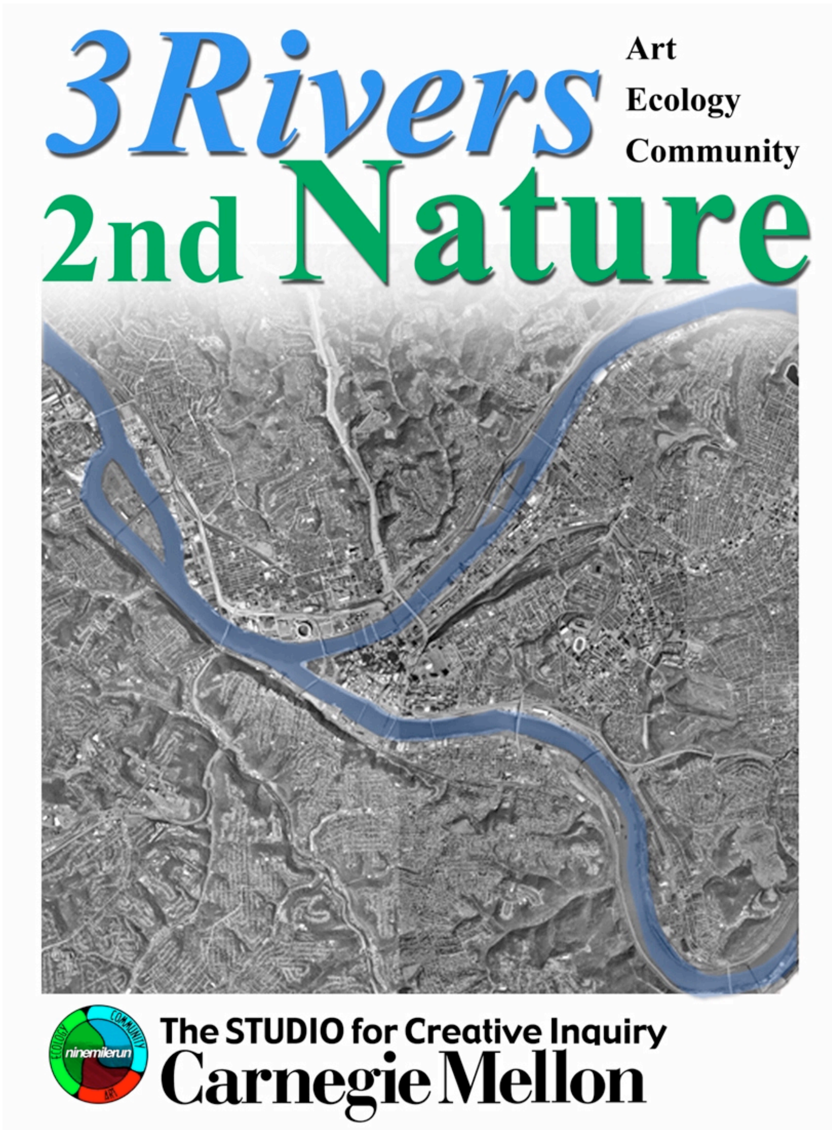
Water Quality
Phase I Report – Year 2000



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For more information on the 3 Rivers – 2nd Nature Project, see http://3r2n.cfa.cmu.edu

If you believe that **ecologically healthy rivers are 2nd Nature!** and would like to participate in a river dialogue about water quality, recreational use and biodiversity in the 3 Rivers Region.

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3 Rivers – 2nd Nature
Water Quality Report

Year 2000

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Introduction

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. The project began in 2000 in the Pittsburgh Pool (the subject of this report). This area is confined by the Lock and Dam #2, at Mile Point 11.2 on the Monongahela River, Lock and Dam #2 at Mile Point 6.7 on the Allegheny River and the Emsworth Lock and Dam at Mile Point 6.2 on the Ohio River. Over a five year period, the project will move to the edges of Allegheny County. In 2001, we will be working in the Monongehela River Valley.

Urban rivers and riverfronts have been used for municipal water and shipping, as a sink for sewage and industrial waste removal and for other commercial purposes. This view of the rivers as an industrial resource and sink for wastes has displaced their value as a natural resource, or as an important amenity amongst 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.

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. We also want to know if it is clean over a broad sampling area. This testing 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 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?

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?

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. Additional chemical and physical analyses were not performed on these river samples since the project advisors have found that, through various studies and observations, there is increased biological diversity and other signs of river ecosystem health. However, the tributary streams have been studied far less, if at all. In order to develop an initial understanding of the water quality of these streams and determine if they have the basic conditions to support aquatic life, the project advisors recommended additional chemical and physical analyses.

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 current 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 (the Pittsburgh Pool), fourteen tributary streams wind through hundreds of neighborhoods, dozens of communities and a significant number of public parks.

FOR MORE INFORMATION:
SEE APPENDIX E TRIBUTARY WATERSHED ANALYSIS

2. 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 work was limited in the first year by the Lock and Dam #2, at Mile Point 11.2 on the Monongahela, Lock and Dam #2 at Mile Point 6.7 on the Allegheny and the Emsworth Lock and Dam at Mile Point 6.2 on the Ohio River.
SEE ATTACHED MAPS FOR OVERVIEW OF SITES

Dry Weather Sampling Program

Sampling Schedule

Sampling occurred from the period of June 21 to October 31, 2000 during dry weather when public recreation is at its greatest, and we have the best opportunity to provide baseline recreational use conditions of our river systems. Dry weather conditions were defined as a minimum of 72 hours after the last rainfall and combined sewer overflow.

One river system was sampled one day per week (weather permitting), resulting in no more than 20 samples per test run (ACHD laboratory limit). This included river sampling points as well as tributary streams in the river system. 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 were beyond the scope of this investigation.)
Cross sections were established at four points within each river in Year 1 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 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 waters.)

TABLE 1: Selected River Monitoring Sites in the Pittsburgh Pool

River	Mile Point	Site Description
Allegheny	0.18	Final Allegheny River Point
Allegheny	2.26	Below Washington's Landing
Allegheny	4.57	Below Pine Creek
Allegheny	6.10	Below Dam
Monongehela	0.23	Final Monongahela River Point
Monongehela	2.82	Above South Side Park
Monongehela	5.66	Below Streets Run
Monongehela	10.21	Below Dam
Ohio	NA	Below Point
Ohio	NA	Above Brunots Island
Ohio	NA	Below Brunots Island/Chartiers
Ohio	NA	Above Dam

River Monitoring Parameters

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 (APHA et al. (1992) Sec. 9060). Total coliform, *E. coli*, and enterococci followed defined substrate method (Idexx Laboratories, Westbrook, ME). Thermotolerant coliform was used as a surrogate to fecal coliform in order to compare the defined substrate method to the accepted membrane filtration method found in Standard Methods (APHA et. al., 1992). This method is a modified total coliform defined substrate test where the sample is incubated in 44.5°C (Yakub et al., 2001).

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
Thermotolerant Coliform	An estimation of fecal coliform	ALCOSAN Lab	Modified Idexx
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	ACHD Lab	9220 D

(methods taken from APHA et al., 1992 except as noted)

Tributary Stream Monitoring

Free-flowing and culverted tributary streams that flow into the three rivers in the Pittsburgh Pool 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 20 feet.

TABLE 3: Selected Tributary Monitoring Sites in the Pittsburgh Pool

Tributary	**River Mile Point**	**Reason for Sampling**
Saw Mill Run	Ohio River	Access/use and affect on river
Chartiers Creek	Ohio River	Access/use and affect on river
Beck's Run	Monongahela MP 4.35	Access/use and affect on river
4 Mile Run culvert	Monongehela MP	Culverted/affect on river
Streets Run	Monongahela MP 6.0	Access/use and affect on river
Homestead Run	Monongahela MP 6.9	Culverted / affect on river
Nine Mile Run	Monongahela MP 7.65	Access/use and affect on river
West Run	Monongahela MP 8.95	Access/use and affect on river
10' brick culvert/32nd St	Allegheny MP 2.68	Culverted /affect on river
Girty's Run	Allegheny MP 3.61	Access/use and affect on river
Pine Creek	Allegheny MP 4.69	Access/use and affect on river
Sipes Run	Allegheny MP 6.55	Access/use and affect on river
Heaths Run	Allegheny MP 6.67	Culverted / affect on river
Guyasuta Run	Allegheny MP 6.67	Access/use and affect on river
* SEE ATTACHED MAPS		

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.)

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
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.

Wet Weather Sampling Program

Wet Weather sampling focused on bacteriological analyses and basic field parameters (Table 2) limited to no more than 20 samples per testing-run. The sites for wet weather sampling included the first two transects on each river starting from the confluence of the three rivers.

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 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. (This is the same indicator used by the Allegheny County Health Department's River Water Advisory Program.) Sampling occurred once after a wet weather event while combined sewer overflows were occurring. The sites were then re-sampled at 12-24 hours and again at 36-48 hours after the overflows stop. Results of all three sample sets were reviewed to determine if additional days of sampling would be needed.

Precipitation data were obtained from rain gauges that belong to the Three Rivers Wet Weather Demonstration Project located with in the Pittsburgh Pool.

Geographical Information System Mapping

Geographic Information Systems (GIS) have become an increasingly necessary component of analysis and decision making processes. GIS serves as a powerful tool in portraying data or a database spatially. In addition to the powerful querying capabilities, GIS allows for the display of this information in the form of a map, a graph, or a report. Geographic Information Systems are continually enhanced by technological advancements, as well as peripheral device improvements, i.e. 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 capture of these sites. 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 in turn will be the link between the spatial location of the site and the data collected. See water quality report for specific protocol.

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, the 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 supplemental to the Water Quality Report.

3. 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, but 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 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, they do not tell us if the fecal matter is from humans and occuring 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 (5 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 entire Pittsburgh Pool during the recreational season. Although we cannot definitively say if the rivers and tributary streams meet the state standards, the standards will be used as a reference point, when comparing our data.

Fecal Coliform as a Pathogenic Indicator

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 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.

E. coli as a Pathogenic Indicator

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 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*.

A brief History 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, 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.

Comparing the Testing: Fecal Coliform v. *E. coli*

This project utilized the traditional membrane filtration method for fecal coliform as well as newer defined substrate methods. Traditional methodologies for members of the Coliform group such as membrane filtration and multiple tube fermentation (APHA et al. 1992) are labor intensive, time consuming, require specialized training, and lab technicians quickly overwhelmed by large numbers of samples.

Idexx Laboratories has developed the Colilert System for the simultaneous enumeration of Total Coliforms and *Escherichia coli* (*E. coli*) in water samples, and the Enterolert System for the enumeration of members of the Enterococcus group in water samples. Both of these systems utilize Defined Substrate Methodology (DSM) to detect the presence of the appropriate organisms. The test uses simple equipment that includes an incubator, ultraviolet light, and a tray sealer. Ready-to-use reagents are added to water samples, resulting in a colorless solution. The solution is poured into a quanti-tray, sealed, and incubated at 35°C for 24 hours. A yellow color indicates the presence of total coliform and fluorescence indicates the present of *E. coli*. The Colilert method has been approved for use by the United States Environmental Protection Agency for source waters and finished drinking waters (USEPA 1999a). These products greatly reduce the time, labor, and skill level needed to perform these bacterial evaluations, allowing a laboratory to process more samples at a lower cost per sample. The American Water Works Association Research Foundation (AWWARF,1993) estimated that the cost savings when using the Colilert test can range from $1.20 to $3.10 per sample for utilities or public health labs. The estimated costs of the traditional membrane filtration test can range from $4.40 to $6.60 and for the Colilert test, from $3.20-$3.50. Our laboratory also showed savings, mostly in reduced labor. Our microbiologist was able to process 20 samples in less than an hour, considerably less than membrane filtration. However, samples were not diluted to determine the upper ranges for each parameter in highly contaminated samples. This would have added more time to the analyses and for this survey, deemed unnecessary. When results exceeded the maximum detection limit, they are reported as being greater than 2,419 CFU/100ml. To properly utilize this method for more detailed water quality studies, dilution of samples is recommended.

Conclusion

The Idexx Laboratories Colilert System has distinct advantages. The reduced skill level, lower labor costs and minimum sterilized equipment needed would make this method desirable for any cost conscious public institution to adopt when conducting water monitoring projects. The reduced costs, skills and equipment would also make this method effective and potentially available to trained non-profit groups. This will become more important if and when Pennsylvania adopts *E. coli* or enterococcus as the indicator organism in place of fecal coliform.

Another aspect of this project compared fecal coliform results to a modified method called thermotolerant coliform as described above. Many different variables were incorporated into this data set, and the two methods were performed by several different analysts at two different lab facilities on identical samples. The resulting data set was Log transformed and subjected to the Pearson linear regression analysis. The correlation coefficient for this data set was 0.845, once again showing that a very strong linear correlation exists between these two methods. These results tend to show that the thermotolerant coliform defined substrate method is an excellent substitute method for the enumeration of fecal coliform bacteria and that the method is robust enough to be used in broad scale comparison studies in which a number of uncontrolled variables are present. More details can be found in Yakub et. al (publication pending) or by contacting the 3R-2N office.

The defined substrate techniques provide a more sensitive, less variable, faster and less expensive alternative to traditional methods of bacterial enumeration. Colilert will become an important tool to municipalities and community organizations trying to develop monitoring programs to evaluate their watersheds. Although this study accounts for the change in status for the fecal coliform analysis, it is our belief that this analysis will remain important due to the large volume of historical data that has been accumulated using this technique.

On the following pages

You will find the results for our survey organized in terms of the three rivers: first the Allegheny, then the Monongahela and finally the Ohio. For each of the rivers, you will find eight graphs with a discussion of the results. Two graphs describe dry weather fecal coliform results, and two describe dry weather *E. coli* results. Within each set of two graphs, the first is a box plot to illustrate the range of water quality data for each of the four sampling events, and the second shows the geometric mean. The last 4 graphs illustrate the water quality during rain events for both fecal coliform and *E. coli*.

<u>Box plots</u> are used to show the spread of a data set and can identify outlying values. The box indicates the range in which 50% of the data lie (from the 25th percentile value to the 75th percentile value.) The middle line within the box indicates the median of the sample set. Since this data has an even number of samples (4), the median is the average of the two middle values. The "whiskers" indicate the 10th and 90th percentile values of the data. Outlying values are indicated by an asterisk. To judge the symmetry of a distribution, if the 25th and 75th percentiles are equally spaced from the median, then the data is symmetrically distributed. If the 75th percentile is farther from the median than the 25th percentile, the data is positively skewed. If the 25th percentile is farther from the median than the 75th percentile, the data is negatively skewed. With only four data points per location, the data set is too small to indicate outliers. The box plot is used in this instance to illustrate the range of the data sets

<u>Geometric mean</u> averages used for fecal coliform and *E. coli* in this study are to be compare with the USEPA and PADEP standards 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 mean is 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). However, using geometric means is still the accepted method for determining the average of microorganism populations. Although we use geometric means in this report, in Appendices B, C and D, and the raw data can be found along with the arithmetic means.

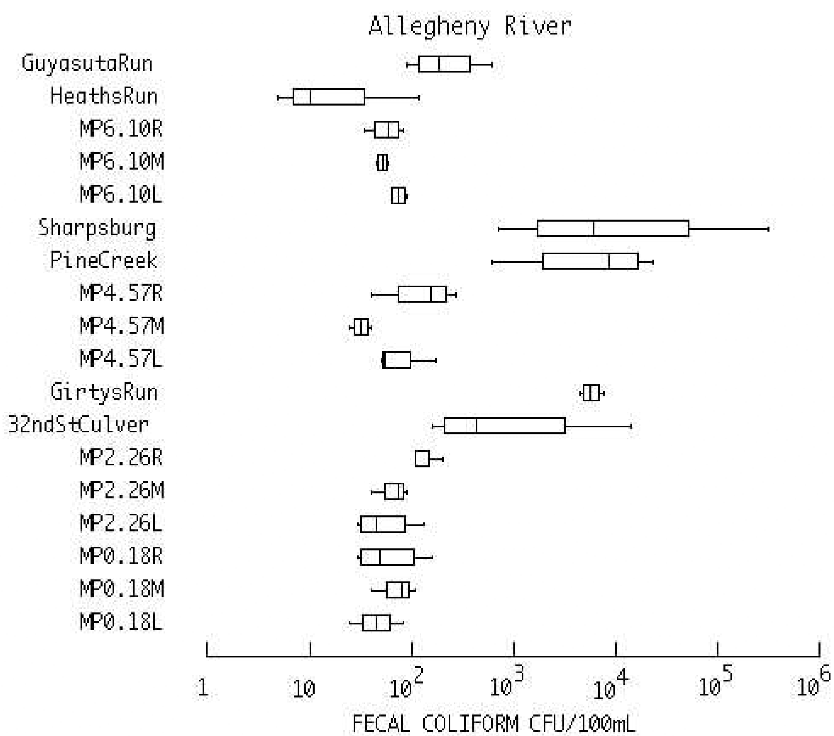
Results and Discussion

4. Allegheny River

Four river transects and five streams were sampled along the Allegheny River from the Highland Park Dam to the confluence with the Ohio River. Sampling of this river system occurred on four different dry weather days from June 29, 2000 to October 31, 2000.

Fecal Coliform Data

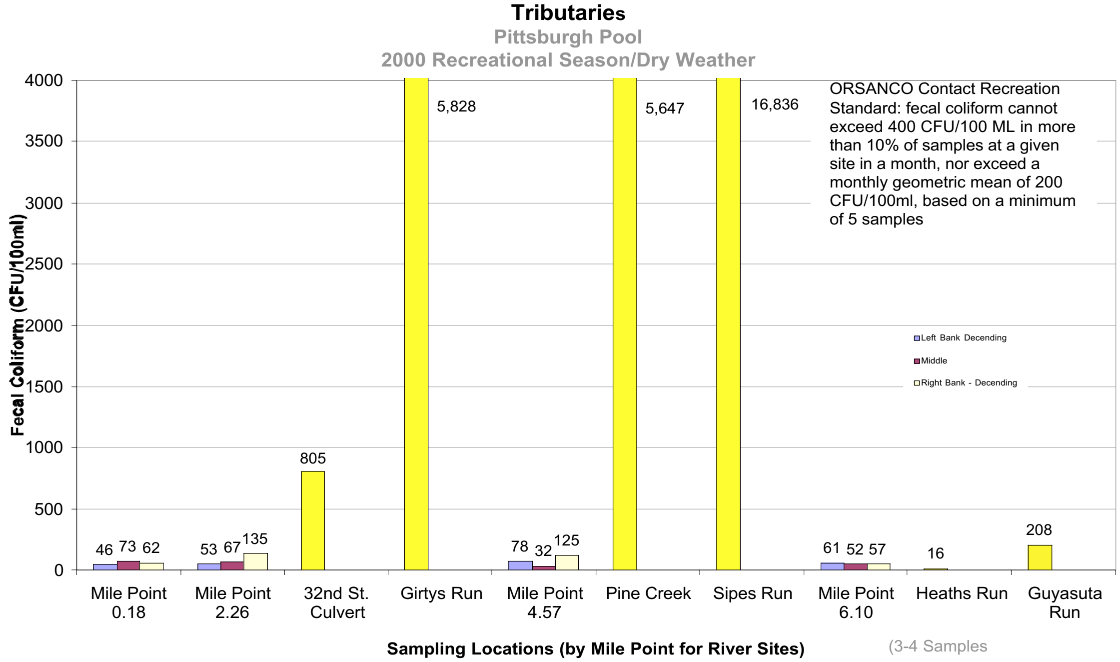
Figure 1: Box Plots of Fecal Coliform Data for 4 River Transects (Mile Points) and Tributaries along the Allegheny River taken during the 2000 Recreational Season.



** 4 samples of Fecal Coliform for all locations*

As previously described above, box plots are used to show the spread of a data set. The box plot in Figure 1 indicates that the fecal coliform data in the four river transects are less variable and lower in concentration than in the stream data. In the case of Sipes Run (shown as Sharpsburg), the data vary by 3 orders of magnitude from 750 to 310,000 CFU/100ml. On the date that the sample result was 310,000 CFU/100ml, sampling crews observed the township dredging the streambed, which likely contributed to this high reading. The variation in fecal coliform results in the streams may be due to their lower and more variable flows. With lower flows, streams are likely to be more sensitive to sources of fecal contamination. However, the high fecal coliform results suggest that these streams have large sources of fecal pollution. The streams with the maximum fecal coliform counts are Sipes Run (shown as Sharpsburg) and Pine Creeks at 310,000 and 23,000 CFU/100ml respectively. Heaths Run has the lowest fecal coliform count of all the data at 5 CFU/100ml. The maximum river sample is found at Mile Point 4.57 Right (downstream of Pine Creek) at 270 CFU/100ml. None of the river samples are above the 400 CFU/100ml ORSANCO standard (see Appendix B for raw data and arithmetic means).

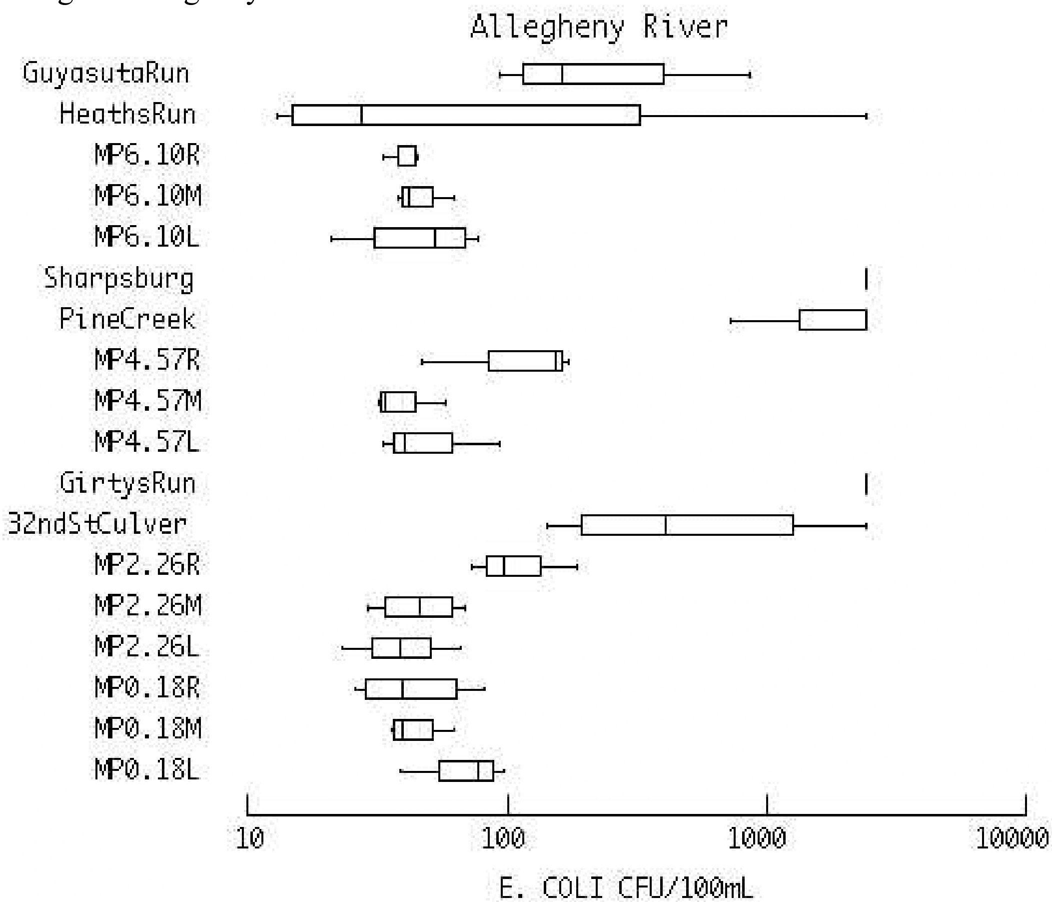
Figure 2: Geometric Means of Fecal Coliform Data in the Allegheny River and its Tributaries



Since our sampling scheme did not permit sampling to take place more than once per month, with no more than four samples collected per site, the above standards shown in Figure 2 cannot be directly applied to this data but are used as a benchmark to compare with our data. With this in mind, the Allegheny River transects are within the geometric mean of 200 CFU/100ml. Only one stream, Heaths Run, is below 200 CFU/100 ml. Guysuta Run is just over at 229 CFU/100ml.

E. coli Data

Figure 3: Box Plots of *E. coli* Data for 4 River Transects (Mile Points) and Tributaries along the Allegheny River.



*4 samples of fecal coliform for all locations.

The box plot in Figure 3 shows the median as well as the range of each data set. In most cases, river transect data are less variable than stream data. Most of the river data are below 100 CFU/100ml except for one sample at MP 4.57 Right, which is downstream of the Pine Creek confluence, and 3 samples at MP 2.26 Right, downstream of Girty's Run. MP 2.26 Right is the only river site to exceed the ORSANCO maximum standard for *E. coli* (240 CFU/100ml) at any point. The horizontal line in Figure 3 for Sipes Run (shown as Sharpsburg) and Girtys Run indicates that all four data points are at the maximum detection limit of 2,419 CFU/100ml. Heaths Run data has the most variation, ranging from a minimum value of 13 CFU/100ml to one sample at the maximum detection limit. This stream has a very low flow within a culvert, thus fecal sources may have a significant impact on its bacteriological concentrations. Only Heath's and Guyasuta Runs and the 32nd Street Culvert have samples below ORSANCO's 240 CFU/100ml maximum standard. (see Appendix B for raw data and arithmetic means).

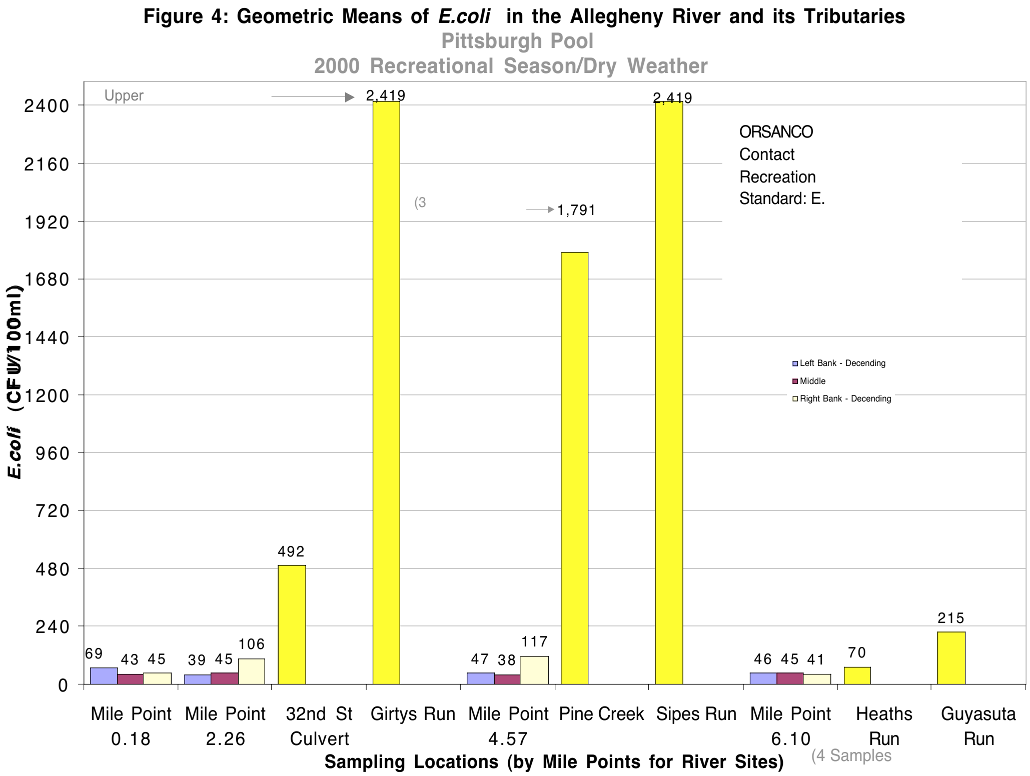


Figure 4 shows the geometric means of the river and tributary data. As stated above, our sampling scheme did not permit sampling to take place more than once per month with no more than four samples collected per site, thus, the standards shown in Figure 4 cannot be directly applied to this data but are used as a benchmark. With this in mind, the geometric means of the river transects are below the ORSANCO standard of 130 CFU/100 ml. With the exception of Heaths Run, the tributaries are above this geometric mean standard.

Additional Parameters for Tributary Streams

Average concentrations of each of the chemical and field parameters are shown in Appendix B. Most parameters are within the Pennsylvania water quality criteria for warm water fisheries, the designated use of the Allegheny River and its tributaries and for Pine Creek which is designated for trout stocking (25 PA Code § 93.9u). Sipes Run has a greater average ammonia concentration than the other streams, average Dissolved Oxygen is lowest at 6.22 mg/L, though no DO readings for this stream were below the 4 mg/L minimum allowable concentration.

Allegheny River Wet Weather

Our survey indicates spatial differences in water quality change and recovery, with some of the river edges having higher fecal coliform and *E. coli* concentrations than the mid points of the river. This is best indicated in Figures 5 - 8 by the effects at the mouth of the Washington's Landing back channel at Mile Point 2.26 Right. There were also high readings at Mile Point 0.18, just upstream from the point as shown in Figure 6, on September 28, 2000. These sites may be affected by nearby combined sewer overflows. Our limited data showed a return to baseline conditions within 15-33 hours after combined sewer discharges. This warrants further study, over a range of conditions.

Figure 5: Wet Weather Survey of Fecal Coliform for Select Allegheny River Sites

2000 Recreational Season

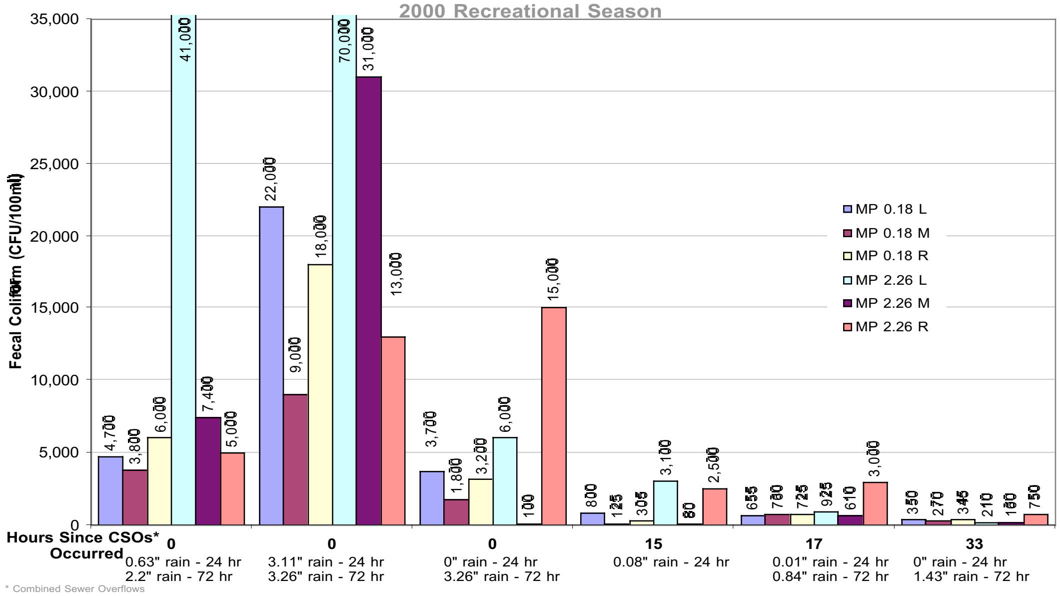
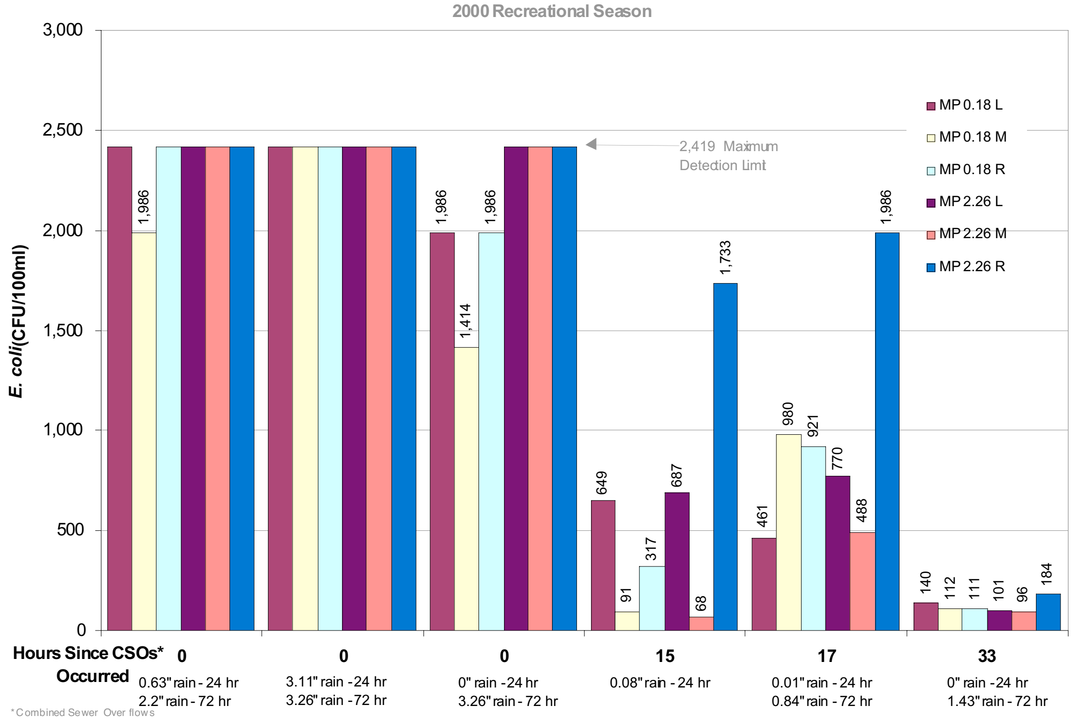
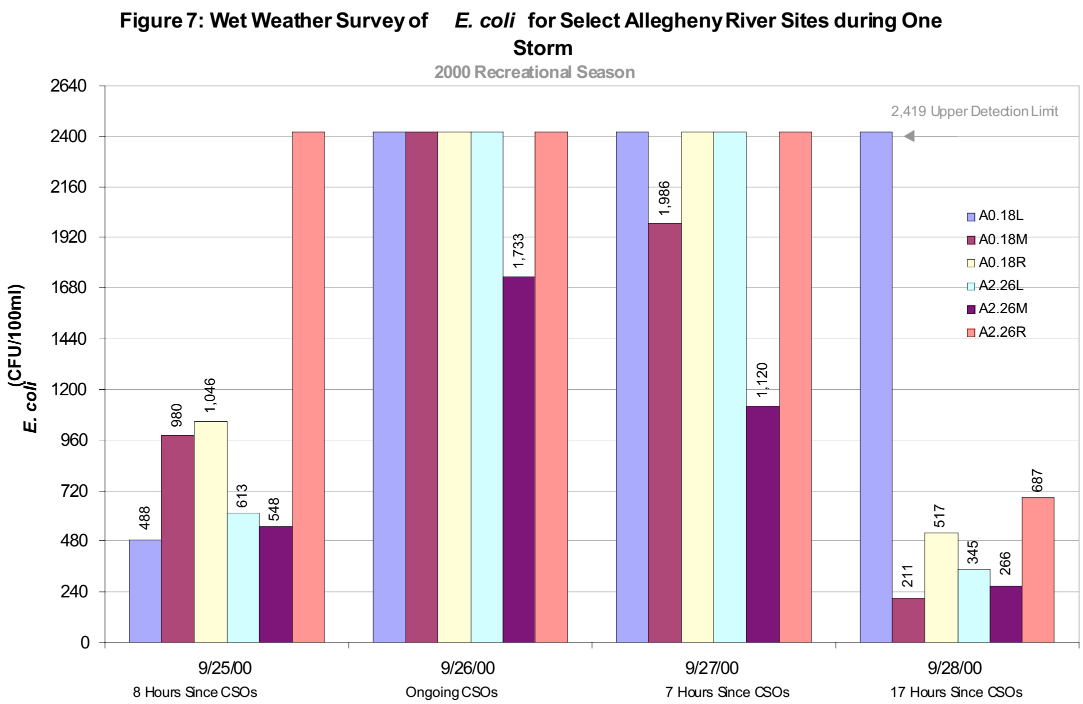


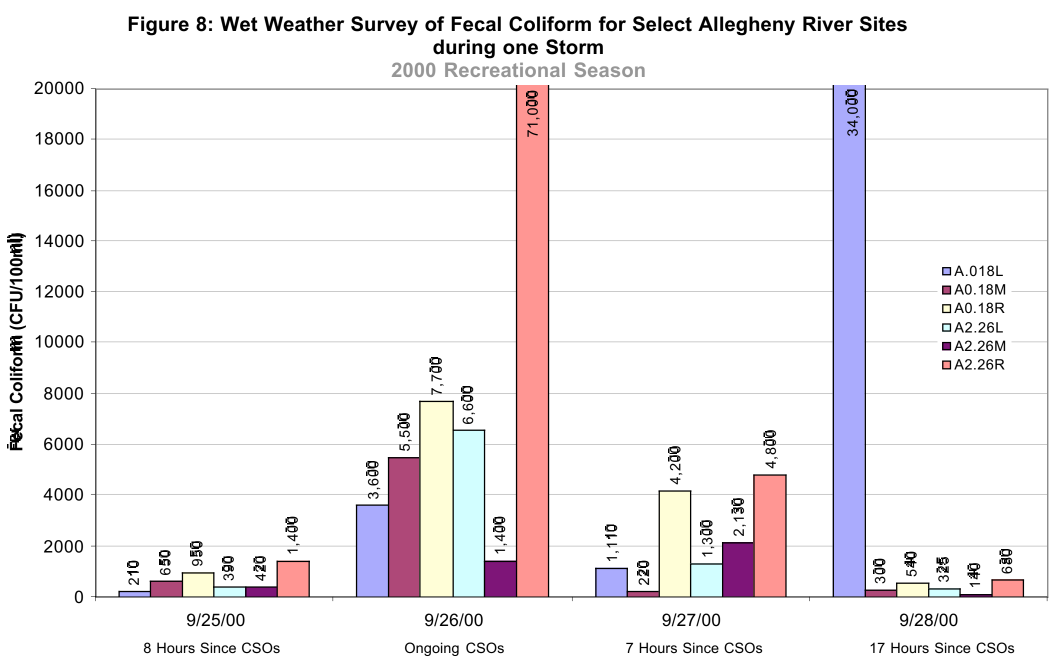
Figure 6: Wet Weather Survey of *E. coli* for Select Allegheny River Sites

2000 Recreational Season





*Rainfall for 9/23 & 9/24/00 equals 0.49 inches. Additional 0.44 inches fell on 9/26/00.



*Rainfall for 9/23 & 9/24/00 equals 0.49 inches. Additional 0.44 inches fell on 9/26/00.

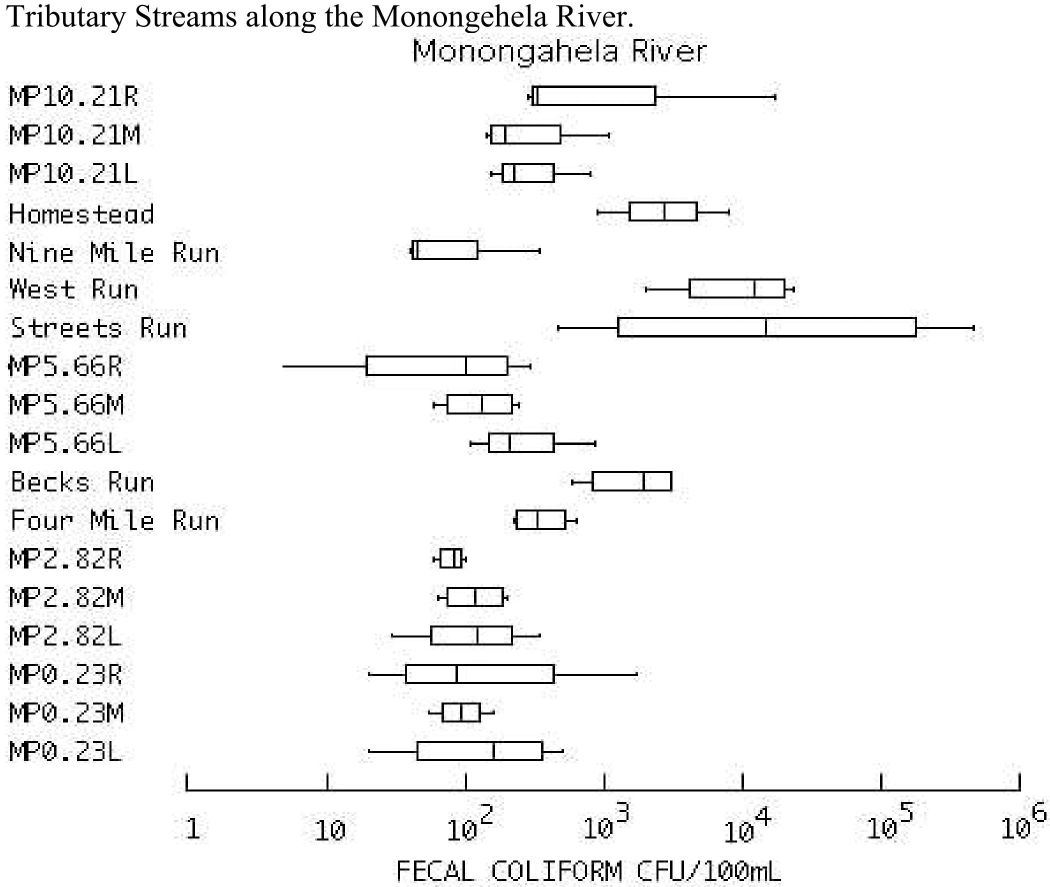
Results and Discussion

5. Monongehela River

Four river transects and six tributary streams were sampled along the Monongehela River from the Braddock Dam to the confluence with the Ohio River. Sampling of this river system occurred on 4 different dry weather days from June 21, 2000 to October 1, 2000.

Figure 9 shows fecal coliform data during dry weather for four transects and tributary streams of the Monongehela. Fecal coliform results are highest for the streams and most variable when compared to the rivers. Some variability is observed in the river transect data, most notably at Mile Points 10.21 Right, 5.66 Right and 0.23 Right. The highest single river sample is observed at MP 10.21 Right at 17,000 CFU/100ml, with its minimum value of 280 CFU/100ml. Although the data cannot be directly compared to the ORSANCO standards, five river samples out of a total of 48 are above 400 CFU/100ml (see Appendix C for raw data).

Figure 9: Box Plots of Fecal Coliform Data for 4 River Transects (Mile Points) and Tributary Streams along the Monongehela River.



* *4 samples of Fecal Coliform for all locations*

The variation in fecal coliform results in the streams may be due to their lower and more variable flows. The high fecal coliform results indicate that these streams are greatly impacted by fecal pollution. Street's Run has the highest values and the greatest range, from 470 to 460,000 CFU/100ml. This high fecal contamination may be due to problems caused by massive flooding on (August 8, 2000). All of the stream samples were above the 400 CFU/100ml standard except for Nine Mile and Four Mile Runs (see Appendix C for raw data). Four Mile Run also had lower fecal coliform concentrations in comparison to the other streams; only one of four samples was below the 400 CFU/100ml standard. This most likely is due to backflow from the river into the culvert where the sample was taken. Nine Mile Run had lowest fecal coliform levels of all the streams. This may be due to the high pH values (average >10.00) rather than a lack of fecal contamination.

The geometric means of the fecal coliform data sets for both the river transects and tributary streams are shown in Figure 10 above. Since our sampling scheme did not permit sampling to occur more than once per month with no more than four samples collected per site, the above standards cannot be directly applied to this data. However, using 200 CFU/100ml as a benchmark to compare our data, the geometric means of 8 of 12 river points fell within 200 CFU/100ml.

In comparison to the river transects, only 2 of streams fell within 200 CFU/100ml geometric mean. The extremely high levels of fecal coliform in the tributary streams warrant further study.

Figure 10: Geometric Means of Fecal Coliform Data in the Monongehela River and its Tributaries

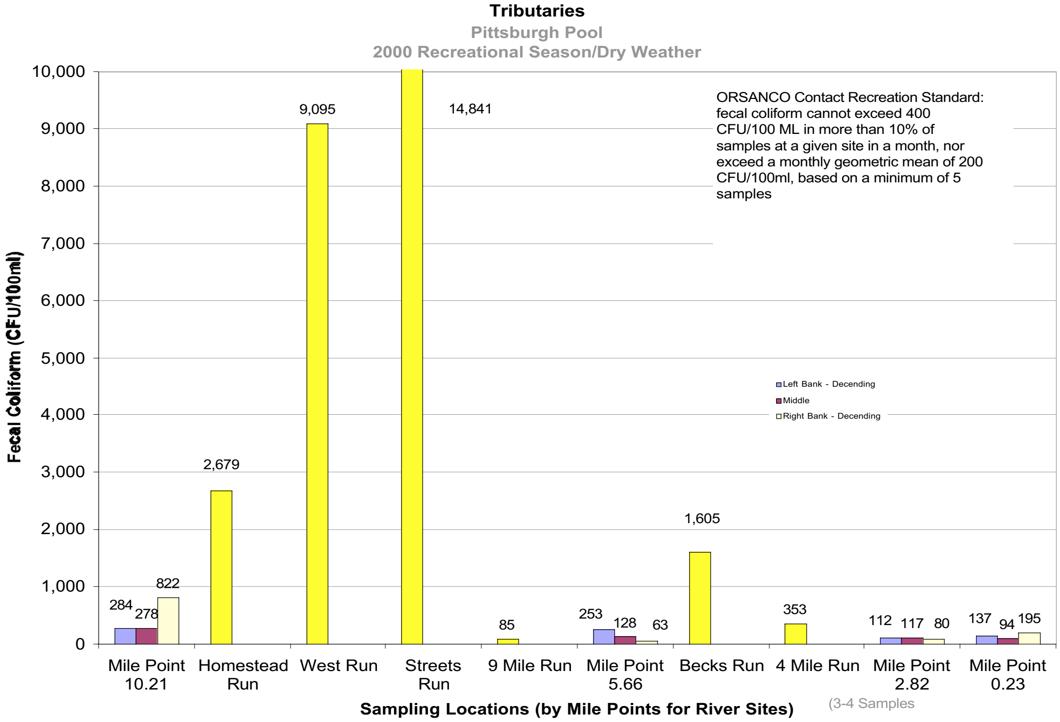
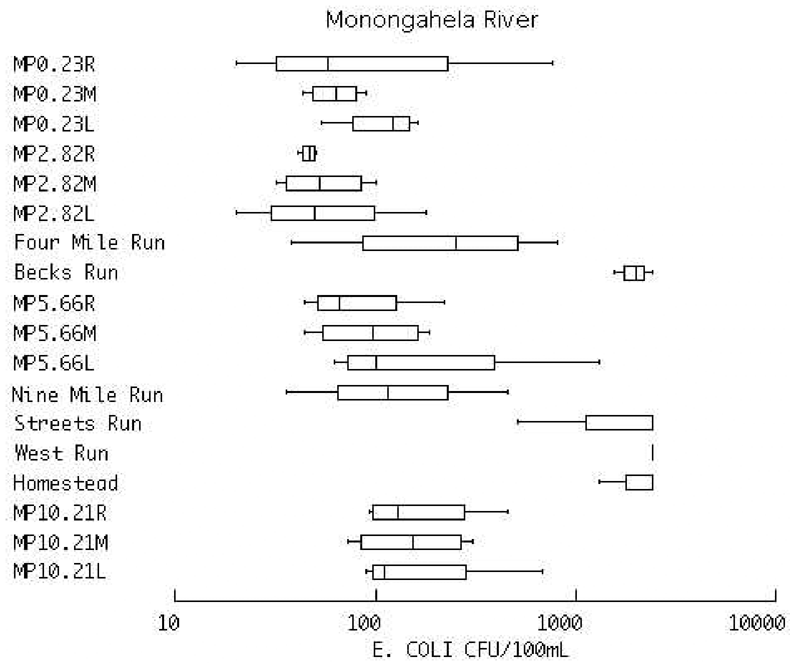


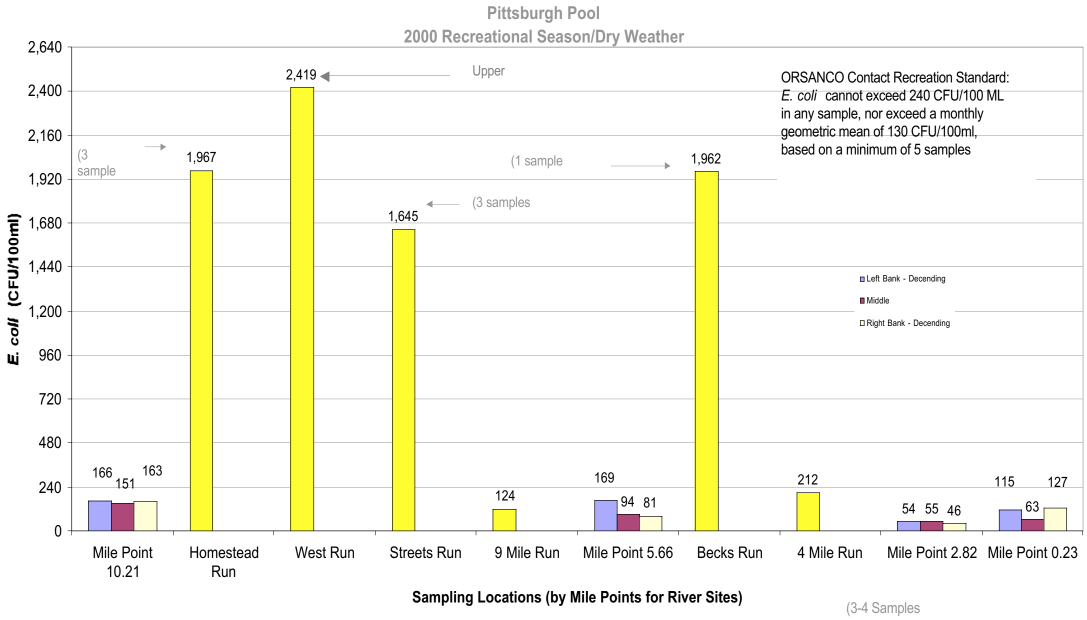
Figure 11: Box Plots of *E. coli* Data for 4 River Transects (Mile Points) and Tributary streams along the Monongehela River.



** 4 samples of E. coli for all locations*

The box plot in Figure 11 shows *E. coli* data during dry weather for four river transects and the six tributary streams of the Monongehela. The river data appear to be more variable than the stream data. Possibly because much of the stream data was at the upper detection limit of 2419 CFU/100ml so we are unable to determine the upper ranges of *E. coli* data in the streams. Most of the tributary data in at least one sampling event is at the maximum detection limit of 2419 CFU/100ml for all but two streams. West Run and Street's Run appear to be the most affected by high *E. coli* levels. Similar to the fecal coliform data, Nine Mile and Four Mile Runs have the lowest *E. coli* levels of the six tributary streams sampled. *E. coli* data taken at the four river transects indicate that the Monongehela River is below the single sample max of 240 CFU/100ml for 43 out of 48 samples. In comparison, only 5 of the 22 tributary samples are below 240 CFU/100ml (see Appendix B for raw data).

Figure 12: Geometric Means of *E. coli* Data in the Monongehela River and its Tributaries



Geometric means of *E. coli* data of both the river and stream data are shown together in Figure 12. This illustrates the relationship between sampling locations of the river transects and tributary streams. As stated above, our sampling scheme did not permit sampling more than once a month, with no more than four samples collected per site, thus we are using thee geometric mean standard of 130 CFU/100ml as a benchmark to compare our data to. Only Mile Point 5.66 Right and Mid and the lower two transects fall within this benchmark. These two lower transects are important relative to the major public points of access and recreation. MP 2.82 is just upstream of the public dock on the South Side of the City of Pittsburgh and MP 0.23 is just above the Point in Downtown Pittsburgh. In comparison to the river data, only the geometric mean of Nine Mile Run fell within the 130 CFU/100ml benchmark. As above the high levels of fecal coliform in the tributary streams warrant further study.

Additional Parameters for Tributary Streams

Average concentrations of each of the chemical and field parameters are shown in Appendix C. Most parameters are within the Pennsylvania water quality criteria for warm water fisheries, the designated use of the Mon River and its tributary streams (25 PA Code § 93.9v) with a few exceptions. As stated above, Nine Mile Run has an average pH of 10, above the permissible range of pH 6-9. Likely due to runoff from the massive slag pile that sits above the stream. Dissolved Oxygen was low for Homestead Run (also known as Whittaker Run). This stream had a very low flow and during one sampling event, no sample was obtained because the stream was dry. Street's Run had one DO reading below the minimum allowable concentration of 4.0 mg/L. The stream also showed the highest averages for ammonia, iron, alkalinity, conductivity, and total dissolved solids than the other 5 streams, though it did not exceed water quality criteria for these parameters. As stated above, Street's Run has continuing problems dating from the August, 2000 flooding.

Monongahela River Wet Weather Data

Wet Weather data is presented in Figures 13-16. This data suggest that the Monongehela River begins to returns to dry weather conditions within 15-33 hours after combined sewer discharges. The data indicate that Mile Point 2.82 has higher fecal coliform and *E. coli* concentrations. This warrants further study, over a range of conditions.

Figure 13: Wet Weather Survey of Fecal Coliform for Select Monongehela River Sites

2000 Recreational Season

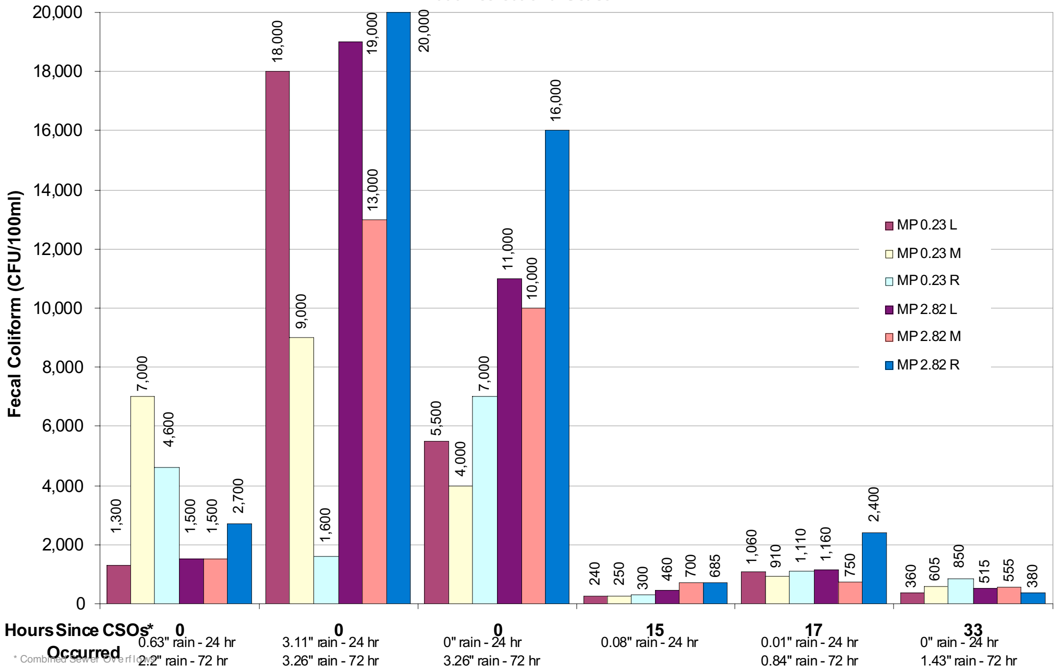


Figure 14: Wet Weather Survey of E. coli for Select Monongehela River Sites

2000 Recreational Season

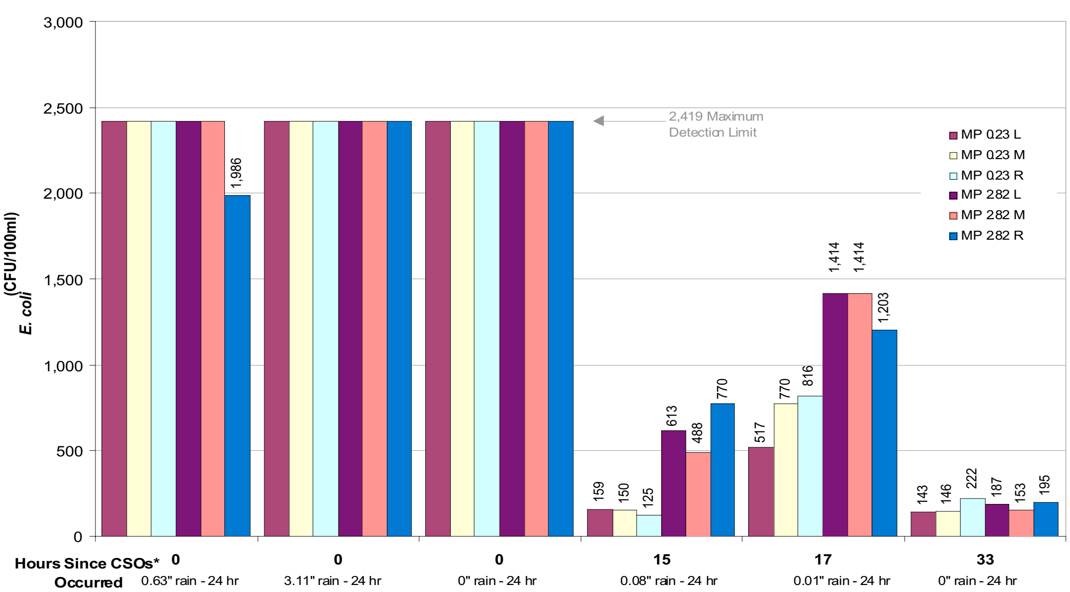
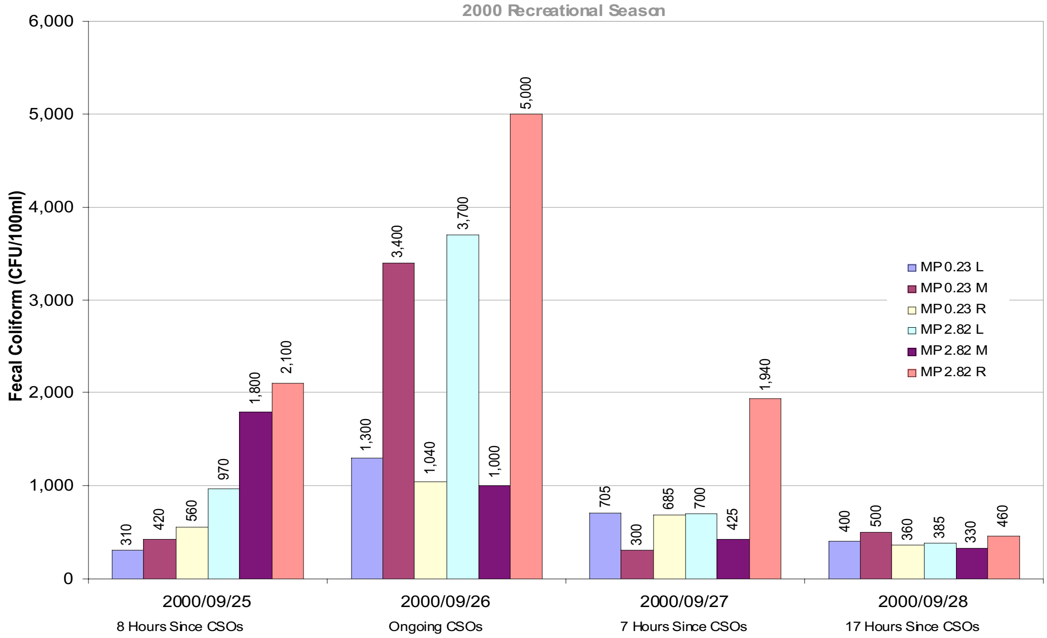
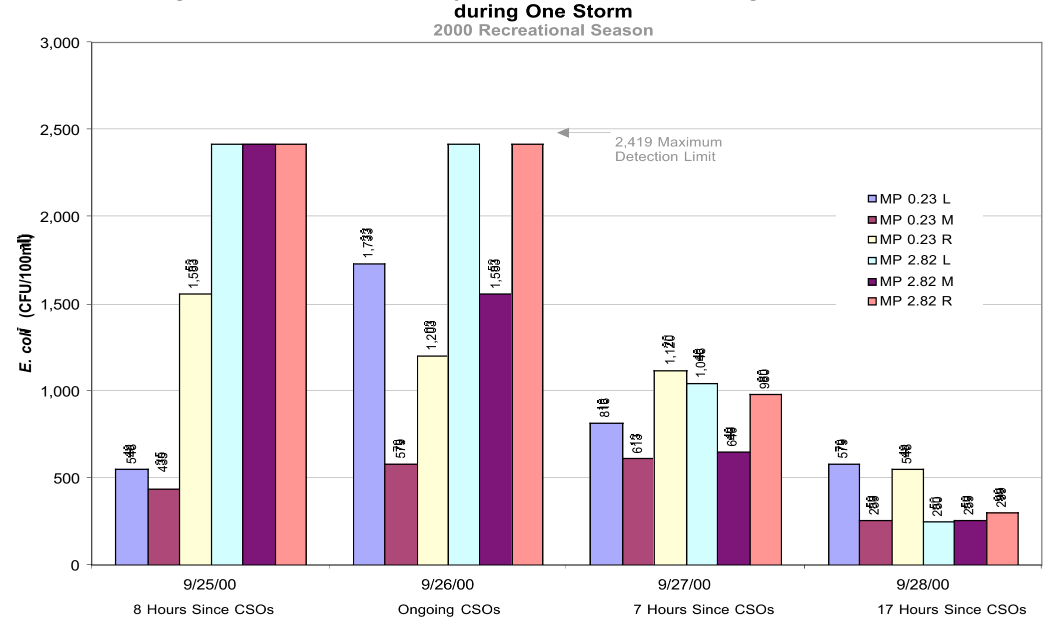


Figure 15: Wet Weather Survey of Fecal Coliform for Select Monongehela River Sites during One Storm



*Rainfall for 9/23 & 9/24/00 equals 0.49 inches. Additional 0.44 inches fell on 9/26/00.

Figure 16: Wet Weather Survey of *E. coli* for Select Monongehela River Sites during One Storm



*Rainfall for 9/23 & 9/24/00 equals 0.49 inches. Additional 0.44 inches fell on 9/26/00.

Results and Discussion

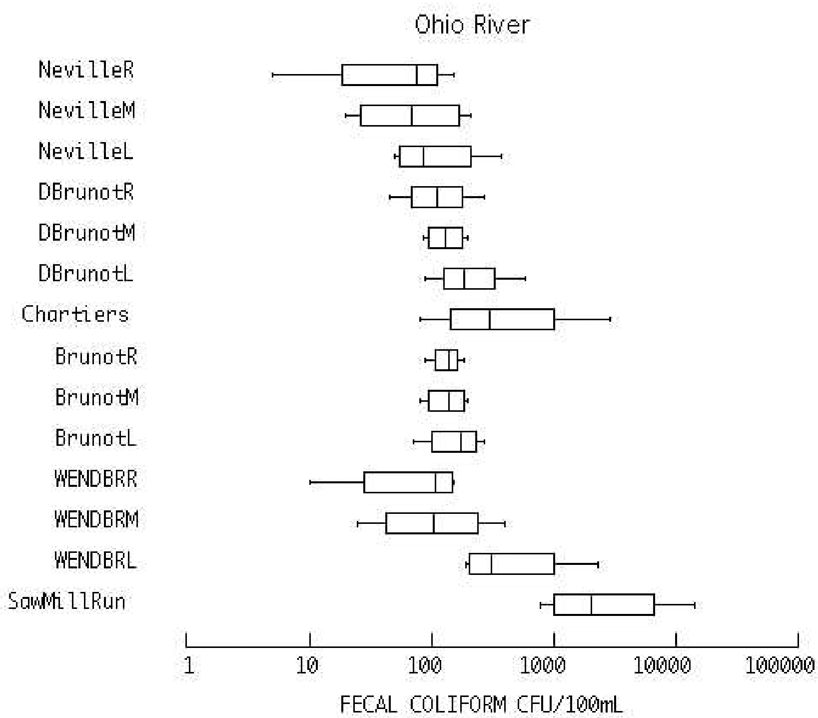
6. Ohio River

Four river transects and five streams were sampled along the Ohio River from the Point to the Emsworth Dam. Sampling of this river system occurred on 4 dry weather days from July 10, 2000 to October 16, 2000.

Figure 17 shows a box plot illustrating the range of the fecal coliform data for the four river transects and tributary streams in the Ohio River. The river sample sites above and below Brunot's Island have the least variability. The highest concentrations of fecal coliform occur in the two tributary streams, Saw Mill Run and Chartiers Creek. The maximum fecal coliform count for Saw Mill Run is 14,000 CFU/100ml. The maximum in Chartiers Creek is 2,900 CFU/100ml.

Although the data cannot be directly compared to the standards, two river sample sites are above the 400 CFU/100ml ORSANCO maximum standard for 10% of the samples at a given site (see Appendix D for raw data). These occur at West End Bridge Left with a maximum of 2,300 CFU/100ml. This site is downstream of the Monongehela River and

Figure 17: Box Plots of Fecal Coliform Data for 4 River Transects (Mile Points) and Tributaries along the Ohio River taken during the 2000 Recreational Season.



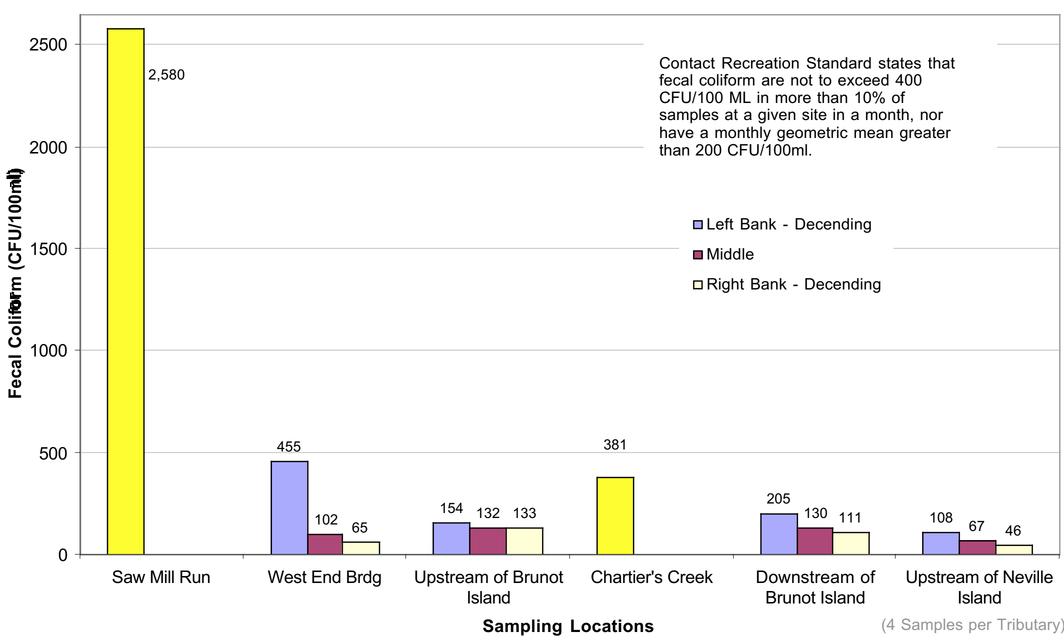
** 4 samples of Fecal Coliform for all locations* the confluence of Saw Mill Run. The observation of maximum concentrations occurred on the same day as the maximum fecal coliform concentration in Saw Mill Run (14,000 CFU/100ml). Downstream of Brunot's Island Left also is above the 400 CFU/100ml standard with a maximum of 575 CFU/100ml. This site is downstream of the confluence with Chartiers Creek. The maximum concentration for Downstream of Brunot's Island left occurred the same day as the maximum concentration for Chartiers Creek (2,900 CFU/100ml).

Figure 18 shows the geometric means of the fecal coliform data for the Ohio River and its tributary streams. Since our sampling scheme did not permit sampling more than once per month with no more than four samples collected per site, the above standards cannot be directly applied to this data. However, using 200 CFU/100ml as a benchmark to compare to our data, Figure 18 illustrates that two river sampling sites (West End Bridge Left and Downstream of Brunot Island Left) are above this benchmark. Both tributary streams are above 200 CFU/100ml as well.

Figure 18: Geometric Mean of Fecal Coliform Data in the Ohio River and its Tributaries

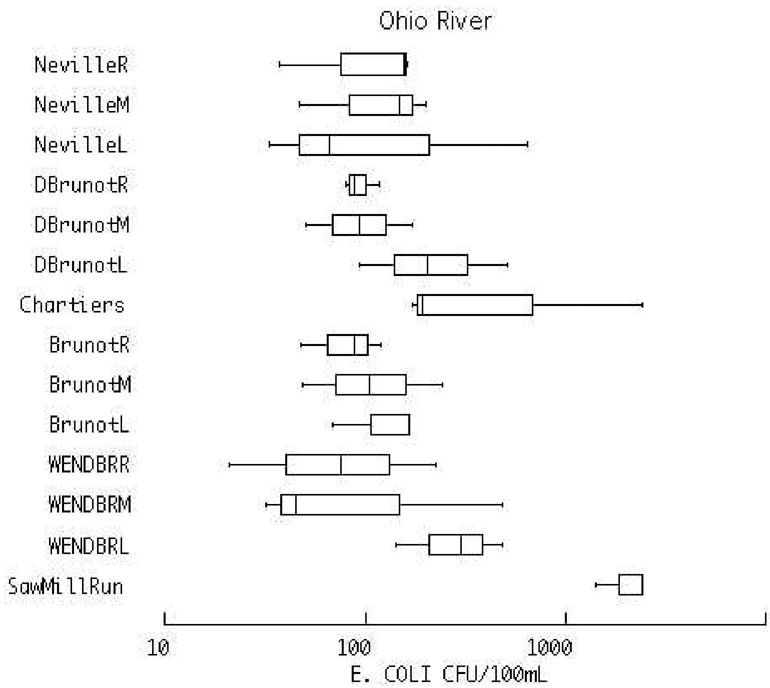
Pittsburgh Pool

2000 Recreational Season/Dry Weather



E. coli Data

Figure 19: Box Plots of *E. coli* Data for 4 River Transects (Mile Points) and Tributaries along the Ohio River.



* 3 samples for *E. coli* for all locations

Figure 19 is a box plot of the *E. coli* data for the Ohio River and its tributary streams. It shows similar observations as the fecal coliform data in Figure 18. This data set has only 3 samples per location. Saw Mill Run and Chartiers Creek have the highest concentrations, with 3 of the 6 samples reaching the 2,419 CFU/100ml maximum detection limit. The West End Bridge Left and Middle, Downstream of Brunot's Island left, and Upstream of Neville Island left have the highest *E. coli* concentrations of the river samples. Five samples taken at these points were above the ORSANCO maximum *E. coli* of 240 CFU/100ml (see Appendix D for raw data).

Figure 20: Geometric Mean of *E. coli* data in the Ohio and its Tributaries

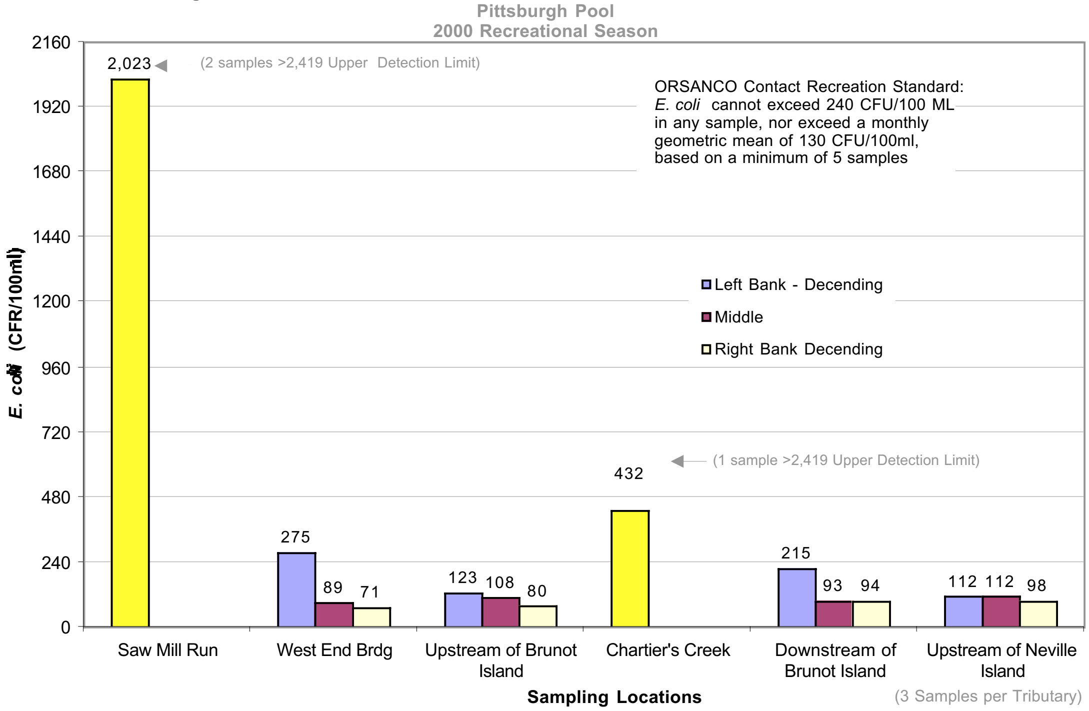


Figure 20 shows the geometric means of the river and tributary *E. coli* data. Although the data cannot be directly compared, the ORSANCO geometric mean maximum of 130 CFU/100ml is used as a benchmark to compare to our data. In Figure 20, only 2 river sites, West End Bridge Left and Downstream of Brunot's Island Left, are above this benchmark. These sites are directly downstream tributary streams, which also exceed this benchmark.

Additional Parameters for Tributary streams

Average concentrations of each of the chemical and field parameters are shown in Appendix D. Most parameters are within the Pennsylvania water quality criteria for warm water fisheries, the designated use of the Ohio River and its tributary streams (25 PA Code § 93.9w) with a few exceptions. The Total Dissolved Solids concentrations for both Chartiers Creek and Saw Mill Run had several readings above the maximum allowable concentration of 750 mg/L.

Ohio River Wet Weather Data

Wet weather data is presented in Figures 21-24. The data suggest that the Ohio River returns to dry weather conditions within 15-33 hours after combined sewer discharges. The West End Left has higher fecal coliform concentrations on some sampling occasions, either affected by the Monongehela River or Saw Mill Run. Wet weather conditions warrant further study, over a range of conditions.

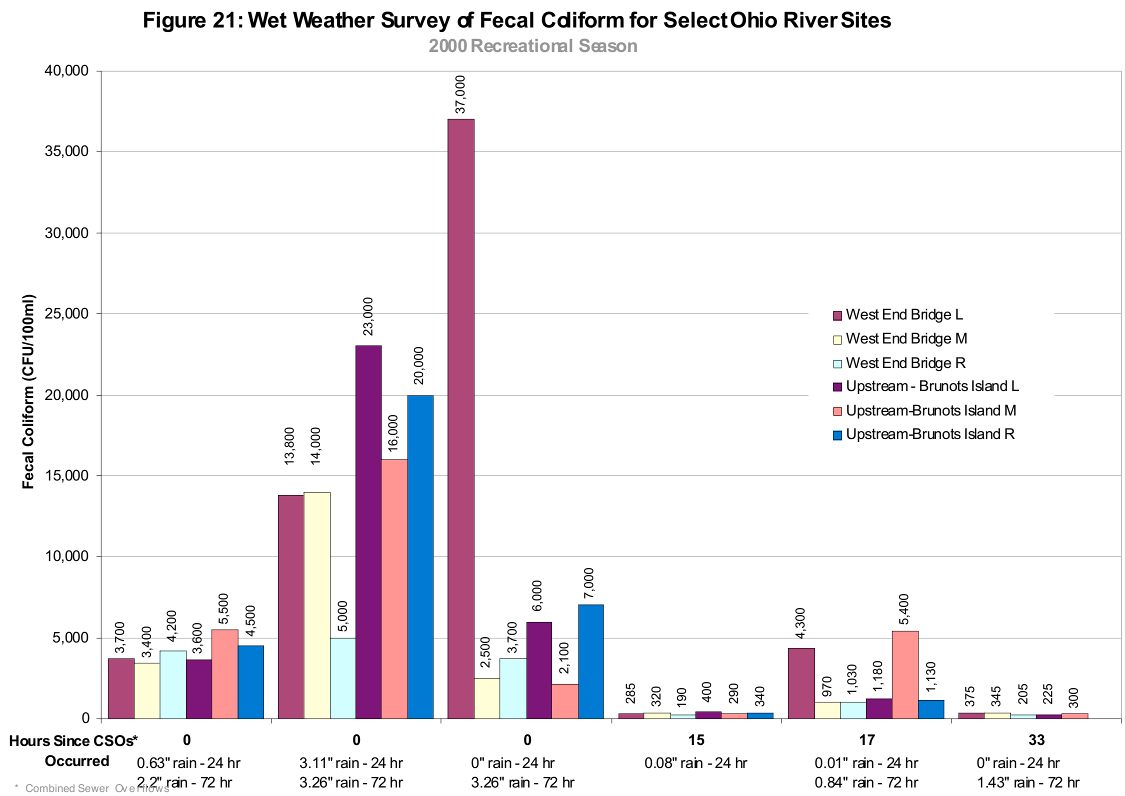


Figure 21: Wet Weather Survey of Fecal Coliform for Select Ohio River Sites
2000 Recreational Season
Fecal Coliform (CFU/100ml)
West End Bridge L
West End Bridge M
West End Bridge R
Upstream - Brunots Island L
Upstream-Brunots Island M
Upstream-Brunots Island R
Hours Since CSOs* Occurred
0
0.63" rain - 24 hr
2.2" rain - 72 hr
0
3.11" rain - 24 hr
3.26" rain - 72 hr
0
0" rain - 24 hr
3.26" rain - 72 hr
15
0.08" rain - 24 hr
17
0.01" rain - 24 hr
0.84" rain - 72 hr
33
0" rain - 24 hr
1.43" rain - 72 hr
* Combined Sewer Overflows

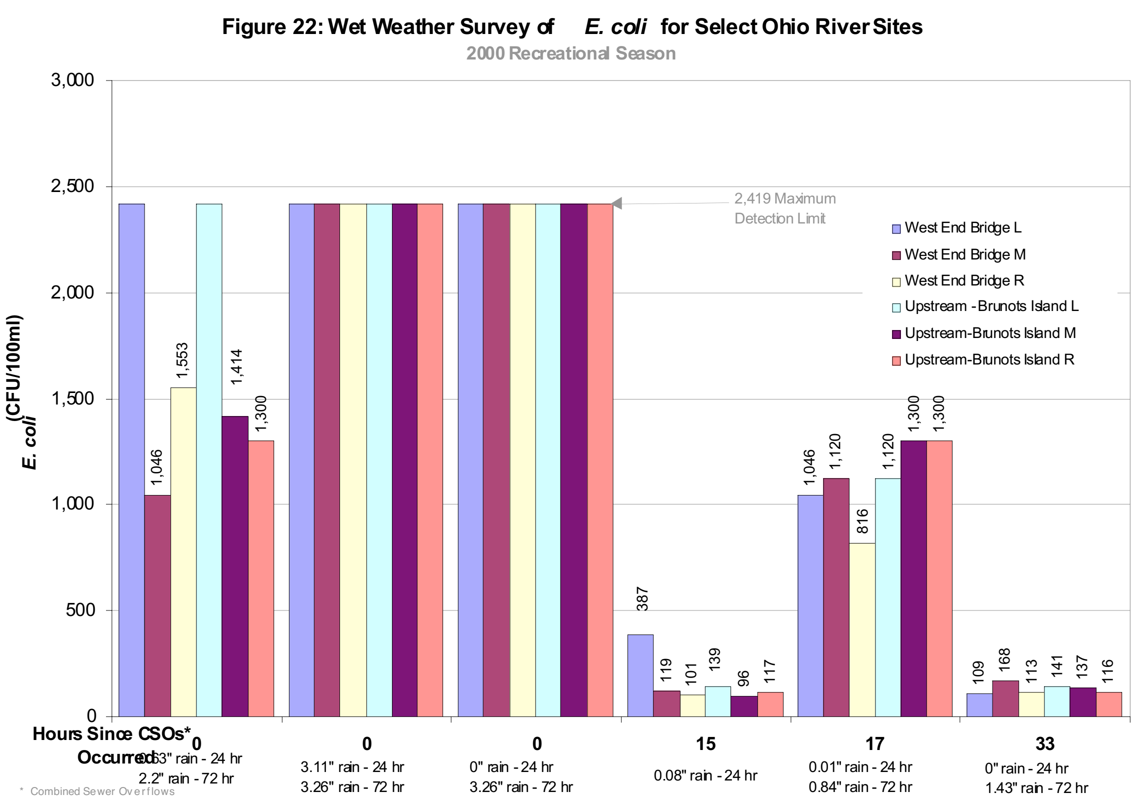
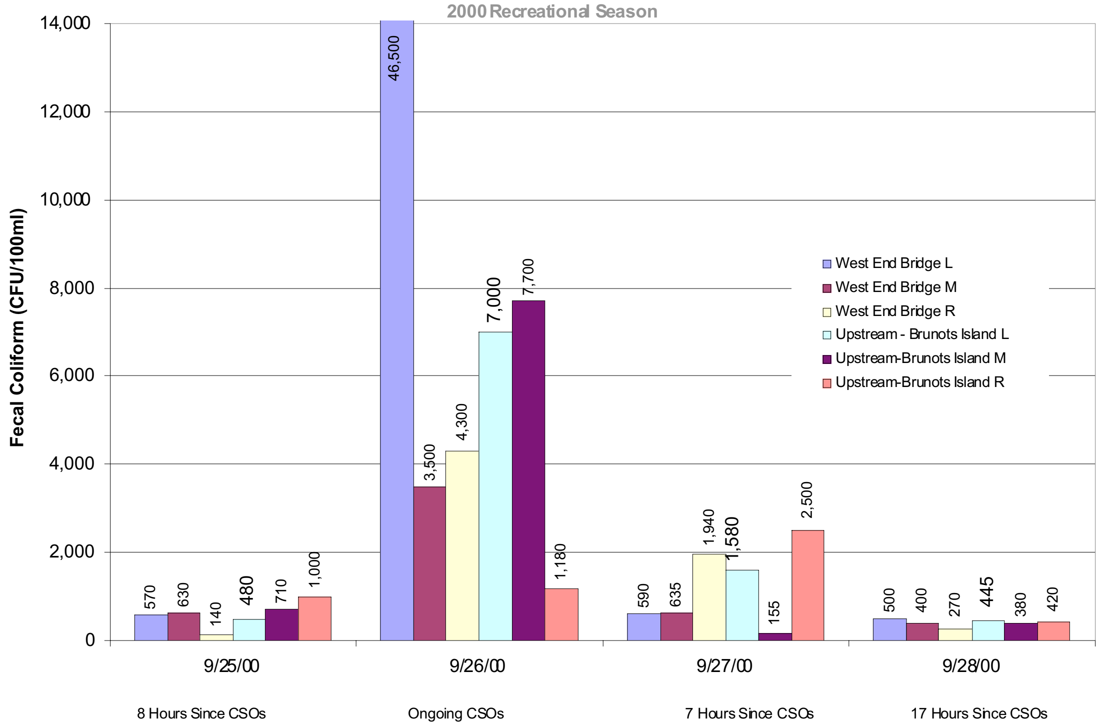


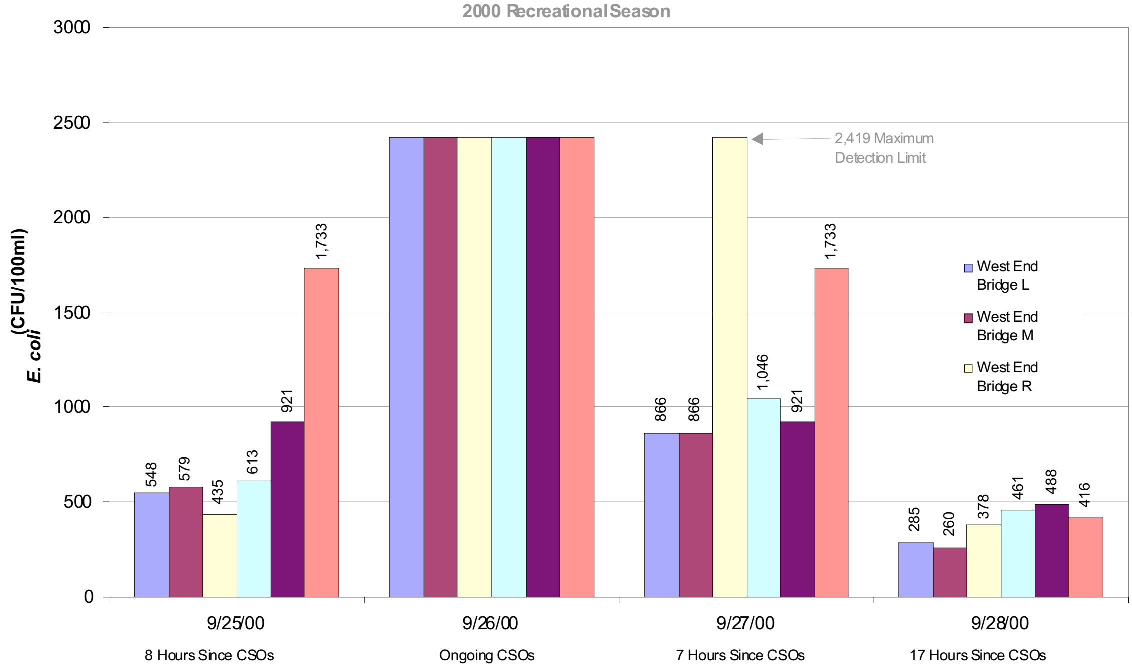
Figure 22: Wet Weather Survey of E. coli for Select Ohio River Sites
2000 Recreational Season
E. coli (CFU/100ml)
2,419 Maximum Detection Limit
West End Bridge L
West End Bridge M
West End Bridge R
Upstream - Brunots Island L
Upstream-Brunots Island M
Upstream-Brunots Island R
Hours Since CSOs* Occurred
0
0.63" rain - 24 hr
2.2" rain - 72 hr
0
3.11" rain - 24 hr
3.26" rain - 72 hr
0
0" rain - 24 hr
3.26" rain - 72 hr
15
0.08" rain - 24 hr
17
0.01" rain - 24 hr
0.84" rain - 72 hr
33
0" rain - 24 hr
1.43" rain - 72 hr
* Combined Sewer Overflows

Figure 23: Wet Weather Survey of Fecal Coliform for Select Ohio River Sites during One Storm



*Rainfall for 9/23 & 9/24/00 equals 0.49 inches. Additional 0.44 inches fell on 9/26/00.

Figure 24: Wet Weather Survey of *E. coli* for Select Ohio River Sites during One Storm



*Rainfall for 9/23 & 9/24/00 equals 0.49 inches. Additional 0.44 inches fell on 9/26/00.

7. 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 in dry weather, the tributary streams are the most impacted by fecal pollution. This is a primary area for further study because stream miles are four times the amount of river miles, and they frequently run through parks and neighborhoods. On the rivers, we found some good news. The dry weather conditions of the rivers for the most part are within 200 CFU/100ml fecal coliform benchmark used in this study. In wet weather conditions, the bench mark was exceed at all river sampling sites, having higher concentrations of fecal coliform as would be expected in this region.

More sampling in both the rivers and tributary streams is needed to further define the relationship between water quality issues and public recreation opportunities within the Pittsburgh Pool. 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 like Pine Creek and West Run (work has already begun on Chartiers Creek). This will help us understand the full potential of these tributary streams as assets to the 3 rivers' 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 5 indicates, each river in the Pittsburgh Pool (calculating a geometric mean for all data for each river) is within our specific target number for fecal coliform of 200 CFU/100ml. Despite this, specific points along the Monongahela and the Ohio Rivers do have higher levels of fecal coliform. This is evident on the Monongahela River just below the Braddock Dam. There, the data are above our target level at all three sampling locations. The highest reading of these test sites is just below the Edgar Thompson Works (880 CFU/100ml). Further down the Monongahela River at Mile Point 5.66 (under the Glenwood Bridge on the Hazelwood side of the river), the data are also above the target fecal coliform level. On the Ohio River, test sites under the West End Bridge show a spike of 455 CFU/100ml of fecal coliform on the left descending bank just below Saw Mill Run.

Table 5: Fecal Coliform Results for River Samples in the Pittsburgh Pool for the 2000 Recreational Season in Dry Weather*

Source	Geometric Mean ** CFU/100ml
Allegheny River	65
Monongahela River	163
Ohio River	119

*at least 3 days without rain or known combined sewer overflows.
**Geometric means are calculated from fecal coliform results from all sampling locations on each river (approx. 48 samples/river).

2. Are there water quality problems indicated at points of public access?
During dry weather, our results indicate high fecal coliform concentrations at the public boat launch and fishing access on the Monongehela River just below the Braddock Dam next to the Edgar Thompson Works. Our results show that this site has high readings at all three transects across the river as well as the single highest concentration of the Monongehela River at the public boat launch. This would indicate significant water quality problems at the Braddock public boat launch.

3. Are there specific areas that warrant further study? Why?
Since our data is limited to four sampling events per river, further study is necessary to more fully understand the dry weather baseline conditions in each river. Study is also needed to investigate the water quality upriver of the Pittsburgh Pool to ascertain the range of inputs affecting water quality. (This is a planned component of this project in years 2, 3, 4, and 5.)

Rivers:
In Wet Weather

1. What is the wet weather water quality and are there spatial variations?
For all three rivers in wet weather, our data show that the fecal coliform concentrations increase and remain high for days after a rain fall (see Table 6) Spatially, our data suggest that the edges of the rivers have higher concentrations and are slower to recover. This is important in terms of public access since most people fish from the banks and come in contact with river water. People can be seen fishing after a storm, even while the Allegheny County River Water Advisory is still in effect.

It is no surprise that the rivers are found to have fecal coliform concentrations above our target number of 200 CFU/100ml. During rainfall sewer overflows and storm water runnoff contribute to the contamination. Other sources of fecal contamination may be present upstream of the Pittsburgh Pool as well as within the tributary streams.

Table 6: Fecal Coliform Results for River Samples in the Pittsburgh Pool for the 2000 Recreational Season in Wet Weather

Source	Geometric Mean*
Alllegheny River	1732
Monongahela River	1365
Ohio River	1518

*Geometric means are calculated from fecal coliform results for wet weather from all sampling locations on each river (approx. 60 samples/river).

2. Are there wet weather water quality problems at points of public access?
The two most notable sites that have high fecal coliform concentrations as well as public access points are along the Allegheny River:

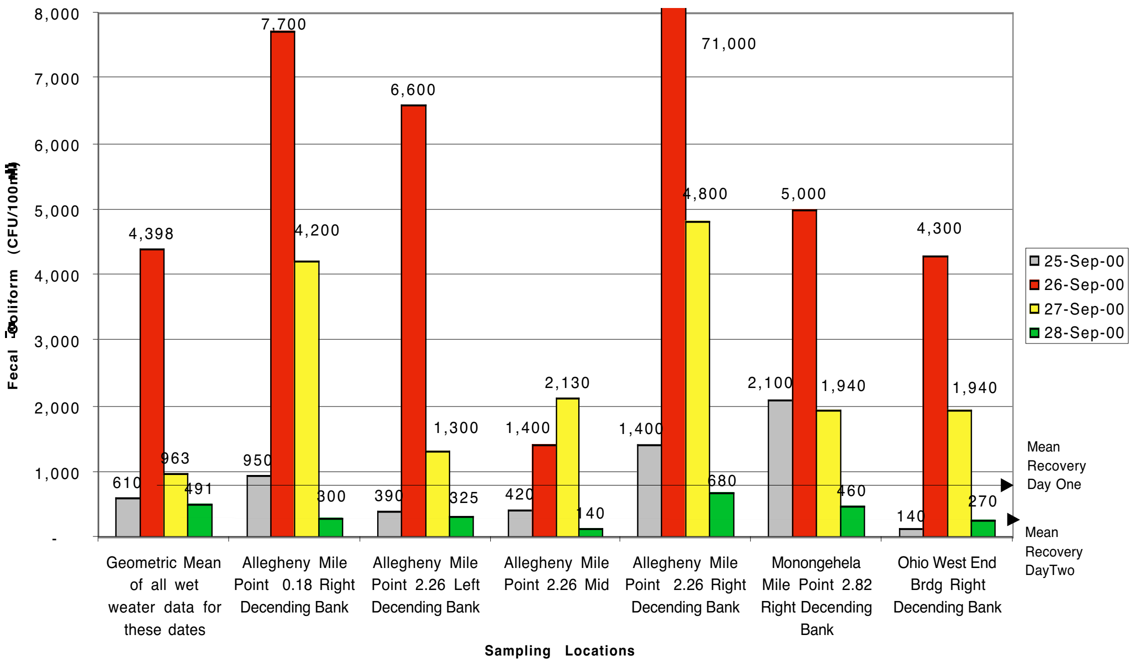
Mile Point 2.26 (Left Descending Bank): Just below the back channel of Washington's Landing, immediately downstream from the 3 Rivers Rowing Association.

Mile Point 2.26 (Right Descending Bank): Just below Washington's Landing near the Strip District and directly upstream from two marinas and a popular waterfront restaurant.

3. Are there space and time differences regarding a return to dry weather conditions?
Figure 25 shows select sites which were slow to return to dry weather conditions during one rain storm occurring over 4 days in September 2000 where approximately one inch of rain fell.

<u>Allegheny River</u>
Mile Point 0.18 (Right Descending Bank): Just below PNC Park.
Mile Point 2.26 (Left Descending Bank): Just below the back channel of Washington's Landing immediately downstream from the 3 Rivers Rowing Association.
Mile Point 2.26 (Right Descending Bank): Just below Washington's Landing near the Strip District and directly upstream from two marinas and a popular waterfront restaurant.
<u>Monongehela River:</u>
Mile Point 2.82 (Right Descending Bank): Just above the Technology Center off of Second Avenue.
<u>Ohio River</u>
OHWE (Left Descending Bank): Just downstream of the West End Bridge and the Carnegie Science Center, and upstream from four marinas.

Figure 25: Fecal Coliform Data for Select Sites Slow to Return to Dry Weather Conditions on the Allegheny, Monongehela and Ohio Rivers during a Rain Storm in September 2000*



*Rain fall for Sept 23 & 24, 2000 equals 0.49." Another 0.44" fell on Sept. 26, 2000.

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

The Allegheny River in the area between the confluent of the three rivers at the Point and the 40th Street Bridge has relatively high shoreline access and recreational boating access. The first priority, the area around Washington's Landing deserves careful analysis with a particular focus on the back channel. A secondary priority should be the area targeted for development on the North Shore in the City of Pittsburgh, and the four marinas immediately downstream on the Ohio River. A more detailed study will provide more complete understanding of wet weather impacts of both point and non-point sources of pollution in both the rivers and tributary streams.

Tributary streams:

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

Fourteen tributary streams discharge into the Pittsburgh Pool. Compared to the fecal coliform target number of 200 CFU/100ml, our data indicate significant dry weather impacts in the tributary streams of the Monongahela River. Of these streams, (6 in total) they have higher fecal coliform concentrations than the two tributary streams on the Ohio River, and the six on the Allegheny River. Table 7 shows the geometric means of all the tributary stream data for each river.

Table 7: Fecal Coliform Results of Tributary Stream Samples in the Pittsburgh Pool for the 2000 Recreational Season in Dry Weather*

Source	Geometric Mean CFU/100ml
6 Tributary streams of the Allegheny River	821
6 Tributary streams of the Monongehela River	1799
2 Tributary streams of the Ohio River	992

*at least 3 days without rain or known combined sewer overflows.
**Geometric means are calculated from fecal coliform results from all tributary stream sampling locations on each river.

Allegheny River Tributary streams

Most Impacted: Girtys Run, Pine Creek, Sipes Run
Least Impacted: Heaths Run, Guyasuta Run
Culverted: 32nd St.

Monongahela River Tributary streams

Most Impacted: Becks Run, Streets Run, West Run
Least Impacted: Nine Mile Run
Little Flow: Homestead (Whittaker) Run
Culverted: Four Mile Run

Ohio River

Most Impacted: Saw Mill Run
Least Impacted: Chartiers Run
No Flow Jacks Run.

2. Do tributary streams add or subtract from the water quality of the main stem rivers?
The relative effect of tributary streams on the amount of water flowing in the rivers is minimal. The mouths of these tributary streams however are of some concern due to shallow waters, good fishing and minimal opportunity for dilution. Our results show higher fecal coliform concentrations along the Ohio River at the West End Bridge sampling location below Saw Mill Run and downstream from Chartiers Creek. Indicating problems in both streams, which do affect the main stem rivers within 50 feet of the bank.

3. Are there water quality problems indicated at points of public access?
At the mouths of most of the larger tributary streams, a shallow water sand bar is created that attracts people. Fishermen and families are often found wading at the mouths of Pine Creek, Girtys Run, Sipes Run, Guyasuta Creek, Heaths Run, Becks Run, and Nine Mile Run. People are also seen fishing along the shores at the mouths of Saw Mill Run and Chartiers Creek. In addition, each stream flows through a number of towns and neighborhoods where children access them easily. Table 8 shows the various parks that

Table 8: Parks and Opens Space along the Stream Corridors.

Allegheny River	Allegheny River	Allegheny River	Allegheny River
Pine Creek	Sipes Run	Heath's Run	Guyasuta Creek
Fall Run Pk	Briarcliff Pk	Highland Pk	Guyasuta Boy Scout
Township Pk	Kerrwood Pk		Reservation
Devonshire Pk	Woodland Pk		
Hartwood Acres Pk			

Ohio
Saw Mill Run
Brookline Pk
McKinley Pk
Mt. Washington Pk
Vabash Pk

Monongahela R	Monongahela R	Monongahela R	Monongahela R
Four Mile Run	Nine Mile Run	Streets Run	Becks Run
Schenley Pk	Frick Pk	Highland Pk	Philip Murray Pk

4. Does each tributary stream have the minimum conditions to support aquatic life?
Despite high fecal coliform concentrations found in our study, these tributary streams support a range of wildlife, as observed during sampling. Based on our sampling, the fourteen tributary streams in the Pittsburgh Pool meet the Pennsylvania Water Quality Criteria for their designated uses, with the exception of Nine Mile Run, which has high pH values, and Heaths Run, which has low DO values. High pH and reduced DO minimize the range of life forms able to live in water.

5. Do these tributary streams warrant further study? Why?
A more detailed look at the biology is important to understand how much "life" these tributary streams are sustaining presently. A benthic macroinvertebrate study has been budgeted and proposed by 3Rivers-2nd Nature and ACHD to the Army Corp of Engineers for each of the main tributary streams in Allegheny County to begin 2001. 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. A targeted study of the upper watersheds of each stream will begin to tell us where sources of pollution are located and whether they are point or non-point sources. This, in turn will guve us a much better sense of the public health issues on each specific watershed.

Appendix E, Tributary Watershed Analysis, contains a GIS based study, assessing each of the tributary watersheds for soils, land-use, natural features, cultural features, stream length and impervious soils.

In the future we will conduct a GIS analysis of the physical, chemical and biological characteristics of each tributary watershed. This will help us understand the complex relationship between natural stream functions and the impacts of urban infrastructure. (3R-2N has worked with the Allegheny County Health Department and the U.S. Army Corp of Engineers to develop a benthic organism study which will begin in 2001.)

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. This was an extremely wet and rainy recreational season (May 15 – September 30) and resulted in 67 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 49% of the time from May to September 30, 2000.

Wet Weather

For all three rivers in wet weather, our data suggest that the fecal coliform concentrations increase and remain at high concentrations for 2-3 days after a storm. Our data also suggest that several sites along the riverbanks are slower to recover than the middle of the river. 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. For the 2000 recreational season, there was a total of 71 of 138 days when it was unsafe (or 51% of the time) for direct contact with river water according to the Allegheny County Health Department.

Tributary Streams

Our study shows that during dry weather, high concentrations of fecal coliform are present in most of the tributary streams studied. Chemical and field tests indicate most parameters within an expected range for this region and within state water quality standards. However, many of these tributary streams flow through municipal parks or neighborhoods. Because of the high fecal coliform concentrations found in most of the tributary streams, public access may increase human exposure to waterborne pathogens.

While the problem of fecal contamination problem is significant in most of the tributary streams, their ecological potential cannot be overlooked. Sightings of great blue herons and schools of fish in Street's Run and an Osprey feeding in the waters of Pine Creek illustrate the value of even the most contaminated tributary streams.

Conclusion

Our study indicates that during dry weather most of our sampling sites along the rivers of the Pittsburgh Pool are below our target number for fecal coliform, indicating little fecal contamination. However, during dry weather the tributary streams have much higher concentrations of fecal coliform. Wet weather river water quality exceeds our target number for fecal coliform several days after a rainfall. Our study further suggests that the is uncertain when it is safe to resume contact recreation on the rivers after a rainfall. Extensive monitoring and modeling of the river systems will be necessary to fully understand this system.

The 3 Rivers - 2nd Nature project will continue its work over the next four years. In 2001 we will bring in additional aquatic ecology expertise to take a better look at the ecology of the tributary streams. In 2001, our effort will take up the Monongahela River to the edges of Allegheny County. We will be conducting a series of community dialogue on the rivers beginning in spring 2001. A web site with this study and more, will be available at **http:3r2n.cfa.cmu.edu.**

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Appendix A – PA Water Quality Criteria, Physical and Chemical 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	0.4	Minimum allowable
Fecal coliform	200	CFU/100ML – Geometric mean for recreational season
Total Iron	1.5	Daily ave
pH	6-9	S.U. – Range of allowable concentration
Temp	28.9-18.9	Celcius – S asonal max from June 15-Oct 31
TDS	1500	Max allowable
TDS	500	Average for Allegheny, Monongehela, Ohio Rivers, Saw Mill Run and Chartiers Creek
	750	Max allowable for Allegheny, Monongehela, Ohio Rivers, Saw Mill Run and Chartiers Creek

Allegheny River, Girtys Run, Guysuta Run , Unnamed tributaries from Plum Creek to Confluence with Mon
Monongehela River, Homestead Run, Nine Mile Run, West Run, Streets Run, Unnamed tributaries from Yough to Mouth
Ohio River, Saw Mill Run, Chartiers Creek

Trout Stocking	(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	Daily ave
pH	6-9	S.U. – Range of allowable concentration
Temp	22.2-18.9	Celcius – Seasonal max from June 15-Oct 31
TDS	1500	Max allowable

Pine 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:

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

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:

$$NH_3 + H_2O \leftrightarrow NH_4^+ + OH^- .$$

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 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 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 Data for the Allegheny River and its Tributaries in the Pittsburgh Pool

	Mile Point 0.18			Mile Point 2.26			32nd St	Girtys	Mile Point 4.57			Pine	Sharpsburg	Mile Point 6.10			Heaths	Guyasuta
	Right	Mid	Left	Right	Mid	Left	Culvert	Run	Right	Mid	Left	Creek	Run	Left	Mid	Right	Run	Run
6/29/00	85	80	160	130	75	205	695	5,300	175	35	135	11,500	4,000	90	55	65	5	610
8/15/00	*	80	35	60	75	*	160	4,500	*	40	270	6,200	9,000	85	45	85	10	220
10/02/00	25	40	30	35	40	110	270	6,200	55	30	40	620	310,000	65	50	35	10	90
10/31/00	45	110	70	30	90	110	14,000	7,800	50	25	170	23,000	720	65	60	55	120	155
Arithmetic mean	**52**	**78**	**74**	**64**	**70**	**142**	**3,781**	**5,950**	**93**	**33**	**154**	**10,330**	**80,930**	**76**	**53**	**60**	**36**	**269**

*Blank entries indicate missing or damaged samples

E. coli Data for the Allegheny River and its Tributaries in the Pittsburgh Pool

	Mile Point 0.18			Mile Point 2.26			32nd St	Girtys	Mile Point 4.57			Pine	Sharpsburg	Mile Point 6.10			Heaths	Guyasuta
	Right	Mid	Left	Right	Mid	Left	Culvert	Run	Right	Mid	Left	Creek	Run	Left	Mid	Right	Run	Run
6/29/00	80	42	50	66	55	94	649	2,419	93	58	173	2,419	2,419	77	41	44	17	866
8/15/00	96	36	26	39	39	185	260	2,419	41	33	151	2,419	2,419	45	43	44	44	144
10/02/00	75	37	31	23	29	98	143	2,419	33	32	47	727	2,419	21	38	33	13	93
10/31/00	39	62	82	39	68	73	2,419	2,419	40	34	153	2,419	2,419	62	62	45	2,419	184
Arithmetic mean	**73**	**44**	**47**	**42**	**48**	**113**	**868**	**2,419**	**52**	**39**	**131**	**1,996**	**2,419**	**51**	**46**	**42**	**623**	**322**

*2419 is the maximum detection limit for this study

Appendix C

Fecal Coliform Data for the Monongehela River and its Tributaries in the Pittsburgh Pool

	Mile Point 0.23			Mile Point 2.82			4 Mile	Becks	Mile Point 5.66			Streets	West	9 Mile	Homestead	Mile Point 10.21		
	Left	Mid	Right	Left	Mid	Right	Run	Run	Left	Mid	Right	Run	Run	Run	Run	Left	Mid	Right
6/21/00	500	160	1,740	110	85	100	240	1,160	220	95	5	470	17,100	*	890	155	145	17,000
7/20/00	250	100	105	30	170	75	635	3,100	110	245	295	3,400	2,000	345	2,700	800	1,100	330
9/20/00	20	55	20	140	65	60	445	595	200	190	140	66,000	23,000	40	8,000	240	220	290
10/01/00	100	90	70	340	200	90	230	3,100	850	60	75	460,000	8,700	45	**	220	170	280
Arithmetic mean	**218**	**101**	**484**	**155**	**130**	**81**	**388**	**1,989**	**345**	**148**	**129**	**132,468**	**12,700**	**143**	**3,863**	**354**	**409**	**4,475**

*stream was inaccessable from river
**no flow

E. coli Data for the Monongehela River and its Tributaries in the Pittsburgh Pool

	Mile Point 0.23			Mile Point 2.82			4 Mile	Becks	Mile Point 5.66			Streets	West	9 Mile	Homestead	Mile Point 10.21		
	Left	Mid	Right	Left	Mid	Right	Run	Run	Left	Mid	Right	Run	Run	Run	Run	Left	Mid	Right
6/21/00	110	89	770	45	40	48	38	1,986	62	44	44	517	2,419	*	1,300	106	72	99
7/20/00	133	56	67	54	70	45	816	1,987	119	185	222	2,419	2,419	461	2,419	687	304	461
9/20/00	54	43	20	20	32	41	199	1,553	85	68	71	2,419	2,419	36	2,419	117	99	93
10/01/00	163	73	50	178	101	51	326	2,419	1,300	140	61	2,419	2,419	115	**	89	238	167
Arithmetic mean	**115**	**65**	**227**	**74**	**61**	**46**	**345**	**1,986**	**392**	**109**	**100**	**1,944**	**2,419**	**204**	**2,046**	**250**	**178**	**205**

*stream was inaccessable from river
**no flow
***2419 is the maximum detection limit for this study

Appendix D

Fecal Coliform Data for the Ohio River and its Tributaries in the Pittsburgh Pool

	Saw Mill	West End Bridge			Upstream of Brunot's Island			Chartiers	Downstream of Brunot's Island			Upstream of Neville Island		
	Run	Left	Mid	Right	Left	Mid	Right	Creek	Left	Mid	Right	Left	Mid	Right
7/10/00	14,000	2,300	25	10	270	110	185	2,900	575	85	270	50	20	70
7/25/00	3,100	190	145	145	70	80	145	350	90	105	45	60	35	5
8/22/00	1,300	220	75	80	200	200	130	260	180	160	120	120	210	80
10/16/00	785	445	400	155	150	175	90	80	190	200	105	375	135	155
Arithmetic mean	**4,796**	**789**	**161**	**98**	**173**	**141**	**138**	**898**	**259**	**138**	**135**	**151**	**100**	**78**

E. coli Data for the Ohio River and its Tributaries in the Pittsburgh Pool

	Saw Mill	West End Bridge			Upstream of Brunot's Island			Chartiers	Downstream of Brunot's Island			Upstream of Neville Island		
	Run	Left	Mid	Right	Left	Mid	Right	Creek	Left	Mid	Right	Left	Mid	Right
7/10/00	2,420	488	32	21	166	49	119	2,419	517	51	117	33	47	37
8/22/00	2,420	143	45	76	68	105	48	192	93	93	80	66	147	157
10/16/00	1,414	299	488	225	166	242	88	173	206	172	88	649	201	162
Arithmetic mean	**2,085**	**310**	**188**	**107**	**133**	**132**	**85**	**928**	**272**	**105**	**95**	**249**	**132**	**119**

*only 3 sets of data were taken

***2419 is the maximum detection limit for this study

Appendix E:

Tributary Watershed Analysis

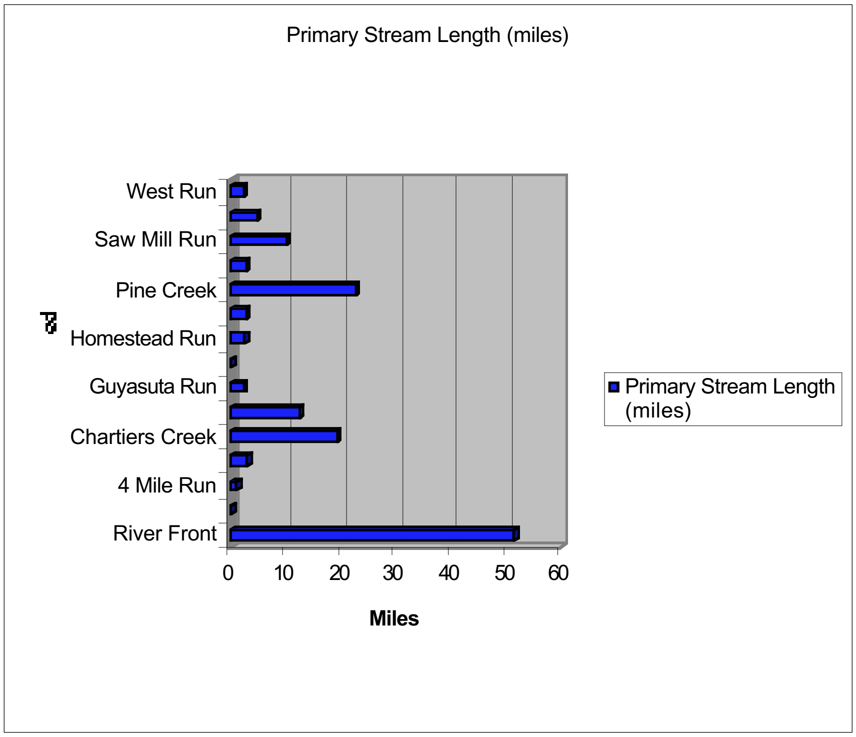
By Beth McCartney and Rene Serrano

The 3R-2N water quality program examined a range of water quality parameters for each stream that discharges into the Pittsburgh Pool. Dry weather water quality in the streams was worse than dry weather water quality in the main stem rivers. This realization led us to question the potential for human access and use of these streams in comparison to the main stem rivers. Water quality data sets were geo-referenced then placed within a Geographic Information Systems (GIS) program for spatial mapping.

We had two goals, to understand the potential access/use issues along the streams, and to understand the human uses which might provide a clue to the denigration of the streams. We measured then compared the length of each steam in miles, then compared the total stream miles in the Pittsburgh Pool to the total river miles, to get an idea of how accessible these polluted streams were. We also examined zoning and land use as well as the relationship between pervious and impervious landscapes. By mapping these elements we can begin to get a spatial understanding of the possible areas contributing pollutant stresses to each stream system.

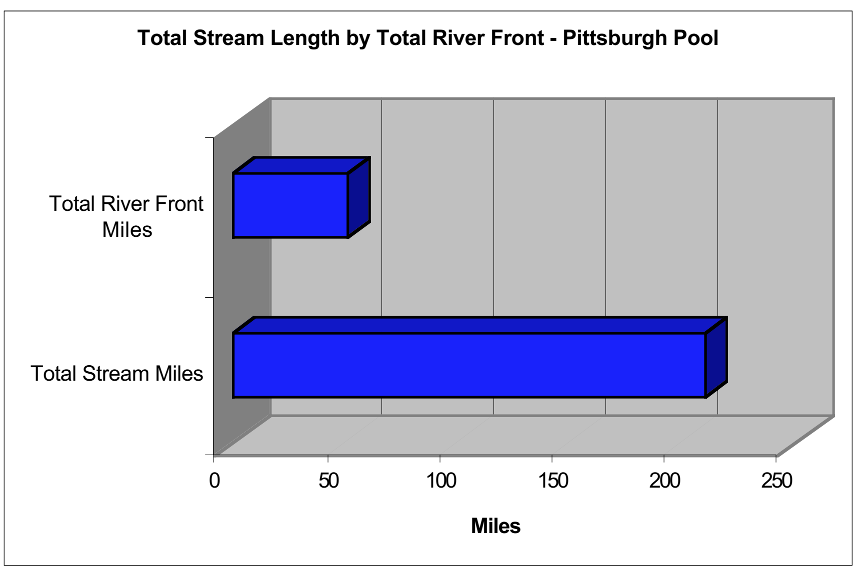
In Chart 1, below you can see a comparison between the streams themselves as well as how they compare to the combined river front of the Allegheny, Monongahela, and Ohio Rivers within the Pittsburgh Pool. Pine Creek is the longest and most complex stream in the system. Complexity would be indicated by the number of creeks, which feed into the stream. Chartiers Run, Girtys Run, Sawmill Run and Streets Run, is a descending list of streams of significant lengthy within the Pittsburgh Pool.

Chart 1.

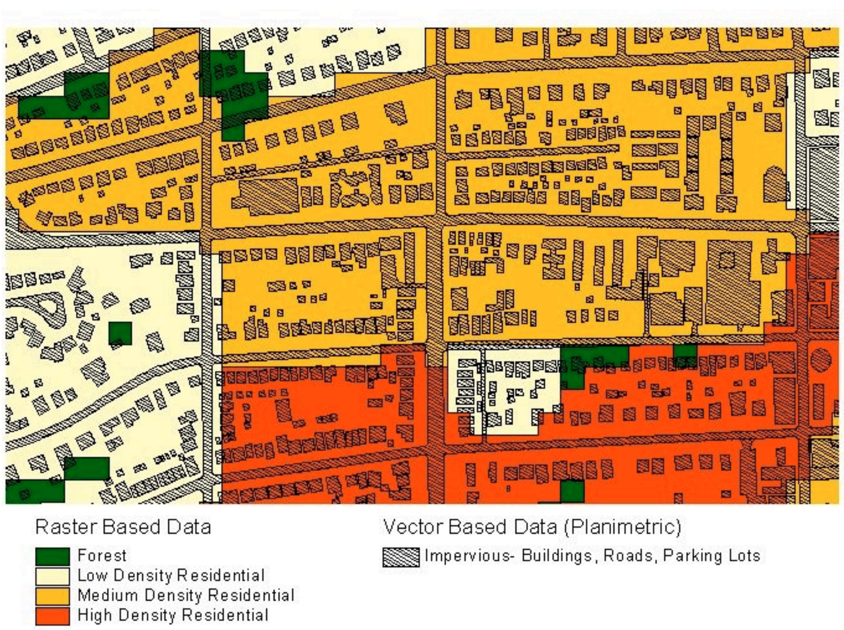


In Chart 2, below you can see a comparison between the total river miles and the total stream miles. The actual length of Pittsburgh Pool Streams, is 4 times that of the main stem rivers.

Chart 2.



In Graphic 3, below you will see an example of our method of analysis for land use and permeability. Two different approaches were used in this process. The percent impervious analysis was conducted using Allegheny County planimetric data, which was developed from aerial photography taken in 1992-93. Impervious surfaces such as buildings, roads and parking lots were extracted from this data and coded as such. The total of these impervious sufaces was then calculated as a percent of the total watershed. The other method, which was used in the “Relationship Between Natural and Built Environmnents” analysis, involved the use of a raster-based landuse GIS coverages, as opposed to the vector or line based planimetric data mentioned previously. Raster data is comprised of cells or pixels which are coded according to their principle use. In this analysis, the natural environment consisted of hydrologic features, forest, grassland/ open space, agriculture/pasture. The built environment included transportation, low medium and high residential, malls, commercial and industrial land, strip mines and areas coded as non vegetated.



Graphic 3

The final analytical process intends to provide a better understanding of the cultural assets of each watershed as well as to continue the landuse analysis by sub-watershed. Totals were compiled for each watershed and are contained in each map.

This analysis provide a foundation for further environmental health and policy decisions as well as to serve to provide a better understanding of these natural systems.