

3R2N Aquatic Report: Allegheny River
Phase 3 - 2002
Water Quality
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I. Abstract

This 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 2002, Year 3, the project focused on the Allegheny River from Locks and Dam 2 at Mile Point 6.7 near the Highland Park Bridge to Mile Point 39, below the confluence with the Kiskiminetas River.

Urban rivers have been used as a source for municipal water supply and as a drain 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 as 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, we seek 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, we hope 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.

Our method and process is 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.

A. Goals and Objectives

The goal of this 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.

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

Rivers in dry weather conditions:

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?

Rivers in wet weather conditions:

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 not performed on these river samples. Project advisors have suggested that there are a number of studies that identify increased biological diversity and other signs of river ecosystem health. It is assumed, but neither tested nor confirmed, that the industrial legacy includes contaminated sediments at the bottom of the rivers.

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).

B. 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 we have seen an increase in marinas on the rivers, as well as a vast number of informal public access points. These are favorite sites for fishing, sunning and other leisure activities.

While we tend to focus on access to the mainstem rivers, it is important to note that there is more potential for informal access along our region’s tributary streams than rivers. In our study area on the Monongahela River, nineteen tributary streams wind through many neighborhoods, dozens of communities and a significant number of public parks.

II. Materials and Methods

Sampling was conducted from a sixteen foot 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 work was limited to Pools 2, 3 and portions of 4 on the Allegheny River. Pool 2 is delimited on the downstream end by Lock and Dam 2 at Mile Point 6.7 to Lock and Dam 3 at Mile Point 14.5. Pool 3 is delimited by Lock and Dam 3 to Lock and Dam 4 at Mile Point 24.2. Pool 4 is delimited from Lock and Dam 4 to Mile Point 39, below the confluence with the Kiskiminetas River.

The wet weather work included areas in Pools 2, and 3 on the Allegheny as well as areas of the Pittsburgh Pool (see maps in Appendix C for overview of sites).

A. Dry Weather Sampling Program

Sampling Schedule: Sampling occurred during dry weather when public recreation is at its greatest, and when we have the best opportunity to provide baseline recreational use conditions of our river systems. Dry weather conditions were defined as a minimum of seventy-two hours after the last rainfall.

One river system was sampled one to two days per week (weather permitting), resulting in no more than twenty-four 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.

River Monitoring: Sample sites were chosen based on the relationship between public access and inflow points into the main stem rivers (see table 1). 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 Allegheny River in the Year 3 study area. Cross-sectional samples were taken at three points across the river (50-100 feet from the left descending bank, midstream and 50-100 feet from the right descending bank) at approximately one foot below the surface. This depth was selected based on our interest in public recreation (swimmers and recreational users are primarily in contact with surface water).

River Monitoring Parameter: The following parameters 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 *Standard Methods for the Examination of Water and Waste Water* (APHA et al. (1992) Sec. 9060). Total coliform, *E. coli* and enterococci followed defined substrate method (Idexx Laboratories, Westbrook, ME).

Tributary Stream Monitoring: Free-flowing

Table 1
Selected River Monitoring Sites in the Allegheny River Pools 2, 3 and 4.

Allegheny River Pool	Mile Point	Site Description
2	7.4	Above Lock and Dam 2
2	9.8	Below Sandy Creek
2	12.8	Oakmont
2	14.0	Below Lock and Dam 3
3	15.2	Above Lock and Dam 3
3	17.7	Downstream of New Kensington
3	22.6	Upstream of New Kensington
3	24.2	Below Lock and Dam 4
4	26.9	Above Locks and Dam 4
4	28.9	Below Kiskiminetas River

and culverted tributary streams that flow into the Allegheny 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 twenty feet.

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).

B. Wet Weather Sampling Program

Wet Weather sampling focused on bacteriological analyses and basic field parameters (table 2) limited to no more than twenty samples per testing-run. In 2001, the Allegheny County Health Department asked that we concurrently sample for wet weather in the Pittsburgh Pool as well as in Pools

Table 2

Selected Parameters for Rivers and Tributary Streams in the Pittsburgh Pool

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*
<i>E. coli</i>	Indicator species of mammalian fecal	ALCOSAN Lab	Idexx*
Enterococci	Indicator species of mammalian fecal	ALCOSAN Lab	Idexx*
Fecal Coliform	Indicator for fecal contamination	ACHD Lab	9220 D

(methods taken from APHA et al., 1992 except those noted with *)

*Idexx Laboratories, Westbrook, ME

Table 3

Selected Tributary Monitoring Sites on the Allegheny River

Tributary	Pool		
Squaw Run	2	Tawney Run	3
Sandy Creek	2	Riddle Run	3
Quigley Creek	2	Pucketta Run	3
Indian Creek	2	Crawford Run	3
Plum Creek	2	Days/Bailey Run	3
Campbells/Guys Run	2	Bull Creek	3
Fallen Springs	2	Chartiers Run	3
Deer Creek	2	Buffalo Creek	4

Table 4

Additional Parameters for Tributary Streams in the Pittsburgh Pool

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
Aluminum*	Indicator of acid mine drainage	ACHD Lab	3500-Al B
Copper**	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 Aluminum

**Dependent on analysis of upstream industrial (NPDES) discharges.

2, and 3 of the Allegheny River so that we could begin to develop an overview of the upstream/downstream relationships. 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 Monongehela and Allegheny Rivers above the confluence of the three rivers. Two sites on the Ohio River, upstream of Brunot's Island and upstream of Neville Island at Mile Point 6.2. Allegheny– the middle transects for Pool 3 and the lower three transects for Pool 2 (see attached maps for overview of wet weather sites).

A wet weather event (rain storm) was defined as occurring after a period of seventy-two hours since the previous rainfall, as recommended by USEPA (1992) for storm water sampling. A combination of the Oakmont, Allegheny Valley Joint Sewage Authority and ALCOSAN combined sewer overflow data, weather forecasts, and rainfall data provided the best indicator of broad-scale regional rainfall and wet weather impacts. The ALCOSAN wet well and interceptor system have been modeled to determine when overflows are occurring. This is based on the water flowing through the plant and wet well levels. We retained this system for the Allegheny River, partially in the ALCOSAN service because this is the same indicator used by the Allegheny County Health Department's Regional River Water Advisory Program. Sampling occurred twelve to twenty-four hours after a rain event, and for two days afterward. Results of all three sample sets were reviewed to determine if additional days of sampling would be needed. Rain gauge data are averaged from data collected by the Oakmont sewage treatment plant, Allegheny Valley Joint Sewage Authority and selected gauges of the Three Rivers Wet Weather Rain Gauge System.

C. 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 have been instituted in almost all aspects of the Three Rivers Second Nature project. The water quality team established procedural protocols and designated test sites. A Global Positioning System (GPS) unit was used for the initial site identification. The GPS unit was also used to navigate back to these sites for sampling (accuracy is within thirty feet). These sites included river transects consisting of three points, designated stream test sites, and wet weather protocol. Each site was given a specific name, which linked 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 streamline database design. With regard to the analysis of the river transects, GIS served as a powerful tool for visualization. By using thematic mapping variations in parameter, test values become more apparent. This can be seen in the GIS maps located in Appendix C.

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 caused by the fecal material of warm-blooded animals that may cause gastrointestinal illness (APHA, et. al, 1992). They also do not tell us the source of the fecal matter, which could come from wild fauna such as raccoons, rabbits or deer, or domesticated animals such as dogs and cats. Furthermore, from the methodology utilized here, they cannot tell us 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. What these pathogenic indicators do tell us is the impact of fecal matter on our rivers.

This survey does not meet the sampling requirements in the regulatory standards, stated below (five samples per site per month). However, by sampling over a five month period instead of one month, we were able to obtain a more complete 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.

A. 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 five 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 our 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.

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

C. 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 four 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, we recognize 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 Allegheny River Sampling

On the following pages you will find the results for our survey. The first three sections describe dry weather results for the three pools of the Allegheny River. For each of the pools, you will find two graphs and a table with a discussion of the results. One graph describes dry weather fecal coliform results, and one describes dry weather *E. coli* results. The table describes additional tributary stream data.

The third section describes all of the Three Rivers Second Nature data for the Allegheny River from Years 1 and 2 for fecal coliform and *E. coli*.

The fourth section describes wet weather results. The wet weather work included areas of the Pittsburgh Pool, as well as areas in Pools 2 and 3 on the Allegheny. One graph illustrates the water quality during rain events for fecal coliform and one graph for *E. coli* for the rain event sampled during the 2002 recreational season.

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 for the Examination of Water and Waste Water*, APHA et. al., 1992, the best estimate of central tendency of log-normal data is the geometric mean. 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.

A. Allegheny River – Pool 2

The Allegheny River was divided into three sections in Year 3 of the study in 2002. In each section, sampling locations include four river transects (except Pool 4) and the major tributary streams. Pool 2 is considered the river section between Lock and Dam 2 at the Highland Park Bridge near Sharpsburg, PA at Mile Point 6.7 to Lock and Dam 3 near Acmetonia, PA at Mile Point 14.5. Sampling for Pool 2 occurred on seven dry weather days from May 22, 2002 to August 21, 2002.

Figure 1 describes the fecal coliform geometric means for river transects and tributary streams for Pool 2 of the Allegheny River. There were six sampling events in which most of the sites were sampled. There are a few exceptions including Squaw Run with five samples and Shades Run which had no flow on three occasions. One sampling event on August 5, 2002 was aborted because of a thunderstorm. The August 5 data for the sites from Mile Point 14 to Plum Creek has been added to the database, making seven data points for some of those sites, except Indian Creek, Fallen Springs Run and Deer Creek (laboratory error) which have six samples each.

Since our sampling scheme did not permit sampling to take place more than twice per month with no more than seven samples collected per site over the 2002 recreation season, the standards shown in figure 1 cannot be directly applied to this data but are used in this instance as a benchmark to indicate relative water quality. With this in mind, the Allegheny River sites (indicated by mile points) are well within the geometric mean standard of 200 CFU/100ml.

On May 22, 2002, data for several of the river transects were above the 200 CFU/100ml benchmark, but below 300 CFU/100ml (see Appendix B for data for each sampling event). These data are below the recreational standard of less than 400 CFU/100ml in 10% of samples within a month. Many of the sites are below 100 CFU/100ml in the remaining sampling events.

On August 20, 2002, the fecal coliform data for the river transect sites at Mile Point 7.4 exceeded

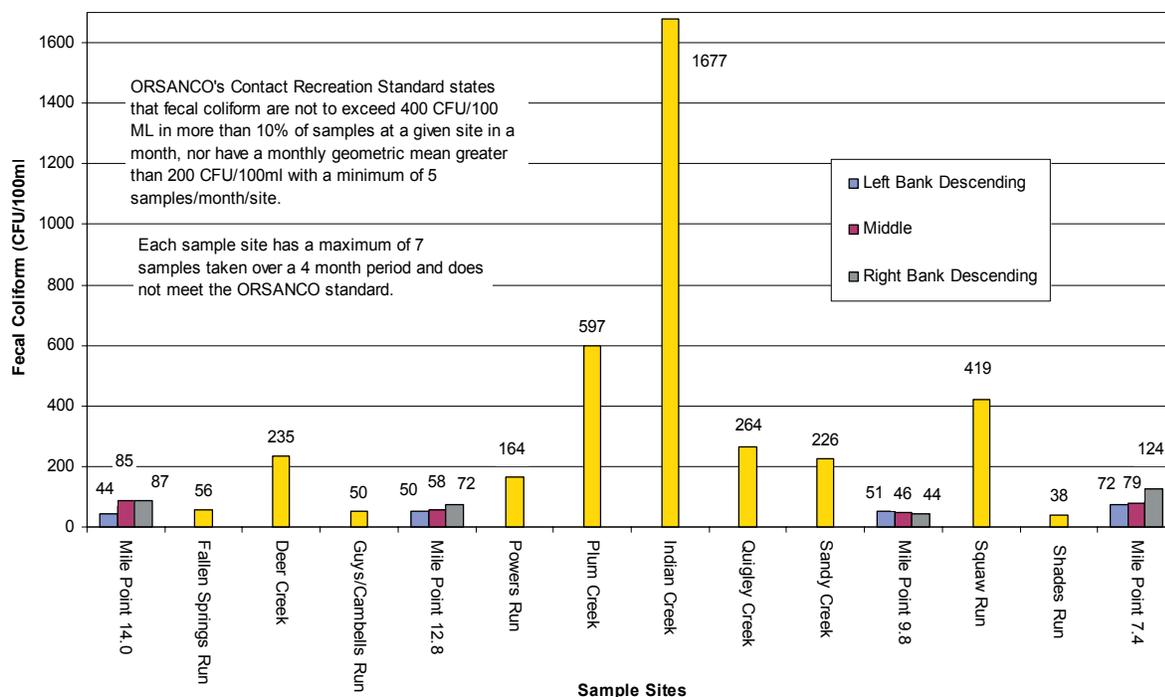


Fig.1. Geometric mean of fecal coliform data in the Allegheny River and its tributaries from Lock and Dam 3 at Acmetonia, PA to Lock and Dam 2 at Sharpsburg, PA in dry weather, 2002 recreational season.

the recreational standards by a factor of ten. For the left, middle and right banks, the data are 4,200, 2,500, and 2,300 CFU/100ml respectively. When the sites were sampled the next day on August 21, 2002, the data for those sites are below 50 CFU/100ml. It is unclear what would cause the data for this section of the river to vary by a factor of 100 within a twenty-four hour period.

While several of the tributary streams are within the 200 CFU/100ml benchmark, many exceed it. Most notably, the geometric mean for fecal coliform in Indian Creek is 1,677 CFU/100ml, with data from four out of six sampling events above 2000 CFU/100ml. The maximum concentration in Indian Creek is 7,100 CFU/100ml, which occurred on July 19, 2002. Indian Creek's watershed is very small and lies almost entirely within an urban environment in Verona, PA. The last segment of the stream flows through a culvert.

For five streams, Deer, Plum, Quigley, and Sandy Creeks, and Squaw Run, the geometric means of fecal coliform range from 226 to 597 CFU/100ml.

While these means may be above the recreational standard benchmark, they are not unexpected in larger somewhat urbanized watersheds (with the exception of Quigley Creek which has a small watershed) with many potential sources of fecal contamination, both human and animal.

Figure 2 shows the geometric means of the river transect and tributary stream data for *E. coli* for Pool 3 of the Allegheny River from May 22, 2002 to August 21, 2002. The numbers of samples per site are the same for *E. coli* as for fecal coliform as stated above. The one exception is Deer Creek which has seven data points for *E. coli* compared to six for fecal coliform (laboratory error occurred on the fecal coliform sample).

As stated above, our sampling scheme did not permit sampling to take place more than twice per month with no more than seven samples collected per site during the 2002 recreational season. Thus, the above standards shown in figure 2 cannot be directly applied to this data but are used in this instance as a benchmark. With this in mind, the geometric means

for *E. coli* data for the river transects are well below the ORSANCO standard of 130 CFU/100 ml. This is similar as the fecal coliform data. As with the fecal coliform data, several river transect sites have higher *E. coli* concentrations for May 22, 2002 compared to the rest of the sampling events. On this day, all of the four transects have concentrations a factor of ten higher than the other events ranging from 152 CFU/100ml at Mile Point 7.4 right descending bank to 461 CFU/100ml at Mile Point 12.8 right descending bank. Five locations are above the 240 CFU/100ml ORSANCO maximum standard (see Appendix B for individual data points).

River transect locations at Mile Point 7.4 also had high *E. coli* results for August 20, 2002 as it did for fecal coliform. *E. coli* concentrations range from 579 to 2,419 CFU/100ml for the three locations at that Mile Point transect. As with the fecal coliform data, *E. coli* concentrations are below 50 CFU/100ml on the following day, August 21. It is unclear what may have caused this spike in *E. coli* concentrations.

Although this data set cannot be directly

compared to the ORSANCO standard for reasons stated above, it is of note that only two of the nine tributary stream sampling locations are within the ORSANCO recreational geometric mean standard of 130 CFU/100ml. Each of the seven tributary streams that exceeds the 130 CFU/100ml geometric mean standard also has at least one sample that exceeds the 240 CFU/100ml standard (the maximum concentration allowed for any one sample). As with the fecal coliform results, Indian Creek has the highest concentration of *E. coli* of any tributary stream sampled. Three of the six data points are over the 2,419 CFU/100ml upper detection limit.

Additional Parameters for Tributary Streams: Average concentrations of each of the chemical and field parameters are shown in table 5. All of the streams are designated as warm water fisheries except Squaw Run, which is considered a high quality warm water fishery (25 PA Code § 93.9v).

Most parameters are within the Pennsylvania water quality criteria for the designated uses of the tributary streams. On June 4th Quigley Creek

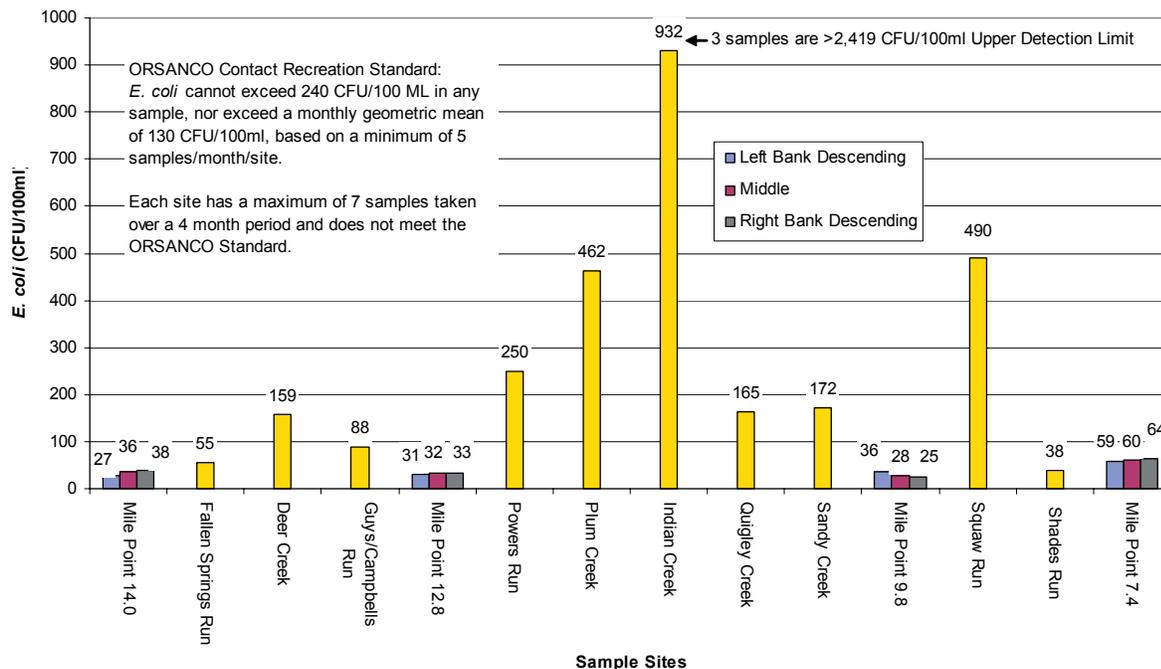


Fig. 2. Geometric mean of *E. coli* data in the Allegheny River and its tributaries from Lock and Dam 3 at Acmetonia, PA to Lock and Dam 2 at Sharpsburg, PA in dry weather, 2002 recreational season.

exceeded the maximum temperature criteria of 26.7°C for June 1st through the 5th with a temperature of 31.8 °C daily maximum. Falling Spring Run had a maximum ammonia concentration of 2.41 mg/L. See Appendix A for the PADEP water quality criteria.

B. Allegheny River – Pool 3

The Allegheny River was divided into three sections in Year 3 of the study in 2002. In each section, sampling locations include four river transects (except Pool 4) and the major tributary streams. The second section, called Pool 3, is bounded by the Lock and Dam 3 near Acmetonia, PA at Mile Point 14.5 and Lock and Dam 4 near Natrona, PA at Mile Point 24.6. Sampling of this river system occurred on six different dry weather days from June 25, 2002 to September 25, 2002. The results are

discussed in the following paragraphs.

Figure 3 describes the fecal coliform geometric means for river transect and tributary stream data for Pool 3 of the Allegheny River. There were six sampling events for which most locations were sampled. Three streams have less than six samples: Clarks/Crawford Run which had flow during two events only, Bailey Run which was sampled four times and Riddle Run which was sampled five times.

Since our sampling scheme did not permit sampling to take place more than once or twice per month with no more than six samples collected per site over the recreations season, the above standards shown in figure 3 cannot be directly applied to this data, but are used in this instance as an benchmark to indicate relative water quality. With this in mind, the Allegheny River transects (indicated by mile points) are within the geometric mean standard of 200

Table 5

Average Concentrations of Additional Parameters for Tributary Streams in Pool 2 of the Allegheny River in the 2002 Recreational Season.

Pool 2	Ammonia mg/L	TDS mg/L	Alkalinity mg/L	Hard- ness mg/L	Total Iron mg/L	Turbidity NTU	Temp °C	PH SU	DO mg/L	Conductivity umhos/cm
Fallen Springs Run	0.8409	377	99	124	0.122	1.08	19.26	7.87	9.64	483
Deer Creek	0.0689	1269	372	168	0.334	3.96	17.79	7.86	9.13	1269
Guys/Campbells Run	0.1997	1213	337	120	0.454	2.55	17.95	7.92	9.70	1474
Powers Run	0.0245	479	135	188	0.038	0.59	19.77	7.93	7.93	796
Plum Creek	0.0387	719	117	219	0.060	2.12	17.57	7.80	8.31	999
Indian Creek	0.0495	780	137	222	0.049	0.76	20.38	7.76	7.90	1147
Quigley Creek	0.0721	572	112	166	0.018	0.40	21.31	8.03	7.76	834
Sandy Creek	0.0580	544	151	192	0.124	4.80	20.10	7.85	8.08	989
Squaw Run	0.0451	577	118	157	0.051	0.86	19.53	7.71	9.65	852
Shades Run	0.0356	966	162	337	0.023	1.23	16.60	7.97	8.43	1322

There are six data points for Tem., pH, DO, and Conductivity and three data points for all other parameters except for Shades Run, Squaw Run, and Plum Creek, which have only two day points.

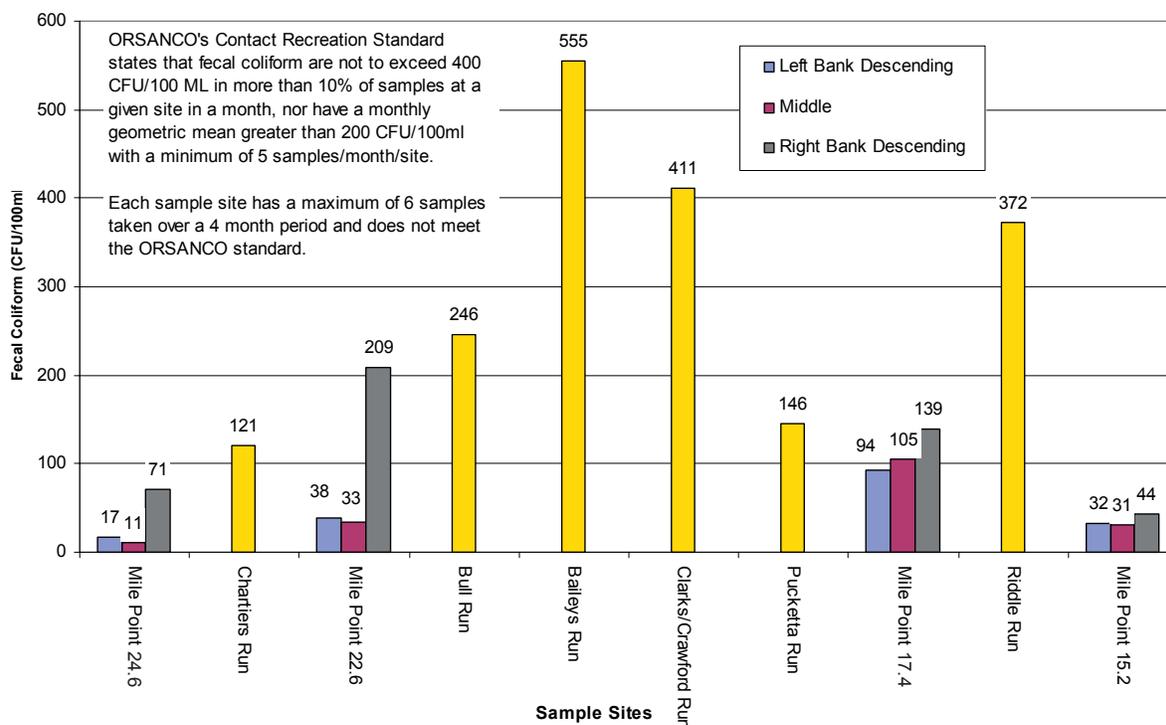


Fig. 3. Geometric Mean of fecal coliform data for the Allegheny River and its tributaries from Lock and Dam 4 at Natrona, PA to Lock and Dam 3 at Acmetonia, PA in dry weather, 2002 recreational season.

CFU/100ml, except for the geometric mean for the right descending bank at Mile Point 22.6 at 206 CFU/100ml. This river location has four of six data points above 400 CFU/100ml, the ORSANCO standard for which no more than 10% of samples for a site should exceed within a month. The maximum concentration for any river location occurred at Mile Point 17.4 right bank on July 2, 2002: 750 CFU/100ml (see Appendix B).

Only two tributary streams out of six are within the 200 CFU/100ml geometric mean recreational standard: Chartiers Run and Pucketta Run with 121 and 146 CFU/100ml respectively. All of the tributary streams except Chartiers Run have at least one sample above 400 CFU/100ml, the ORSANCO standard for which no more than 10% of samples for a site should exceed within a month. Bailey Run has the highest fecal coliform concentration of the tributary streams at 4,000 CFU/100ml which occurred on July 18, 2002. While these results may be above the recreational standard benchmark, they are not unexpected in larger

somewhat urbanized watersheds with many potential sources of fecal contamination, both human and animal.

Figure 4 shows the geometric means of the Allegheny River Pool 3 data for *E. coli* over a three month period from June 25 to August 28, 2002. There were six sampling events as stated above in the fecal coliform results section. *E. coli* data for the September 25, 2002 event was discarded due to an apparent laboratory error. On three occasions, Clarks/Crawford Run had no flow and was not sampled. Baileys Run and Riddle Run have only four data points each.

As stated in previous sections, the standards shown in figure 4 cannot be directly applied to this data but are used in this instance as a benchmark. With this in mind, the geometric means for *E. coli* of the river transects are below the ORSANCO standard of 130 CFU/100 ml, except for the right descending bank at Mile Point 22.6, similar to the fecal coliform results shown in figure 3. The data at this sampling location also exceed the 240 CFU/100ml maximum

Table 6

Average Concentrations of Additional Parameters for Tributary Streams in Pool 3 of the Allegheny River in the 2002 Recreational Season.

Pool 3	Ammonia mg/L	TDS mg/L	Alkalinity mg/L	Hardness mg/L	Iron mg/L	Turbidity NTU	Temp °C	PH SU	DO mg/L	Conductivity umhos/cm
Chartiers Run	0.3252	530	96	147	0.718	5.79	25.11	7.76	6.78	441
Bull Creek	0.0757	1238	134	222	0.336	2.87	23.25	7.33	7.57	698
Baileys Run	0.0303	932	191	195	0.381	1.90	23.35	7.16	8.14	1504
Clarks/ Crawford Run							22.76	8.02	8.51	676
Pucketta Creek	7.000	605	142	156	0.618	9.59	22.54	7.85	7.97	1000
Riddle Run	0.2001	638	144	277	3.340	7.06	26.05	7.69	6.42	391

There are six data points for Temp., pH, DO, and Conductivity except for Clarks/Craford Run which have two data points. There are three data points for other parameters except for Bailey Run which has one data point.

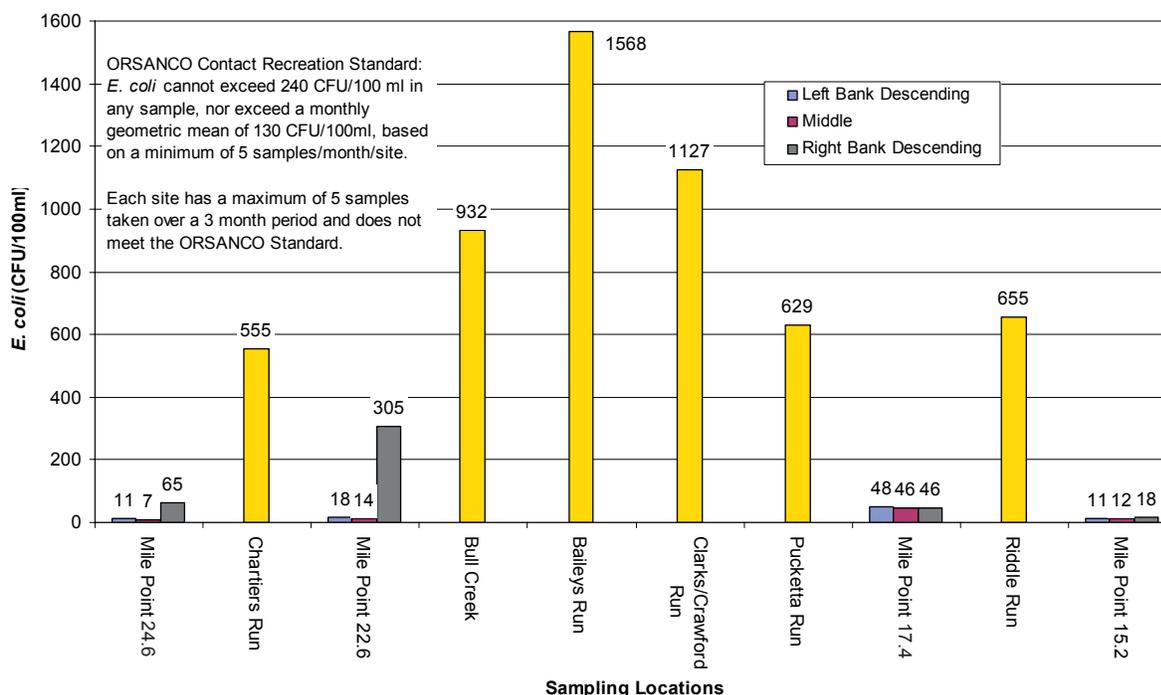


Fig. 4. Geometric mean of *E. coli* data in the Allegheny River and its tributaries from Lock and Dam 4 at Natrona, PA to Lock and Dam 3 at Acmetonia, PA in dry weather, 2002 recreational season.

recreational standard for three of the five samples. Mile Point 24.3 right descending bank has one sample that exceeds the 240 CFU/100ml maximum standard for any one sample at 461 CFU/100ml on August 28, 2002 (see Appendix B).

No tributary stream meets the 130 CFU/

100ml geometric mean standard. Only two samples are below the 240 CFU/100ml maximum standard—these occur in Chartiers Run and Bull Creek.

Additional Parameters for Tributary Streams: Average concentrations of each of the chemical and field parameters are shown in table 6. All of the

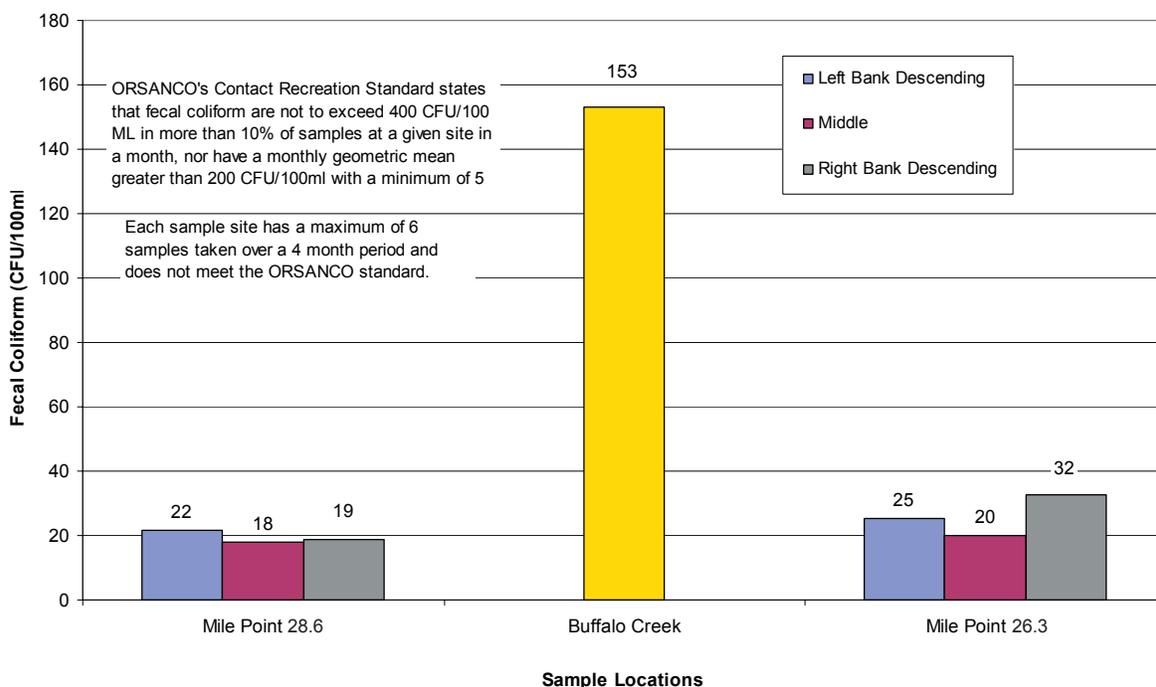


Fig. 5. Geometric mean of fecal coliform data for the Allegheny River and its Tributaries below the Kiskiminetas River to lock and dam 4 at Natrona, PA in dry weather, 2002 recreational season.

tributary streams are designated as warm water fisheries except Chartiers Run, Bull Creek and Pucketa Creek, which are designated for trout stocking (25 PA Code § 93.9v).

Most parameters are within the Pennsylvania water quality criteria for the designated uses of the tributary streams. Pucketa Creek had ammonia nitrogen concentrations of 13.6 and 7.35 mg/L on two occasions with the third result 0.06 mg/L. Riddle Run had a maximum iron concentration of 6.1 mg/L. See Appendix A for the PADEP water quality criteria.

C. Allegheny River – Pool 4

The Allegheny River was divided into three sections in Year 3 of the study in 2002. In each section, sampling locations include four river transects (except Pool 4) and the major tributary streams. The third section, called Pool 4, is bounded by the Lock and Dam 4 near Natrona, PA at Mile Point 24.2 and the Kiskiminetas River at Mile Point 28.9. Sampling of this river system occurred on six different

dry weather days from July 25, 2002 to October 9, 2002. The results are discussed in the following paragraphs.

Figure 5 describes the fecal coliform data for Pool 4 for the 2002 recreational season. There were six sampling events over a three month period, therefore the ORSANCO standards cannot be directly applied to the data but used as a benchmark. The geometric means of both river transects are within the 200 CFU/100ml ORSANCO geometric mean recreation standard. All of the individual river data points are below the 400 CFU/100ml maximum standard for individual samples as well. The geometric mean of Buffalo Creek is also within the 200 CFU/100ml standard. However, two of the six data points are above 400 CFU/100ml at 450 and 540 CFU/100ml. These results are not unexpected because of the less urbanized nature of Buffalo Creek and the upper Allegheny River. In such places there is less potential for human sources of fecal contamination. Also, few agricultural sources exist in this section of the river, making livestock sources of contamination unlikely as

Table 7

Average Concentrations of Additional Parameters for Bull Creek in Pool 4 of the Allegheny River in the 2002 Recreational Season (six samples)

	Temp (°C)	pH (SU)	DO (mg/L)	Conductivity (umhos/cm)
Bull Creek	17.31	6.45	8.90	418

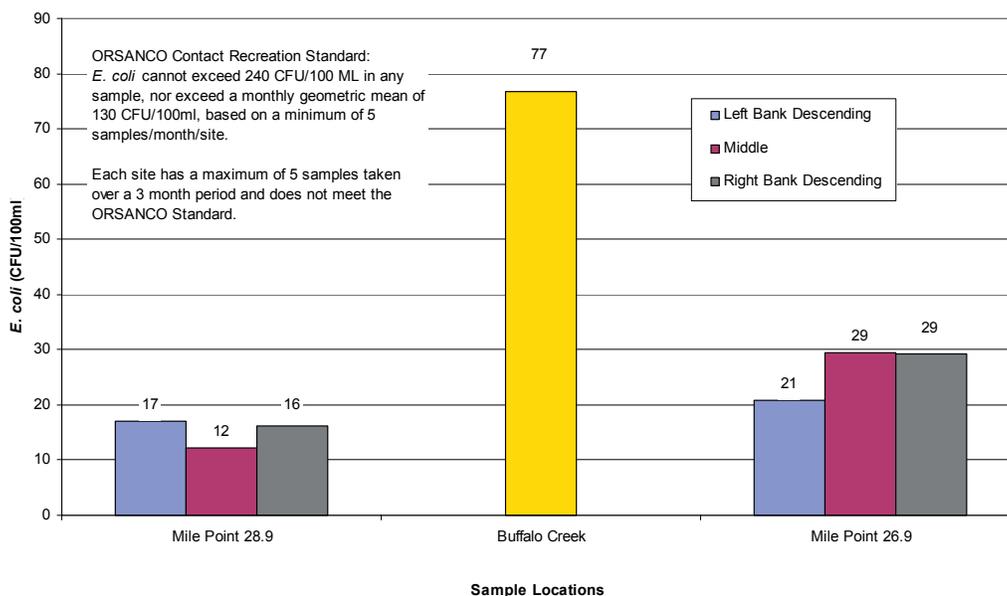


Fig. 6. Geometric mean of *E. coli* data for the Allegheny River and its tributary below the Kiskiminetas River to Lock and Dam 4 at Natrona, PA in dry weather, 2002 recreational season.

well.

Figure 6 describes the *E. coli* data for Pool 4 for the 2002 recreational season. There were six sampling events over a three month period, however the October 9, 2002 data set is unavailable due to laboratory error. The ORSANCO standards in figure 6 are used only as a benchmark in this study. All of the river data are within both the geometric standard of 130 CFU/100ml and the maximum standard of 240 CFU/100ml. The maximum river sample of 87 CFU/100ml occurred at Mile Point 26.9 right descending bank on August 1, 2002. Buffalo Creek also is within the 130 CFU/100ml geometric mean standard. Only one of the five data points is above the 240 CFU/100ml maximum standard, at 278 CFU/100ml. This also occurred on August 1, 2002.

Additional Parameters for Tributary Streams:

Buffalo Creek is the only tributary stream in our study area in Pool 4. Only temperature, pH, dissolved oxygen (DO) and conductivity were measured. Buffalo Creek is designated as a trout stocked fishery. Our data indicates that the creek meets the requirements of the parameters in table 7 as a trout stream. See Appendix A for the PADEP water quality criteria.

D. Allegheny River Transects – Mile Points 28.9 – 0.18

The length of the Allegheny River in Allegheny County is approximately thirty miles from Downtown Pittsburgh to the border with County just south confluence with the Kiskiminetas River. In Years 1 and 3 of the Three Rivers Second Nature project, the twelve transects along the thirty-mile length have been sampled. Three Locks and Dams split the river into four pools. The following graphs compare the data

from the river from Mile Points 28.9 – 0.18.

Figure 7 illustrates that all but one of the river transects sampled on the Allegheny River in Allegheny County are within the 200 CFU/100ml ORSANCO recreational standard that is used in this study as benchmark. The only site that exceeds this benchmark (Mile Point 22.6 right descending bank) does so by 6 CFU/100ml. These data would indicate that during dry weather the Allegheny River from the confluence with the Monongahela River at Point State Park to Pool 4 is within the acceptable recreational standards for contact with the water. Wet weather impacts were investigated in Year 3 and are discussed below.

Figure 8 illustrates the *E. coli* data for the Allegheny River from Mile Point 28.9 to 0.18. The data are similar to the fecal coliform data shown in figure 7. As with fecal coliform data, the only site with high *E. coli* concentrations that exceed the ORSANCO geometric mean recreational standard of 130 CFU/100ml that is used here as a benchmark is Mile Point 22.6, right bank descending. Clearly, there is a source of contamination on the right bank near the town of Blackenridge or farther upstream that should be investigated.

E. Allegheny River Wet Weather

For the 2002 season, there was only one wet weather event sampled. Select sites in the Allegheny River in Pools 2 and 3 as well as select sites in the Pittsburgh Pool along the Monongahela, Allegheny, and Ohio Rivers were sampled. Sampling occurred twenty-four to seventy-two hours (one to three days) after a rain event (see Appendix B for raw data). Rain gauge data are averaged from data collected by three gauges of the Three Rivers Wet Weather Rain Gauge System in the vicinity of the Allegheny River sites: Shaler Municipal Building, Highland Park Reservoir and ALCOSAN's Sandy Creek Pump Station. Combined Sewer Overflow data was gathered from the Allegheny County Sanitary Authority.

Figures 9 and 10 illustrate the fecal coliform and *E. coli* data for the September rain event. An average of 0.6 inches of rain fell over the Allegheny

River Valley on September 15, 2002 within a two hour time span starting at approximately noon. An additional 0.2 inches of rain fell between five-thirty and six o'clock pm on September 15. No additional precipitation was recorded from September 16-18. Combined sewer overflows were reported for the ALCOSAN service area that includes Mile Point 9.8 as well as the Pittsburgh Pool for September 15 ending at ten o'clock pm, nearly twenty-four hours before sampling occurred. CSO information is not available to other treatment plants in the Allegheny Valley.

In figure 9, the fecal coliform data for the right bank at Mile Point 22.6 is a factor of ten higher on all three sampling days (2000, 650 and 1700 CFU/100ml) than the middle or left bank of Mile Point 22.6 (Appendix B). Although not clearly illustrated in figure 10, Mile Point 22.6 right bank has the highest *E. coli* concentrations in Pools 2 and 3 on September 16 at 1120CFU/100ml. For the middle and left descending bank at Mile Point 22.6, *E. coli* concentrations were 93 and 82 CFU/100ml respectively. On September 18, Mile Point 22.6 right bank had the highest *E. coli* concentration of all the sampling sites at 1986 CFU/100ml. These data again illustrate that a source of fecal contamination exists in that section of the river.

In figures 9 and 10, the other sites in Pools 2 and 3 have higher fecal coliform results in this wet weather event than in dry weather on September 16 and 17, 2002. Mile Point 12.8 had the lowest fecal coliform and *E. coli* concentrations than all of the sites. Not surprisingly, the Pittsburgh Pool sites have higher concentrations of both fecal coliform and *E. coli* than in Pools 2 and 3 on September 16, nearly twenty-four hours after the rain event. On September 18, almost seventy-two hours from the rain event, the sites (except for Mile Point 22.6 right) have returned to near base line conditions.

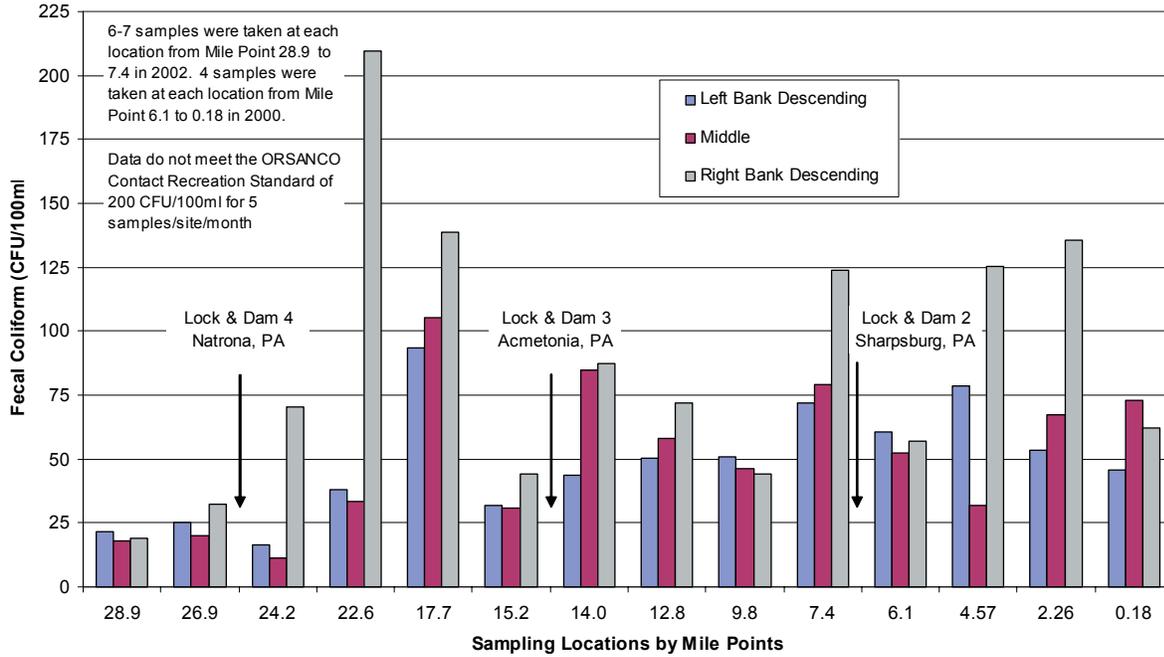


Fig. 7. Geometric mean of fecal coliform data for the Allegheny River from the Kiskiminetas River to the confluence with the Monongahela River in dry weather, 2000 & 2002 recreational seasons.

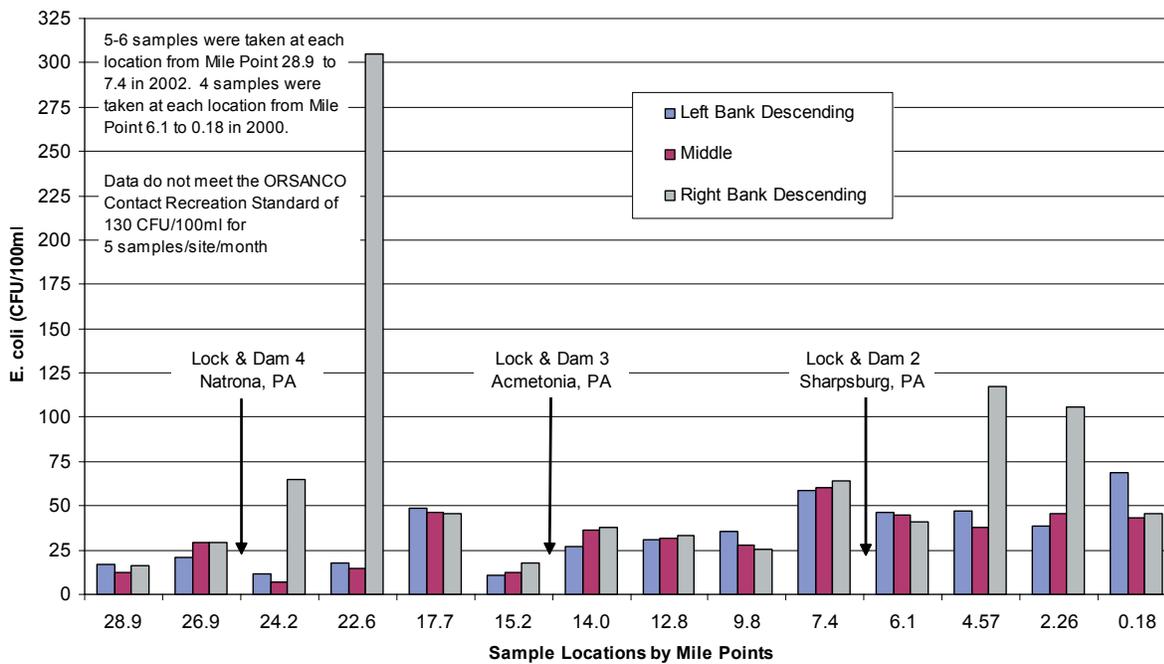


Fig. 8. Geometric mean of *E. coli* data for the Allegheny River from the Kiskiminetas River to the confluence with the Monongahela River in dry weather, 2000 & 2002 recreational seasons

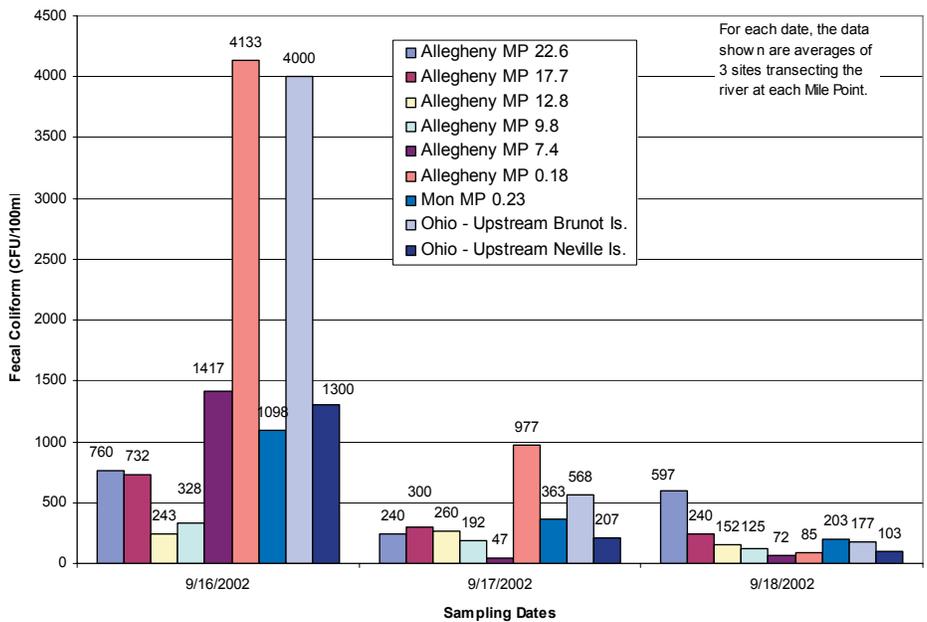


Fig. 9. Average fecal coliform data for select sites along the Allegheny, Monongahela, and Ohio Rivers following a wet weather event in September 2002.

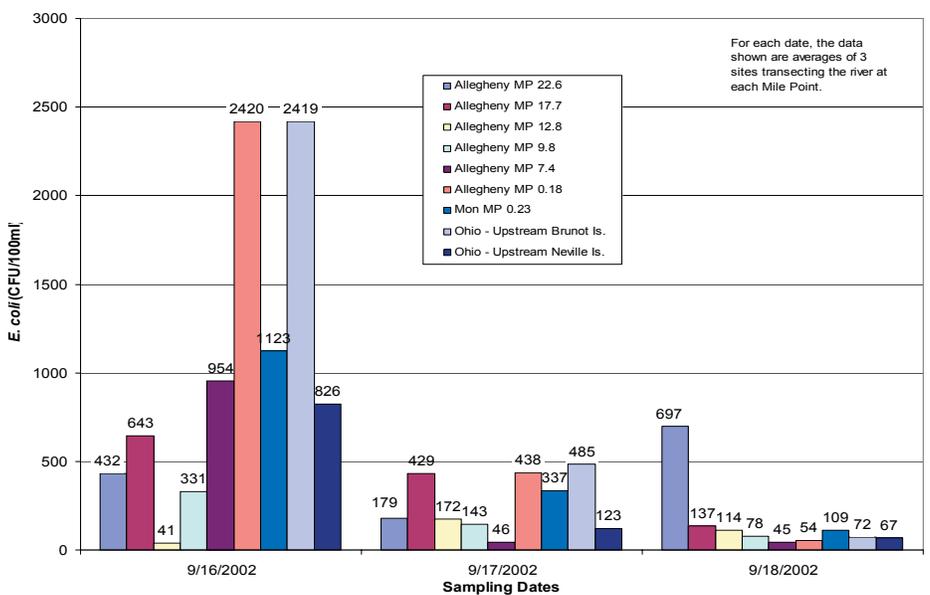


Fig. 10. Average *E. coli* data for select sites along the Allegheny, Monongahela, and Ohio Rivers following a wet weather event in September 2002.

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.

Our data indicate that fecal pollution impacts tributary streams in dry weather. This is a primary area for further study because the number of stream miles is twenty times the number of river miles in Allegheny County. Streams frequently run through parks and neighborhoods.

On the rivers, we found some good news. 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 are limited to one event and indicate that the Pittsburgh Pool is more greatly impacted by fecal contamination than upstream pools.

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.

A. Rivers in Dry Weather:

1. What is the water quality baseline and are there spatial variations in quality? As table 8 indicates, the Allegheny 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, only one test location exceeds this geometric mean benchmark for fecal coliform and E. coli. This site is in Pool 3 at Mile Point 22.6, right descending bank downstream of Tarentum

and Brackenridge, underneath the Tarentum 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 lies along the right bank and at Mile Point 22.6, has not fully mixed with the river flow.

Another point of concern is Mile Point 7.4 in Pool 2. The data for this point are within the fecal coliform and E. coli standards except for one sampling event on August 20. Data for this event are a factor of ten higher than the recreational standards, with fecal coliform data ranging from 2,300 to 4,200 CFU/100ml. Within twenty-four hours, the fecal coliform data are below 50 CFU/100ml. This indicates that during dry weather, this site have quite variable fecal coliform and E. coli concentrations.

2. Are there water quality problems indicated at points of public access? As discussed above, fecal coliform data at Mile Point 22.6 right descending bank exceeded benchmark concentrations. This area is located at a PA Fish and Boat Commission public boat ramp and is downstream of several private marinas.

3. Are there specific locations that warrant further study? Why? The fate and transport of fecal coliform and E. coli should be studied to determine how long these bacteria survive in the river and how far they travel. This will help determine the impact of upstream sources.

B. Rivers In Wet Weather:

1. What is the wet weather water quality and are there spatial variations? Only one wet weather event was sampled in 2002. This storm had 0.8 inches of rain more than twelve hours before sampling occurred. Therefore no strong conclusions can be drawn. However, on the first day of sampling on September 16, high fecal coliform results were obtained in Pool 3 at Mile Point 17.7 at the middle and left descending bank sampling locations (1,200 and 715 CFU/100ml, respectively), which is downstream of the town of New Kensington. These sites showed decreased fecal coliform concentrations the following two days. Also in Pool 3, the right

Table 8
Fecal Coliform Results for River Samples in the Allegheny River for
the 2002 Recreational Seasons in Dry Weather*

Allegheny River Pools	Geometric Mean ** CFU/100ml
Pool 4 – MP 26.9 – 28.9	22
Pool 3 – MP 24.2 – 15.2	49
Pool 2 – MP 14.0 – 7.4	64
Pittsburgh Pool – MP 6.01 – 0.18***	65-

*At least three 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

Table 9
Arithmetic means of fecal coliform wet weather data for the Allegheny River on September 16-18, 2002

Fecal Coliform	Pittsburgh Pool (12 data points/day)	Pool 2 Sharpsburg-Acmetonia (9 data points/day)	Pool 3 Acmetonia-County Line (6 data points/day)
Day 1 Sept 16, 02 Arithmetic Mean (CFU/100ml)	2,633	663	745
Day 2 Sept 17, 02 Arithmetic Mean (CFU/100ml)	529	166	270
Day 2 Sept 18, 02 Arithmetic Mean (CFU/100ml)	142	116	418

descending bank at Mile Point 22.6 had high concentrations of fecal coliform for all three sampling days (2,000, 670, 1,700 CFU/100ml). This is the same location with high fecal coliform concentrations in dry weather.

Pool 2, the sampling locations at Mile Point 7.4 had high fecal coliform concentrations on the first day of sampling, September 16 (400, 2,310, and 1,540 CFU/100ml, right, middle and left descending banks respectively). On the following sampling days, fecal coliform concentrations were less than 100 CFU/100ml for these sites.

Figure 9 illustrates the average concentrations of fecal coliform for each pool on each day of the wet weather sampling event. The Pittsburgh Pool had the highest concentrations on Days 1 and 2 than the other pools in the Allegheny River. By Day 3, the Pittsburgh Pool had returned to near baseline fecal coliform concentrations, as did Pool 2. Pool 3 data remained higher than baseline due to the results from Mile Point 22.6 right descending bank. The results indicate that the Pittsburgh Pool, which is affected by the Allegheny County Sanitary Authority combined sewer overflows, has higher fecal coliform concentrations than up river in Pools 2 and 3, although this needs further study.

The results are similar to Year 2 wet weather results in the Monongahela River (see 3R2N Year 2-2001 Water Quality Report). Pittsburgh Pool sites were generally higher in fecal coliform concentrations and took longer to return to baseline concentrations than sites in the Monongahela River Pools 2 and 3. Like the upper pools of the Monongahela River, the Allegheny River upper pools in this study are not as heavily urbanized and do not have the high concentrations of combined sewer overflows as the Pittsburgh Pool.

2. Are there wet weather water quality problems at points of public access? As in the previous years' data (see 3R2N Year 1-2000 Water Quality Report and 3R2N Year 2-2001 Water Quality Report), the sampling locations in the Pittsburgh Pool have high concentrations of fecal coliform after a rain storm. These sites are either near points of public

access or near areas with heavy river recreation. In the upper pools, our one wet weather event indicated that the two areas that have high fecal coliform concentrations in the range of 2,000 – 2,300 CFU/100ml in wet weather also have high concentrations in dry weather: Mile Point 22.6 right descending bank (the location of a PA Fish and Boat Commission public boat ramp) and Mile Point 7.4, which is influenced by ALCOSAN combined sewer overflow structures and near several private marinas.

3. Are there space and time differences regarding a return to dry weather conditions? While any broad conclusions are difficult to determine with only one wet weather event sampled, Mile Point 22.6 right descending bank had high concentrations of fecal coliform for all three days, at 1,700 CFU/100ml on Day 3, while the fecal coliform concentrations at the other sampling locations in all pools were below 245 CFU/100ml on Day 3 (September 18, 2002).

4. Are there specific areas that warrant further study? Why?—More wet weather sampling in the Allegheny River is necessary to support the conclusions of the one wet weather sampling done in 2002.

Our results indicate that there is a relationship between urban density and wet weather water quality problems. If this relationship is confirmed, then land use and development density will provide better indications of wet weather water quality problems than was previously considered. This would occur due to the relative impervious nature of urban systems and the more pervious nature of rural systems. Further testing could be indicated by mapping development density in relative relationship to specific surface stream, or river drainage areas. The next round of wet weather testing could then target areas just downstream from highly urbanized areas.

C. Tributary streams

1. What is the water quality and how does it vary among the tributary streams? Of the seventeen tributary streams sampled in the Allegheny River Pools 2, 3 and 4, few have been thoroughly studied.

The Allegheny County Natural Heritage Inventory (1994) lists Deer Creek Valley as having exceptional significance for its flood plain forest and high species diversity. It also cited improving water quality as important increased fish populations. Our results indicate that Deer Creek's fecal coliform and *E. coli* concentrations are just above the recreational standards used as benchmarks for this study by 35 and 29 CFU/100ml, respectively.

Several of the streams have variable fecal coliform and *E. coli* concentrations from sampling event to sampling event (see Appendix A). This may indicate a intermittent source of contamination.

The geometric means of fecal coliforms for twelve of the seventeen tributary streams were below 400 CFU/100ml. Only one stream, Indian Creek in Pool 2 had a geometric mean greater than 1000 CFU/100ml at 1,677 CFU/100ml. For *E. coli*, nine of the seventeen streams had *E. coli* results greater than 400 CFU/100ml, with two of the ten (Clarks/Crawford Run and Bailey Run) greater than 1,000 CFU/100ml.

Allegheny River Tributary Streams Pool 2

Most Impacted with Fecal Coliform (>400 CFU/100ml): Indian Creek, Plum Creek, Baileys Run, Squaw Run

Least Impacted with Fecal Coliform (<60 CFU/100ml): Shades Run, Falling Spring Run, Guys/Campbells Run

Allegheny River Tributary Streams Pool 3

Most Impacted (>400 CFU/100ml): Baileys Run, Clarks/Crawford Run

Least Impacted (<150 CFU/100ml): Chartiers Run and Pucketa 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? Many private marinas are located on the Allegheny River in the study area. The notable public access boat ramp (PA Fish and Boat Commission) is just upstream of Bull Creek. The geometric mean of Bull Creek fecal coliform data is 246 CFU/100ml, with a maximum of 1,400 CFU/100ml. The geometric mean of *E. coli* data for Bull Creek 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.

4. Does each tributary stream have the minimum conditions to support aquatic life? Most of these tributary streams support a range of wildlife, as observed during sampling and meet the criteria for their designated uses. Benthic macroinvertebrates are the insects and other invertebrates that live on the bottom of rivers and tributary streams. They are the food sources for fish and birds. Monitoring these benthic communities tells us significant information about the health of the stream from a biological point of view. The results of the macroinvertebrate study performed by Three Rivers Second Nature will indicate in a more complete sense whether the tributary streams can sustain aquatic life.

5. Do these tributary streams warrant further study? Why? A targeted pathogen study of the upper watersheds of each stream will indicate where sources of pollution are located and whether they are point or non-point sources. This, in turn will give us a much better sense of the public health issues on each specific watershed.

D. In Summation

Dry Weather: Our sampling indicates that dry weather water quality conditions meet our target water quality standard for recreational use most

of the time. The exception is Mile Point 22.6, right descending bank.

From May to October, the Allegheny County Health Department notifies the general public of health concerns during and after a rainfall through their River Water Advisories. In the 2002 recreational season (May 15 – September 30), there were 55 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 40% of the time from May to September 30, 2002.

Wet Weather: Our data suggest that the Pittsburgh Pool is more impacted by fecal contamination the days following a wet weather event than Pools 2 and 3. This is based on only one wet weather event and further studies are suggested.

For the 2000 recreational season, there was a total of 83 of 138 days when it was unsafe (or 60% of the time) for direct contact with river water according to the river advisories. The longest advisory lasted from May 15 to June 27, 2002 or 44 days.

Tributary Streams: Our study shows that during dry weather, fecal coliform concentrations vary among the tributary streams studied. Results for several tributary streams vary among sampling events, indicating an intermittent sources of contamination. While several streams had fecal coliform concentrations under 200 CFU/100ml, only one had a mean greater than 1,000 CFU/100ml. Chemical and field tests indicate most parameters within an expected range for this region and within state water quality standards.

E. Conclusion

Our study indicates that during dry weather most of our sampling sites along the Allegheny River are below our target number for fecal coliform, indicating little fecal contamination. Tributary streams have much higher concentrations of fecal coliform than river sites. Wet weather river water quality is poorer at the Pittsburgh Pool sampling

locations than sampling locations in Pools 2 and 3. Extensive monitoring and modeling of the river systems will be necessary to fully understand this system.

The Three Rivers Second Nature project will continue its work over the next two years. In 2003, our effort will focus on the Ohio River to the edges of Allegheny County. This study and more information will be available at <http://3r2n.cfa.cmu.edu/>.

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VII. Appendices

Appendix A. Physical and Chemical Water Quality Parameters

Warm Water Fisheries	(mg/L) unless noted	25 PA Code § 93-7, 93-9u-v
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
		Allegheny River, Bailey Run, Crawford Run, Riddle Run, Falling Springs Run, Deer Creek, Plum Creek, Powers Run, Indian Creek, Quigley Creek, Sandy Creek, Shades Run
Trout Stocked	(mg/L) unless noted	25 PA Code § 93-7, 93-9u
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
		Buffalo Creek, Chartiers Run, Bull Creek, Pucketa Creek

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:

$$\text{pH} = -\log[\text{H}^+]$$

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 (CO₂) 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 CO₂ form a weak acid. Because plants take in CO₂ 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 (CaCO₃) is present, carbonates (HCO₃⁻, CO₃²⁻) 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. Furthermore, 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. Runoff 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 to 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. Runoff 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 bicarbonate 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. Bicarbonate 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:



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 10°C 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 runoff, 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.

VII. Appendices
Appendix B. Raw Data

Pool 2 Fecal Coliform Data

	Mile Point 14.0 Left	Mile Point 14.0 Mid	Mile Point 14.0 Right	Mile Point 12.8 Left	Mile Point 12.8 Mid	Mile Point 12.8 Right	Mile Point 9.8 Left	Mile Point 9.8 Mid	Mile Point 9.8 Right	Mile Point 7.4 Left	Mile Point 7.4 Mid	Mile Point 7.4 Right
25-May-02	70	270	290	240	140	290	170	270	150	170	170	130
4-Jun-02	50	55	40	10	30	70	35	25	20	50	35	185
9-Jul-02	35	70	55	100	80	65	25	60	25	5	20	25
10-Jul-02	70	90	95	55	40	35	45	40	115	20	40	65
5-Aug-02	10	70	75	45	40	65						
20-Aug-02	45	70	95	30	40	65	175	15	60	4200	2500	2300
21-Aug-02	80	70	90	45	105	50	15	40	15	40	20	40
Arithmetic Mean	51	99	106	75	68	91	78	75	64	748	464	458

	Falling Springs Run	Deer Creek	Guys/Campbells Run	Powers Run	Plum Creek	Indian Creek	Quigley Creek	Sandy Creek	Squaw Run	Shades Run
25-May-02		270	40	35	330		300	110	95	10
4-Jun-02	70	155	50	2500	365	2400	525	250		
9-Jul-02	5	250	95	70	910	5100	40	100	600	
10-Jul-02	45		170	260	1600	7100	2310	400	1800	
5-Aug-02	175	300	70	100		255	680			
20-Aug-02	185	205	70	190	700	435	140	240	310	100
21-Aug-02	60	260	5	105	370	2310	65	510	405	55
Arithmetic Mean	90	240	71	466	713	2933	580	268	642	55

Pool 2 *E. coli* Data

	14.0 Left	14.0 Mid	Mile Point 14.0 Right	Mile Point 12.8 Left	Mile Point 12.8 Mid	Mile Point 12.8 Right	Mile Point 9.8 Left	Mile Point 9.8 Mid	Mile Point 9.8 Right	Mile Point 7.4 Left	Mile Point 7.4 Mid	Mile Point 7.4 Right
25-May-02	184	192	178	285	291	461	260	167	260	236	185	152
4-Jun-02	26	40	50	29	35	38	25	25	23	23	27	59
9-Jul-02	36	59	37	37	44	47	12	33	12	14	24	23
10-Jul-02	27	23	52	18	35	28	33.00	31	31.00	16	13	21
5-Aug-02	2	4	1	5	2	3						
20-Aug-02	24	31	70	18	28	36	45	10	11	2419	1414	579
21-Aug-02	53	56	99	57	38	19	18	11	11	14	22	28
Arithmetic Mean	50	58	70	64	68	90	66	46	58	454	281	144

	Falling Springs Run	Deer Creek	Guys/Campbells Run	Powers Run	Plum Creek	Indian Creek	Quigley Creek	Sandy Creek	Squaw Run	Shades Run
25-May-02		104	45	138	178		411	114	184	15
4-Jun-02	139	167	53	2419	649	2420	659	276		
9-Jul-02	25	261	179	82	770	2420	43	138	727	
10-Jul-02	56	365	108	387	980	2420	60	860	1986	
5-Aug-02	119	75	272	167		770	1046	88		
20-Aug-02	28	111	57	225	411	130	71	144	345	70
21-Aug-02	45	185	55	152	272	461	63	93	308	51
Arithmetic Mean	69	181	110	510	543	1437	336	245	710	45

Pool 3 Fecal Coliform Data

	24.3 Left	24.3 Mid	24.3 Right	22.6 Left	22.6 Mid	22.6 Right	17.7 Left	17.7 Mid	17.7 Right	15.2 Left	15.2 Mid	15.2 Right
25-Jun-02	40	5	105	165	100	5	90	125	285	100	35	80
2-Jul-02	45	20	10	30	5	425	40	110	750	10	40	30
16-Jul-02	5	10	250	25	45	415	20	30	25	5	5	5
18-Jul-02	15	10	60	35	90	600	240	120	105	30	35	215
28-Aug-02	15	40	225	35	45	335	155	100	45	95	80	70
25-Sep-02	10	5	35	20	15	475	250	275	285	70	45	40
Arithmetic Mean	22	15	114	52	50	376	133	127	249	52	40	73

	Chartiers Run	Bull Creek	Baileys Run	Clarks/Crawford Run	Pucketa Creek	Riddle Run
25-Jun-02	20	35	110	225	125	
2-Jul-02	100	760	1600	750	260	1800
16-Jul-02	240	70	135		530	345
28-Aug-02	250	140	4000		300	500
25-Sep-02	205	600			370	200
Arithmetic Mean	163	321	1461	488	317	711

Pool 3 E. coli Data

	24.3 Left	24.3 Mid	24.3 Right	22.6 Left	22.6 Mid	22.6 Right	17.7 Left	17.7 Mid	17.7 Right	15.2 Left	15.2 Mid	15.2 Right
25-Jun-02	11	9	24	22	4	130	110	61	173	46	14	67
2-Jul-02	8	7	15	13	4	117	26	65	41	4	8	13
16-Jul-02	15	3	206	25	18	435	11	11	7	1	3	1
18-Jul-02	4	6	33	11	54	649	162	53	86	26	16	91
28-Aug-02	35	13	461	24	40	613	52	93	47	38	46	27
Arithmetic Mean	15	8	148	19	24	389	72	57	71	23	17	40

	Chartiers Run	Bull Creek	Baileys Run	Clarks/Crawford Run	Pucketa Creek	Riddle Run
25-Jun-02	2420	194	2420	2420	167	
2-Jul-02	1986	920	665	525	260	1203

Pool 4 Fecal Coliform Data

Fecal Coliform	Mile Point 26.9 Left	Mile Point 26.9 Mid	Mile Point 26.9 Right	Mile Point 28.0 Left	Mile Point 28.0 Mid	Mile Point 28.0 Right	Buffalo Creek
25-Jul-02	5	15	30	40	5	5	120
1-Aug-02	55	50	105	45	30	50	540
1-Oct-02	35	55	45	20	30	20	65
2-Oct-02	40	30	55	40	35	30	450
8-Oct-02	70	5	15	15	10	20	105
9-Oct-02	10	10	10	5	20	15	65
Arithmetic Mean	36	28	43	28	22	23	224

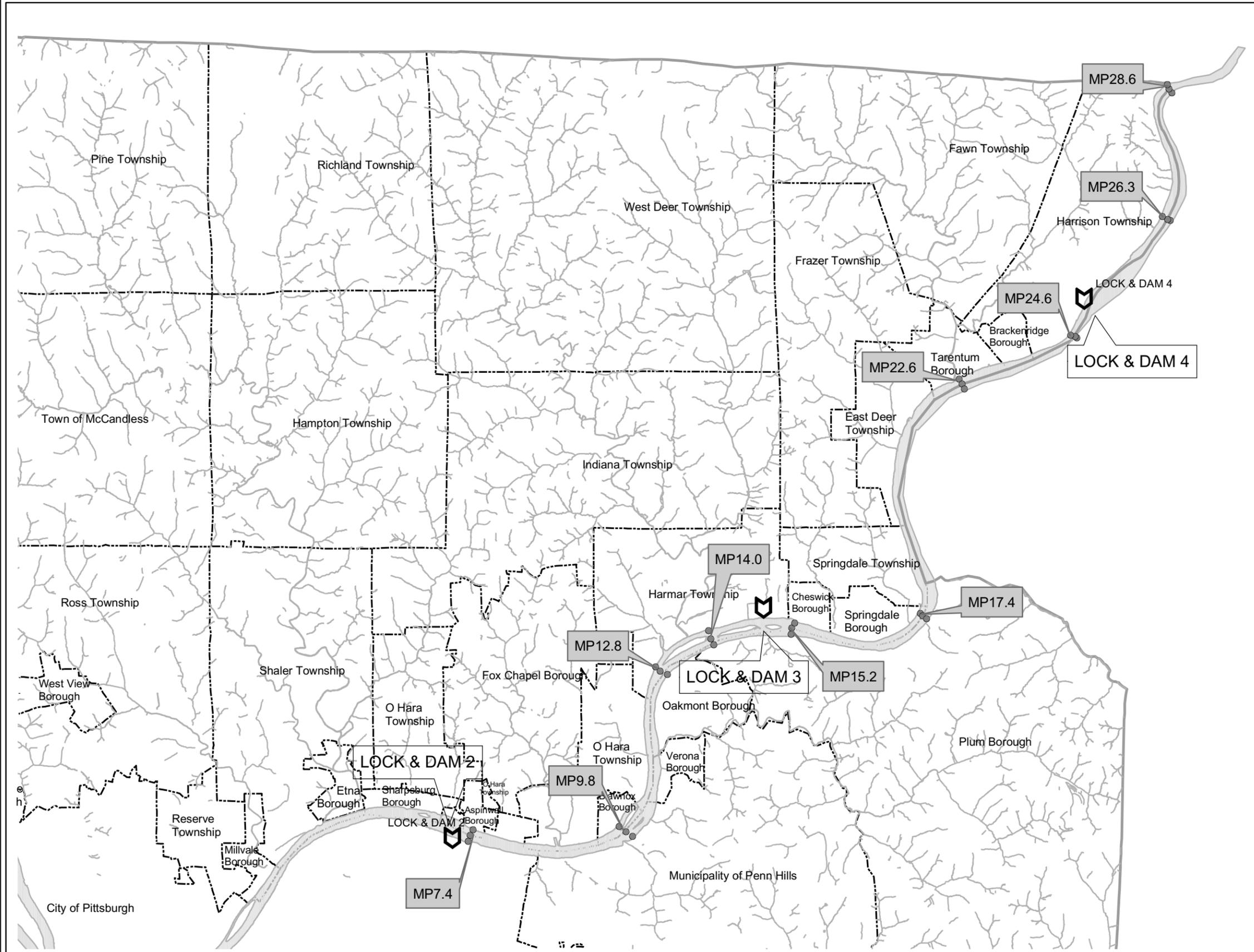
Pool 4 *E. coli* Data

	Mile Point 26.9 Left	Mile Point 26.9 Mid	Mile Point 26.9 Right	Mile Point 28.0 Left	Mile Point 28.0 Mid	Mile Point 28.0 Right	Buffalo Creek
25-Jul-02	10	24	20	37	7	7	9
1-Aug-02	31	40	87	20	27	61	278
1-Oct-02	29	36	49	18	26	28	135
2-Oct-02							
8-Oct-02	17	21	14	12	5	7	98
9-Oct-02	25	30	18	9	11	13	80
Arithmetic Mean	22	30	38	19	15	23	120

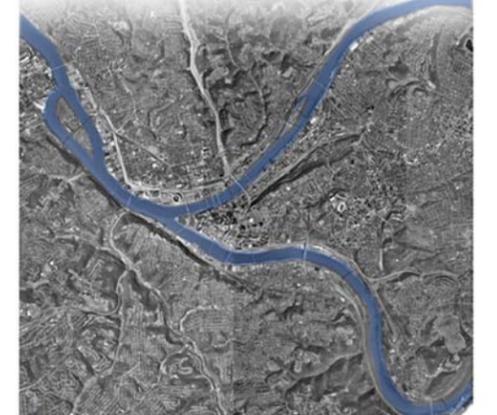
VII. Appendices

Appendix C. Sampling Sites and Wet Weather Maps

3R2N Aquatic: 2002 Dry Weather River Sites



3 Rivers Art Ecology Community 2nd Nature



The STUDIO for Creative Inquiry
Carnegie Mellon

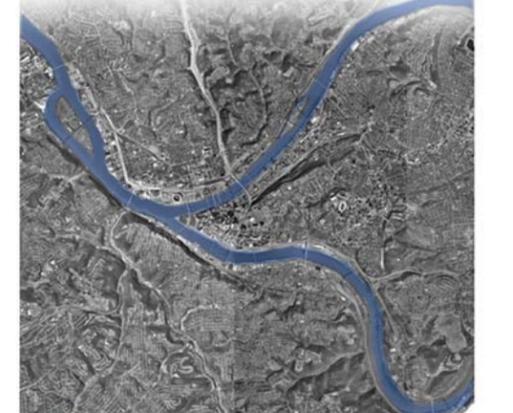
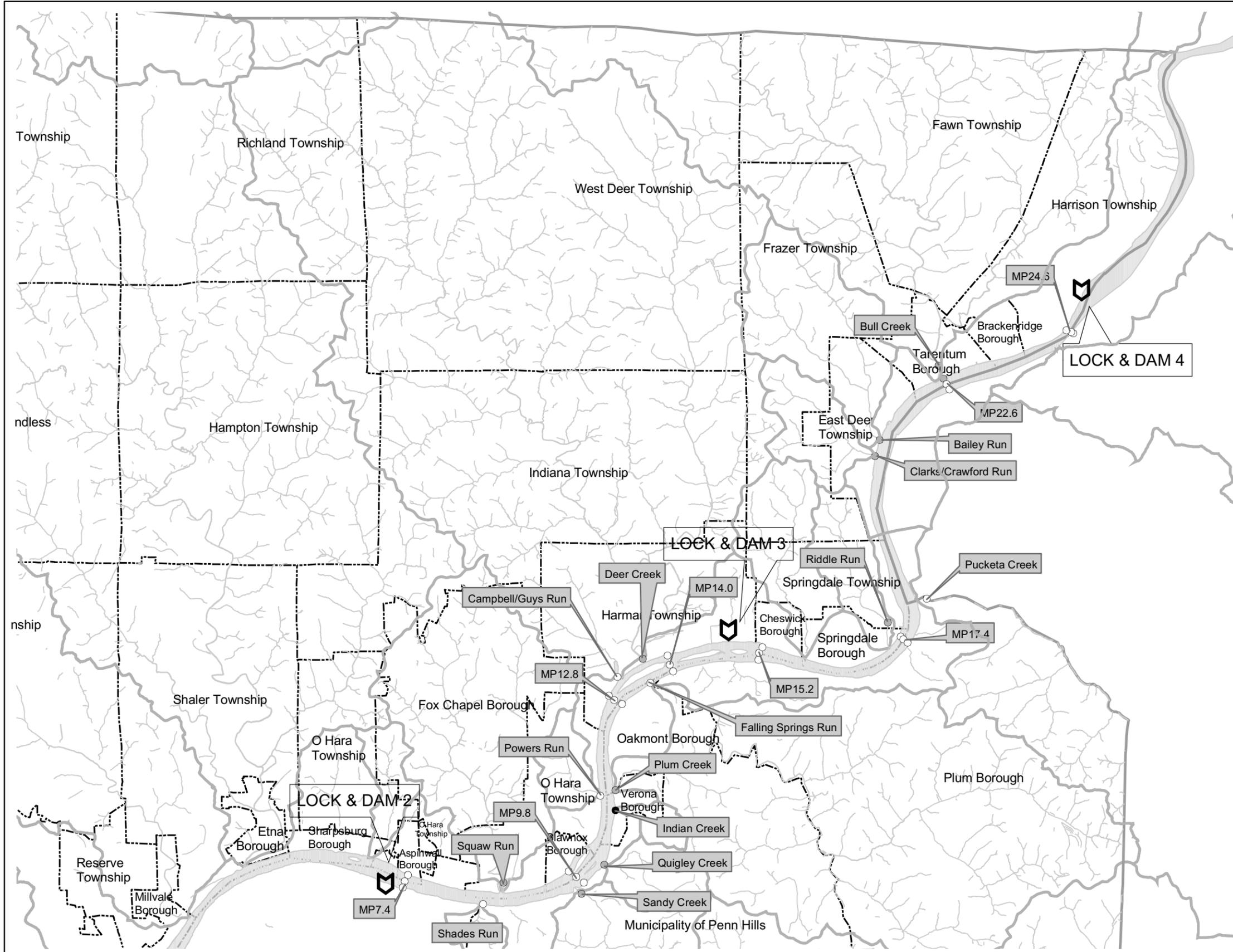
- Dry Weather River Test Site
- ⌋ Lock and Dam
- Hydrology
- - - Municipal Boundary
- County Boundary



0 3,250 6,500 13,000 19,500 26,000 Feet

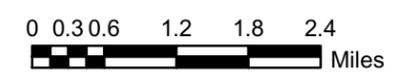
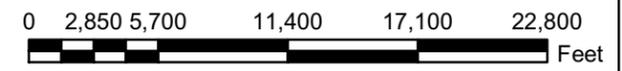
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3R2N River/Stream Field Testing
Phase 3, Project Year 2002



The STUDIO for Creative Inquiry
Carnegie Mellon

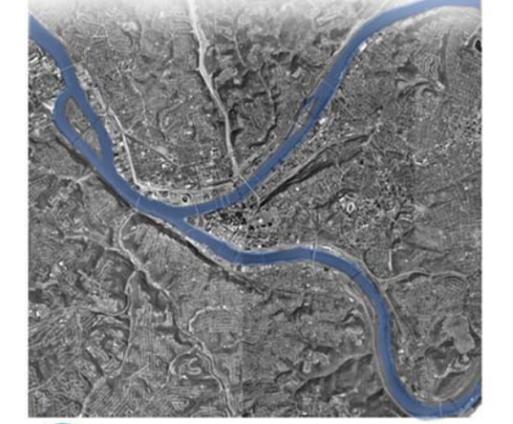
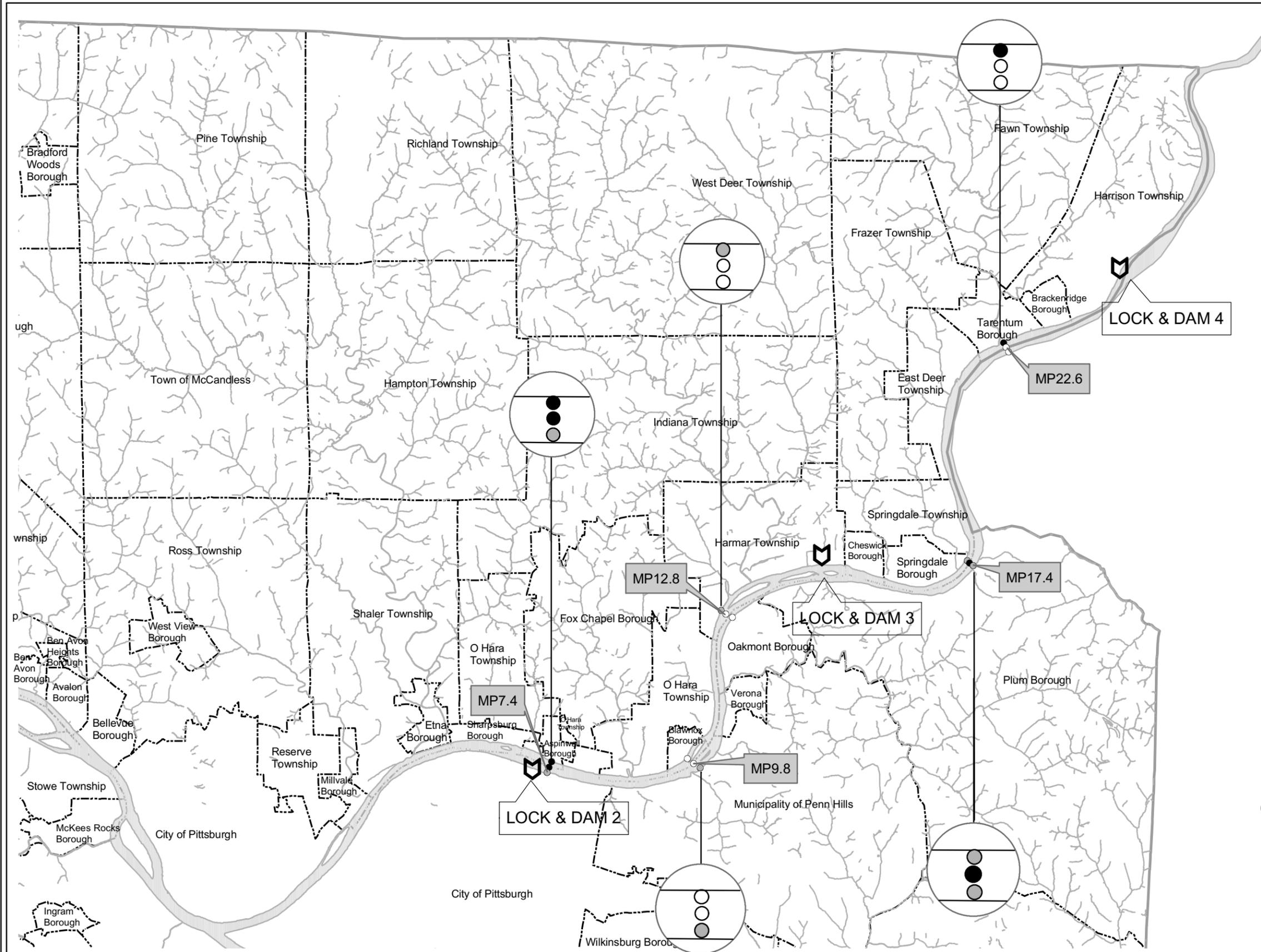
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- Fecal Coliform Geometric Mean**
- 11.22 - 200.00 (CFU per 100ml)
 - 200.01 - 1000.00
 - 1000.01 - 5000.00
- Ⓜ Lock and Dam
 - Hydrology
 - - - Municipal Boundary
 - County Boundary
 - Watershed Boundary



3R2N River/Stream Field Testing
Phase 3, Project Year 2002

3R2N Aquatic: 2002

Wet Weather Day 1 - Fecal Coliform Results



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Carnegie Mellon

Wet Weather Test Site

Fecal Coliform Results *

- 0 - 200 (CFU per 100ml)
- 201 - 1000
- 1001 - 5000

- Ⓜ Lock and Dam
- Hydrology
- - - Municipal Boundary
- County Boundary

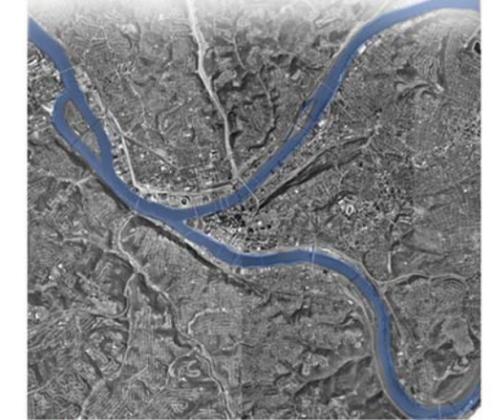
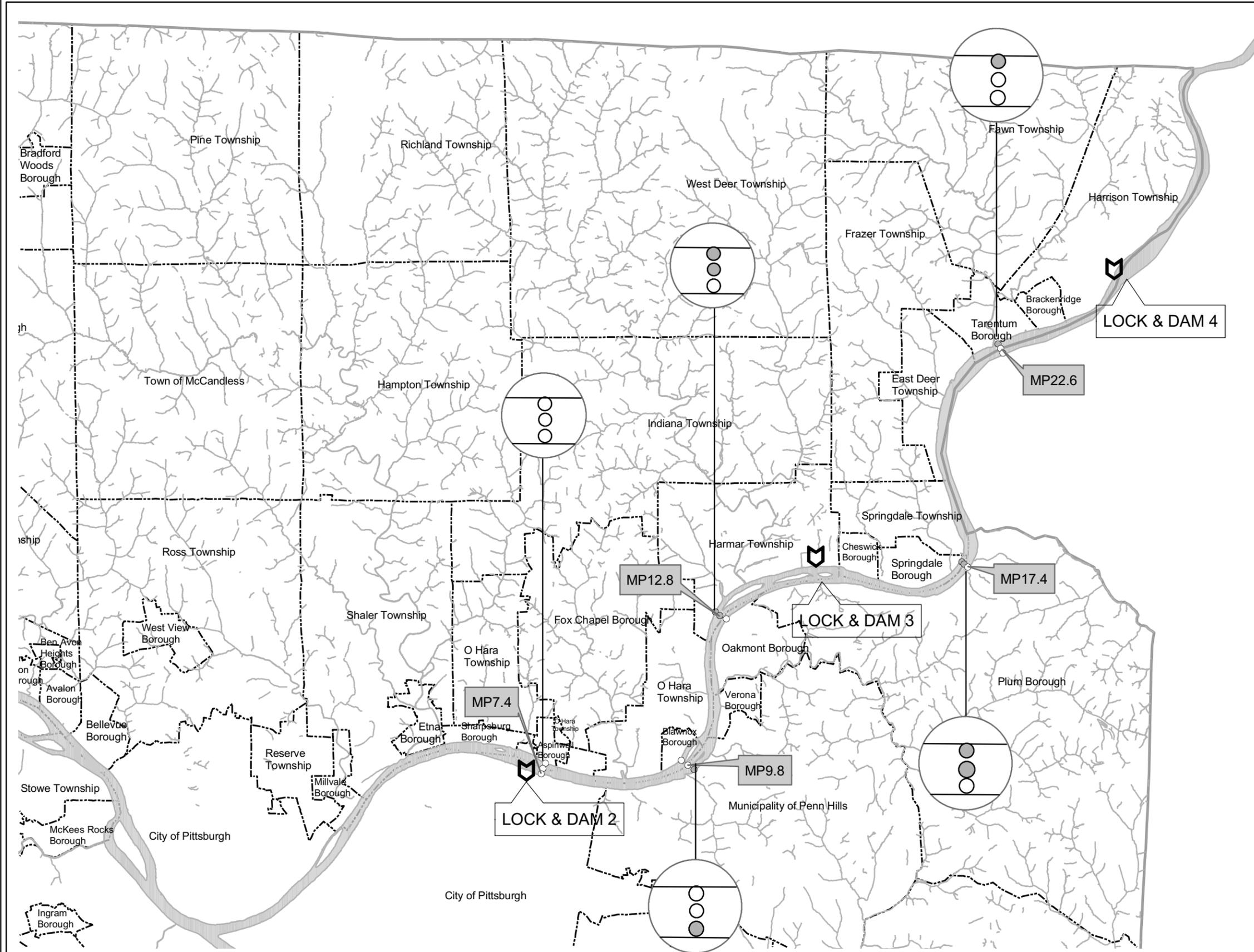
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3R2N River/Stream Field Testing
Phase 3, Project Year 2002

3R2N Aquatic: 2002

Wet Weather Day 2 - Fecal Coliform Results



The STUDIO for Creative Inquiry
Carnegie Mellon

Wet Weather Test Site

Fecal Coliform Results *

- 0 - 200 (CFU per 100ml)
- 201 - 1000
- 1001 - 5000

Lock and Dam

Hydrology

Municipal Boundary

County Boundary

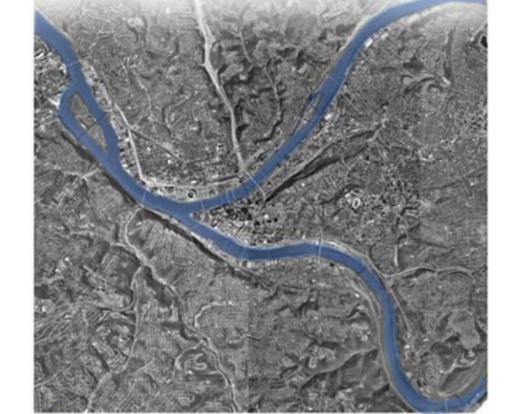
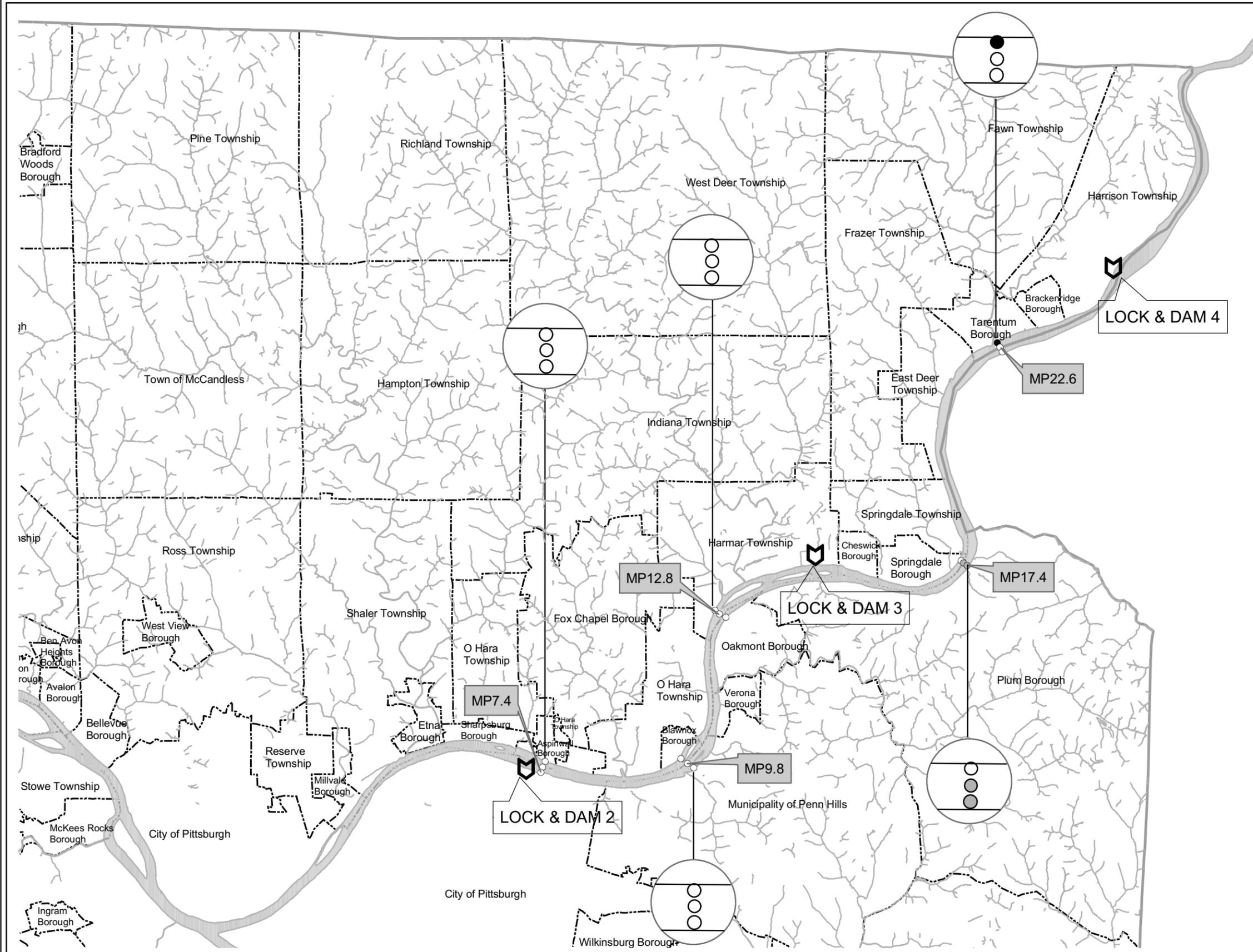
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3R2N River/Stream Field Testing
Phase 3, Project Year 2002

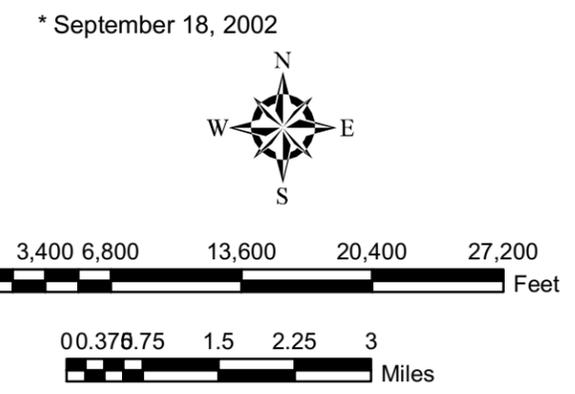
3R2N Aquatic: 2002

Wet Weather Day 3 - Fecal Coliform Results



The STUDIO for Creative Inquiry
Carnegie Mellon

- Wet Weather Test Site
- Fecal Coliform Results *
- 0 - 200 (CFU per 100ml)
 - 201 - 1000
 - 1001 - 5000
 - Ⓜ Lock and Dam
 - Hydrology
 - - - Municipal Boundary
 - County Boundary



3R2N River/Stream Field Testing
Phase 3, Project Year 2002