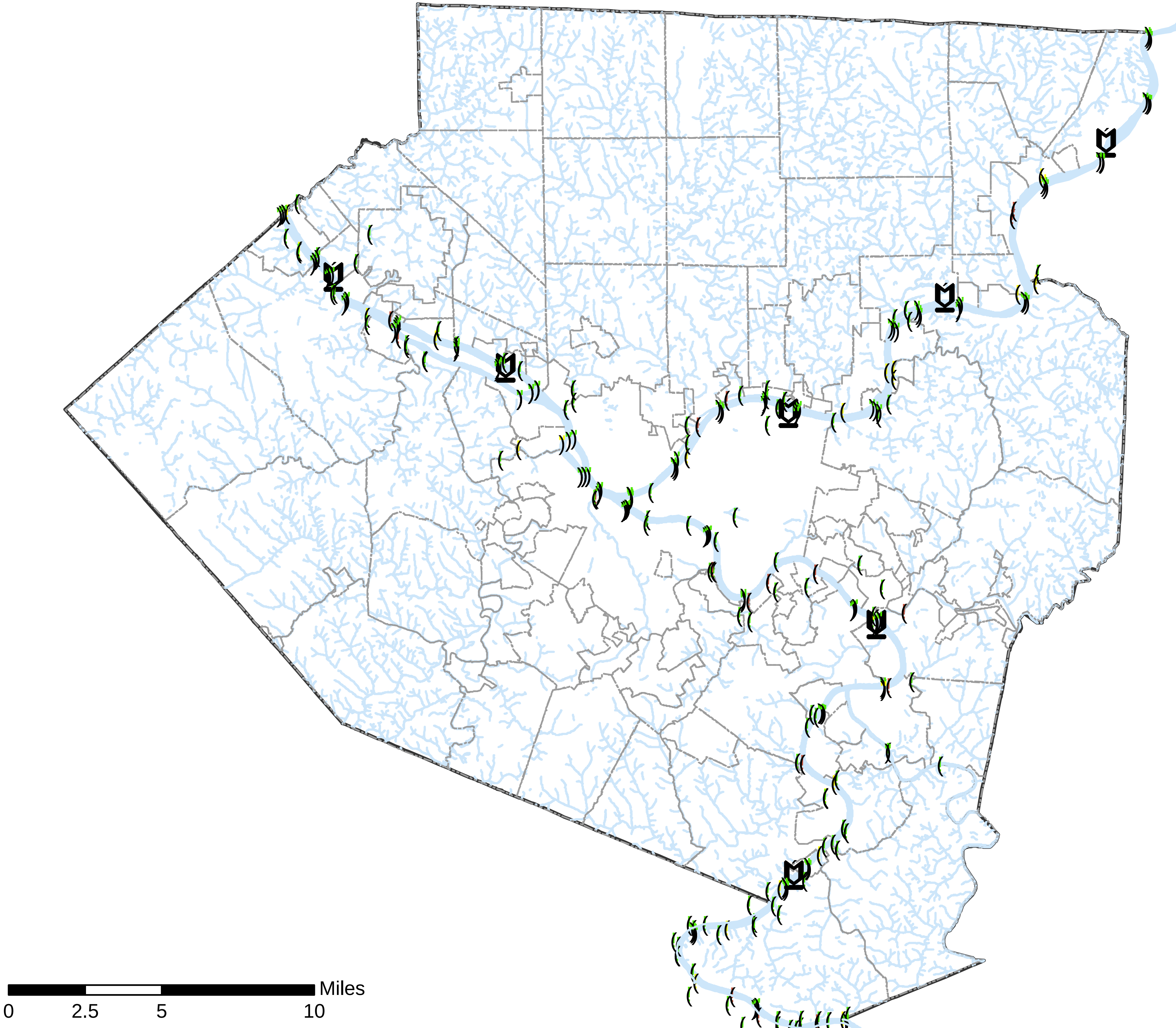
Dry Weather Sites
Ecoli Geometric Mean



Legend

Streams

- Good (<200)
- Fair (200 - 1,000)
- Poor (1,000 - 10,000)

River

- Good (<200)
- Fair (200 - 1,000)
- Poor (1,000 - 10,000)
- Lock and Dam
- Hydrology
- Municipal Boundaries

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Author: An Lewis