STORM WATER MANAGEMENT PROGRAM

National Pollution Discharge Elimination System (NPDES) Permit
No. PA 0054712
Covering the Period from July 1st, 2005 to June 30th, 2006

Submitted to:

PENNSYLVANIA DEPARTMENT OF ENVIRONMENTAL PROTECTION
Bureau of Water Quality Management

And

ENVIRONMENTAL PROTECTION AGENCY – REGION III
Water Protection Division

CITY OF PHILADELPHIA

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EXECUTIVE SUMMARY

Managing and mitigating the impacts of stormwater in older and dense urban environments represents a significant challenge nationwide. In Philadelphia, our challenges are no less significant, but we believe that we can implement strategies which overcome these challenges while protecting and restoring our natural resources. PWD has worked with PADEP, EPA, and other stakeholders to manage storm water as a resource using groundbreaking initiatives to solve this long-term challenge.

This past year represented a watershed moment in our program development. This year, ten years since the initiation of our defective lateral program, we created new requirements for storm water BMPs in new development throughout the City of Philadelphia; changing development standards for stormwater management and E&S controls. Though we have made significant strides to improve the management of storm water in Philadelphia, our job is not done. We are now embarking on watershed plans that will guide our future efforts to protect and restore our streams and rivers while still providing necessary storm water conveyance and help address flooding concerns citywide.

This report provides a summary of the various efforts to manage storm water in Philadelphia as related to permit obligations. However, we've attempted to provide additional information to demonstrate our commitment to go beyond regulation and achieve meaningful outcomes and to emphasize the myriad of efforts throughout the city that are linked to storm water management. Here are some of the highlights of our progress:

BMP Implementation

PWD is implementing many innovative restoration projects throughout its watersheds. This year PWD conducted its first Natural Channel Stream Design and Restoration on the Wises Mill tributary of the Wissahickon Creek (1 of the top 3 tributaries designated for restoration in the prioritization). The Saylor Grove Wetland, the first stormwater treatment wetland in the city, was constructed and has been operational since May 2006. A project to address runoff from the Monastery Stables into the Wissahickon Creek has been completed. In October 2006, PWD will be distributing approximately 200 rainbarrels to citizens in the Wissahickon Creek working with community organizations and schools as part of a long term annual rain barrel distribution program. Also, projects are scheduled to start for the natural channel stream design and restoration of the Red Rambler Run tributary of the Pennypack Creek. Another project is scheduled to be initiated at the Saul Agricultural High School to develop stream bank fencing and riparian buffers to address runoff.

Cleaning & Greening

During this year PWD initiated the following activities to keep pollution out of our waterways with the following impacts:

- Inlet Cleaning – 77,603 inlets cleaned removing over 20,000 tons of debris.
- Waterways Restoration Unit – Removal of 424 tons of debris at 124 sites in 2006 including 21 cars, 396 tires, and 124 shopping carts from local waterways.
- Skimming/Floatable Vessel – Delaware and tidal Schuylkill River: 17 tons of floatable debris removed during 2 month period in 2006.
- Skimming/Floatable Pontoon Boat - non-tidal Schuylkill River: Just obtained in June 2006 and undergoing field testing.
- With technical and financial assistance from PWD (through EPA STAG), the School District of Philadelphia constructed a new high school in West Philadelphia that includes a 9,800 SF vegetated roof. The remainder of roof runoff is collected in a 25,000 gallon cistern to be reused for toilet flushing. Other site BMP features include grass pavers and disconnected impervious surfaces.

Development Stormwater Management

In January 2006, PWD implemented new storm water management regulations for new and redevelopment in the City of Philadelphia and developed staffing capabilities to coordinate with PADEP and function in the capacity similar to a Conservation District. Now not only is development greater than 5,000 square feet of earth disturbance subject to storm water management for water quality, channel erosion, and flood control, but erosion and sediment control and construction inspections are performed by 2 new full time PWD E&S inspectors. From January to June 2006, 63 E&S plans were reviewed and 51 site visits were conducted to 33 construction sites including actions such as reporting to PADEP for violations or issuance of site shut-down order from Licenses and Inspection.

In addition, through the efforts to implement new storm water regulations, PWD has worked with other city agencies to revamp the city development process to require conceptual approval for storm water management prior to zoning to ensure developers are aware of their storm water management requirements prior to zoning permit issuance to prevent site redesigns. As a result of these efforts, PWD has reviewed plans for storm water management that will impact storm water management for future development covering over a square mile of the city and over 18 million gallons of stormwater annually that will be infiltrated instead of sent to the storm sewers. PWD's regulations also provided incentives for Low Impact Development Techniques which has encouraged an increased number of submissions proposing over 8 green roofs and several porous pavement parking lots. From January to June 2006, 364 conceptual plans for zoning approval have been reviewed for storm water management and 105 full technical plan reviews have been conducted.

Defective Laterals

Ten years ago PWD initiated its Defective Lateral Program. Since that time, we have abated hundreds of defective laterals and conducted thousands of inspections and tests. A comprehensive review of our efforts in the Monoshone Creek has shown dramatic reductions in outfall and in-stream bacteria measurements suggesting that efforts to date have made significant progress towards meeting in-stream water quality goals. The study also identifies that defective lateral abatements were the most cost-effective technique resulting in much lower cost per bacteria unit reduced compared to sewer relining and stormwater treatment wetlands.

The positive in-stream results and overall low annual bacteria load contribution compared to stormwater runoff suggests that these activities may be reaching of point of diminished returns in the Monoshone sewershed on a per-dollar-spent basis and a discussion between PADEP and PWD regarding standards for lowering the priority of these outfalls on the priority list should be considered. In addition, PWD is conducting studies of cutting edge technologies such as antimicrobial filters inside storm water outfalls as an interim method of reducing high dry weather bacteria concentrations to receiving streams while the defective lateral testing and abatement programs continue to achieve long term solutions.

Education

PWD has been conducting education about water for over 21 years. Some of the highlights this year include the following:

- Homeowner Stormwater Management Manual
- *Watershed Information Center Website* – www.phillyriverinfo.org – an on-line internet based compendium and clearinghouse of watershed information including studies, data, and resources for public access.
- *Fairmount Fish Ladder Web Viewer* – www.phillyriverinfo.org – this website allows the public to view real time and on-line the passage of fish and other creatures through the Fairmount Fish Ladder. In the past two years, we have observed species that have not been seen in the area for over a century including river otters, red bellied turtles, and other endangered species.
- *Philly Rivercast* – www.phillyrivercast.org – the first on-line internet based tool in the world that predicts bacteria water quality for recreation on the Schuylkill River for the 100,000 annual users in and along the river. It has received over 40,000 visits annually.
- *Fairmount WaterWorks Interpretive* Center – educates over 30,000 visitors annually

- More than 30 educational activities ranging including events, tours, handbooks, public meetings, certification and training programs, partnerships, etc.
- Twelve storm water related educational "billstuffers" mailed to over 460,000 households

Monitoring Programs

During the first year of the permit PWD has developed and implemented an extensive sediment monitoring program which was used to help develop our tributary restoration feasibility ranking for the Wissahickon Creek. The study suggested a large majority of sediment load in the city is a result of streambank erosion helping to focus restoration efforts towards appropriate solutions. Special monitoring included infrastructure assessments of the entire Wissahickon, Pennypack, and Poquessing watersheds listing outfalls and structures in the stream and tributaries. Infrared monitoring via helicopter flyovers was conducted to detect potential dry weather discharges of sewage inside and outside the city in these watersheds. Continued monitoring as part of our 5-year monitoring plan is aimed to refining future estimates. Projects have been initiated to employ cutting edge research with Drexel University and Lehigh University to use DNA fingerprinting of *Cryptosporidium* and *E. Coli* as well as multiple antibiotic resistance to identify sources of pathogens in the watershed.

Planning

A PCB Pollutant Minimization Plan has been completed for the MS4 areas. The Wissahickon Watershed Plan has been initiated and is scheduled to be completed in 2007. The Wissahickon Creek Characterization Plan is schedule for distribution in Fall, 2006. PWD is also participating in a 104-b3 grant to prioritize and design retrofits of detention basins for the Wissahickon Creek Watershed, but also develop a template to be used in other regional watersheds. The Pennypack Creek River Conservation Plan has also been completed and work has started on the Poquessing Creek River Conservation Plan.

Partnerships

We are sponsors and active members in over 7 active watershed partnerships including hundreds of stakeholders covering the city's watersheds and the entire Schuylkill and Delaware River. These partnerships have been able to reach out to public officials, change policies, educate stakeholders, develop plans, and secure funding and implement projects to restore and protect local streams. It is PWD's belief that sustainable protection and restoration of our watersheds for future generations cannot be achieved without partnerships that create a shared sense of stewardship of these resources through cooperation and communication.

INTRODUCTION

This Annual Report is submitted to the Pennsylvania Department of Environmental Protection (PADEP or the Department), in accordance with requirements of the City of Philadelphia's NPDES Storm Water Management Permit No. PA 0054712. This Report is a compilation of the progress made on the Storm Water Management Program, during the reporting period from July 1st, 2005 to June 30th, 2006.

A. LEGAL AUTHORITY

The City maintains adequate legal authority to enforce the Storm Water Management Program, in accordance with the National Pollutant Discharge Elimination System (NPDES) regulations 40 Code of Federal Regulations CFR122.26(D)(2)(i). Legal authority to operate and maintain the Storm Water Management Program includes various ordinances, regulations, and policies enforced by City departments, many of them in place prior to the EPA Storm Water Regulation. The ordinances and regulations may be found at www.phila.gov.

B. SEDIMENT TOTAL MAXIMUM DAILY LOAD (TMDL) FOR WISSAHICKON CREEK – FEASIBILITY STUDY & MONITORING PLAN

The City has achieved the first goal of the sediment TMDL effort which requires the City "to establish baseline data on the City's contribution of sediment loading and flow variations". The City conducted a feasibility study to determine MS4 outfalls and tributaries to the Wissahickon Creek (within its boundaries) that cause an adverse impact to in-stream habitats as a result of transport of sediment and/or stream-bank erosion. The study, conducted between October 2005 and September 2006, included an evaluation of the outfalls and tributaries that have the greatest potential for improvement through implementation of BMPs and/or other methods. The study lists all MS4 outfalls and tributaries to the Wissahickon Creek that have been evaluated and/or chosen for further study, rational for selection, and modeling results and is provided in Appendix A. The following section provides a summary of the findings of the study.

As a result of the study, the City has designed and implemented a monitoring plan that is provided in this report in Appendix A. The plan includes modeling results and monitoring for Total Suspended Solids (TSS) and flow at selected MS4 outfalls and at the confluence of selected tributaries to the Wissahickon Creek during various flow events (low flow, normal flow, and storm flow).

The following provides a brief summary of the major elements, actions, and findings of the sediment and stream restoration feasibility study. The entire feasibility study document and supporting data is located in Appendix A.

1. SUMMARY OF SEDIMENT & STREAM RESTORATION FEASIBILITY STUDY

1. STUDY OBJECTIVES

- To identify stream reaches with the most degradation and the most potential for restoration
- To estimate sediment loads from erosion, suspended sediments, bed load from tributaries and outfalls
- Establish flow rating curves for tributaries
- To provide a sediment budget
- Provide an objective means of ranking the stream reaches for restoration

2. STUDY APPROACH

The TMDL is based on models used to estimate Total Suspended Solids (TSS) from stream bank erosion and storm water runoff. PWD developed an approach based on field data and modeling, with conclusions tested using each of the following approaches:

- SWMM modeling to estimate runoff loads and flows from outfalls and tributaries.
- Stream assessment techniques (BEHI scores) and Rosgen derived stream bank erosion rates to estimate in-stream TSS load. (can be applied to entire watershed)
- Bank pin measurements to verify or improve BEHI score approach. (reality check on BEHI based estimates)
- Measured TSS and flow to estimate total annual load and compare to SWMM and BEHI score TSS load estimates. (reality check on sum of SWMM and BEHI estimates)
- Estimate of total volume of soil eroded from pre-development conditions to current stream profile. This was used to estimate time to reach current stream profile using estimated erosion rates from BEHI (an independent reality check on the estimated erosion rate using an entirely different approach).

Methods used to develop storm water outfall flows and loads are described in detail in the Wissahickon Comprehensive Characterization Report. Drainage area and estimated mean annual runoff volume for each outfall, estimated mean annual pollutant loads for each outfall and a summary of the total number of outfalls per tributary are reported in tabular form. Each of these tables is included in Appendix A**.**

There are two elements to the monitoring program. The first estimates the sediment load originating from stream banks. The second estimates the total sediment load being carried by the stream. Data collection is ongoing for both parts.

PWD employed the Bank Erosion Hazard Index (BEHI) and Near Bank Stress (NBS) as defined by Rosgen (1996) to predict erosion rates and classify the erosion potential of the tributaries. Three hundred and sixty eight reaches in 13 tributaries have been assessed using BEHI and NBS criteria. Reaches were assessed based on visual inspection of obvious signs of erosion. BEHI and NBS scores were grouped as very low, low, moderate, high or very high. Table 4 summarizes the portion of each tributary that was assessed using the BEHI/NBS method.

Table 1 - Portion of Each Tributary Assessed Using BEHI/NBS Method

Site	BEHI/NBS Assessed (ft)	Channelized (ft)	Visually Assessed - Low Erosion (ft)
Monoshone	147	3,074	9,537
Kitchens Ln	1,250	0.00	12,946
Cresheim	1,835	1,062	29,143
Valley Green Run	270	277	3,859
Hartwell	340	0.00	6,358
Rex Ave	270	0.00	2,982
Thomas Mill	625	0.00	6,895
Hill Crest	75.0	2,128	6,929
Paper Mill	2,640	8,576	48,298
Gorgas Ln	350	325	3,261
Wises Mill	1,042	1,057	11,301
Cathedral	1,135	0.00	4,227
Bells Mill	1,759	0.00	7,781

Bank pins were installed in Bells Mill, Cathedral Run, Wises Mill and Monoshone tributaries in October and November 2005. Nine bank pin sites were chosen in each of the tributaries listed with the exception of Monoshone. Only four bank pin sites were chosen in Monoshone because much of the tributary is channelized. Bank pins were installed in reaches with varying BEHI and NBS scores in order to validate and calibrate the prediction model. Three of the nine sites were in reaches visually assessed to have low erosion rates. Additional bank pin sites in these tributaries and others are planned for the future. The current bank pin installation locations and planned bank pin installation locations can be seen on the map in Figure 1.

Bar samples, sub-pavement samples and pebble counts were collected at 9 sites in 5 tributaries to Wissahickon Creek in order to gather information on channel stability. Bar and sub-pavement samples as well as pebble counts were collected following methods described on EPA’s Watershed Assessment of River Stability and Sediment Supply (WARSSS) website. Additionally, Riffle Stability Index (RSI) Assessments and pebble counts were completed at 14 sites in the same 5 tributaries.

Automated water collection devices (ISCO model no. 6712) were used to collect water samples during wet weather events in the Wissahickon Creek tributaries. In the attempt to characterize an entire storm event, automated samplers were triggered by a 0.2 ft elevation change in stream height and collected samples every 20 minutes for the first hour. Following this step, samples were then collected every 2-4 hours until discharge returned to base flow conditions. Suspended sediment loads were related to the discharge at which they were collected to create a suspended sediment rating curve. Four tributaries were selected based on visual inspection of obvious signs of erosion to estimate sediment loads and calibrate methods used in other tributaries. The location of installed samplers can be seen in Figure 2.

Stage data from Bells Mill, Cathedral Run, Wises Mill and Monoshone were recorded near the Wissahickon confluence downstream of all storm water outfalls. Stage was measured every six minutes by either an ultrasonic down-looking water level sensor or a pressure transducer and recorded on a Sigma620.

Discharge rating curves were established in Monoshone, Wises Mill and Bells Mill following a modified version of the USGS protocol (Buchanan and Somers 1969). Discharge was measured in a cross section close to the staff gage using a SonTek Flowtraker Handheld ADV and plotted against the stage it was recorded at. Due to lack of a suitable monitoring location, the discharge rating curve in Cathedral Run will be mathematically modeled instead of measured in the field.

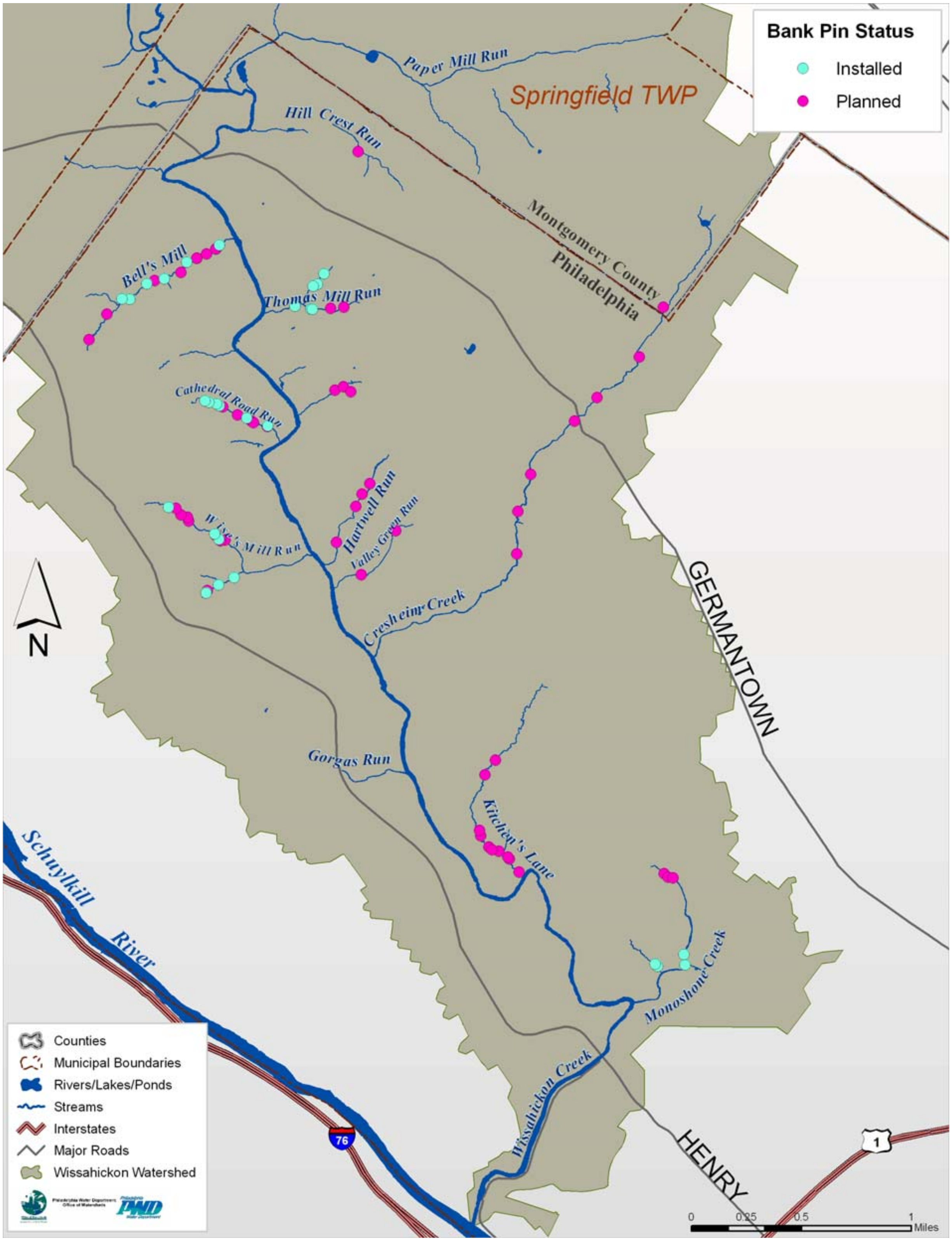


Figure 1 - Current and Planned Bank Pin Locations

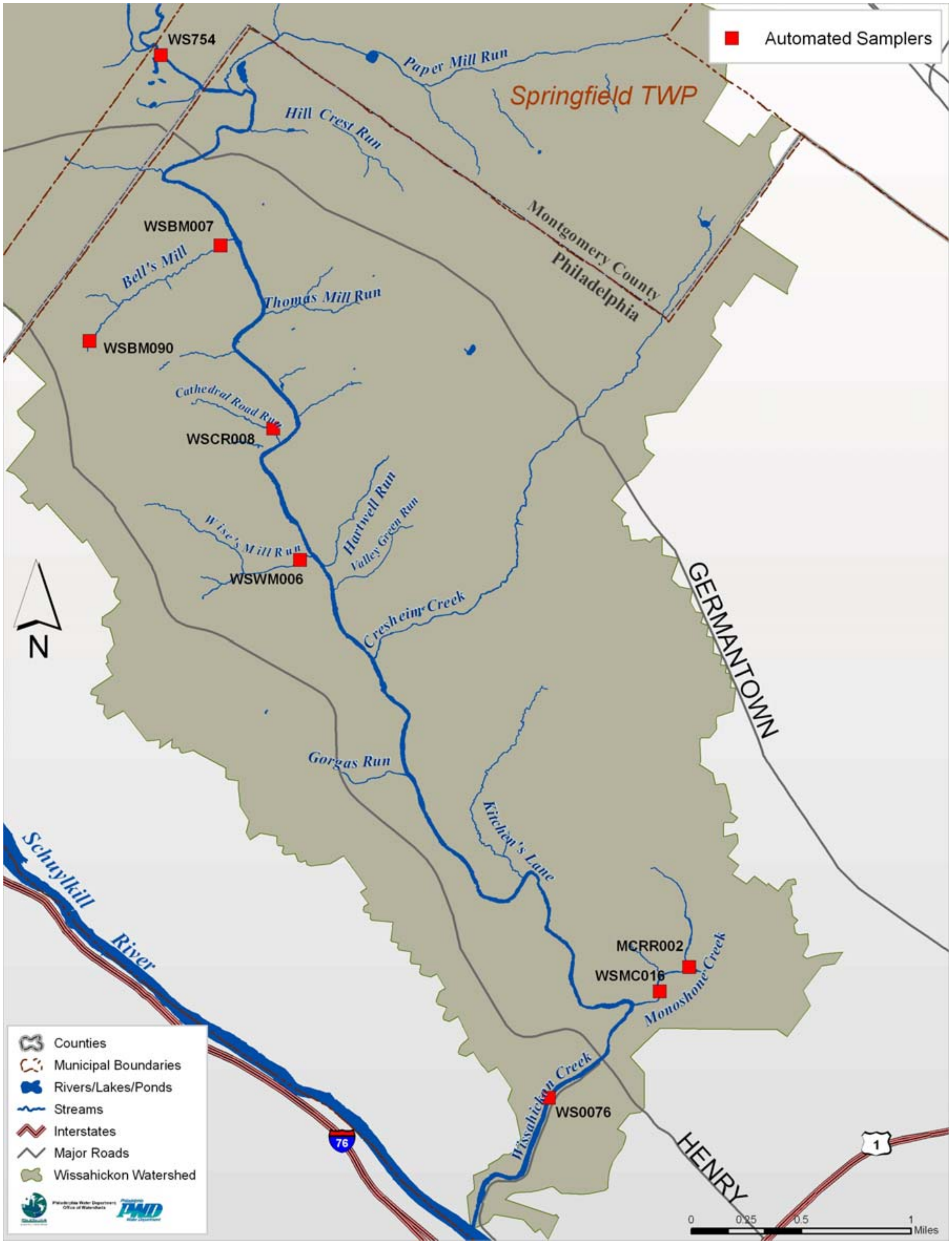


Figure 2 - Automatic Sampler Locations

2. TRIBUTARY RESTORATION POTENTIAL RANKING

Any stream channel and corridor restoration plan for the Wissahickon requires a ranking of tributaries. EVAMIX has been chosen to rank the restoration potential of tributaries and stream reaches. EVAMIX is a matrix-based, multi-criteria evaluation program that makes use of both quantitative and qualitative criteria within the same evaluation; regardless of the units of measure. The algorithm behind EVAMIX is unique in that it maintains the essential characteristics of quantitative and qualitative criteria, yet is designed to eventually combine the results into a single appraisal score. This critical feature gives the program much greater flexibility than most other matrix-based evaluation programs, and allows the evaluation team to make use of all data available to them in its original form.

Criteria chosen to evaluate restoration potential are summarized in Table 2 and discussed in more detail below.

Table 2 - Ranking Criteria

		Need for Restoration				Potential for Restoration	
Criterion	Unit	Sediment Reduction	Habitat	Riparian	Infrastructure	Channel	Riparian
Estimated stream bank erosion load	lb/ft/yr	XX	X	N/A	N/A	N/A	N/A
Habitat index	% ref. cond.	N/A	XX	N/A	N/A	N/A	N/A
Benthic macroinvertebrate index	# species	N/A	XX	N/A	N/A	N/A	N/A
Construction difficulty and disturbance	TBD	N/A	N/A	X	N/A	XX	XX
Fairmount Park projects	number	N/A	N/A	N/A	N/A	XX	XX
Identified sanitary sewer problems	number	N/A	N/A	N/A	XX	N/A	N/A

XX - need or potential for restoration is highly related to the criterion
X - need or potential for restoration is somewhat related to the criterion

RESTORATION PRIORITY RESULTS

Ranking analyses were performed with several sets of criteria weights. One set of weights for the restoration project is shown in Table 3. The results obtained with that weight set are presented in Table 4. Also shown in Table 4 is the sum of all the reach lengths for each category identified as low, medium, and high priority within each tributary. The tributary restoration ranking is graphically represented in Figure 3, and reach restoration ranking is graphically represented in **Figure 4**.

Table 3 – Criteria Weights

Criteria	Weight 0<wt<1
estimated stream bank erosion load	0.300
habitat index	0.100
benthic macroinvertebrate index	0.100
Fairmount Park projects	0.100
identified sanitary sewer problems	0.100
construction difficulty/disturbance index	0.300

Table 4 – Tributary Ranking Results

			Total Reach Length (ft)		
Options	**Ranking**	**Mean Rank**	**low**	**medium**	**high**
Cathedral Road Run	High	1.0	0	0	2771
Bell's Mill	High	3.0	1834	1078	1846
Wise's Mill	High	4.0	0	1507	4052
Cresheim Creek	Medium	5.0	9997	5383	0
Gorgas Run	Medium	5.5	0	0	1750
Hill Crest Run	Medium	5.5	2035	1781	0
Monoshone Creek	Medium	6.0	3236	0	1658
Kitchen's Lane	Medium	8.5	4720	0	2019
Paper Mill Run	Low	8.5	788	4653	0
Valley Green Run	Low	10.5	2868	0	0
Thomas Mill Run	Low	11.0	0	2689	0
Hartwell Run	Low	11.5	3423	0	0

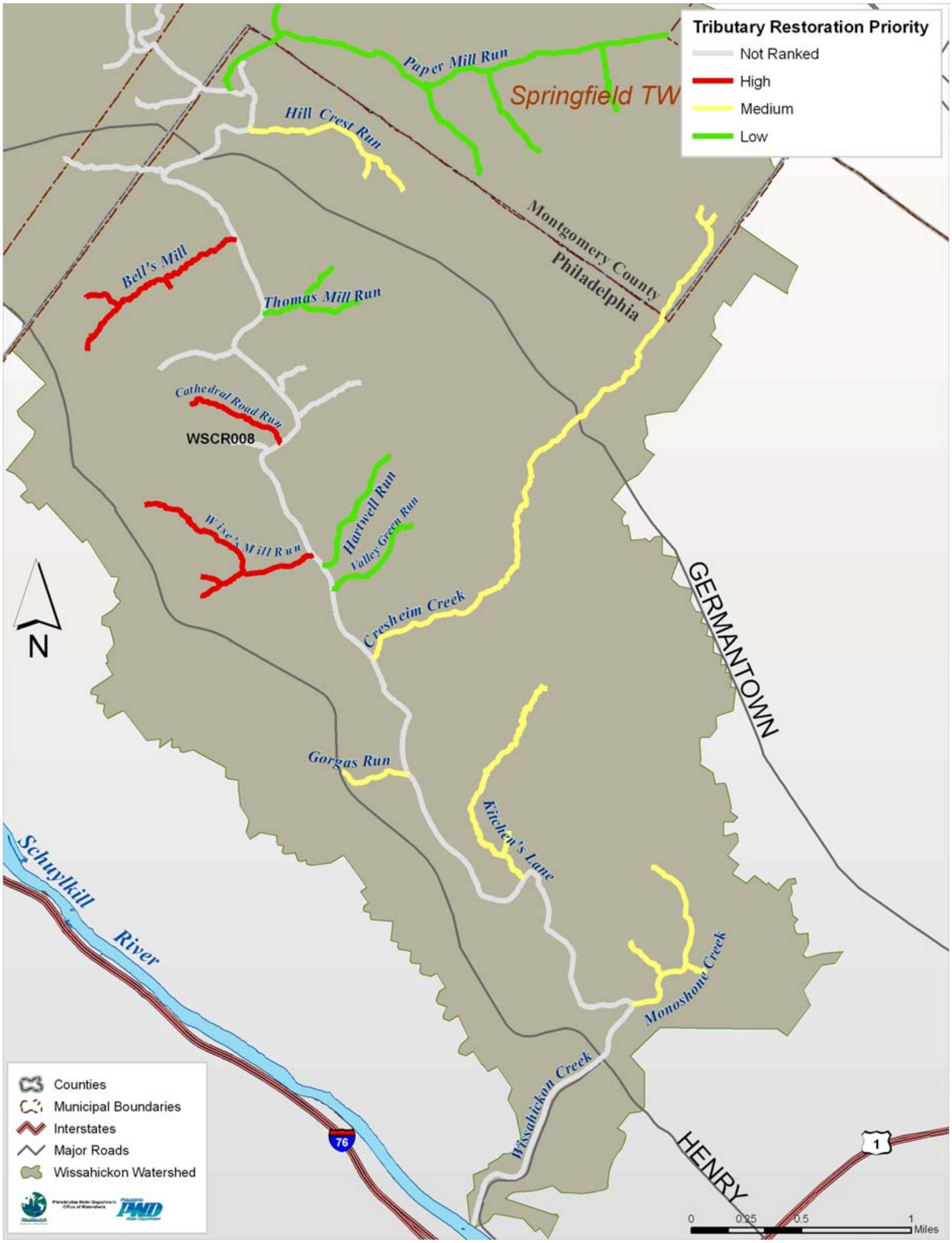


Figure 3 – Tributary Restoration Ranking

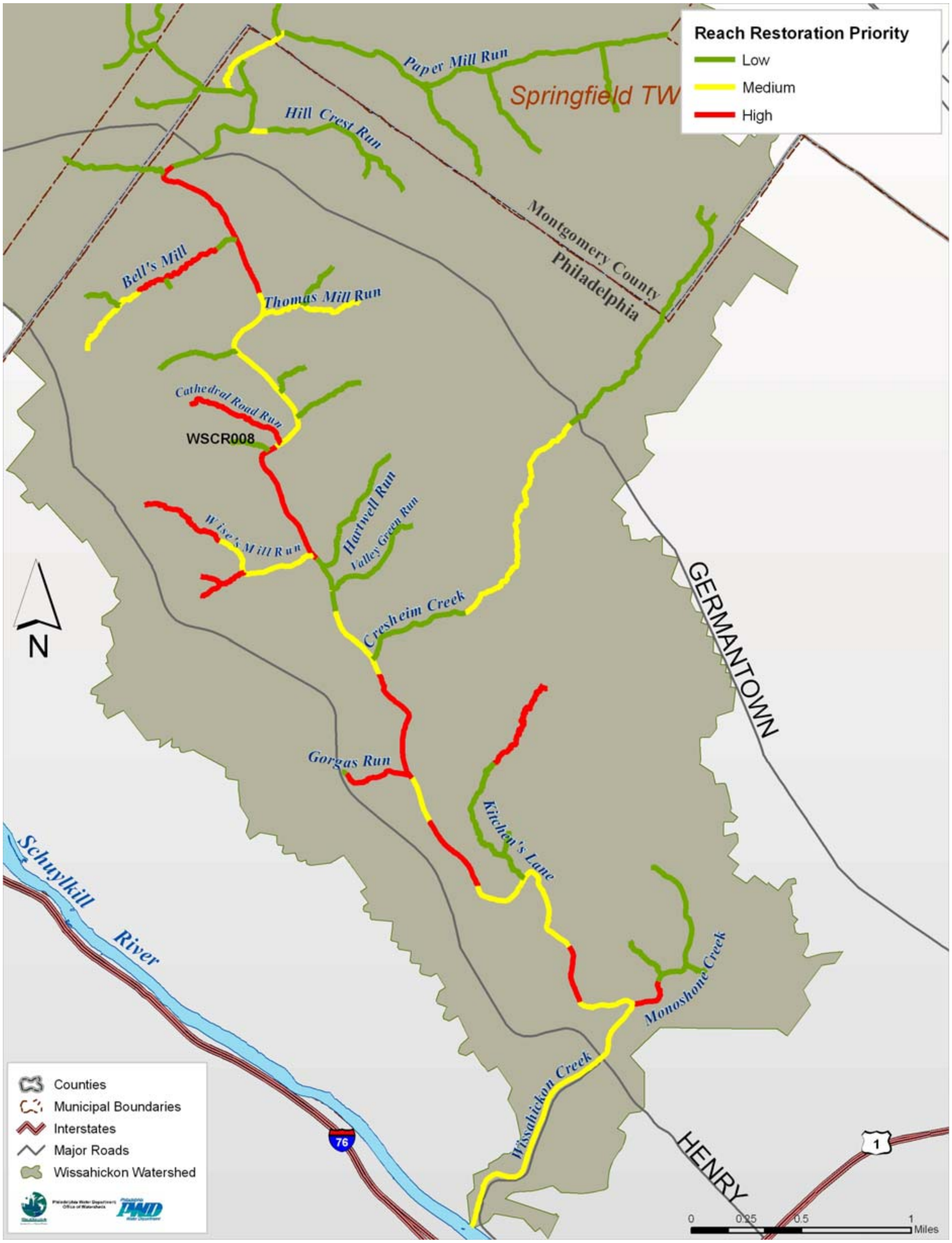


Figure 4 – Reach Restoration Ranking

SEDIMENT LOADING & EROSION RESULTS

- Several different ways of estimating erosion rates have led to the conclusion that the estimates from the study are reasonable and accurate.
- The estimate of total sediment load in Philadelphia tributaries (4.075 million lb/yr) was approximately 3 times the load reported in the USEPA TMDL (1.5 million lb/yr) for tributaries plus Wissahickon main stem.
- PWD’s SWMM model estimated overland flow load matches the TMDL model estimated load quite closely.
- PWD’s estimated erosion load for just the tributaries is 23 times higher than the rate estimated in the TMDL for the tributaries plus main stem.
- PWD’s estimated erosion rate is estimated using bank pin extrapolation and Rosgen based erosion rate estimates, and “reality checked” against the total mass eroded over the past century. All the numbers are consistent.
- PWD’s assessed rate of erosion would result in the downcutting of the streams from their natural state to today’s condition in 155 years, a very plausible length of time and independent confirmation of our estimated erosion rate. EPA’s erosion rate would take 3,500 years to create today’s stream profile.
- PWD’s results suggest that the load is comprised of approximately 77% stream bank erosion and 23% overland runoff load. The TMDL indicates that the load is approximately 10% stream bank erosion and 90% overland runoff.
- PWD’s estimate of stream bank erosion indicates that approximately 40% (1.2 million lb/yr) is generated by the high-erosion areas (17% of total tributary length), while 60% (1.9 million lb/yr) is generated by the low-erosion areas that were not assessed.
- While the load from stream bank erosion is larger and must be addressed, the load from overland flow is also significant. A mix of stream restoration and storm water management practices will most likely be needed to address the problem.
- Restoring the high-erosion stream reaches (17% of tributary length) identified by the field team would address approximately 40% of the stream bank load. If the combination of storm water management and restoration of these reaches is not sufficient to meet the reduction target, restoration of the lower-priority reaches may be necessary. It is expected that reducing sediment loads in these areas would be much less cost-effective.

Table 5 - Estimates of Existing Loads

System	TSS Stream bank Existing Load (lb/yr)	TSS Stream bank Existing Load (ton/sq. mi/yr)	Calculation Method
Philadelphia Tributaries Only	3,142,358	203	BEHI/NBS Analysis and Colorado Reference Stream
Philadelphia Tributaries and Main Stem	3,685,717	176	Flow-TSS Regression
Philadelphia Tributaries and Main Stem	1,413,863	67.4	EPA TMDL Existing Load

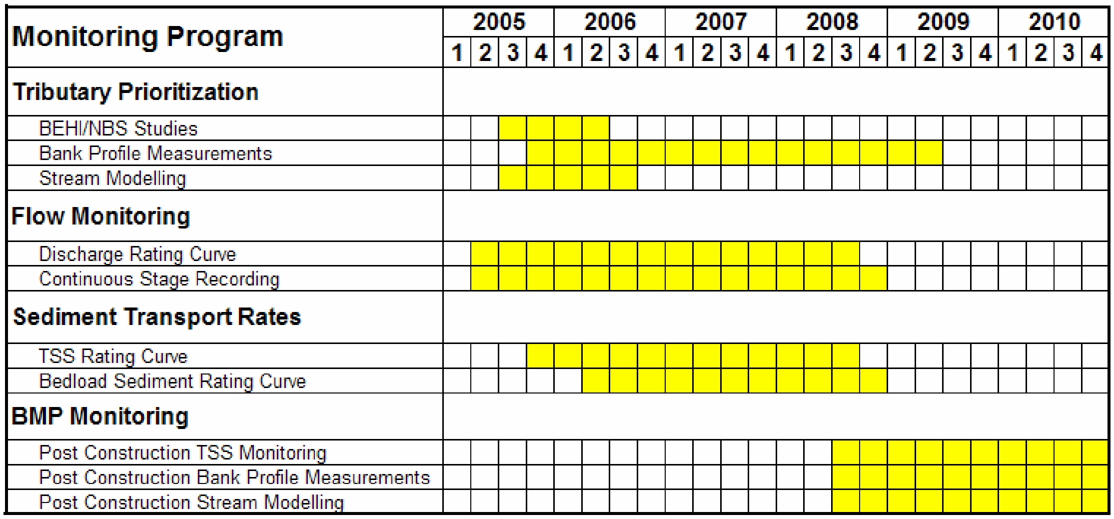
Table 6 - Estimates of Sediment Endpoints

System	TSS Stream bank Load Endpoint (lb/yr)	TSS Stream bank Load Endpoint (ton/sq. mi/yr)	Calculation Method
Philadelphia Tributaries Only	2,806,162	181	Estimated BEHI/NBS stream bank erosion load using low-low scores and average assessed bank heights
Philadelphia Tributaries and Main Stem	4,355,983	208	Estimated BEHI/NBS stream bank erosion load using low-low scores and average assessed bank heights
Philadelphia Tributaries Only	1,866,345	120	Estimated BEHI/NBS stream bank erosion load using low-low scores and FGM cross section data
Philadelphia Tributaries and Main Stem	3,549,865	169	Estimated BEHI/NBS stream bank erosion load using low-low scores and FGM cross section data
Philadelphia Tributaries and Main Stem	115,091	5.49	EPA TMDL Endpoint
French Creek	7,570,800	54.0	French Creek Estimated Sediment Load (USGS, 1985)
Neshaminy Creek	32,831,254	54.4	Neshaminy Creek TMDL Endpoint
East Branch Perkiomen Creek (reference stream for Skippack TMDL)	28,148,642	356	Skippack Creek TMDL Endpoint

3. Future Sampling

In efforts to comply with the Wissahickon Creek Sediment TMDL and the continuing goal of reducing sediment load from tributaries within City boundaries, PWD has developed a five-year strategy (Table 7).

Table 7 - Time Line Strategy for Monitoring Components of the Wissahickon TMDL.



i. Expanded Bank Pin Program

The program of installing bank pins to measure actual erosion rates is being greatly expanded. The objective of this program is to define a local relationship between measured stream bank erosion and qualitative stream bank erosion (using Rosgen's BEHI/NBS method).

PWD plans to establish approximately 100 new sites to better estimate the true standard deviations. If these are lower than current estimates, the number of sites needed for a statistically meaningful estimate will also decrease.

ii. Bank Erosion Hazard Index and Near Bank Stress

Total sediment yields are composed of sediment derived from overland runoff and from that originating in the creek. To determine the relative importance of these two components, PWD is conducting an expanded Bank Erosion Hazard Index (BEHI) and Near Bank Stress (NBS) study as defined by Rosgen (1996) to predict stream bank erosion rates.

Additional reaches of the thirteen tributaries within Philadelphia will be assessed by PWD staff and sections of stream bank will be scored based on the BEHI and NBS criteria. This study will be combined with the expanded bank pin program to develop a local relationship between these indices and measured erosion.

iii. Bank Erosion Hazard Index and Near Bank Stress

Additional discharge rating curves will be established and existing ones will be refined as necessary for the tributaries within Philadelphia County limits following a modified version of the USGS protocol (Buchanan and Somers 1969). Currently, discharge rating curves have been completed on three tributaries (Bells Mill, Monoshone, and Wises Mill). Discharge will be measured using a SonTek Flowtraker during low and medium flow events and a Gurley pygmy meter during high flow events.

iv. Continuous Stage Recording

Discharge characterization on the thirteen tributaries within Philadelphia County limits will be completed based on the aforementioned prioritization ranking. Stage data will be recorded at the designated monitoring site using a fixed Sigma ultrasonic sensor and/or pressure transducer. Stage data will be downloaded bimonthly and QA/QC will be performed by PWD staff.

v. TSS Rating Curve

Automated water collection devices (ISCO model no. 6712) will be used to collect water samples during additional wet weather events as needed in the Wissahickon Creek tributaries. In the attempt to characterize an entire storm event, automated samplers are triggered by a 0.2 ft elevation change in stream height and will continue to collect samples every 20 minutes for the first hour. Following this step, samples are then collected every 2-4 hours until discharge has returned to base flow conditions. Suspended sediment loads will be related to the discharge at which they were collected to create a suspended sediment rating curve. To date, two wet weather events have been captured on Monoshone Creek, Wises Mill and Cathedral Run, and three runoff producing events have been captured on Bells Mill. Wet weather monitoring will continue through 2006-2007 in attempt to characterize TSS in relation to discharge.

vi. Bedload Sediment Rating Curve

In order to estimate a total sediment load, bedload sediment samples will be collected in addition to suspended sediment samples. Bedload sediment samples will be collected at different stages according to a modified version of USGS protocol (Edwards and Glysson 1999). Samples will be collected using a Helley-Smith handheld sampler with a 15cm orifice. Samples will be dried, sieved and weighed in order to determine a rate of transport as well as a particle size distribution.

vii. Post-Construction Monitoring

The final objective of the TMDL monitoring program is to measure (i.e., quantify) the efficacy of Best Management Practices (BMPs) and their benefit in terms of sediment reduction in the Wissahickon drainage. In 2005, PWD conducted extensive wet-weather monitoring on three tributaries where various storm water BMPs have been proposed or are currently under construction.

C. Pollutant Minimization Plan (PMP) for Polychlorinated Biphenyls (PCBs) in the City's Municipal Separate Storm Sewer System (MS4)

The City has PCB Pollutant Minimization Plans in effect under each of the three Water Pollution Control Plants individual NPDES permits which set forth a more stringent plan than is requested within the City's Municipal Separate Storm Sewer System NPDES Permit. For additional information on the City's PCB PMP, see the City's NPDES permits for each of its three wastewater treatment plants:

NEWPCP - PA0026689
SEWPCP - PA0026662
SWWPCP - PA0026671

1. City PMP Contact Information

Keith Houck, Manager
(215) 685 - 4910
Industrial Waste Unit
Aramark Tower, 3rd Floor
1101 Market Street
Philadelphia, PA 19107

2. City of Philadelphia MS4 Service Area

Appendix B contains a table and maps for the MS4 service area referencing known locations where PCB material, equipment, processes, soil area, or facilities are or have been located.

3. PCB Locations

Within the City's MS4 service area, there are no known materials, equipment, processes, soil areas or facilities that are known to be released, directly or indirectly. To that effect, there are also no known PCB sources within its MS4 system that the City believes may require some degree of control to reduce its discharge. However the City has compiled a list of known locations where PCB material, equipment, processes, soil area, or facilities are or have been located. This list has been compiled from 2 lists discussed below:

Description of "Devices" List

This list is a compilation of information obtained from USEPA, PADEP, DRBC, Partnership for the Delaware Estuary, the Philadelphia Fire Department, the Philadelphia Department of Public Health and PECO, along with PWD's inventory of PCB-containing equipment. The sites listed are those within PWD's MS4 service area and at which PCB-containing devices may exist. In accordance with PWD's PCB Pollutant Minimization Plan (PCB PMP) which was submitted to DRBC on September 30, 2005, PWD's Industrial Waste Unit (IWU) will visit the listed sites over a five-year period to determine the status of each site's PCB-containing devices. IWU will characterize that status using a list of forty (40) descriptors to determine the site's potential as a possible source of PCBs. Appropriate corrective steps will be taken for any site found to be releasing or having the potential to release PCBs.

Description of "Health Dept." List

This list contains sites at which the Philadelphia Department of Public Health has some record of a past PCB release. In accordance with PWD's PCB PMP mentioned above, IWU will visit the listed sites over a two-year period to determine the status of each and will recommend additional risk reduction measures where appropriate.

4. IN-STREAM PCB SAMPLING

At this time, PWD is awaiting input from the Department and the DRBC with respect to the locations of the in-stream PCB sampling. The City wishes that this round of sampling supports the existing PCB TMDL for the Delaware Estuary. As the results of this data become available, the City looks forward to sharing this data with the Department. In addition, any actions taken in the furtherance of the PMP will also be reported accordingly.

5. DELAWARE RIVER BASIN COMMISSION (DRBC) COOPERATION

As the City moves forward in implementing its PCB PMP, it looks forward to continuing to enlist the cooperation of stakeholders throughout the Delaware Estuary in developing a template for other MS4 systems. PWD's PCB PMP was also submitted to the DRBC on September 30, 2005.

D. GIS DATA LAYERS

Table 8 - GIS Layers included on accompanying CD

GIS Data Layers	*Filename*
Pennypack Watershed	pennypack_watershed.shp
Poquessing Watershed	Poquessing_Watershed.shp
Wissahickon Watershed	Wissahickon_Watershed.shp
Philadelphia Hydrology {Polygons}	philly area hydro best poly.shp
Philadelphia Hydrology {Polylines}	philly area hydro best.shp
Wissahickon Watershed Hydrology {Polygons}	Wissahickon_Shed_Hydrology_Polygon_Final.shp
Wissahickon Watershed Hydrology {Polylines}	Wissahickon_Shed_Hydrology_Line_Final.shp
Industries w/ Wastewater Discharge Permit	Permitted Industries FY 2006.shp
Known Historical PCB Locations	PCB Locations.shp
PWD Monitoring Locations	All_PWD_Monitoring_Locations.shp
MS4 Outfalls	outfalls.shp
MS4 Outfall Sewersheds	modelsheds.shp
Philadelphia Land Uses	Mergepaside.shp
Philadelphia Population Densities	blk11stp_Intersec.shp
Stormwater Permit Application Locations	Storm waterPermitTracking.shp
E&S Inspection Locations	ens_inspections.shp
Philadelphia Detention Basins	philly_detentionbasins.shp
Points Sources in Wissahickon Watershed	AllPointSourcesinWiss2004.shp

PWD has included the GIS layers referenced above on the accompanying CD to this report in response to the requirements of the Permit. Maps referencing these layers have also been included in Appendix B, Appendix C and Appendix H.

E. DISCHARGE MANAGEMENT, CHARACTERIZATION, AND WATERSHED-BASED ASSESSMENT AND MANAGEMENT PROGRAM

1. STEP 1 – PRELIMINARY RECONNAISSANCE: PERMIT ISSUANCE THROUGH END OF YEAR 2

i. LAND USE AND RESOURCE MAPPING

The City has conducted extensive mapping of information relevant to storm water management planning. These GIS layers include MS4 outfalls and contributing drainage areas, land uses, populations density estimates, and monitoring locations (Table 8). Each of these figures and supporting GIS layers has been included on the accompanying CD. These figures have also been included in Appendix C – Land Use and Resource Mapping separated by watershed.

ii. Preliminary Physical, Chemical, and Biological Quality Assessment

1. Comprehensive Watershed Monitoring Program: *2005-2010 Strategy*

Under Section 2 of the City's storm water National Pollutant Discharge Elimination System (NPDES) permit, the City of Philadelphia recognizes the potential impacts of discharges from storm water, CSO and other discharges and conditions that affect drinking water and other designated uses of our waterways.

Comprehensive assessment of our waterways is integral to planning for the long-term health and sustainability of our water systems. The Philadelphia Water Department (PWD) considers such assessments as essential to raising awareness in Southeastern Pennsylvania as to the impact that land development activities are having on waterbody health. By measuring all factors that contribute to supporting fishable, swimmable, and drinkable water uses, appropriate management strategies can be developed for each watershed land area that Philadelphia shares.

Specifically, biological monitoring is a useful means of detecting impacts to the aquatic ecosystems necessary for sustainable fisheries and other designated uses. Biological communities respond to wide variety of chemical, physical and biological factors in the environment and can reveal natural and anthropogenic stressors. In this respect, resident biota in a water body act as natural monitors of environmental quality and can reveal the effects of episodic and cumulative pollution and habitat alteration.

Bioassessments, however, must be integrated with appropriate chemical and physical measures, land use characterizations, and pollutant source information necessary to establish linkages between stressors and environmental quality. These linkages can then be used to create decision-making frameworks for selecting restoration techniques that are appropriately balanced between in-stream restoration, land-based management practices, and new water and sewer infrastructure

From 1999 to 2005, the Office of Watersheds has implemented a comprehensive watershed assessment strategy, integrating biological, chemical and physical assessments to provide both quantitative and qualitative information regarding the aquatic integrity of the Philadelphia regional watersheds. This information is being used to plan improvements to the watersheds in the Southeast Region of Pennsylvania.

The Philadelphia Water Department has carried out extensive sampling and monitoring programs to characterize conditions in the seven watersheds both within the county boundaries and outside counties/municipalities. The program is designed to document the condition of aquatic resources and to provide information for the planning process needed to meet regulatory requirements imposed by EPA and PA DEP. The program includes hydrologic, water quality, biological, habitat, and fluvial geomorphological aspects. PWD is well suited to carry out the program because it merges the goals of the city's storm water, combined sewer overflow, and sourcewater protection programs into a single unit dedicated to watershed-wide characterization and planning.

Under the provisions of the Clean Water Act, the National Pollutant Discharge Elimination System (NPDES) requires permits for point sources that discharge to waters of the United States. In the six watersheds entering Philadelphia, storm water outfalls and wet weather sewer overflow points discharging to surface waters are classified as point sources and are regulated by NPDES.

Regulation of storm water outfalls under the NPDES program requires operators of medium and large municipal storm water systems or MS4s to obtain a permit for discharges and to develop a storm water management plan to minimize pollution loads in runoff over the long term. Partially in administration of this program, PADEP assigns designated uses to water bodies in the state and performs ongoing assessments of the condition of the water bodies to determine whether the uses are met and to document any improvement or degradation. These assessments are performed primarily with biological indicators based on the EPA's Rapid Bioassessment Protocols (RBPs) and physical habitat assessments.

PWD's Office of Watersheds is responsible for characterization and analysis of existing conditions in local watersheds to provide a basis for long-term watershed planning and management. The extensive sampling and monitoring program described in this section is designed to provide the data needed for the long-term planning process. PWD will include new data and analysis in each year's annual report with respect to physical, chemical, and biological water quality as it becomes available. A complete discussion of PWD's Comprehensive Watershed Monitoring Program is included in this report as Appendix D.

iii. INVENTORY OF POINT AND NON-POINT SOURCES

There is only one NPDES permitted discharge located in the MS4 area within the City of Philadelphia. The location of the discharge is within the Wissahickon Creek Watershed and the owner of the discharger is David Fishbone. The permit number is PA0054577, but the type and flow is not known.

Table 9 is a list of the remaining NPDES permitted dischargers in Philadelphia all located in the direct drainage areas of the Schuylkill and Delaware Rivers or in combined sewer areas. The list was downloaded from the EPA envirofacts website (http://oaspub.epa.gov/enviro/ef_home2.water).

Table 9 - Inventory of Point Sources in Philadelphia

NPDES No.	Facility Name	Industry Classification	Permit Expired as of 9/22/2006*	Flow (MGD)*	Receiving Waterbody*
PA0011533	121 POINT BREEZE TERMINAL	PETROLEUM REFINING	NO	6.4	Schuylkill
PAR600091	A & H AUTO PARTS	MOTOR VEHICLE PARTS, USED	NO	NA	Schuylkill
PAR800029	ABF FREIGHT SYSTEM INC	TRUCKING, EXCEPT LOCAL	YES	NA	Delaware
PAR200041	ABINGTON METALS REFIN & MFG IN	PRIMARY SMELTING AND REFINING OF NONFERROUS METALS, EXCEPT COPPER AND ALUMINUM	NO	NA	Delaware
PAR800118	ACAD RECYCLING TORRESDALE FAC	REFUSE SYSTEMS	NO	NA	Delaware
PAR600034	ACER ENGINEERS INC	MOTOR VEHICLE PARTS, USED	YES	NA	Delaware
PA0056090	AIRCRAFT SVC INTL GROUP TINICUM TWP FAC	PETROLEUM BULK STATIONS AND TERMINALS	YES	NA	Delaware
PAR600026	ALLEGHENY IRON & METAL TACONY FAC	SCRAP AND WASTE MATERIALS	NO	NA	Frankford
PAR200002	ALLIED TUBE & CONDUIT NORCOM RD PLT	STEEL PIPE AND TUBES	NO	NA	Walton Run
PA0011428	AMERADA HESS BULK TERM IW	PETROLEUM BULK STATIONS AND TERMINALS	NO	NA	Schuylkill
PAR600054	AMERICAN AUTO PARTS & SALV CO	MOTOR VEHICLE PARTS, USED	YES	NA	Schuylkill
PA0054241	AMOCO OIL COMPANY	PETROLEUM BULK STATIONS AND TERMINALS	NO	NA	Schuylkill
PAR230044	ASHLAND CHEM	PLASTICS MATERIALS, SYNTHETIC RESINS, AND NONVULCANIZABLE ELASTOMERS	YES	NA	Delaware
PAR600080	ATLANTIC USED AUTO PARTS	MOTOR VEHICLE PARTS, USED	NO	NA	Schuylkill
PAR600056	B & L AUTO PARTS 61ST STREET FAC	MOTOR VEHICLE PARTS, USED	YES	NA	Schuylkill
PAR800041	BFI TRANSF SYS OF PA CHRISTOPHER COLUMBUS BLVD FAC	LOCAL TRUCKING WITHOUT STORAGE	NO	NA	Delaware
PAR800064	BFI WASTE SVC OF PA	LOCAL TRUCKING WITHOUT STORAGE	NO	NA	Frankford
PAU123244	BILL'S AUTOGLASS	MOTOR VEHICLE PARTS, USED	NA	NA	NA
PA0012572	BLUEGRASS FOLDING CARBON CO LLC	PAPERBOARD MILLS	NO	4.1	Schuylkill
PAR600073	BRUCE PAUL AUTO PARTS	MOTOR VEHICLE PARTS, USED	NO	NA	Delaware
PAR200036	BUDD COMP	AUTOMOTIVE	YES	NA	Schuylkill

		STAMPINGS			
PAR600081	BUTCHS AUTO PARTS	MOTOR VEHICLE PARTS, USED	NO	NA	Schuylkill
PAR800055	CF MOTOR FREIGHT PHL	TRUCKING, EXCEPT LOCAL	YES	NA	Delaware
PAR600028	CIMCO TERMINAL INC	SCRAP AND WASTE MATERIALS	YES	NA	Delaware
PAR900017	CLEAN EARTH OF PHILA FAC	REFUSE SYSTEMS	NO	NA	Schuylkill
PAR800019	CROWLEY AMERICAN TRANS	LOCAL TRUCKING WITHOUT STORAGE	YES	NA	Delaware
PAR110036	CROWN CORK & SEAL COMPANY INCORPORATED	SPECIAL INDUSTRY MACHINERY, NOT ELSEWHERE CLASSIFIED	YES	NA	Pennypack
PAR800088	CSX INTERMODAL	RAILROADS, LINE-HAUL OPERATING	YES	NA	Delaware
PAR800027	CSX TRANSPORTATION	RAILROADS, LINE-HAUL OPERATING	NO	NA	Schuylkill
PAR800060	DEGUSSA CORP	SPECIAL WAREHOUSING AND STORAGE, NOT ELSEWHERE CLASSIFIED	NO	NA	Delaware
PAR120008	DEGUSSA FLAVORS & FRUIT SYS	CANNED FRUITS, VEGETABLES, PRESERVES, JAMS, AND JELLIES	YES	NA	Byberry
PAR900005	DELAWARE VALLEY RECYCLING INC	REFUSE SYSTEMS	YES	NA	Schuylkill
PAR800138	DHL EXPRESS USA INC	COURIER SERVICES, EXCEPT BY AIR	NO	NA	Schuylkill
PAR230043	DICKLER CHEMICAL LABORATORIES INCORPORATED	SPECIALTY CLEANING, POLISHING, AND SANITATION PREPARATIONS	YES	NA	Delaware
PAR120002	DIETZ & WATSON INCORPORATED	SAUSAGES AND OTHER PREPARED MEAT PRODUCTS	YES	NA	Delaware
PAR600089	DRIVE LINE AUTO PARTS	MOTOR VEHICLE PARTS, USED	NO	NA	Schuylkill
PAR600066	DRIVE TRAIN EXCHANGE	MOTOR VEHICLE PARTS, USED	NO	NA	Schuylkill
PA0010855	DU PONT MARSHALL LAB	PAINTS, VARNISHES, LACQUERS, ENAMELS, AND ALLIED PRODUCTS	NO	0.06	Schuylkill
PAR600071	ESSINGTON AVE AUTO PARTS	MOTOR VEHICLE PARTS, USED	NO	NA	Schuylkill
PA0011622	EXELON DELAWARE STA	ELECTRIC SERVICES	NO	257.0	Delaware
PAG100018	EXELON GENERATION CO LLC	BROADWOVEN FABRIC MILLS, COTTON	NO	NA	Delaware
PA0011088	EXXON PHILADELPHIA TERMINAL	PETROLEUM BULK STATIONS AND TERMINALS	NO	NA	Schuylkill
PAR800113	FEDERAL EXPRESS CORP	AIR COURIER SERVICES	NO	NA	Schuylkill
PAR800131	FEDEX GROUND	COURIER SERVICES, EXCEPT BY AIR	NO	NA	NA
PAR140020	FIBREFLEX PACKING & MANUF CO	DIE-CUT PAPER AND PAPERBOARD AND CARDBOARD	YES	NA	Schuylkill

PAR600055	FIORES AUTO PARTS	MOTOR VEHICLE PARTS, USED	YES	NA	Schuylkill
PAR600074	FREDDIES AUTO PARTS	MOTOR VEHICLE PARTS, USED	NO	NA	Schuylkill
PAR200011	GROSS METALS	COATING, ENGRAVING, AND ALLIED SERVICES, NOT ELSEWHERE CLASSIFIED	YES	NA	NA
PAR600072	HAROLDS USED AUTO PARTS	MOTOR VEHICLE PARTS, USED	NO	NA	Schuylkill
PAR200007	HENSHELL CORPORATION	COATING, ENGRAVING, AND ALLIED SERVICES, NOT ELSEWHERE CLASSIFIED	YES	NA	Schuylkill
PAR110047	HOWARD MCCRAY REFRIG CO INC	AIR-CONDITIONING AND WARM AIR HEATING EQUIPMENT AND COMMERCIAL AND INDUSTRIAL REFRIGERATION EQUIPMENT	YES	NA	NA
PAR120011	HYGRADE FOOD PROD	SAUSAGES AND OTHER PREPARED MEAT PRODUCTS	YES	NA	Delaware
PAR230068	IMPERIAL METAL & CHEM	SPECIALTY CLEANING, POLISHING, AND SANITATION PREPARATIONS	YES	NA	Byberry
PAR130004	IMPERIAL METAL & CHEMICAL CO	PLATEMAKING AND RELATED SERVICES	YES	NA	Byberry
PAR140005	INTERNATIONAL PAPER	SANITARY FOOD CONTAINERS, EXCEPT FOLDING	YES	NA	Byberry
PAR600076	JACKS AUTO PARTS SALES	MOTOR VEHICLE PARTS, USED	NO	NA	Schuylkill
PA0058955	JDM MATERIALS CO	READY-MIXED CONCRETE	NO	NA	Schuylkill
PA0058947	JDM MATERIALS CO - GRANT AVE B	READY-MIXED CONCRETE	NO	NA	Pennypack
PAR600084	JIMS AUTO RECYCLING INC	MOTOR VEHICLE PARTS, USED	NO	NA	Schuylkill
PAR600090	JKL'S AUTO SALES & PARTS	MOTOR VEHICLE PARTS, USED	NO	NA	Schuylkill
PAU123248	JOHN'S USED AUTO PARTS	MOTOR VEHICLE PARTS, USED	0	NA	NA
PAR200016	JOWITT & RODGERS	ABRASIVE PRODUCTS	NO	NA	Pennypack
PAR600065	JT S USED AUTO PARTS S 61ST ST FAC	MOTOR VEHICLE PARTS, USED	NO	NA	Schuylkill
PAU123245	JT'S AUTOMOBILE PARTS	MOTOR VEHICLE PARTS, USED	NA	NA	NA
PAR600079	K & A AUTO SALVAGE	MOTOR VEHICLE PARTS, USED	NO	NA	Delaware
PAR600078	KNOCK OUT AUTO PARTS	MOTOR VEHICLE PARTS, USED	NO	NA	Delaware
PAR110048	KURZ HASTINGS INCORPORATED	MANUFACTURING INDUSTRIES, NOT ELSEWHERE CLASSIFIED	YES	NA	Walton Run
PA0057690	KVAERNER PHILA	SHIP BUILDING AND	YES	NA	Delaware/

	SHIPYARD	REPAIRING			Schuylkill
PA0058483	KVAERNER PHILADELPHIA SHIPYARD, INC.	ADMINISTRATION OF URBAN PLANNING AND COMMUNITY AND RURAL DEVELOPMENT	NO	29.0	Delaware
PAR110040	LAVELLE AIRCRAFT COMP	AIRCRAFT ENGINES AND ENGINE PARTS	YES	NA	Pennypack
PAR150006	LAWRENCE MCFADDEN	PAINTS, VARNISHES, LACQUERS, ENAMELS, AND ALLIED PRODUCTS	YES	NA	Delaware
PAR110007	MARTIN MARIETTA ASTRO SPACE	GUIDED MISSILE AND SPACE VEHICLE PARTS AND AUXILIARY EQUIPMENT, NOT ELSEWHERE CLASSIFIED	YES	NA	NA
PAR110015	MELCO AUTO PARTS	OIL AND GAS FIELD MACHINERY AND EQUIPMENT	YES	NA	Schuylkill
PA0057479	METRO MACHINE CORPORATION	SHIP BUILDING AND REPAIRING	NO	0.727	Delaware
PAR600057	MICHAEL MACHINO DBA	MOTOR VEHICLE PARTS, USED	NO	NA	Schuylkill
PAR600039	MORRIS IRON & STEEL CO INC	SCRAP AND WASTE MATERIALS	YES	NA	Delaware
PAR120025	NABISCO	COOKIES AND CRACKERS	NO	NA	NA
PA0050202	NATIONAL RAILROAD PASSENGER CO	RAILROADS, LINE-HAUL OPERATING	NO	NA	Schuylkill
PAR200010	NESBITT DIV OF MESTEK INC	FABRICATED METAL PRODUCTS, NOT ELSEWHERE CLASSIFIED	YES	NA	Pennypack
PA0026689	NORTHEAST WPCP	SEWERAGE SYSTEMS	YES	210.0	Delaware
PAR600030	ORTHODOX AUTO UNRUH AVE FAC	MOTOR VEHICLE PARTS, USED	NO	NA	Schuylkill
PAR600070	PASCO INC	SCRAP AND WASTE MATERIALS	NO	NA	Cobbs
PAR120003	PEPSI COLA BOTTLING GROUP	BOTTLED AND CANNED SOFT DRINKS AND CARBONATED WATERS	YES	NA	Walton Run
PAR140021	PERFECSEAL BUSTLETON AVE FAC	PACKAGING PAPER AND PLASTICS FILM, COATED AND LAMINATED	NO	NA	Pennypack
PAR900024	PGW PASSYUNK PLANT	MIXED, MANUFACTURED, OR LIQUEFIED PETROLEUM GAS PRODUCTION AND/OR DISTRIBUTION	NO	NA	Schuylkill
PA0046876	PHILA GAS WORKS PASSYUNK AVE PLT	MIXED, MANUFACTURED, OR LIQUEFIED PETROLEUM GAS PRODUCTION AND/OR	YES	NA	Schuylkill

		DISTRIBUTION			
PA0012882	PHILA GAS WORKS RICHMOND PLT	MIXED, MANUFACTURED, OR LIQUEFIED PETROLEUM GAS PRODUCTION AND/OR DISTRIBUTION	NO	12.8	Delaware
PAR800112	PHILA INTL AIRPORT	AIRPORTS, FLYING FIELDS, AND AIRPORT TERMINAL SERVICES	NO	NA	Walton Run
PA0026662	PHILA SOUTHEAST POTW	SEWERAGE SYSTEMS	YES	112.0	Delaware/ Schuylkill
PA0040991	PHILA TERM	PETROLEUM BULK STATIONS AND TERMINALS	NO	0.0	Frankford
PAR120018	PHILADELPHIA BAKING CO	BREAD AND OTHER BAKERY PRODUCTS, EXCEPT COOKIES AND CRACKERS	YES	NA	Pennypack
PA0054712	PHILADELPHIA CITY	SEWERAGE SYSTEMS	NO	NA	NA
PAR600042	PHILADELPHIA CITY POLICE DEPT	MOTOR VEHICLE PARTS, USED	YES	NA	Delaware
PAR900013	PHILADELPHIA CITY WATER DEPT	SEWERAGE SYSTEMS	NO	NA	Frankford/ Delaware
PA0036447	PHILADELPHIA NAVAL BUSINESS CENTER	COMMERCIAL PHYSICAL AND BIOLOGICAL RESEARCH	NO	36.0	Delaware
PAR900020	PHILADEPHIA WATER DEPT	SEWERAGE SYSTEMS	NO	NA	Delaware
PAR600075	POOR BOYS USED AUTO PARTS W ANNSBURY ST FAC	MOTOR VEHICLE PARTS, USED	NO	NA	Delaware
PAR230060	RICHARDS APEX	CHEMICALS AND CHEMICAL PREPARATIONS, NOT ELSEWHERE CLASSIFIED	YES	NA	Manayunk Canal
PA0011649	RICHMOND - EXELON	ELECTRIC SERVICES	NO	1.5	Delaware
PAR800085	ROADWAY EXPRESS INC	TERMINAL AND JOINT TERMINAL MAINTENANCE FACILITIES FOR MOTOR FREIGHT TRANSPORTATION	NO	NA	Frankford
PAR600083	ROBERT VOLIO	MOTOR VEHICLE PARTS, USED	NO	NA	Schuylkill
PA0012777	ROHM & HAAS CHEMICAL RICHMOND ST PLT	INDUSTRIAL ORGANIC CHEMICALS, NOT ELSEWHERE CLASSIFIED	NO	1.549	Delaware
PAR600024	S D RICHMAN SONS WHEATSHEAF LN FAC	SCRAP AND WASTE MATERIALS	NO	NA	Frankford
PAR600082	SAMMYS AUTO PARTS/61ST ST FAC	MOTOR VEHICLE PARTS, USED	NO	NA	Schuylkill
PA0011657	SCHUYLKILL GEN STA	ELECTRIC SERVICES	YES	360.4	Schuylkill
PAR800033	SEPTA	LOCAL AND SUBURBAN TRANSIT	YES	NA	Schuylkill

PAR800035	SEPTA	LOCAL AND SUBURBAN TRANSIT	NO	NA	Schuylkill
PAR140023	SMURFIT STONE CONTAINER ENTER	CORRUGATED AND SOLID FIBER BOXES	NO	NA	Delaware
PA0026671	SOUTHWEST WATER POLLUTION CONTROL PLANT	SEWERAGE SYSTEMS	YES	NA	NA
PAR600025	SPC PENROSE AVE FAC	HOMEFURNISHINGS	NO	NA	Schuylkill
PAR110042	SPD TECH	SWITCHGEAR AND SWITCHBOARD APPARATUS	YES	NA	Byberry
PAR600085	STEVEN NGO	MOTOR VEHICLE PARTS, USED	NO	NA	Schuylkill
PAR230088	SUN CHEM HUNTING PARK AVE PLT	PRINTING INK	NO	NA	Schuylkill
PAR802212	SUN COMPANY INC	PETROLEUM BULK STATIONS AND TERMINALS	YES	NA	NA
PAG100012	SUN PIPELINE CO	PETROLEUM REFINING	NO	NA	Delaware
PAR230045	SUNOCO INCORPORATED FRANKFORD PLANT	INDUSTRIAL ORGANIC CHEMICALS, NOT ELSEWHERE CLASSIFIED	NO	NA	Frankford
PA0024252	SUNOCO M & T LP DELMONT TERM	PETROLEUM BULK STATIONS AND TERMINALS	YES	NA	NA
PAR600086	T&E AUTO PARTS W PASSYUNK AVE FAC	MOTOR VEHICLE PARTS, USED	NO	NA	Schuylkill
PAR800052	TDSI PHILADELPHIA BIDS TERM	RAILROADS, LINE-HAUL OPERATING	YES	NA	Schuylkill
PAR200038	TJ COPE NORCOM RD FAC	FABRICATED PLATE WORK (BOILER SHOPS)	NO	NA	Walton Run
PAR230089	UNITED COLOR MANUF INC	INDUSTRIAL ORGANIC CHEMICALS, NOT ELSEWHERE CLASSIFIED	NO	NA	Delaware
PAR800062	US POSTAL SERV	UNITED STATES POSTAL SERVICE THIS INDUSTRY INCLUDES ALL ESTABLISHMENTS OF THE UNITED STATES POSTAL SERVICE.	NO	NA	Byberry
PAR600015	WASTE MGMT OF PA	SCRAP AND WASTE MATERIALS	NA	NA	Schuylkill
PAR800067	WASTE MGMT OF PA INC	WOMEN'S CLOTHING STORES	NA	NA	Delaware
PAR600088	WILLIAM DORTONE DBA BILLS AUTO	MOTOR VEHICLE PARTS, USED	NA	NA	Schuylkill

The City is also actively involved in developing annual and seasonal estimates of non-point source pollutants. As the results of this analysis become available, they will be included in subsequent annual reports.

iv. Preliminary Problem Assessment

1. Wissahickon Creek Watershed

As described in Section 2 (Step 1, part b), the Philadelphia Water Department will complete a comprehensive characterization report of the Wissahickon Creek Watershed in October 2006. This report will serve as the technical framework for the Wissahickon Creek Watershed Integrated Watershed Management Plan (WCWIWMP) to be completed in 2007. The technical report will also provide state and federal agencies and local officials with a succinct problem statement, outlining the biological, physical and chemical integrity of the system and the potential sources of impairment. The comprehensive characterization report will be disseminated to the public through the internet at the following address: www.phillyriverinfo.org.

2. Pennypack Creek Watershed

A comprehensive characterization report for the Pennypack Creek Watershed, including problem statements will be completed in 2008.

3. Poquessing Creek Watershed

A comprehensive characterization report for the Poquessing-Byberry Creek Watershed including problem statements will be completed in 2010.

2. Step 2 – Watershed Plan Development: Permit Issuance Through End of Year 4

i. Monitoring and Sampling

1. Introduction

To meet the regulatory requirements and long-term goals of its storm water, and drinking water source protection programs, as well as the Wissahickon Creek Total Maximum Daily Load (TMDL) for Siltation, the Philadelphia Water Department (PWD) has embraced a comprehensive watershed characterization, planning, and management program for the Wissahickon Creek Watershed. Watershed management fosters the coordinated implementation of programs to control sources of pollution, reduce polluted runoff, and promote managed growth in the city and surrounding areas, while protecting the region's drinking water supplies, fishing and other recreational activities, and preserving sensitive natural resources such as parks and streams. PWD has helped form watershed partnerships with surrounding urban and suburban communities to explore regional cooperation based on an understanding of the impact of land use and human activities on water quality.

Coordination of these different programs has been greatly facilitated by PWD's creation of the Office of Watersheds (OOW), which is composed of staff from the PWD's planning and research, CSO, collector systems, laboratory services, and other key functional groups. One of OOW's responsibilities is to characterize existing conditions in local watersheds to provide a basis for long-term watershed planning and management.

OOW is developing a series of watershed management programs for each of the City's watersheds. Cobbs Creek was the first watershed for which an integrated watershed management plan was completed; the Tookany/Tacony-Frankford Watershed Partnership was second to complete a plan. This Comprehensive Characterization Report for the Wissahickon Creek is third in this series of technical documents; this document forms the scientific basis for the Wissahickon Creek Integrated Watershed Management Plan (WCIWMP). The report characterizes the land use, geology, soils, topography, demographics, meteorology, hydrology, water quality, ecology, fluvial geomorphology, and pollutant loads found in the watershed. It presents and discusses data collected through the spring of 2006. This report is intended as a single compilation of background and technical documents that can be periodically updated as additional field work or data analyses are completed. Completion date of the Wissahickon Comprehensive Characterization Report is planned for October 2006.

2. WATER QUALITY SAMPLING AND MONITORING

In order to comply with the State-regulated storm water permit obligations, water quality sampling was conducted during 2005-2006. A range of water quality samples were collected at 8 mainstem sites and 8 tributary sites in the Wissahickon Creek Watershed. The sites are shown on Figure 5 and listed in Table 10. Three different types of sampling were performed as discussed below. Parameters were chosen based on state water quality criteria or because they are known or suspected to be important in urban watersheds. The parameters sampled during each type of sampling are listed in Table 11.

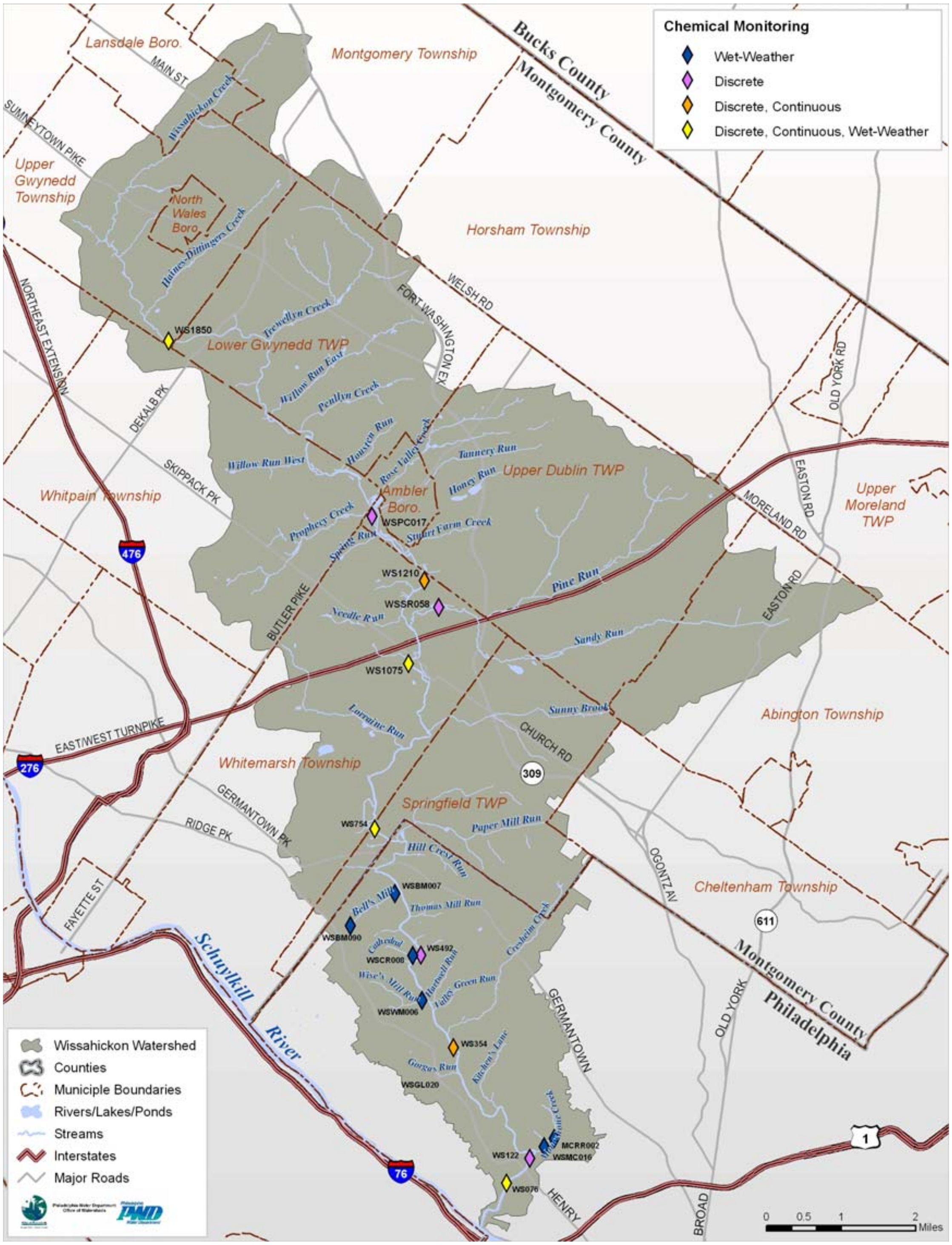


Figure 5 - Water quality monitoring stations in the Wissahickon Creek Watershed

SITE	ASSESSMENT		
	Discrete	Continuous	Wet Weather
WS005			
WS076	X	X	X
WS122	X		
WS209			
WS354	X	X	
WS492	X		
WS622			
WS754	X	X	X
WS899			
WS1075	X	X	X
WS1210	X	X	
WS1475			
WS1560			
WS1850	X	X	X
WS2245			
WS2305			
WSWM039			
WSWM006		X	X
WSVG009			
WSTM002			
WSTM020			
WSSR096			
WSSR058	X		
WSRA005			
MCRR002		X	X
WSPC017	X		
WSPM018			
WSMC025			
WSMC016		X	X
WSLR005			
WSHR009			
WSGL020			
WSCC070			
WSCC009			
WSCR008		X	X
WSCW003			
WSBM007		X	X
WSBM090		X	X

Table 10 - Summary of water quality sampling locations in the Wissahickon Creek Watershed

Parameter	Units	Discrete	WETW	Continuous
Physical Parameters				
Temperature	deg C	X	X	X
pH	pH units	X	X	X
Specific Conductance	μMHO/cm @ 25C	X	X	X
Alkalinity	mg/L	X	X	
Turbidity	NTU	X	X	X
TSS	mg/L	X	X	
TDS	mg/L	X	X	
Oxygen and Oxygen Demand				
DO	mg/L	X	X	X
BOD_5	mg/L	X	X	
BOD_{30}	mg/L	X	X	
$CBOD_5$	mg/L	X	X	
Nutrients				
Ammonia	mg/L as N	X	X	
TKN	mg/L	X	X	
Nitrite	mg/L	X	X	
Nitrate	mg/L	X	X	
Total Phosphorus	mg/L	X	X	
Phosphate	mg/L	X	X	
Metals				
Aluminum (Total)	mg/L	X	X	
Aluminum (Dissolved)	mg/L	X	X	
Calcium (Total)	mg/L	X	X	
Cadmium (Total)	mg/L	X	X	
Cadmium (Dissolved)	mg/L	X	X	
Chromium (Total)	mg/L	X	X	
Chromium (Dissolved)	mg/L	X	X	
Copper (Total)	mg/L	X	X	
Copper (Dissolved)	mg/L	X	X	
Fluoride (Total)	mg/L	X	X	
Fluoride (Dissolved	mg/L	X	X	
Iron (Total)	mg/L	X	X	
Iron (Dissolved)	mg/L	X	X	
Magnesium (Total)	mg/L	X	X	
Manganese (Total)	mg/L	X	X	
Manganese (Dissolved)	mg/L	X	X	
Lead (Total)	mg/L	X	X	
Lead (Dissolved)	mg/L	X	X	
Zinc (Total)	mg/L	X	X	
Zinc (Dissolved)	mg/L	X	X	
Biological				
Total Chlorophyll	μg/L	**X**	**X**	
Chlorophyll-*a*	μg/L	X	X	
Fecal Coliform	CFU/100mls	X	X	
E. coli	CFU/100mls	X	X	
Miscellaneous				
Phenolics	mg/L	X	X	

Table 11 - Water quality parameters sampled during 2005-2006 in Wissahickon Creek Watershed

a. Discrete Interval Sampling

PWD staff collected surface water grab samples at ten (n=10) locations within Wissahickon Creek Watershed for chemical and microbial analysis. Each site along the stream was sampled once during the course of a few hours, to allow for travel time sample processing/preservation. The purpose of discrete sampling is initial characterization of water quality under both dry and wet conditions and identification of parameters of possible concern.

Sampling events were planned to occur at each site at weekly intervals for one month during three separate seasons. Actual sampling dates were as follows: "winter" samples collected 1/13/05, 1/20/05, 1/27/05, and 2/3/05; “spring” samples collected 4/21/05, 4/28/05, 5/5/05, and 5/12/05; “summer” samples collected 8/4/05, 8/11/05, 8/18/05 and 9/8/05. A total of 120 discrete samples, comprising 4920 chemical and microbial analytes, were collected and recorded during the 2005 assessment of Wissahickon Creek Watershed. To add statistical power, additional discrete water quality samples from PWD's wet-weather chemical sampling program were included in analyses when appropriate. Discrete sampling was conducted on a weekly basis and was not specifically designed to target wet or dry weather flow conditions.

b. Continuous Monitoring

Physicochemical properties of surface waters are known to change over a variety of temporal scales, with broad implications for aquatic life. Several important, state-regulated parameters (*e.g.*, dissolved oxygen, temperature, and pH) may change considerably over a short time interval, and therefore cannot be measured reliably or efficiently with grab samples. Self-contained data logging continuous water quality monitoring Sondes (YSI Inc. Models 6600, 600XLM) were deployed from 3/9/2005 to 11/21/2005 at six (n=6) sites within Wissahickon Creek Watershed in order to collect DO, pH, temperature, conductivity and depth data.

c. Wet Weather Event Sampling

Automated samplers (Isco, Inc.) were used to collect samples from 4 mainstem and 4 tributary sites during runoff producing rain events in 2005. Samples were collected from 4 mainstem locations during three wet weather events that took place 7/8/05, 10/8/05 and 11/16/05. Additionally, samples were collected from Monoshone on 5/20/05 and 7/8/05; Bells Mill on 9/15/05, 9/26/05 and 10/8/05; Cathedral Run on 11/10/05 and 11/15/05; and Wises Mill on 11/16/05. Wet weather data collection in tributary sites is on-going. The data allow characterization of water quality responses to storm water runoff.

Automated samplers were equipped with vented in-stream pressure transducers that allowed sampling to commence beginning with an increase in stage. While in the testing phase of automated sampler installation, it was determined that diel fluctuations in flow volume from the various dischargers regularly caused stream stage to increase 0.1-0.3 ft regularly during dry weather, so the protocol for initiating the start of a sampling event had to be modified from the protocol used in storm water/CSO only systems. Once sampling was initiated, a computer-controlled peristaltic pump and distribution system collected the first 4 grab samples at 40 minute intervals and the remaining samples at 1 hr. intervals.

3. Biological Assessments

a. Benthic Macroinvertebrate Assessments

During 2/23/05 to 3/17/05, the Philadelphia Water Department conducted Rapid Bioassessment Protocols (RBP III) at thirty (n=30) locations within Wissahickon Creek Watershed**.** Surveys were conducted at 11 mainstem locations and 19 tributary locations. 16 of the 19 tributary sites were located within Philadelphia County. There were a disproportionate number of assessment sites within Philadelphia because of the need to establish baseline conditions for future BMPs.

b. Fish Assessments

Between 6/1/05 and 6/17/05, PWD biologists conducted fish assessments at ten (n=10) locations within Wissahickon Creek Watershed. Surveys were conducted at eight mainstem locations and two tributary locations.

c. Algae Assessments

Periphyton communities were sampled from sites WS122, WS354, WS1075, and WS1850, chiefly to assess the role of periphyton regulating stream metabolism. Surveys were conducted at mainstem locations only, and 2 sites were located within Philadelphia County. Sites were chosen based on proximity to continuous water quality monitoring stations, but some adjustments were made in order to situate the periphyton sampling locations in areas with sufficient depth and substrates and to attempt to control for differences in canopy cover.

The intensity of PWD's 2005 periphyton monitoring in the Wissahickon Creek Watershed was curtailed because of a periphyton study being conducted concurrently by Penn State University with assistance from PADEP. PWD's sampling program was thus limited to surface water chlorophyll-*a* from grab samples and estimates of periphyton chlorophyll-*a* at four sites in spring and summer (24 periphyton samples total).

d. Physical Assessments

i. EPA Habitat Assessment

Immediately following benthic macroinvertebrate sampling procedures, habitat assessments were completed at thirty sites (n=30) based on the Environmental Protection Agency's *Rapid Bioassessment Protocols for Use in Wadeable Streams and Rivers* (Barbour *et al*. 1999). Reference conditions were used to normalize the assessment to the "best attainable" situation.

Habitat parameters were separated into three principal categories: (1) primary, (2) secondary, and (3) tertiary parameters. Primary parameters are those that characterize the stream "microscale" habitat and have greatest direct influence on the structure of indigenous communities. Secondary parameters measure "macroscale" habitat such as channel morphology characteristics. Tertiary parameters evaluate riparian and bank structure and comprise three categories: (1) bank vegetative protection, (2) grazing or other disruptive pressure, and (3) riparian vegetative zone width.

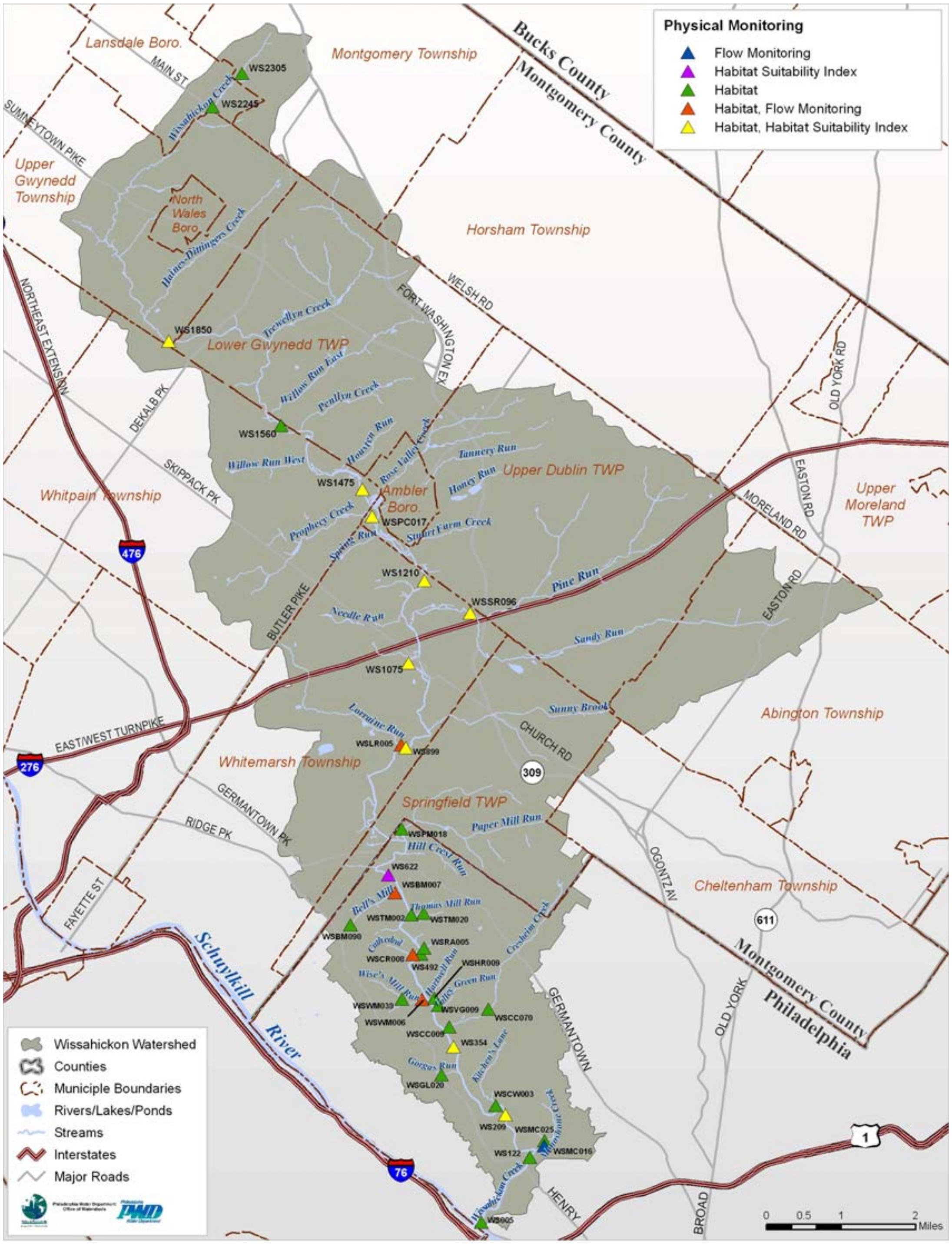


Figure 6 - Physical assessments conducted in Wissahickon Creek during 2005-2006.

ii. HABITAT SUITABILITY INDEX (HSI) EVALUATION

HSI models for nine species were selected for Wissahickon Watershed. Models were chosen to reflect the range of habitat types and attributes needed to support healthy, naturally-reproducing native fish communities and provide recreational angling opportunities in the watershed. Two centrarchid fish, redbreast sunfish (*Lepomis auritus*), and smallmouth bass (*Micropterus dolomieu*), were included in the analysis. These species are tolerant of warmer water temperatures and require extensive slow, relatively deep water (*i.e.*, pool) habitats with appropriate cover or structure to achieve maximum biomass.

While black basses (*M. dolomieu* and its congener *M. salmoides*) are not native to Southeast Pennsylvania, they occupy the top carnivore niche and are among the most sought-after freshwater game fish in water bodies where they occur. Moreover, the only other large bodied piscivores known to occur naturally in Wissahickon Creek Watershed are American eels, native catadromous fish for which no HSI have been developed. Salmonid HSI models were used for Brown trout (*Salmo trutta*) and Rainbow trout (*Oncorhynchus mykiss*). While these coldwater fish generally cannot establish and maintain reproducing populations in warmwater streams, PFBC actively stocks both Rainbow and Brown trout in Wissahickon Creek Watershed.

Four native minnow species were selected for HSI analysis: blacknose dace (*Rhinichthys atratulus*), common shiner (*Luxilis cornutus*), creek chub (*Semotilus atromaculatus*), and longnose dace (*Rhinichthys cataractae*). These minnow species have different habitat requirements and tend to occur in different portions of a watershed overall. Furthermore, these species are known to occur in Wissahickon Creek Watershed, and are generally common throughout southeast Pennsylvania streams with appropriate habitat.

HSI model output for each site was compared to EPA habitat data results. With the exception of fallfish, brown trout and rainbow trout HSI data, HSI model output was compared to observed fish abundance and biomass with correlation analyses. As fish known to associate primarily with pool habitats generally grow to larger sizes, a successful model should perhaps correlate with the biomass per unit volume. Conversely, models that aim to predict habitat suitability for small minnows that inhabit riffles might be expected to have a stronger relationship with fish abundance per unit surface area. Several habitat models likely require modification in order to be useful in guiding or evaluating stream habitat improvement activities. While time constraints precluded the modification of models to better suit Wissahickon Creek Watershed, it is hoped that such modifications will increase the usefulness of these models in the future. Simple correlations between habitat and fish abundance/biomass data are included in individual model results when appropriate, and PWD is currently exploring other statistical tools to study fish and macroinvertebrate habitat relationships.

iii. INFRASTRUCTURE ASSESSMENT

As an extension of the fluvial geomorphological investigation of stream channels within Wissahickon Creek Watershed during 2006, an infrastructure assessment was completed. In order to document infrastructure throughout the basin, PWD staff and trained consultants walked along stream segments with GPS, digital photography, and portable computer equipment, compiling an inventory of every infrastructure feature encountered. These features included bridges, culverts, dams, storm water outfalls and drain pipes greater than 8" in diameter, sewers, pipe crossings, confluences, manholes, and areas where one or more of the stream banks were artificially channelized. As of September 2006, approximately 84miles of the Wissahickon Creek Watershed have been mapped, with additional surveys planned for 2006-2007.

Preliminary findings of the infrastructure assessment will be disseminated in the Wissahickon Creek Watershed Comprehensive Characterization Report to better integrate the results with the findings of other assessments (e.g., to help explain observed impairments found in the biological assessments). Because the inventory of infrastructure features in the City of Philadelphia is complete and the City portion of the watershed, tributaries in particular, was subject to more scrutiny in other assessments, findings have been divided into features within the city of Philadelphia and features within Montgomery County (Figure 7 and Figure 8).

e. REPORTING

The final version of the Wissahickon Creek Watershed Comprehensive Characterization Report is planned for October 1st, 2006. Upon completion, three copies will be delivered to the Pennsylvania Department of Environmental Protection (Southeast Regional Office) and will be disseminated to the public at the following web address: www.Phillyriverinfo.org.

f. 2007 SAMPLING AND MONITORING PROGRAM

As discussed in Section 2: Step 1 (part b) of the City's Storm water Permit, the Philadelphia Water Department plans to embark on a comprehensive assessment in the Pennypack Creek Watershed during 2007-2008. Discrete chemical sampling will commence in the winter months of 2007 and will continue throughout the year. Similarly, continuous and wet weather monitoring will begin in March/April of 2007 and will progress through 2008. Biological and physical assessments will also commence in 2007 and will continue through the year. Completion of the characterization report is allotted for fall of 2008.

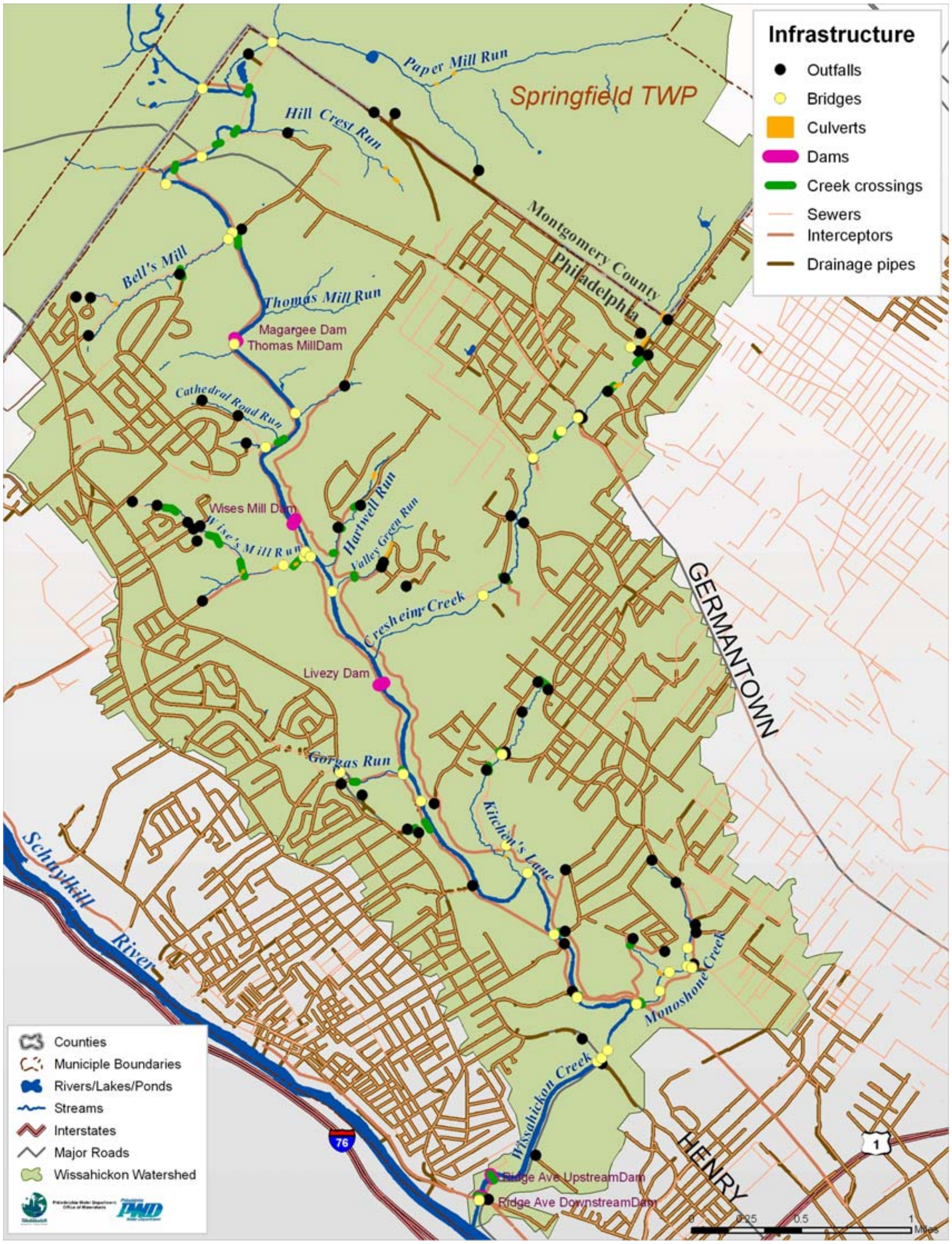


Figure 7 - Infrastructure assessment completed within Philadelphia County 2005 – 2006.

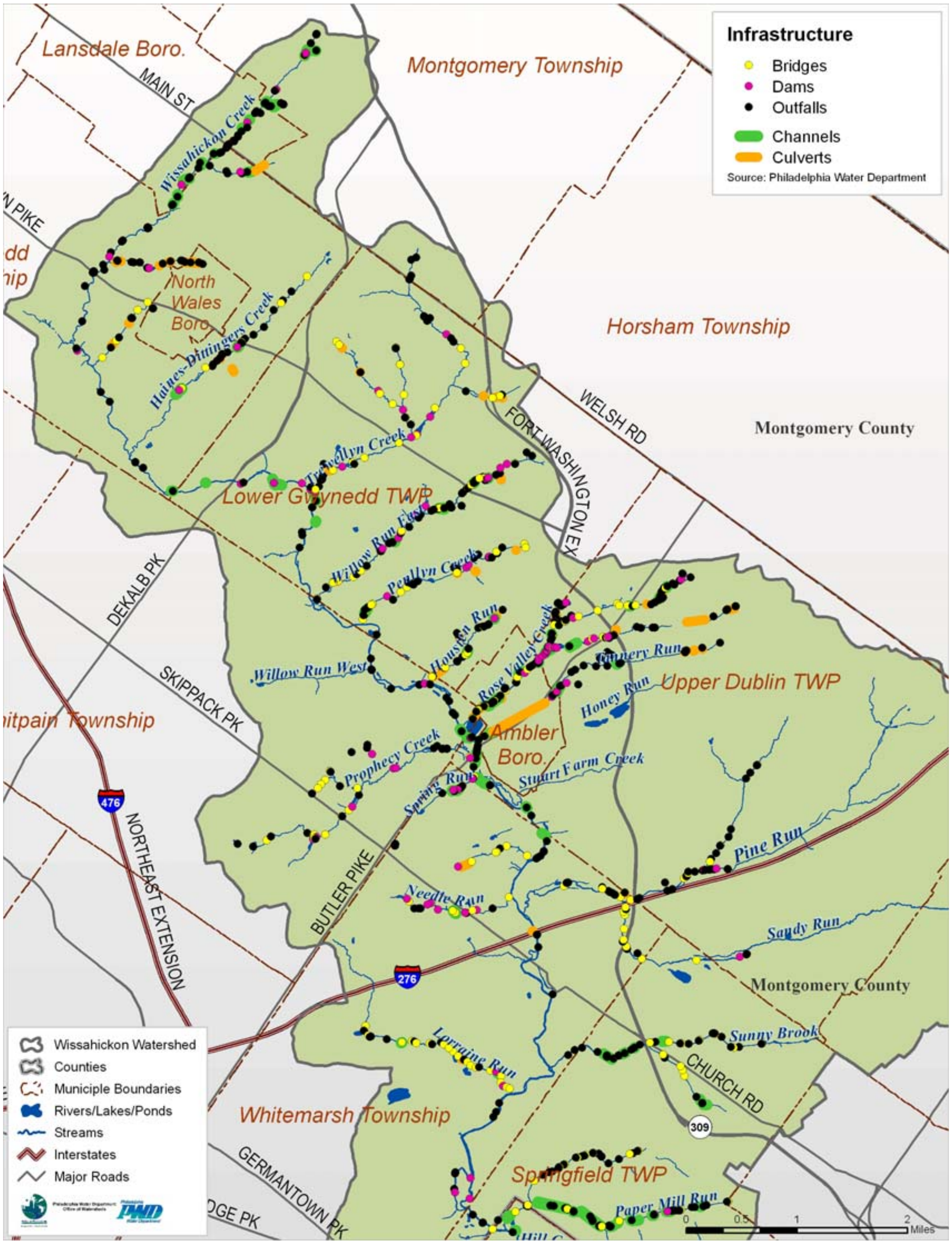


Figure 8 - Infrastructure assessment completed above Philadelphia County 2005-2006).

ii. QA/QC AND DATA EVALUATION

The Office of Watersheds (OOW) and Bureau of Laboratory Services (BLS) have planned and carried out an extensive sampling and monitoring program to characterize conditions in Wissahickon Creek Watershed. The program includes hydrologic, water quality, biological, habitat, and fluvial geomorphological components. Again, because the OOW has merged the goals of the city's storm water, combined sewer overflow, and source water protection programs into a single unit dedicated to watershed-wide characterization and planning, it is uniquely suited to administer this program.

Sampling and monitoring follow the Quality Assurance Project Plan (QAPP) and Standard Operating Protocols (SOPs) as prepared by BLS. These documents cover the elements of quality assurance, including field and laboratory procedures, chain of custody, holding times, collection of blanks and duplicates, and health and safety. They are intended to help the program achieve a level of quality assurance and control that is acceptable to regulatory agencies. Standard Operating Procedures for chemical and biological assessments can be found at the following address: www.phillyriverinfo.org.

1. WATER QUALITY CRITERIA FOR WISSAHICKON CREEK WATERSHED

An analysis was conducted on the water quality data collected in the Wissahickon Watershed. Using the data collected from discrete wet and dry weather sampling, comparisons were made to PADEP water quality standards. National water quality standards and reference values were used if state water quality standards were not available. The water quality standards or reference values and their sources are listed in Table 12

A color coding system was used to indicate problems (red) and potential problems (yellow). Problems were identified if more than 10% of samples exceeded the applied water quality standard or criterion. Potential problems were identified if between 2% and 10% of samples exceeded the standard or criterion.

Parameter	Criterion	Water Quality Criterion or Reference Value	Source
Alkalinity	Minimum	20 mg/L	PA DEP
Aluminum	Aquatic Life Acute Exposure Standard	750 ug/L	PA DEP
Aluminum	Aquatic Life Chronic Exposure Standard	87 ug/L (pH 6.5-9.0)	53FR33178
Chlorophyll *a*	Reference reach frequency distribution approach for Ecoregion IX, subregion 64, 75th percentile	3 ug/L, (Spectrophotometric) ***	EPA 822-B-00-019
Dissolved Cadmium	Aquatic Life Acute Exposure Standard	0.0043 mg/L *	PA DEP
	Aquatic Life Chronic Exposure Standard	0.0022 mg/L *	PA DEP
	Human Health Standard	10 mg/L	PA DEP
Dissolved Chromium	Aquatic Life Acute Exposure Standard	15 mg/L	PA DEP
	Aquatic Life Chronic Exposure Standard	10 mg/L	PA DEP
Dissolved Copper****	Aquatic Life Acute Exposure Standard	0.013 mg/L *	PA DEP
	Aquatic Life Chronic Exposure Standard	0.0090 mg/L *	PA DEP
	Human Health Standard	1000 mg/L	PA DEP
Dissolved Iron	Maximum	0.3 mg/L	PA DEP
Dissolved Lead	Aquatic Life Acute Exposure Standard	0.065 mg/L *	PA DEP
	Aquatic Life Chronic Exposure Standard	0.025 mg/L *	PA DEP
	Human Health Standard	50 mg/L	PA DEP
Dissolved Zinc	Aquatic Life Acute Exposure Standard	0.120 mg/L *	PA DEP
	Aquatic Life Chronic Exposure Standard	0.120 mg/L *	PA DEP
	Human Health Standard	5000 mg/L	PA DEP
Dissolved Oxygen	Average Min (August 1 to February 14)	5 mg/L	PA DEP
	Instantaneous Min (August 1 to February 14)	4 mg/L	PA DEP
	Average Min (February 15 to July 31)	6 mg/L	PA DEP
	Instantaneous Min (February 15 to July 31)	5 mg/L	PA DEP
Fecal Coliform	Maximum	200/100mL (Swimming season) or 2000/100mL (Non-swimming season)	PA DEP
Fluoride	Maximum	2.0 mg/L	PA DEP
Iron	Maximum	1.5 mg/L	PA DEP
Manganese	Maximum	1.0 mg/L	PA DEP
NH_3-N	Maximum	pH and temperature dependent	PA DEP
NO_{2-3}-N	Nitrates – Human Health Consumption for water + organisms	2.9 mg/L ***	EPA 822-B-00-019
$NO_2 + NO_3$	Maximum (Public Water Supply Intake)	10 mg/L	PA DEP
Periphyton Chl-*a*		Ecoregion IX – 20.35 mg/m2	USEPA 1986 (Gold book)
pH	Acceptable Range	6.0 - 9.0	PA DEP
Phenolics	Maximum	0.005 mg/L	PA DEP
TDS	Maximum	750 mg/L	PA DEP
Temperature		Varies w/ season. **	PA DEP
TKN	Maximum	0.675 mg/L ***	EPA 822-B-00-021
TN	Maximum	4.91 mg/L ***	EPA 822-B-00-020
TP	Maximum	140 ug/L ***	EPA 822-B-00-022
TSS	Maximum	25 mg/L	Other US states
Turbidity	Maximum	8.05 NTU ***	EPA 822-B-00-023

* - Water quality standard requires hardness correction; value listed is water quality standard calculated at 100 mg/L $CaCO_3$ hardness

** - Additionally, discharge of heated wastes may not result in a change of more than 2°F during a 1-hour period.

*** - Ecoregion IX, subregion 64 seasonal median

**** - All locations except site WS1850 have permitted exemptions of state dissolved copper standards due to a Water Effects Ratio.

Table 12 - Water Quality Standards and Reference Values

iii. Watershed & Water Body Modeling – Estimates of Loadings from the City's MS4 System

1. Introduction

PWD's approach to resolving impacts of storm water discharges is one part of a carefully developed approach to meeting the challenges of watershed management in an urbanized setting. Designed to meet the goals and objectives of numerous, water resources related regulations and programs, the approach recommends the use of adaptive management approaches to implement recommendations on a watershed-wide basis. Its focus is on attaining priority environmental goals in a phased approach, making use of the consolidated goals of the numerous existing programs that directly or indirectly require watershed planning. Central to the approach is development of integrated watershed management plans for each of the watersheds that drains to the City of Philadelphia. The Wissahickon Creek Integrated Watershed Management Plan is the third to be completed, following the Cobbs Creek Integrated Watershed Management Plan (CCIWMP) in 2004 and Tookany/Tacony-Frankford Integrated Watershed Management Plan (TTFIWMP) in 2005. Watershed management plans for the Pennypack and Poquessing watersheds are planned for completion during the term of the current NPDES storm water permit.

The approach followed has four major elements, each with multiple tasks specific to the planning efforts within the watershed.

- Data collection, organization and analysis
- Systems description
- Problem identification and development of plan objectives
- Strategies, policies and approaches

<u>Data Collection, Organization and Analysis</u>

The initial step in the planning process is the collection and organization of existing data on surface water hydrology and quality, pollutant loads, wastewater collection and treatment, storm water control, land use, stream habitat and biological conditions, and historic and cultural resources. In addition, existing rules, regulations, and guidelines pertaining to watershed management at federal, state, basin commission, county, and municipal levels also are examined for coherence and completeness in facilitating the achievement of watershed planning goals.

Data are collected by many agencies and organizations in various forms, ranging from reports to databases and Geographic Information System (GIS) files. Field data collection efforts were undertaken throughout the study, and expanded as data gaps were identified.

<u>Systems Description</u>

The planning approach for an urban stream must focus on the relationship between the natural watershed systems (both groundwater and surface water) and the constructed systems related to land use that influence the hydrologic cycle, such as water supply, wastewater collection and treatment, and storm water collection. A critical step in the planning process is to examine this relationship in all its complexity.

PROBLEM IDENTIFICATION AND DEVELOPMENT OF PLAN OBJECTIVES

Existing problems and issues of water quality, stream habitat, and streamflow related to the urbanization of the watershed can be identified through analyses of:

- Prior studies and assessments;
- Existing data;
- New field data;
- Stakeholder input.

Problems and issues identified through data analysis must be compared with problems and issues brought forward by stakeholders. An initial list of problems and issues then are transformed into a preliminary set of goals and objectives. These goals and objectives may reveal data gaps and may require additional data collection and analysis. Ultimately, with stakeholder collaboration, a final list of goals and objectives is established that truly reflects the conditions of the watershed. These goals and objectives are prioritized by the stakeholders based on the results of the data analysis.

The priority of objectives becomes the basis for developing planning alternatives. Potential constraints on implementation require that the objectives be broken down into phased targets, in which alternatives are developed to meet interim objectives. In this way, the effectiveness of implementation can be monitored, and targets adjusted, as more is learned about the watershed, its physical characteristics, and evolving water quality regulations.

In conjunction with Section D (Sediment Total Maximum Daily Load (TMDL) For Wissahickon Creek) of the City's storm water permit, PWD has initiated a monitoring plan that addresses the adverse impacts to in-stream habitats as a result of transport of sediment and/or stream bank erosion. Baseline data from 13 perennial tributaries that originate in the City will be monitored to define their contribution of sediment loading.

There are two elements to the monitoring program. The first estimates the sediment load originating from stream banks. The second estimates the total sediment load being carried by the stream. Data collection is ongoing for both parts.

STRATEGIES, POLICIES AND APPROACHES

Once end targets and interim targets are established, with a clear list of associated planning objectives based on sound scientific analysis and consensus among stakeholders, effective sets of management alternatives are developed to meet the agreed upon targets and objectives. These alternatives are a combination of options that may include suggested municipal actions, recommendations on water supply and wastewater collection system improvements, potential measures to protect water quality from point sources, best management practices for storm water control, measures to control sanitary sewer overflows, changes to land use and zoning, stream channel and stream bank restoration measures, etc.

Integrated watershed management plans provide guidelines on how best to combine the many options in a coherent fashion within the context of the watershed-wide management objectives. The plans are designed to provide an implementation process and guidelines to achieve the stated objectives over a specified period of time.

2. WISSAHICKON WATERSHED

A detailed hydrologic model has been developed for the Wissahickon watershed using EPA's Storm Water Management Model (SWMM). The procedure for developing geographic information for the Wissahickon model started with the delineation of the subsheds. For this task the subsheds were delineated to each surveyed stream cross-section with consideration taken where municipal separate storm sewer (MS4) subsheds alter the natural drainage. In these cases the delineation of the MS4 subshed took precedence over the direct drainage subshed.

Once the subsheds were finalized, intersects with impervious cover, soils and slopes were performed. Inside the City of Philadelphia, a planimetric impervious layer developed from 1996 orthophotography was used. This layer classifies all surface elements as either impervious or natural surfaces. For each subshed, the sum of the impervious area in acres was generated for input to the model. Excluded from this summation were some hydrologic features (i.e., pools, lakes, ponds and marshes) which are not considered hydrologically effective as they do not contribute runoff directly to Wissahickon Creek.

Soil types available from the U.S. Department of Agriculture, Natural Resources Conservation Service (NRCS) Soil Survey Geographic (SSURGO) Database were downloaded from the internet (www.soils.usgs.gov). The soil layer was classified based on the soil textures (i.e., loam, silt, sand, etc.) and intersected with the subsheds. Soil properties were assigned to each subshed based on soil texture classification. Soil classifications can vary widely within each subcatchment and an area-weighted initial value was calculated for each of the three parameters in each subcatchment.

The DEM used for developing the subsheds was also used for determining the area-weighted percent slope for each subshed. The DEM, which is a raster of elevation, was converted to a raster of percent slope. Since the cells analyzed are all a uniform size (10 m by 10 m for this task) the average slope calculated for each modeling shed is an area-weighted average. It should be noted that the area-weighted average percent slope may not be the same as the slope of the overland flow path.

For all subcatchments, impervious depression storage was set initially as 0.02 inches and pervious depression storage was set at 0.15 inches. These values were modified for each modeled tributary during calibration to match monitored event runoff totals.

Fifteen minute precipitation data was obtained from PWD rain gauges for the calibration of the model. The fifteen minute data from the nearest PWD rain gauge to a subshed was used as input to the model. Data from the other gauges close to the watershed was compared to this gauge in order to determine the spatial variability of individual rainfall events and to determine if precipitation observed at the nearest gauge is representative for the entire watershed.

Limited long-term daily evaporation data exists for the Philadelphia area. The Philadelphia Airport does not record evaporation data. Average monthly evaporation (inches per day) from a site in Wilmington, Delaware was used for the Wissahickon Creek hydrologic model. This data is discussed in more detail in the Hydrologic Characterization section of the Comprehensive Characterization Report.

Hydraulic and hydrologic data sets were obtained from several sources for varying time periods and used in the calibration process. Streamflow data were obtained for two active USGS gauges in Wissahickon Creek and for each tributary with available level monitoring data.

The model calibration philosophy divides storms into three magnitudes:

1. Small storms where no runoff occurs from pervious or impervious areas. These storms allow rough calibration of depression storage, although depression storage may be of a similar magnitude to uncertainty in rainfall and flow measurements.
2. Medium storms where runoff occurs from impervious surfaces but not from pervious surfaces. These storms allow calibration of directly connected impervious area (DCIA).
3. Large storms where runoff occurs from both impervious and pervious areas. These storms allow calibration of soil properties. For the current study, only saturated hydraulic conductivity was modified.

Model validation consists of choosing a set of physical parameters that allows the model to achieve a best fit between observed and simulated runoff event volumes. Choice of the best fit scenario is made by a combination of quantitative methods and best professional judgment. For this model validation, the quantitative method used was a simple error function. The areas below the cumulative distribution graph for both observed and simulated events were calculated and the error was the difference between these two values. Directly connected impervious cover (DCIA), impervious and pervious depression storage and hydraulic conductivity were then modified to minimize this error. In addition, professional judgment was used in certain instances. For example, it was considered important to calibrate larger (greater runoff) events as closely as possible, but not at the expense of misrepresenting a large percentage of events.

Calibration of the model is an iterative process by which model variables are changed, within acceptable ranges based on available data, from initial estimated values to ones that quantitatively and qualitatively provide the best match between modeled results and observed data. The events are distinguished by those included in the calibration process and those excluded using the set of protocols described previously. The four tributaries with available data were calibrated first. These calibrated tributaries were then combined with the remaining area of Wissahickon Creek within Philadelphia, and the remainder of the system was calibrated so that the system as a whole matched USGS gauge station data.

3. PENNYPACK AND POQUESSING WATERSHEDS

Estimates of storm water volumes and loads for the Pennypack and Poquessing watersheds were prepared in two stages, or tiers. Tier 1 results, based on a simplified representation of system hydrology, will provide initial estimates prior to development of a comprehensive watershed management plan for each system. The refined Tier 2 results, based on more detailed representations of hydrologic and elements, will support development, implementation, and monitoring of the comprehensive watershed management plans.

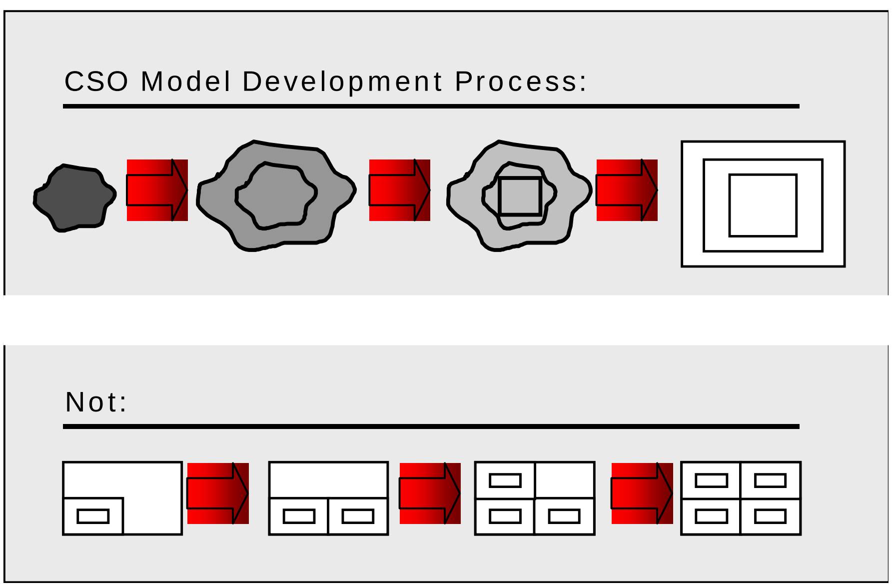


Figure 9 - CSO Model Development Process

Tier 1 estimates were prepared using two independent evaluation methods. In the first method, streamflow records collected by USGS were analyzed to estimate mean annual and seasonal runoff volumes. Storm water event mean concentrations reported by Smullen, Shallcross, and Cave (1999) were applied to these runoff volumes to yield pollutant load estimates.

In the second Tier 1 method, the MS4 drainage area was modeled in the United States Army Corps of Engineers (USACOE) Storage, Treatment, Overflow, Runoff Model (STORM), providing a simple algorithm for the computation of rainfall excess. Impervious cover estimates in this model were derived from GIS information collected in the early 1990s. Because these values represent total impervious cover, a correction factor was applied to represent the portion of the area that is directly connected to the drainage system. Based on detailed studies conducted in the Wissahickon watershed, a 40% reduction was applied. STORM thereby provides a relatively coarse-level wet weather characterization that is useful for initial assessment of impacts and for planning-level alternatives screening used to establish the direction for more detailed planning and design. The hourly rainfall record at Philadelphia International Airport between 1902 and 2005 was run in a continuous simulation mode to estimate runoff volumes.

iv. PROBLEM DEFINITION AND WATER QUALITY GOAL SETTING

Over the last permit year the City has continued to work with the Department, DCNR, and stakeholders throughout Philadelphia's watersheds. The work to this end is represented in each of the projects discussed herein.

v. TECHNOLOGY EVALUATION

1. HOUSEHOLD HAZARDOUS WASTE COLLECTIONS

During FY 2006, the City of Philadelphia held 7 Household Hazardous Waste Collection events, during which a total of more than 150 tons of hazardous waste and 33 tons of computer material were collected and disposed of properly. These materials include oil, paint, and other toxic household substances. A summary of the collections over the last 3 fiscal years is provided below in Table 13. Examples of educational brochures distributed by the Streets Department are provided in Appendix E. In addition, more information is available to the public at http://www.phila.gov/streets/hazardous_waste.html

Table 13 - Household Hazardous Waste Collection Statistics (FY 2004 - 2006)

Collection Event		Number of Participants	Quantity Accepted (lbs)		
			HHW	Computers	Total
State Road and Ashburner (Thurs)	24-Jul-03	588	50,361		50,361
Ridge and Sedgley	6-Sep-03	231	15,152		15,152
63rd Street	25-Oct-03	235	27,432		27,432
Delaware and Wheatsheaf * (HHW)	8-Nov-03	467	39,227	9,693	39,227
State Road and Ashburner	17-Apr-04	891	80,828		80,828
Domino and Umbria (HHW)	12-Jun-04	953	70,716	37,900	70,716
Propane Pick-up at Sanitation Yards	9/16/03	n/a	980		980
Disposal of Uranium Acetate (Apr. 04 event)		n/a	*special disposal*		
Total FY 2004		**3,365**	**284,696**	**47,593**	**284,696**
State Road and Ashburner (Thurs)	22-Jul-04	742	42,686		43,428
Ridge and Sedgley	28-Aug-04	297	26,024		26,321
63rd Street	9-Sep-04	225	21,449		21,674
Delaware and Wheatsheaf	6-Nov-04	767	57,270	4,508	62,545
State Road and Ashburner (HHW)	16-Apr-05	897	65,581	21,600	88,078
Domino and Umbria	11-Jun-05	812	66,247	4,685	71,744
Propane Pick-up at Sanitation Yards	25-Aug-04	n/a	1,115		1,115
Propane Pick-up at Sanitation Yards	11/23 &12/20/2004	n/a	350		350
Total FY 2005		**3,740**	**280,722**	**30,793**	**315,255**
State Road and Ashburner (Thurs)*	21-Jul-05	704	55,157		55,157
22nd and York	20-Aug-05	193	12,312		12,312
63rd Street	24-Sep-05	250	16,765		16,765
Lead Contaminated Dedris and Propane	24-Sep-05	*Special Pick-up*	*17,942*		17,942
Delaware and Wheatsheaf	5-Nov-05	890	63,061	30,339	93,400
State Road and Ashburner (HHW)*	Apr 22, 2006	866	75,428	17,922	93,350
Domino and Umbria	June 10, 2006	983	65,552	19,058	84,610
Propane Pick-up at Sanitation Yards	3-Mar-06	n/a	330		330
Propane Pick-up at Sanitation Yards	scheduled	n/a	160		160
Total FY 2006		**3,886**	**306,707**	**67,319**	**374,026**

2. Infrared Analysis in the Wissahickon Watershed

Aerial infrared (IR) imaging of all the hydrology in the Wissahickon Creek Watershed (105 miles), Cobbs Creek Watershed (24 miles) and Tacony Creek Watershed (32 miles) was conducted for the purpose of finding thermal anomalies indicative of liquid contamination of the surface water. Possible causes of the thermal anomalies are leaking sewer lines, ground water seeps, unidentified surface or subsurface outfalls in the form of pipes or drains, storm sewers and any other detectable source of liquid that may be of interest.

Davis Aviation of Beryl, Ohio was contracted to conduct the imaging and report the results. The cost was $115 per mile plus a ferry/deployment fee of $1324. All 161 miles of the above mentioned creeks were imaged at a cost of $19,839. The deliverables consisted of DVD+R's with raw IR video imagery, CD-ROM's with captured digital IR images of suspected anomalies, digital topography map segments showing the location of each anomaly, a comma delimited text file of WGS-84 geo-coordinates and anomaly number for each anomaly noted on the maps, and a short report describing the conditions of the flight and listing each anomaly by number with a short description of the suspected nature of the anomaly.

This information allows the Water Department to easily locate and investigate the exact nature of each thermal anomaly so that appropriate decisions can be made regarding remediation of surface water contamination problems.

The IR imaging work was performed in late March 2006 with the data delivered in early April 2006. The PWD has processed the data since receiving it in April. A shapefile was created showing spatial location of each thermal anomaly and all associated data such as suspected cause of the anomaly. Maps were created showing each of the anomalies in Philadelphia and the surrounding area and infrastructure to help better identify problems and to help in locating the point in the field. Field investigation of thermal anomalies occurring within the Philadelphia boundaries was started. Sites were visited and the source of the anomaly was identified and if problems existed, corrective actions were taken.

The field investigation of the thermal anomalies is ongoing. The PWD is also anticipating working with outside communities to identify the source of thermal anomalies documented in their community.

3. FLOATABLES CONTROL

R.E. ROY SKIMMING VESSEL

PWD's desire to improve public awareness of an individual's contribution to coastal aesthetics— notably in the Delaware and Schuylkill Rivers—and to improve water quality and aesthetics of surrounding parks and recreational areas recommended the use of a skimming vessel to remove debris from targeted reaches of the tidal portions of these two rivers.

In 2003, the PWD evaluated skimmer vessel technology types, models, and vendors, based on critical decision points such as material handling, vessel speed, mobile off-loading, seaworthiness, and O&M, and capital and life-cycle costs. The PWD determined that the Rover 12 - a 40ft, container type, debris vessel, was the vessel capable of safely and efficiently servicing these rivers.

On June 18th, 2004, the initial payment for the construction of the vessel was authorized by the PWD and the fabrication of the skimming vessel officially began. On December 17th, 2004 the PWD sent a team to Rhode Island for a vessel inspection at Hewitt Environmental's contractors manufacturing facility - Blount Boats, Inc. Fabrication continued throughout the first half of 2005 and the boat was delivered in June 28th, 2005. The vessel completed sea trials and after a few minor modifications, was accepted by the PWD. The total cost of the vessel was $526,690.

The vessel, now known as the R. E. Roy, was operated in-house, by Philadelphia Water Department personnel from delivery until April 2006. These personnel were trained by the vessel construction company on proper operations of the vessel. The vessel was in operation on the Schuylkill and Delaware Rivers performing general debris collection and removal. The vessel was also used to clean up for and service as a public relations highlight at events such as the Schuylkill Regatta.

The PWD went through the process of securing a contractor for the permanent operation of the skimming vessel from October 2005 through March 2006. The vendor selected through this process has become the full-time operator of the skimming vessel for a contract period of at least one year, with the option for contract renewal. The vessel is now operated five days per week, 8 months of the year.

The contract was awarded to River Associates, Inc of Philadelphia, PA in the spring of 2006. River Associates began operation in April 2006. Since that time, they have been operating the vessel and performing general debris cleanup on both the Delaware and Schuylkill Rivers. They have also participated in numerous public events including the PECO Energy Earth Day Cleanup, the Jam on the River at Penn's Landing, the Schuylkill River Sojourn, and the Godspeed Sail & Landing Party at Penn's Landing.

The R.E. Roy was in operation for 2 months of FY 2006 (April, May, June). During these months 2.88 tons, 14.24 tons, and 3.43 tons of floatable debris were removed from the Delaware and Schuylkill due to the vessel's operations.

PONTOON BOAT

While the process of procuring and operating the R.E. Roy was ongoing, the idea of obtaining grant funding for a pontoon vessel to assist the R.E. Roy in its daily operations in floatables assessment and collection was conceived. The portability, speed, and maneuverability of a pontoon vessel would provide a much needed resource to the floatables management program. In such, PWD applied for grant funding from CZM to pursue this endeavor.

By June, 2006, PWD has acquired the pontoon vessel, made all necessary modifications, and has begun field testing the vessel in floatables reclamation efforts. Presently, PWD is continuing its field testing of the vessel to discover the best operational schedule given its advantages, as well as its limitations.

The operational area of the Pontoon Vessel will include:

- The Lower Schuylkill above Fairmount Dam up to Flatrock Dam (7.2 miles)
- The Lower Tidal Schuylkill down to the confluence with the Delaware River (8.1 miles)

- The Delaware River from the confluence up to the Philadelphia City Boundary (18.8 miles)

In addition to the items summarized above, a discussion of various BMPs that have been designed and/or implemented is given in E.3 STEP 3 – WATERSHED PLAN IMPLEMENTATION AND PERFORMANCE MONITORING: PERMIT ISSUANCE THROUGH EXPIRATION.

vi. ECONOMIC ASSESSMENT AND FUNDING REQUIREMENTS

As watershed management plans are completed for the Wissahickon, Pennypack and Poquessing watersheds each report will include an economic assessment. The assessment will detail funding requirements including identifying known and potential funding sources necessary for successful plan implementation. Subsequent annual reports will provide appropriate assessments as the Watershed Management Plans are completed.

vii. PUBLIC INVOLVEMENT

See E.3.ii.1- Integrated Storm Water Management Plans

3. STEP 3 – WATERSHED PLAN IMPLEMENTATION AND PERFORMANCE MONITORING: PERMIT ISSUANCE THROUGH EXPIRATION

i. DRY WEATHER WATER QUALITY AND AESTHETICS

1. DEFECTIVE LATERAL PROGRAM

Over the last permit year, the City has continued to successfully operate its Defective Lateral Program. A detailed discussion of this program is provided within this report in Section F - DETECTION, INVESTIGATION, AND ABATEMENT OF ILLICIT CONNECTIONS AND IMPROPER DISPOSAL

2. WATERWAYS RESTORATION TEAM

The Fairmount Park Commission (FPC) and the Philadelphia Water Department (PWD) are intricately linked by a common heritage dating from the 19th century – the protection of Philadelphia's drinking water supply. It was in this spirit that FPC and PWD joined together in a venture that resulted in the creation of the Waterways Restoration Team (WRT), a PWD team dedicated to removing the trash from the city's streams and restoring stream areas damaged by our sewer infrastructure.

The Fairmount Park Commission and the Philadelphia Water Department initiated this exciting partnership in July 2003 to improve the environmental quality of our precious City parks and streams.

The FPC assumed responsibility for over 200 acres of land dedicated to the City for storm water management purposes - land that was a mowing and landscaping maintenance burden for the Water Department. The FPC is using this land to further its vision of developing "watershed parks," creating natural connections between neighborhoods and existing park areas.

In exchange, the Water Department has instituted the Waterways Restoration Team (WRT) – a crew dedicated to removing large trash – cars, shopping carts, and other short dumped debris - from the 100 miles of stream systems that define our City neighborhoods. This crew is also restoring eroded stream banks and streambeds around outfall pipes and in tributaries as a part of PWD's goal to naturally restore our streams while meeting Clean Water Act permit requirements. The Waterways Restoration Team is working in partnership with the FPC staff and the various Friends of the Parks groups to maximize resources and the positive impacts to our communities. This partnership focuses on the core strengths of our two agencies. The FPC continues to improve landscape management of the City's parks and dedicated lands, while the Water Department focuses its efforts on water quality improvements, a mandate it has under its state and federal water quality related permits.

	Totals	
Fiscal Year 2006 Waterways Restoration Team	Debris Removed (ton)	425
	Cars Removed	21
	Tires Removed	396
	Shopping Carts Removed	161
	Number of Clean-up Sites	124

Table 14 - PWD Waterways Restoration Team Statistics

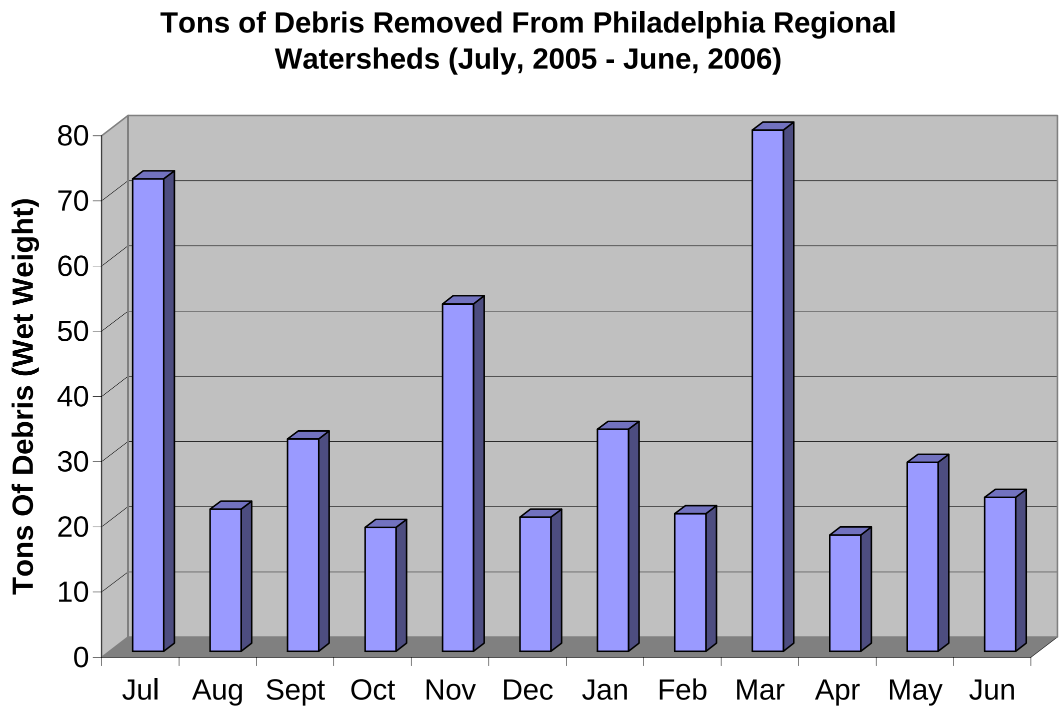


Figure 10 - WRT Debris Removal Stats (July, 2005 - June, 2006)

During FY 2006, WRT performed clean-up work at more than 124 sites. Table 14 - PWD Waterways Restoration Team Statistics and Figure 10 - WRT Debris Removal Stats (July, 2005 - June, 2006). Figure 10 highlights the amount and types of material removed from Philadelphia's rivers and streams.

In addition to the unbelievable amounts of trash that have been eliminated from our park and stream systems, the Waterways Restoration Team completed its second plunge pool restoration project at the Tustin Street outfall in the Pennypack Creek and completed the final stabilization of the lower segment of the Wises Mill Road Tributary to the Wissahickon Creek.

3. Sewer Relining Project along Lincoln Drive

In the spring of 2003, the City conducted CCTV sewer exams of both the storm and sanitary systems under Lincoln Drive. Given the high vehicle volume on this major artery for the City, this was a very difficult and time-consuming effort as all exams had to be done during weekends. A leak from the sanitary interceptor under Lincoln Drive, in the vicinity of Johnson Street, into the storm system was detected. The CCTV examinations showed that the integrity of the sanitary sewer was generally in excellent condition except for one area where bricks appeared to be missing in the vicinity of where the infiltration into the storm system was noted.

The City decided to move forward with a lining contract to address this situation. The contract provided for the lining of 3,160 feet of 2'-6" brick interceptor sewer under Lincoln Drive from Washington Lane (paper street only) to Arbutus Street. This scope included the entire length of sanitary sewer that is not physically lower in depth than the storm sewer system. The contract was bid, awarded, and completed in Fiscal Year 2004.

4. STORM WATER OUTFALL INSPECTIONS

Please reference Section F - DETECTION, INVESTIGATION, AND ABATEMENT OF ILLICIT CONNECTIONS AND IMPROPER DISPOSAL for a more detailed discussion of this subject.

5. DRY WEATHER FLOW OUTFALL SAMPLING

Please reference Section F - DETECTION, INVESTIGATION, AND ABATEMENT OF ILLICIT CONNECTIONS AND IMPROPER DISPOSAL for a more detailed discussion of this subject.

6. PRIORITY OUTFALL CLOSURE TESTING

Please reference Section F - DETECTION, INVESTIGATION, AND ABATEMENT OF ILLICIT CONNECTIONS AND IMPROPER DISPOSAL for a more detailed discussion of this subject.

ii. HEALTHY LIVING RESOURCES

1. INTEGRATED STORM WATER MANAGEMENT PLANS

In the development of watershed partnerships, the scope and importance of each task will vary among watersheds as a result of site-specific factors such as the environmental features of the watershed, regulatory factors such as the need to revise permits or complete TMDLs for the watershed, available funding, extent of previous work, land use and size of the watershed, the nature of businesses and industry, the level of involvement and resources of other stakeholders, and numerous other factors. Philadelphia watersheds have a diverse range of planning needs that range from those of the Delaware that has a long-standing river basin commission, and has been the focus of major monitoring and modeling studies, to its tributaries for which very little data and analysis are available. The actual scope of each task is developed and described in a work plan or similar document by each stakeholder group at the commencement of watershed planning activities. PWD has completed the watershed management plans for the Cobbs Creek sub-basin (using the Cobbs plan as a model for the entire Darby-Cobbs Watershed) and the Tookany/Tacony-Frankford Creek Watershed, which was developed in hand with the river conservation plan that the department spearheaded for the watershed. These plans will serve as templates for urban watersheds. In November 2005, the PWD launched the Wissahickon Watershed Partnership with the goal of completing this watershed management plan in 2008.The following is a list of typical tasks and subtasks included in most watershed planning programs.

DARBY-COBBS WATERSHED

The Darby-Cobbs Watershed Partnership was facilitated by the Philadelphia Water Department to create a framework for all stakeholders in the 75 square mile Darby-Cobbs watershed basin to work together to provide environmentally sound solutions to improve the water quality of Darby and Cobbs Creeks. Permit holders, participating agencies, and community-based organizations are constructing this framework upon regulatory and voluntary activities. The Partnership itself is a public participation mechanism, and acts as a forum for participating members to work together to develop a watershed strategy that meets state and federal regulatory requirements and embraces the environmental/public sensitive approach to improve stream water quality and quality of life in communities.

As one of the first steps in defining its framework, the Partnership developed a mission statement: “To improve the environmental health and safe enjoyment of the Darby-Cobbs Watershed by sharing resources through cooperation of the residents and other stakeholders in the Watershed.”

The Partnership formed a Public Participation Committee to ensure that the Partnership identifies and recruits representatives of the diverse array of stakeholders in this basin, including municipalities. Members of the Public Participation Committee include representatives of the following agencies/organizations: the Philadelphia Water Department, the Fairmount Park CAC, Fairmount Park Commission, Dove Communications, US Fish and Wildlife Service, Heinz National Wildlife Refuge Center, Pennsylvania Environmental Council (PEC), Cobbs Creek Community Environmental Education Center (CCCEEC), Delaware Creek Valley Association, DCNR, PA Department of Environmental Protection, Trail Boss Program, Delaware County Planning Department, EPA Region III, Delaware Riverkeeper Network, Academy of Natural Sciences, and the Men of Cobbs Creek.

Under the direction of the Partnership Steering Committee, the Partnership will evolve from one that was based upon a planning mandate to one that will focus on the implementation of the watershed management plan. During the summer of 2005, the Partnership Steering Committee teamed with the Eastern Delaware County Council of Government (COG) and the SE PA Resource and Conservation District to apply for a William Penn Foundation grant to facilitate the implementation of the plan in Delaware County. Currently, we are waiting to hear back from the foundation.

More recently, the Partnership reconvened in the spring of 2006 to begin sharing and tracking implementation projects in the Cobbs Creek portion of the watershed. A new steering committee is in formation to guide these efforts.

TOOKANY/TACONY-FRANKFORD WATERSHED

The PWD sponsored Tookany/Tacony-Frankford Watershed Partnership kicked off with its first Partnership meeting on October 4, 2001. The Tookany/Tacony-Frankford Watershed drains 29 square miles, or 20,900 acres in Philadelphia and Montgomery counties. It is, for the most part, a highly urbanized watershed with a large diverse population that includes portions of the inner city as well as wealthy suburban communities. This partnership, geographically less diverse than the Darby-Cobbs Watershed, was able to benefit from a number of organizations and groups that are already involved in neighborhood revitalization. Its members are eager to tackle projects that will see immediate benefits. Members include:

Tacony-Frankford Partnership

- Philadelphia Water Department
- Fairmount Park Commission and the Natural Lands Restoration Project
- Pennsylvania Environmental Council
- Frankford Group Ministry
- Melrose Park Neighbors Association
- Friends of Tacony Park
- Edison High School
- Rohm and Haas Co.
- Senior Environmental Corps.
- Awbury Arboretum
- Frankford United Neighbors
- Frankford Style Community Arts
- PA Department of Environmental Protection
- US Environmental Protection Agency
- US Army Corps of Engineers
- Philadelphia Green
- Phila. Urban Resources Partnership
- Cheltenham Township

This Partnership has been modeled after the Darby-Cobbs Partnership in working structure and the technical documents generated. However, PWD envisions that more “hands-on” type projects will be encouraged and requested on a regular basis. To supplement the work of the Partnership and to further the development of a watershed management plan, the Water Department, Fairmount Park and the Frankford Group Ministry received a DCNR grant in October 2001 to develop a River Conservation Plan for the Philadelphia county portion of the Tacony-Frankford watershed. The Partnership has worked closely to coordinate this grant with the River Conservation Plan in its final draft on the Tookany Watershed in Montgomery County. Cheltenham Township, a Partnership member, is developing this RCP.

The creation and completion of a River Conservation Plan (RCP) for the Tacony-Frankford Watershed has provided the Partnership with an environmental and cultural planning inventory for a highly urbanized watershed with the ultimate goal to develop a holistic management plan that will facilitate restoration, enhancement and sustainable improvements in the watershed. The watershed management was completed in June 2005.

This Partnership has elected a Board and has received its tax-exempt status as the first multi-municipal Watershed Partnership in the region. The mission of the Partnership is the implementation of the watershed management plan. A search for an Executive Director who will report directly to the Board will begin in fall 2006.

PENNYPACK CREEK WATERSHED

The PWD and its partners – the Fairmount Park Commission, the Friends of Pennypack Park, the Friends of Fox Chase Farms, the Pennypack Ecological Trust and the Montgomery County Planning Commission – received notice in Summer 2002 that it was awarded a grant from DCNR to develop a river conservation plan for the Pennypack Creek Watershed – Philadelphia, Montgomery and Bucks Counties. In the Fall 2002, team members toured various sections of the watershed to gain a better understanding of its current physical topography and condition. Also, the team developed a Request for Proposals for a consultant to lead the data collection and public outreach components of the plan, under the guidance of the RCP team. The consultant, F.X. Browne, Inc. was selected to oversee both the data collection and public outreach components of the RCP and began this work in the Fall 2003. In January 2004, the first RCP Steering Committee took place and a public outreach schedule and suggested public workshops were discussed and planned for the spring. In 2005, a number of public outreach and education events took place, including:

- April 2005 Stream Restoration Workshop
- April 2005 Watershed Friendly Homeowners Workshop
- September 2005 Fish Shocking Demo on Pennypack and presentation of draft plan
- September 2005 Presentation of draft plan at Pennypack Trust Ecological Restoration Plant Sale
- October 2005 – Presentation of draft plan at Montco Trout Unlimited
- October 2005 – Presentation of draft plant at annual Applefest Celebration at Fox Chase Farms

The RCP Plan was completed in December 2005. Work to implement some of its recommendations will continue into the future and will act as a platform for the development of a watershed management plan in 2007.

Currently, the stakeholders who participated in the RCP process are now working with the Montgomery County Planning Commission in the development of a Pennypack Greenway, one of the major recommendations of the Pennypack RCP.

POQUESSING CREEK WATERSHED

In 2004, the PWD, along with its partners, the Fairmount Park Commission and the Friends of Poquessing Creek, were awarded a state river conservation plan grant for the Poquessing Creek Watershed. In 2005, our RCP consultant, Borton-Lawson, began the data collection and public outreach components of the plan, including civic presentations, surveys, key person interviews, and have conducted a number of steering committee meetings. The first public meeting was held in April 2006 and the first public event – a major clean up of a stream segment, was co-hosted with PA Cleanways in April 2005. Currently, the Steering Committee is finalizing management options for the RCP and is planning a watershed-wide celebration to present the final plan in spring 2007.

WISSAHICKON CREEK WATERSHED

In November 2005, the Philadelphia Water Department (PWD) sponsored the Wissahickon Creek Watershed Partnership to begin the development of an integrated watershed management plan – a long-range road map designed to serve the twin goals of protecting natural resources and advancing vital communities. It reaches out to include municipal and conservation planning efforts that strive to ensure that growth within the watershed occurs only with special care to the environment.

The integrated Watershed Management Plan aims to:

- Serve as a holistic, comprehensive management tool that facilitates restoration and revitalization efforts throughout the watershed.
- Accommodate all regulatory and planning requirements affecting municipalities, which must address “point” (specific discharges) and “non-point” (generalized runoff) sources of pollution and flooding.
- Improve the water quality and natural environment of these heavily stressed streams, including highly urbanized areas.
- Boost the ability of the streams to support a diversity of wildlife, such as fish, insects, and birds.
- Enhance parkland and “riparian” (riverside) buffers, creating an enjoyable natural environment for the communities within the watershed.
- Develop a flexible “adaptive management” approach that will ensure sustainable improvements to the watershed.

This planning effort also benefits from the resources of other earlier and ongoing planning processes. In addition, the integrated plan is designed to serve the needs of municipal and government entities by addressing and satisfying the many related regulatory programs. Some of the reports, plans, and programs that will be taken into consideration by the Wissahickon Creek Integrated Watershed Management Plan include the following:

- Phase I and Phase II of the Clean Water Act's storm water regulations to control pollution due to discharges from municipal storm water systems.
- PA Sewage Facilities Act 537 to protect and prevent contamination of groundwater and surface water by developing proper sewage disposal plans.
- PA Storm water Management Act 167 to address management of storm water runoff quantity, particularly in developing areas.
- The Wissahickon TMDL (Total Maximum Daily Load) process to improve water quality of impaired streams and water bodies by calculating and limiting pollutant loads.
- Schuylkill Action Network (SAN) ongoing partnership projects.
- Fairmount Park Commission Master Plan for the Wissahickon Creek.
- Wissahickon Creek River Conservation Plan (2000).
- Sandy Run River Conservation Plan (2003)
- "Wissahickon Creek Watershed: Physical Characteristics and Water Quality," National Institute for Environmental Renewal (1999).

The foundation of this planning effort is the comprehensive collection of data that will prioritize pollution and impairment sources and confirm the best strategies for alleviating these impairments and restoring the watershed to one that is fishable, swimmable and enjoyable. PWD has committed to the watershed-wide collection of biological, chemical and physical data (including fluvial geomorphologic analysis and modeling), in addition to providing professional facilitation services to support the Wissahickon Creek Watershed Partnership.

Wissahickon Watershed Partnership

- Wissahickon Valley Watershed Association
- Whitpain Township
- PA DEP
- Whitemarsh Township
- Merck & Co., Inc.
- Abington Township
- McNeil CSP
- Center for Sustainable Communities
- Philadelphia Water Department
- Pennsylvania Environmental Council

- Lower Gwynedd Township
- Upper Gwynedd Township
- Ambler Wastewater Treatment Plant
- Upper Dublin Township
- US EPA
- Lansdale Borough
- Morris Arboretum
- Friends of the Wissahickon
- FX Browne, Inc.
- Cheltenham Township
- Montgomery County Planning Commission
- Fairmount Park Commission
- Montgomery County Conservation District
- North Wales Water Authority
- EEMA, Inc.
- Philadelphia University
- Schuylkill Riverkeeper
- Clean Water Action
- Wissahickon Restoration Volunteers
- Senior Environmental Corps, Center in the Park
- Schuylkill Center for Environmental Education

While the plan is in development, the Partnership has held or is developing a number of outreach materials including:

- Best Practices Municipal Workshops (for MS4 municipalities) – February 2006
- Homeowners' Storm water Workshop (for MS4 municipalities) – February 2006
- Rain Barrel Workshops for Homeowners – October 2006
- Watershed-wide Wissahickon Brochure – in planning
- Public education re unusual events in the Wissahickon – in planning

2. NATURAL STREAM CHANNEL DESIGN (NSCD)

a. COBBS CREEK – MARSHALL ROAD STREAM RESTORATION

The concept behind this project was to implement a sustainable approach to stream habitat restoration that would mitigate the impacts of urban development and related hydrologic and hydraulic modifications. By enlisting the members of the Darby-Cobbs Watershed Partnership and national experts, this local watershed restoration effort restored 1000 linear feet of the Cobbs Creek stream corridor between Pine Street and Cedar Avenue using natural restoration techniques. The primary goal of this project was to identify and document existing stream conditions, develop conceptual alternatives, prepare final design and construction drawings, and stabilize a reach of Cobbs Creek using fluvial geomorphologic principals and natural channel design techniques. The most appropriate restoration techniques were selected based upon a comprehensive, watershed-wide, fluvial geomorphologic characterization completed by our project team using Rosgen methodologies.

The project team assembled believed that a holistic approach to stream restoration was necessary to ensure the successful restoration and stabilization of Cobbs Creek. This holistic approach recognized that a stable stream channel is not just a function of the balance of in-stream morphological features but also recognizes the importance and interconnections with the surrounding riparian ecosystem. Consequently, the Philadelphia Water Department assembled a project team that developed an approach for the restoration of Cobbs Creek that encompassed the replication of natural hydrologic and ecological cycles, sustainability, enhancement to riparian and in-stream aquatic habitat, improved aesthetics, and significant cost savings over structural solutions. The results of this approach include not just stable stream bank geometry, but also long term ecological stability.

In general, this approach to stream bank stabilization combines the disciplines of fluvial geomorphology, hydraulics, hydrology, and applied ecology. This approach depends on accurate identification of stream classification type, an understanding of hydrologic actions within the watershed and their effects on a stream channel, and clearly defined restoration goals. Sound fluvial geomorphologic principles and an understanding of the natural stream system are integral to creating a stable stream channel that facilitates the restoration of the riparian ecosystem.

In summary, the objective was to create a segment of the stream system that was stable, required little maintenance, and was self-sustaining. A holistic, ecologically sensitive approach to stream restoration has many benefits to the Commonwealth of Pennsylvania, including replication of natural hydrologic and ecologic cycles, enhancement of riparian and in-stream aquatic habitat, improved aesthetics, and significant long-term cost savings over structural or simplified natural stream bank solutions. This project was a direct output of the Darby-Cobbs Watershed Initiative and was a priority project recommended as part of the Fairmount Park Commission's Natural Lands restoration and Environmental Education Program (NLREEP). As a result, this project was very refined and well matched with Watershed-wide environmental goals.

This project was constructed during the fall, 2004, with additional planting occurring during the spring, 2005

This project has upheld the following goals:

- Implemented recommendations of the basin-wide watershed planning initiative and Fairmount Park Commissions Natural Lands Master Plan for the Cobbs Creek Park.
- Implemented restoration techniques specifically targeted at removing stream impairments identified by the Pennsylvania Department of Environmental Protection and restored ecological resources.
- Served as a pilot project for integrated habitat restoration, stream bank stabilization, natural channel design, water quality improvement, and infrastructure protection.
- Mitigated the impacts of urban runoff and non-point source pollution.
- Restored native vegetation to the riparian corridor to enhance bank stability.
- Reduced the likelihood of further stream erosion and exposure of sanitary sewage infrastructure.
- Completed a fluvial geomorphologic assessment of the Cobbs Creek to serve as a tool for integrated bank stabilization/habitat restoration for this and future projects.

Throughout the term of the Permit, the following goals will also be served:

- To monitor the effectiveness of natural stream restoration techniques based upon Rosgen physical stream assessment techniques for improving aquatic habitat and equilibrium of the stream channel.
- To serve as an educational model for teaching multi-objective watershed restoration.

b. TACONY CREEK - WHITAKER AVENUE

The Tacony Creek – Whitaker Avenue stream restoration project is situated in the Tacony Creek Park located of Roosevelt Boulevard (US 1) downstream of the Whitaker Avenue Bridge and upstream of the Wyoming Avenue Bridge in northeastern Philadelphia. This project will implement a sustainable approach to stream habitat restoration that will mitigate the impacts of urban development and related hydrologic and hydraulic modifications over approximately 2,000 feet of stream length. The Philadelphia Water Department has assembled a project team to develop an approach for the restoration of Tacony Creek that encompasses the replication of natural hydrologic and ecological cycles, sustainability, enhancement to riparian and in-stream aquatic habitat, improved aesthetics, and significant cost savings over structural solutions. The results of this approach include not just stable stream bank geometry, but also long term ecological stability.

The project site involves 2 stakeholders, Fairmount Park Commission and the Scattergood Foundation, both of whom are partners in working to see this project to fruition.

Currently the project is at 65% Design and PWD is anticipating submitting necessary permit applications by December, 2006. Based on the current schedule, the project should be bid during the Spring, 2007, with construction occurring during Fall, 2007 or Summer, 2008.

Through the restoration of this reach of Tacony Creek, PWD hopes to accomplish the following:

- Minimization of impacts of non-point source pollution contributed by upstream runoff.
- An integrated restoration of 2000 ft. of stream that improves the physical, chemical, and ecologic metrics of stream health.
- A stable channel in dynamic equilibrium with it's surrounding watershed
- Stream bank stabilization measures featuring soil bioengineering and natural channel design measures that protect infrastructure and the environment in a highly sustainable manner.
- A healthy, vegetated riparian zone to add biological diversity to the stream system.
- Enhanced, In-stream aquatic habitat
- Opportunities for the community to learn about stream ecology and morphology
- Increased habitat heterogeneity (i.e. pools, riffles, runs)

c. PENNYPACK CREEK WATERSHED– REDD RAMBLER RUN

Over the years, the PWD has received numerous complaints and petitions from residents in the vicinity of Redd Rambler Run, a tributary of the Pennypack Creek (Paul's Run Watershed) located in Northeast Philadelphia, about property erosion, periodic flooding and safety concerns. PWD has since had the opportunity to evaluate and participate in natural restoration technologies – engineering and stream studies that focus on the natural characteristics of a stream and incorporate techniques such as reconnecting the stream to its floodplain, fortifying the stream's banks and floodplains with deep rooted vegetation, and installing boulders and rocks to decrease the stream's energy under storm conditions. Natural restorations enhance the existing beauty of streams while giving them back their ability to better handle higher flows. In addition, natural restoration techniques provide habitat for fish and insects, creating a "healthy" stream.

In March of 2004, PWD contracted the services of KCI Technologies, an environmental engineering design firm, to prepare final design and construction plans for the restoration of approximately 2,500 feet of Redd Rambler Run bounded by Verree Road to the north and Walley Avenue to the south.

D.S. Winokur & Associates, a local surveying firm, was contracted to perform the survey work and base mapping for the initial phase of the design. The completion of the base mapping was completed in December, 2004.

KCI then commenced conceptual design plans that holistically considered the engineering requirements for a stable stream with the current physical characteristics of the stream and its neighboring properties. Together, this information details the proposed stream alignment and channel treatments that will meet the residents' goals (a stable, aesthetically pleasing stream) and PWD's overall restoration design goals (a clean stream with the potential to nurture habitat). The concept design involves minor channel realignment at localized reaches, bank re-grading and stabilization using stone and planted materials, and channel bed stabilization through a combination of shallow riffles (a shallow area of a stream in which water flows rapidly over a rocky or gravelly stream bed). Riffles will typically be situated along straight stretches of the stream while pools will typically be situated along the bends in the stream.

A series of public meetings in April and May, 2005 were held at the Pennypack Environmental Center for the purpose of presenting conceptual design plans with the local residents affected by the restoration efforts and to provide a forum for review and comment.

Thirty (30) percent Design Plans were submitted to the PWD by KCI in September 2005. During the end of 2005 and the beginning of 2006, work continued on developing 60% Design Plans. Sixty (60) percent Design Plans were received in August 2006.

During late 2005 and early 2006, public meetings were conducted to discuss concerns the residents had about the impacts of the design on their property. Additional meetings are scheduled for late summer to address construction access issues.

A pre-application meeting with state and federal agencies for a construction permit is being planned for September 2006. Moving forward, PWD is planning to bid the construction of this design and build some time during late summer, 2007.

d. WISSAHICKON CREEK WATERSHED - CATHEDRAL RUN

In the Cathedral Run Watershed, a sub-watershed of the Wissahickon, the steep grades and high flows associated with storm flows have resulted in heavy bank erosion along the stream in several areas. In addition to water from the outfall structures, there is significant overland flow that cascades down the bank into the stream, causing severe erosion. Erosion from the banks of Cathedral Run is contributing to a significant sediment load to the Wissahickon. The large amount of impervious surface in the watershed is clearly an important factor in the runoff problems. All downspouts are connected to the storm sewer, so all roof area is piped directly to the storm water outfalls in Cathedral Run.

The PWD is working with Fairmount Park to develop a comprehensive watershed management program to improve the water quality of Cathedral Run, a tributary to the

Wissahickon Creek. This multiyear project includes near-term, mid-term, and long-term goals aimed at reducing runoff volumes and peak flow velocities, reducing non-point source pollution, stabilizing eroding stream banks, and repairing defective sanitary laterals and terminating illicit connections to the storm sewer system.

TRC Omni Environmental Corporation (TRC) was contracted by the PWD to develop a Watershed Management Plan for Cathedral Run to address these issues. The Cathedral Run Preliminary Watershed Management Plan was prepared by TRC and delivered in March 2005.

A basic precept of the plan is to disconnect impervious area wherever possible and treat storm water in distributed BMPs wherever feasible, with an overall goal of reducing both the volume and peak flows of runoff to the stream.

Working in conjunction with the Fairmount Park Commission, the PWD continues to work with TRC in the development of a detailed alternatives analysis. Once this analysis is completed, the PWD can begin implementing the most beneficial phases of this Management Plan. The plan is due sometime in late summer, 2006.

e. WISSAHICKON CREEK WATERSHED - WISE'S MILL

The Wises Mill Road stream restoration project is an exciting collaboration between the Philadelphia Water Department (PWD)'s Waterways Restoration Team (WRT) and the Fairmount Park Commission (FPC) to restore and stabilization a tributary to the Wissahickon Creek. PWD hired the Harrisburg engineering firm of Skelly and Loy, which specializes in natural stream channel design and restoration, to develop an interim stabilization plan for the lowest segment of the Wises Mill Road tributary of Wissahickon Creek. This tributary was severely impacted by the 2004 tropical storms of August 1 and September 28. A small parking lot which protruded into the stream was destroyed, endangering a section of the roadway. Culverts to the confluence of the Wissahickon were completely blocked after both storms, causing massive flooding and undermining of the roadway. Most recently, following a June 2005 storm, the lowest dam on the Wise's Mill tributary, directly above the point where the stream enters the Forbidden Drive culvert, was found to be in failure.

The long term goal for this project is the complete restoration of the Wises Mill Road tributary, including its main stem which originates on Summit Avenue and the segment of the stream which begins just below Henry Avenue. The short term stabilization plan focused on the lowest 250 foot segment of the stream, as this was the section that needed immediate attention.

The interim stabilization plan included the following components:

- The repair of the historic dam directly above Forbidden Drive by FPC stone masons

- The establishment of a new low flow stream channel
- The installation of a step pool and several boulder vanes to dissipate storm flows in the steam and to reduce potential erosion impacts to the roadway
- The stabilization of several large trees along the stream bank

This work required:

- Erosion and sediment control measures
- A stream pump around operation to ensure that sediment laden water did not flow into the Wissahickon Creek
- Approximately 400 tons of large boulders and stone
- A heavy track hoe excavator that could work in the stream
- Temporary stabilization of the area that once was occupied by the small parking lot

The PWD's WRT and the FPC are very excited about this project – a first for both agencies of a project of such a large scale. Our goal is to complete the restoration of the entire Wises Mill Road tributary within the first two years of the Permit term, and to use this project as a standard for many small streams throughout the city.

3. MONITORING EFFECTIVENESS OF NSCD

As each of the aforementioned NSCD projects are constructed and mature, PWD realizes the importance of extensive monitoring and O&M that accompanies such projects. It is very rare that such projects do not require additional "tweaking" or maintenance. In addition, each project provides the opportunity to learn about what techniques do and do not work in their respective hydrologic and hydraulic regimes. To provide data on the level of success of each project, such monitoring programs will include:

- Regular inspections of operation and Maintenance as required
- Measurement of relevant physical parameters, banks pins
- Regular surveying of channel morphology over time
- Assessment of biological and/or chemical parameters

iii. WET WEATHER WATER QUALITY AND QUANTITY

In addition to the implementation of the NSCD projects discussed above, the City also understands the need to address wet weather water quality and quantity issues prior to the flow entering its rivers and streams. In such, the City has implemented various BMP projects in which PWD has partnered with groups in each watershed. In the years to come, PWD plans to monitor each of these projects to assess their efficacy such that lessons can be learned and applied in future projects.
A comprehensive list of BMP projects are presented in Table 15 below. The table includes projects in both MS4 as well as combined sewer sheds since the projects, regardless of location within the City, present an opportunity to assess implemented

technologies. The assessments can then be used to select appropriate practices for improving water quality and quantity. Each project is listed by name, watershed, project status and location of related narrative within this report.

Table 15 - PWD BMP Projects

Project Name	Project Status	Shed Type	Page #
BLS Storm water Retrofit Phase I	Construction complete	Combined	81 – 83
Mill Creek Basketball Court	Construction complete	Combined	81 – 83
Mill Creek Farm	Construction complete	Combined	81 – 83
N. 50th Street	Construction complete	Combined	81 – 83
School of the Future	Construction complete	Combined	81 – 83
Marshall Road Stream Restoration	Construction complete	Combined	69
Fox Chase Farms Riparian Buffer Project	Construction complete	Separate	76
Courtesy Stables Runoff Treatment Project	Construction complete	Separate	77
Monastery Stables Storm water Diversion & Detention Project	Construction complete	Separate	78
Saylor Grove Storm water Treatment Wetland	Construction complete	Separate	78
West Mill Creek Playground	Design complete	Combined	81 – 83
East Falls Parking Lot	Design complete	Separate	81 – 83
Pennypack Park Wetland & Parking Lot	Design complete	Separate	81 – 83
Wissahickon Charter School	Design complete	Separate	81 – 83
Wise's Mill	In Construction	Separate	74
47th and Grays Ferry	In design	Combined	81 – 83
Clark Park	In design	Combined	81 – 83
Jefferson Square Park	In design	Combined	81 – 83
Whitaker Avenue Stream Restoration	In design	Combined	71
BLS Storm water Retrofit Phase II	In design	Combined	81 – 83
Baxter Visitors' Parking Lot	In design	Separate	81 – 83
Venice Island	In design	Separate	81 - 83
Redd Rambler Run	In design	Separate	72
Cathedral Run	In design	Separate	73
W.B Saul High School Project	Ongoing	Separate	79

1. FOX CHASE FARMS RIPARIAN FENCING AND BUFFER INSTALLATION

The purpose of the Fox Chase Farm project is to utilize agricultural BMPs to reduce the amount of harmful pathogens and nutrients entering the Pennypack Creek from the farm's tributary. Prior to project implementation, cows were allowed free access to the stream and the pasture land surrounding the stream was mowed to the stream's edge. Without the proper fencing to keep cows out of the stream, cows lingered in the tributary for long periods of time, especially in the warmer summer months. The access of the cows to the tributary, coupled with the lack of proper vegetation surrounding the tributary, allowed tremendous amounts of fecal coliform, E. Coli, and nutrients to enter directly into the stream and then into the Pennypack Creek from the farm. To address this situation, PWD and Fairmount Park Commission (FPC), along with volunteers, planted a 1.85 acre riparian buffer along the approximately 430 yard length of the tributary in May of 2002. Approximately 400 trees and 700 shrubs were planted to create approximately 45 ft of buffer on each side of the stream for the cost of $13,000. Stream bank fencing and a cattle crossing were also installed to limit the impact of cows on the stream.

PWD conducted regular water quality monitoring in 2003 and 2004 to evaluate project performance and observed a 90% reduction in fecal coliform, a 94% reduction in *E. Coli*, 37% reduction in nitrate, and a 36% reduction in turbidity at the origin of the tributary as a result of project implementation. These same parameters, along with ammonia, nitrite, and orthophosphate also decreased significantly at the mouth of the tributary before entering the Pennypack Creek. In FY06 water lines were installed to provide an alternative drinking water source for cows in order to further restrict access to cattle crossing and further reduce their impact on the water quality of the tributary. PWD continues to support this project by coordinating annual invasive species removal in the riparian buffer and by conducting additional water quality monitoring.

2. Courtesy Stables Runoff Treatment Project

PWD is partnering with the Fairmount Park Commission (FPC) to address storm water and agricultural runoff at this FPC property in the Wissahickon Watershed. The Courtesy Stables Runoff Treatment Project is aimed at correcting a suite of problems contributing to nutrient-laden storm water that flows from the barnyard through an adjacent wetland and into a tributary of the Wissahickon Creek. The project diverts storm water from the barnyard and surrounding area into a grassed waterway/filter strip where nutrients and sediment is removed and a portion of the water infiltrated before reaching the wetland. Flow from a springhouse has been routed directly to the wetland, serving as a continuous source of clean water, rather than through the riding ring, where it adsorbs nutrients and creates muddy conditions. Invasive plant species onsite has been removed and replaced with Philadelphia-native trees and shrubs and educational signage will be erected to link the nutrient runoff reduction to the improvement of the Schuylkill River watershed. FPC received a grant from NFWF to conduct this project and construction was completed in the fall of 2004. PWD is committed to providing matching funds ($13,000) and in-kind services in the form of pre and post construction water quality monitoring. Pre-construction monitoring has been completed and PWD will continue to support this project through the completion of post-construction monitoring and a thorough evaluation of project performance.

Initial post-implementation sampling conducted in FY06 shows a dramatic decrease in bacteria levels. Pre-implementation values for both E. coli and Fecal Coliform counts were greater than the detection limit of 200,000 #/100 ml on 7/12/04, and both parameters were 118,000 #/100 ml on 9/28/04. Post-implementation values averaged 6333 #/100 ml for E. coli and 24,425 #/100 ml for Fecal Coliform. Removal rates proved greater than 97% for E. coli and 79% for Fecal Coliform.

3. MONASTERY STABLES STORM WATER DIVERSION & DETENTION PROJECT

PWD is partnering with the FPC to address storm water and agricultural runoff at this FPC property in along the Wissahickon Creek. Lack of proper storm water management controls, a sloping topography toward the bordering creek, and the intensity of horse activity on the site make Monastery Stables a potentially significant source of contamination to Wissahickon Watershed. Before implementation, rainfall collected in the paddocks and discharges toward the Wissahickon through several eroded gullies, carrying sediment, nutrients, and harmful pathogens. This project introduced storm water management controls to increase storm water infiltration, and direct and treat storm water runoff, reducing sediment, nutrient, and harmful pathogen loadings on the Wissahickon Creek. PWD supported FPC in their 2004 Growing Greener Application for funding for this project and will offer in-kind match in the form of pre and post implementation monitoring estimated at $7000.

The project was completed in the Fall of 2005. Sampling of the effluent from the detention pond discharge apparatus is ongoing. Analysis of project benefits will follow once an adequate number of sample events are attained.

4. SAYLOR GROVE STORM WATER TREATMENT WETLAND

PWD proposed to design and construct a storm water treatment wetland at Saylor Grove, a 3-acre parcel of Fairmount Park. The 1-acre wetland will be designed to treat an estimated 70 million gallons of urban storm water per year before it's discharged into the Monoshone Creek. The Monoshone Creek is a tributary of the Wissahickon Creek- a source of drinking water for the City of Philadelphia. The function of the wetland is to treat storm water runoff in an effort to improve source water quality and to minimize the impacts of storm-related flows on the aquatic and structural integrity of the riparian ecosystem. This project is a visible Urban Storm water BMP Retrofit in the historic Wissahickon Watershed.

In March of 2002, TRC-OMNI, from Princeton, New Jersey, was chosen to prepare design plans and provide construction oversight services for the wetland project.

In January of 2005, the final plans and specifications were sent to PWD's Projects Control Unit for review. The project was advertised in March, 2005 and March 8, 2005 with bids due in early April. The bids ranged from the low bid winner, Anchor Environmental, $494,010 to the high bid of $927,524.

Anchor Environmental was awarded the job and a construction Notice to Proceed (NTP) in early May. However, Anchor Environmental declared bankruptcy and PWD was forced to re-bid the project and ask for a project deadline extension from June 30, 2005 to September 30, 2005.

The project was re-bid on June 28, 2005, with construction commencing in September, 2005. The project was completed in December, 2005, with planting continuing into Spring, 2006. Currently, PWD is monitoring the ability of the wetland to convey flow and remove pollutants. Daily monitoring at the site on the weeks of 4/24/06 and 5/8/06 demonstrated reductions in fecal coliform counts averaging 90% during dry-weather conditions. Reductions during wet-weather events weren't able to be monitored due to lack of rain immediately preceding sampling. Also, effectiveness of the wetland during rain events would have been limited due to lack of mature plantings.

In FY07 ISCOs will be installed to collect continuous samples of the influent and effluent to the wetland during wet weather conditions. This sampling will indicate actual project performance in treating wet weather events.

5. W.B. SAUL HIGH SCHOOL PROJECT

In FY04, PWD utilized a PADEP Growing Greener Technical Assistance Grant to complete a conceptual design to implement storm water BMPs at this Agricultural High School in the Wissahickon Watershed. PWD is currently conducting wet weather monitoring at the project site prior to project implementation. This will allow for a quantitative assessment of the effectiveness of the BMPs upon completion of the project. The W.B. Saul High School project combines urban storm water and agricultural BMPs to reduce the harmful impact of the school's runoff on the water quality of the Wissahickon Creek. Prior to discharging into the sewer, which then flows to the Wissahickon, agricultural runoff from the livestock and farming practices, as well as storm water runoff from the school's roofs and parking lots, will be captured and treated though a series of long pools connected by wetland swales. This project will add a significant educational component to the curriculum of Saul High School, already one of the nation's premier agricultural high schools, by demonstrating proper management of agricultural runoff.

6. SCHUYLKILL ACTION NETWORK (SAN) – SCHUYLKILL WATERSHED INITIATIVE GRANT (SWIG)

Philadelphia is the furthest downstream city in the Schuylkill watershed, which provides a source of drinking water for Philadelphia residents. The primary source of impairment of the Schuylkill watershed is storm water, which accounts for 273 of its 1,000 total impaired stream miles. The majority of these impaired stream miles are within and just outside Philadelphia. A preliminary restoration analysis found that it would cost approximately $288 million to design and reconstruct all impaired stream miles through natural stream channel design. The Schuylkill Action Network (SAN) Storm water Workgroup, a partnership of representatives from the Philadelphia Water Department, Pennsylvania Department of Environmental Protection, conservation districts, watershed organizations, municipalities, and others groups throughout the watershed, was formed to identify a more cost effective approach. Several projects identified through the Storm water Workgroup will be funded through the Environmental Protection Agency's Watershed Initiative Grant Program, which awarded approximately 1.15 million dollars to the SAN for its innovative and collaborative approach to watershed management. Of the total dollar amount, approximately $300,000 will go toward storm water-related projects over a three year period. The storm water workgroup spent much of FY05 prioritizing and planning activities to set the stage for these projects.

In FY06, the SAN storm water group moved forward with implementation. The group made contact with Mount Saint Joseph’s Academy, which was targeted due to its location, property size, and the large amount of impaired stream running through the site. The group received approval from the school and selected a contractor to proceed with a conceptual storm water management plan at the site. Final design of a comprehensive storm water management plan is also underway at Lansdale Borough Park, located at the headwaters of the Wissahickon Creek, and additional funds were secured for implementation. Final design for priority storm water management projects at Norristown Area School District has also started, with implementation planned for Fall 2006. The group also spent time developing a list of priority townships in Berks County for Environmental Advisory Council (EAC) outreach. Of six townships contacted, one has formed an EAC and another is interested in doing so. The group also worked closely with PADEP to investigate the feasibility of a watershed-wide Act 167 plan, and to review and provide input on PADEP’s new storm water model ordinance.

While the majority of storm water-related activities are conducted by the Storm water workgroup, activities of other SAN workgroups under the EPA grant are also linked with storm water. The Agriculture Workgroup spent much of FY06 implementing riparian buffers along streams in farm areas in Berks County. These buffers will not only filter contaminated runoff prior to its entering Schuylkill tributaries, they will also impact storm water volume and velocity. The Pathogens Workgroup spent much of FY06 focusing on inflow and infiltration – which are intricately linked with storm water flows -- at priority wastewater treatment plants in the watershed. The Pathogens workgroup is also setting the stage to focus on wet weather discharges in FY07. Passive treatment systems being implemented by the Abandoned Mine Drainage (AMD) workgroup to control pH and reduce metals are complicated by storm water runoff. Storm water is typically best managed by increasing ground infiltration. AMD treatment systems, however, are generally designed to prevent infiltration of runoff in order to preclude contamination of the water through contact with metals in the ground. These systems must address increased flows during storm events through other means. Storm water also plays a role in monitoring efforts by AMD workgroup members to develop correlations between streamflow and water quality and to develop a water budget for the AMD-impacted area of the watershed.

7. Low Impact Development Demonstration Program

Low-impact development (LID) is an ecologically friendly approach to site development and storm water management that aims to mitigate development impacts to land, water, and air by conserving or replicating natural systems. For storm water management, LID designs mimic the natural water cycle by using small-scale, decentralized practices that detain, infiltrate, evaporate, and transpire water. Through these practices three major goals of storm water management are met: reduction of peak flow, reduction of total volume, and reduction of pollutants.

When implementing LID, storm water controls such as bioretention gardens, green roofs, permeable paving, and infiltration areas are integrated into built and landscaped areas close to the source of the storm water. In addition to better management of storm water, LID techniques provide ancillary benefits, such as the reduction of the urban heat island effect, energy and water conservation, and improved aesthetics. It is the goal of PWD that be initiating the LID Demonstration Program, the benefits of this approach will be illustrated and these methods will become more familiar to designers, builders, developers, and community groups.

With funding from PADEP, PWD has administered the Technical Assistance Grant (TAG) program, which has supported the development of LID demonstration site plans for schools, community groups, and other nonprofit organizations. During FY 2005, PWD assisted with the creation of three site plans (including full construction drawings for two sites) for the School District of Philadelphia. In addition, a final site plan and construction drawings were completed for a parking lot bioretention project for the East Falls Development Corporation in concert with the City's Commerce Department. PWD also continues to provide technical assistance to applicants and recipients of PA-DEP's Growing Greener program. For instance, PWD is partnering with three local nonprofit organizations and one school to implement storm water management demonstrations utilizing Round V Growing Greener funding awards and provided design technical assistance to three nonprofit organizations for their Growing Greener Round VI applications.

During FY 2006, PWD completed the following LID project work:

- Wissahickon Charter School – Completed design of an outdoor learning garden and storm water management area at Wissahickon Charter School that will include rain gardens, porous paver installations, and subsurface infiltration
- East Falls Parking Lot – Bids were solicited for construction of parking lot and bioretention garden in East Falls.

- Baxter Visitors' Parking Lot – Began design of a bioinfiltration area that will manage runoff from a proposed visitors' parking lot at PWD's Baxter Water Treatment Plant

During FY 2007, PWD plans to complete construction at Wissahickon Charter School and the East Falls Parking lot, and to complete design and solicit bids for the Baxter Visitors' Parking lot bioretention area.

Finally, PWD is managing the implementation of two large-scale LID demonstration programs. The first is the Mill Creek Watershed Redevelopment Project, supported by PA-DEP Growing Greener funding. This program demonstrates LID and specific storm water best management practices as a tool reclaim vacant land and improve recreation facilities, while also creating a legacy of environmental education for school children and opportunities for experiential learning for people of all ages within highly urbanized, inner-city neighborhoods.

During FY 2006, PWD completed the following activities as part of the Mill Creek Watershed Redevelopment Project:

- Mill Creek Basketball Court – construction of a porous asphalt basketball court at the Mill Creek Playground
- Mill Creek Farm – implementation of storm water management elements at a new urban farm on vacant land, including swales and depressions to capture and infiltrate street runoff, a green roof on the farm shed, and a cistern that captures overflow from the green roof for farm irrigation
- N. 50th Street – Conversion of vacant lots to a community park and installation of rain barrels. Vacant lots were re-graded to prevent storm water runoff, and the downspout of an adjacent rowhouse was diverted to three rain barrels that provide a water supply for garden plots at the park. Rain barrels were also installed at several houses on the block to capture diverted porch roof runoff and provide a water source for the care of street trees that were planted as part of this project.
- West Mill Creek Playground – Design of an infiltration tree trench overlaid by porous pavers that will capture and infiltration runoff from the street and sidewalk, while increasing tree canopy and providing shade for the adjacent playground and houses.

During FY 2007, PWD plans to complete construction at the West Mill Creek infiltration tree trench and monitor all projects that were implemented under this program.

The second is a program entitled "Restoring Urban Watersheds in Philadelphia Using Decentralized Water Resources Management," funded by a STAG grant from the U.S. EPA. This is a long-term, comprehensive approach to addressing watershed degradation due to urban development. Integral to this approach is the development of land-based strategies to control the impacts of development and redevelopment on area rivers and streams, while at the same time enhancing community aesthetics and minimizing infrastructure maintenance and replacement costs. This project will pilot a range of decentralized storm water practices throughout urban areas of Philadelphia. The goal is to construct Low Impact Development (LID) demonstration projects appropriate to the urban environment and evaluate their environmental effectiveness, stakeholder acceptance, and the watershed-based life cycle cost benefit. The program will implement a comprehensive suite of land-based technologies, applicable to both redevelopment and retrofit of existing development, that provide for on-site management and re-use of storm water runoff, improvement of deteriorated drainage systems with modern conservation devices, educational programs, and assessment of public perceptions of LID in the urban context.

During FY 2006, PWD completed the following activities as part of this project:

- BLS Storm water Retrofit Phase I – Completed design and installation of native meadow at PWD's Bureau of Laboratory Services facility. The meadow project reduces runoff by converting lawn to meadow, and included re-grading to prevent runoff from flowing into an existing yard drain.
- BLS Storm water Retrofit Phase II – Began design of storm water management elements that will capture storm water from the BLS parking lot and the parking lot of an adjacent city-owned facility.
- 47th and Grays Ferry – Finalized design of a traffic triangle retrofit project that will divert runoff from adjacent streets and sidewalks to a vegetated depression that will allow storm water infiltration.
- Clark Park – Began design of a storm water management system that will divert storm water runoff from adjacent streets, parking lot, and proposed basketball court to a subsurface infiltration bed beneath the proposed basketball court.
- Venice Island – Began design of storm water management elements for recreation center and parking lot on Venice Island in Manayunk.
- With technical and financial assistance from PWD (through EPA STAG), the School District of Philadelphia constructed a new high school in West Philadelphia that includes a 9,800 SF vegetated roof. The remainder of roof runoff is collected in a 25,000 gallon cistern to be reused for toilet flushing. Other site BMP features include grass pavers and disconnected impervious surfaces.

During FY 2007, PWD plans to finalize design and construct the BLS Storm water Retrofit Phase II, 47th and Grays Ferry, and Clark Park projects and to begin design on several new projects, including storm water management areas at several parks.

F. Detection, Investigation, and Abatement of Illicit Connections and Improper Disposal

1. Compliance with Permit Requirements

The City of Philadelphia's Defective Lateral Detection and Abatement Program was developed under the City's initial Municipal Separate Storm Sewer System (MS4) permit signed in 1995 and further refined under a Consent Order & Agreement (COA), reached with the Pennsylvania Department of Environmental Protection (PADEP) on June 30, 1998. On March 18, 2004, the COA was officially terminated. However, the City has remained faithful to the terms of that agreement and many of the COA requirements have now been incorporated into the City's new MS4 permit. As in previous years, during Fiscal Year 2006, the results of dry weather outfall and subsystem sampling were used to evaluate priorities for the Defective Lateral Detection and Abatement Program.

i. Staffing

As in prior years, the City maintains 4 crews dedicated to the identification and abatement of defective connections. Additional resources such as CCTV truck and crews are regularly assigned as needed to assist the program.

ii. Funding

In addition to the staff resources dedicated to the identification and abatement of defective connections, the City funds abatement of owner-occupied, residential cross connections through the Cross Connection Repair Program. Funding for cross connection abatement and other customer assistance programs is budgeted at $2.5 million annually. During the reporting period, of the 69 abatements completed under the program, the City funded abatement of 66 cross connections at residential properties at an average cost of $4,586.72, for a total cost of $302,723.50. Additionally, 3 commercial properties were abated at an average cost of $10,123.46, for a total cost of $30,370.37. The total cost of the 69 abatements completed in Fiscal Year 2006 was $333,093.87.

2. Outfall Investigations

During Fiscal Year 2006, 97 outfalls not included in the Priority Outfall sampling program were inspected and 56 were sampled due to observed dry-weather flow. In addition, 90 outfalls were inspected and 76 sampled due to observed dry-weather flow under the Priority Outfall quarterly sampling program during Fiscal Year 2006. These samples are used to evaluate priorities for the Defective Lateral Detection and Abatement Program. A synopsis of the work in the priority areas is provided below.

i. T-088-01 (7TH & Cheltenham)

In this priority outfall area, as of June 30, 2006, 2,828 properties have had complete tests as defined by the MS4 permit. Of these properties, 130 (4.6%) have been found to have defective laterals and been abated.

Additionally, at the end of Fiscal Year 2002, six (6) dry weather diversion devices were installed to intercept contaminated flow within the storm system from five (5) identified areas and redirect the flow into the sanitary system. These devises are inspected regularly by the City's Collector System Flow Control Unit. The locations of these devices, the number of inspections, blockages, and discharges found in Fiscal Year 2006 are listed below:

Table 16 - Dry Weather Diversion Device Installation Locations

Location	ID#	Inspections	Blockages	Discharges
Plymouth Street, West of Pittville Ave.	CFD-01	34	6	1
Pittville Avenue, South of Plymouth St.	CFD-02	42	9	4
Elston Street, West of Bouvier Street	CFD-03	33	6	0
Ashley Street, West of Bouvier Street	CFD-04	26	5	1
Cheltenham Ave, East of N. 19 Street	CFD-05	33	9	1
Verbena Street, South of Cheltenham Ave.	CFD-06	26	0	0

Fecal coliform sampling at this outfall continues quarterly. Results for the outfall samples and a stream sample taken approximately 50 feet downstream of the outfall in Mill Run are listed below:

Table 17 – T-088-01 Quarterly Fecal Coliform Sampling

Date	Outfall (Fecal Colonies per 100 ml)	Stream (Fecal Colonies per 100 ml)
07/05/05	2,600	710
10/03/05	3,900	4,800
03/01/06	400	450
06/20/06	5,100	5,700

As part of the City's efforts to improve conditions at this outfall, stream embankment repairs and elimination of the pooling area on the outfall apron were proposed. Design work for these improvements was completed and the project was bid in Fiscal Year 2003. Construction was completed in Fiscal Year 2005.

ii. W-060-01 (MONASTERY AVE.)

In this priority outfall area, as of June 30, 2006, 610 properties have had complete tests as defined by the MS4 permit. Of these properties, 16 (2.6%) have been found to have defective laterals. All 16 have been abated.

Additionally, two (2) dry weather diversion devices were installed to intercept contaminated flow within the storm system and redirect the flow into the sanitary system.

These devises are inspected regularly by the City's Collector System Flow Control Unit. The locations of these devices and the number of inspections, blockages, and discharges in Fiscal Year 2006 are listed below:

Location	ID#	Inspections	Blockages	Discharges
Jannette Street, West of Monastery Ave.	MFD-01	27	3	0
Green Lane, North of Lawnton Street	MFD-02	27	3	0

iii. MONOSHONE CREEK OUTFALLS

Of the seven (7) storm water outfalls that discharge to the Monoshone Creek, the focus of the City's efforts is primarily just one outfall, W-068-05. This outfall is the largest in the watershed and essentially constitutes the headwaters of the creek since the historic creek has been encapsulated into this storm system and daylights at this outfall. This outfall is also the source of the majority of the fecal contamination in the creek. For this priority outfall, as of June 30, 2006, 2,360 properties have had complete tests as defined by the MS4 permit. Of these properties, 82 (3.5%) have been found to have defective laterals and subsequently abated.

In the spring of 2003, the City conducted CCTV sewer exams of both the storm and sanitary systems under Lincoln Drive. Given the high vehicle volume on this major artery for the City, this was a very difficult and time-consuming effort as all exams had to be done during weekends. A leak from the sanitary interceptor under Lincoln Drive, in the vicinity of Johnson Street, into the storm system was detected. The CCTV examinations showed that the integrity of the sanitary sewer was generally in excellent condition except for one area where bricks appeared to be missing in the vicinity of where the infiltration into the storm system was noted.

The City decided to move forward with a lining contract to address this situation. The contract provided for the lining of 3,160 feet of 2'-6" brick interceptor sewer under Lincoln Drive from Washington Lane (paper street only) to Arbutus Street. This scope included the entire length of sanitary sewer that is not physically lower in depth than the storm sewer system. The contract was bid, awarded, and completed in Fiscal Year 2004.

The City was also concerned about the erosion that had been occurring to the channelized section of Monoshone Creek at the W-068-05 outfall. The erosion had created a large pool at the outfall that the City believed exasperated the nuisance odors experienced and created an unsafe condition for small children that might wade in the creek. After discussion with the local community group, the Friends of the Monoshone, the City decided to make repairs to the channelized section to remove the pool and shore up the retaining walls. This work was designed as part of the sewer-lining contract above and performed at the same time.

Since that time, periodic follow up examinations of the storm system during dry weather periods have been conducted by the Industrial Waste Unit in attempts to locate additional isolated areas where fecal contamination may be occurring.

Additionally, the City of Philadelphia completed construction of a 1-acre storm water treatment wetland this past year at outfall W-060-10. This wetland treats the dry weather flow fed by springs in this outfall as well as the wet weather runoff from the outfall's 156-acre drainage area. During and following the construction of this wetland, the City has been continuing to investigate dry weather contaminations within this outfall area.

Fecal coliform sampling at these outfalls continues quarterly. A listing of the results for the W-068-05 outfall samples in Fiscal Year 2006 are listed below:

Table 18 - W-068-05 Quarterly Outfall Sampling

Date	Outfall (Fecal Colonies per 100 ml)
07/07/05	1,400
07/27/05	5,100
07/27/05	4,600
08/11/05	5,800
08/11/05	2,500
08/18/05	16,000
08/18/05	27,000
08/18/05	15,000
09/06/05	4,700
09/07/05	6,000
09/08/05	44,000
09/12/05	9,200
09/26/05	4,500
09/28/05	5,000
09/28/05	3,500
10/17/05	25,000
10/19/05	39,000
12/21/05	10
01/09/06	50
01/26/06	260
02/09/06	270
02/09/06	250
02/22/06	50
03/29/06	75,000
03/29/06	68,000
05/22/06	48,000
05/22/06	53,000

iv. P-090-02 (SANDY RUN)

The City has previously installed a dry weather diversion device to intercept contaminated flow within the storm system and redirect the flow into the sanitary system. This devise is inspected regularly by the City's Collector System Flow Control Unit and continues to function properly. The number of inspections in Fiscal Year 2006 was 42. There was 1 blockage and 7 discharges reported in conjunction with these inspections.

v. MANAYUNK CANAL OUTFALLS

Of the 13 storm water outfalls that discharge into the Manayunk Canal, the City is focusing on 7 that have recorded dry weather flow with some amount of fecal contamination. These 7 outfalls are listed below:

- S-051-06
- S-058-01
- S-059-01
- S-059-02
- S-059-03
- S-059-04
- S-059-09

In these 7 outfalls, as of June 30, 2006, 2,444 properties have had complete tests as defined by the MS4 permit. Of these properties, 59 have been found to have defective laterals and subsequently abated.

3. DYE TESTS AND ABATEMENTS

During Fiscal Year 2006, the Defective Connections Abatement staff conducted 3,799 complete tests. Of the complete tests, 95 (2.5 %) were found defective. A total of 66 residential abatements and 3 commercial abatements were completed. The total cost for these 69 abatements, both residential and commercial, was $333,093.87.

4. PREVENTION OF ILLICIT DISCHARGES

i. SEWER AND LATERAL DISCHARGES

The City requires plumbing permits for connections to the municipal sewer system. The permit affords the property owner an inspection of the plumbing work performed. Corrections of defective connections are confirmed to ensure that the ultimate discharge to the receiving waters does not contain sanitary waste.

ii. ABATEMENT OF RESIDENTIAL CROSS CONNECTIONS

The City maintains a Defective Lateral and Abatement Program in compliance with the MS4 permit issued by the Pennsylvania Department of Environmental Protection. The City requires abatement of all residential defective connections upon discovery. An annual funding allotment of $2.5 Million is available through customer assistance programs in the form of City-funded cross connection abatements and HELP loans. Information on the assistance programs accompanies the homeowner's notification of defect. The City also publicizes the assistance programs through bill stuffers to ratepayers, and through public education events. The City also maintains the legal authority to take administrative action to cease the pollution condition. During the reporting period, the City funded abatement of 66 residential cross connections at an average cost of $4,586.72, for a total cost of $302,723.50.

iii. ABATEMENT OF COMMERCIAL AND INDUSTRIAL CROSS CONNECTIONS

The City maintains a Defective Lateral and Abatement Program in compliance with the MS4 permit issued by the Pennsylvania Department of Environmental Protection. The City requires prompt abatement of all commercial and industrial defective connections upon discovery, and maintains the legal authority to take administrative action to cease the pollution condition. In Fiscal Year 2006, 3 commercial or industrial cross connections were abated.

5. INVESTIGATION OF ILLICIT DISCHARGE SOURCES

The City maintains a storm water outfall monitoring system in compliance with the MS4 permit issued by the Pennsylvania Department of Environmental Protection. All 434 of City's permitted storm water outfalls are routinely inspected such that all outfalls are inspected at least once per permit cycle. Those with dry weather discharges are sampled for fecal coliform and fluoride analysis. Outfalls are prioritized for investigative work by the Industrial Waste Unit or the Defective Lateral and Abatement Program. In addition, outfalls identified as priority outfalls under the MS4 permit are sampled quarterly.

The City also investigates all potential reports of an illicit discharge from the storm water system through either the Industrial Waste Unit or the Sewer Maintenance Unit. The City investigates and reports all discovered illicit discharges to receiving waters. During Fiscal Year 2006, the City investigated 47 sewage discharges.

In addition to programs above, the City also has initiated a monitoring and modeling effort within the separate sanitary sewer areas to target specific areas where infiltration and/or ex-filtration may be likely. In the summer of 1999, the City initiated a portable flow-monitoring program to augment monitoring data that was collected by an existing network of permanent monitoring sites at fixed locations. Under this program, fifteen (15) American Sigma 920 portable flow monitors were purchased. These monitors have multiple sensors that use a combination of pressure transducer and ultrasonic technologies for measuring depths and Acoustic-Doppler technology for velocity measurement. Additionally, a consultant, Camp Dresser & McKee, was chosen to assist the City in the startup of this program. Data from this program is routinely analyzed and compared to data provided from the City's extensive Storm Water Management Model (SWMM) hydraulic model.

One of the goals of the monitoring program was for the City's in-house instrument technicians to receive training and experience in the proper setup, use, maintenance, and trouble-shooting of flow monitoring equipment. Beginning with the third round of deployments in October 2000, the City's personnel began running this program completely in-house.

Another initiative started by the City is a very large undertaking to evaluate and enhance our existing sewer assessment program. The City awarded a contract for $5.7 Million over two years to the engineering firm of Hazen & Sawyer Environmental Engineers & Scientists to inspect approximately 200 miles of sewers in 9 pilot areas using CCTV equipment. Four of these areas (Manayunk, Rhawnhurst, Oak Lane, and Bustleton) are in separate storm and sewer system areas. Additionally, the consultant provided training to the City's in-house sewer inspection personnel on the standard NASSCO rating system. This consultants work was completed Fiscal Year 2006 and the City is now running the entire program in-house

6. 2006 MONOSHONE STUDY

In FY06, PWD conducted an analysis of the 82 defective lateral abatements and sewer relining work performed in the sewershed of outfall W-068-04/05 which discharges to the Monoshone Creek in the Wissahickon Creek watershed. The purpose of this analysis was to determine the water quality improvements achieved as a result of this work and to compare this improvement with the additional water quality benefits anticipated from the Saylor Grove Storm water Wetland BMP, also located in the Monoshone. The reductions achieved in fecal coliform concentrations and loadings in outfall W-068-04/05 as a result of defective lateral abatements and sewer relining, and a further comparison of these load removals with those anticipated from the Saylor Grove Storm water Wetland BMP during dry and wet conditions are provided in the figure and tables below.

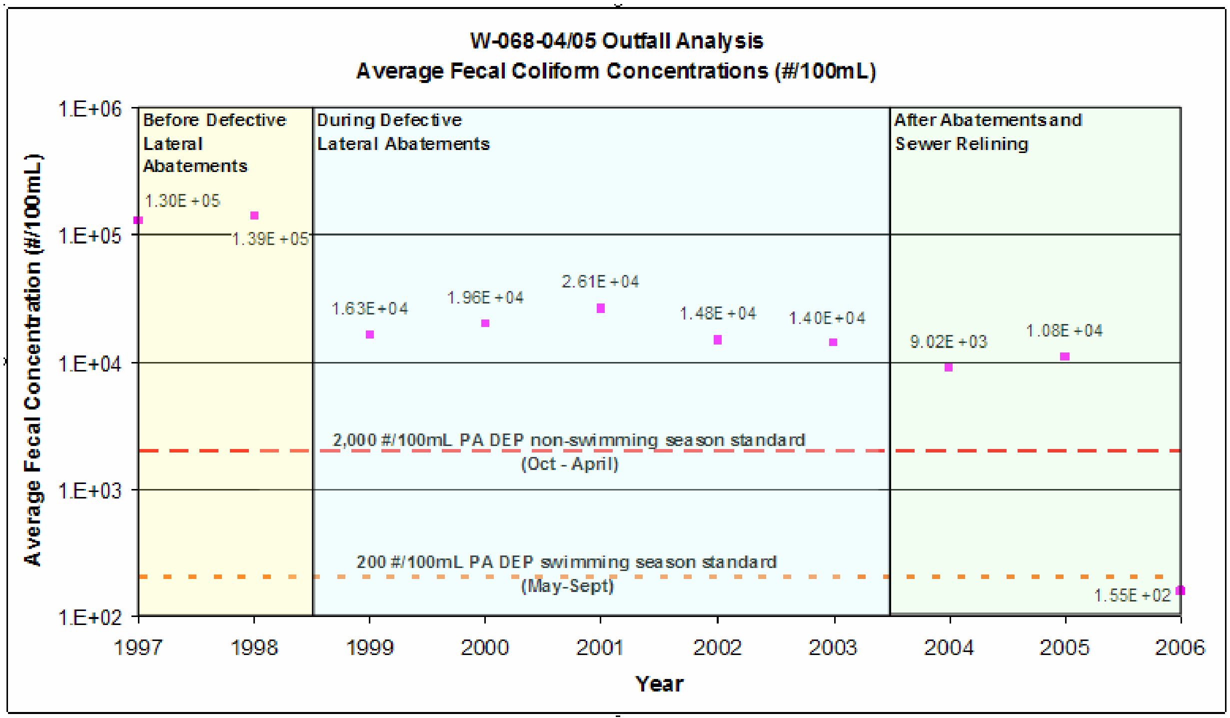


Figure 11 - W-068-04/05 Outfall Analysis

Table 19 - Fecal Coliform reductions observed in outfall W-068-04/05 (1999-2006)

	Concentration Reductions (#/100mL)		Loading Reductions (#/day)	
	%	log	%	log
Defective Lateral Abatements (1999-2003)	87%	7/8	88%	1
Sewer Relining (2004)	50%	1/3	44%	1/4
Total	93%	1 1/6	93%	1 1/6

Table 20 - Comparison of dry weather fecal coliform loading reductions at outfall W-068-04/05 with anticipated dry and wet reductions from Saylor Grove Wetland

		Costs	Load removal (#/day)	Removal/day/$	Removal/yr/$
Dry	W-68-04/05 Abatements	$288,800	68,021,714,536	235,532	85,969,272
	W-68-04/05 Sewer Relining	$729,600	4,131,423,512	5,663	2,066,844
	Saylor's Grove Wetland	$575,000	1,330,930,733	2,315	844,852
Wet	Saylor's Grove Wetland		210,572,567,127	366,213	133,667,803

This analysis shows that significant reductions have resulted from defective lateral abatements and sewer relining in outfall W-068-04/05. It is anticipated that the Saylor Grove wetland will play a significant role in further reducing bacteria contributions to the Monoshone. While reductions anticipated from the wetland are not significant in dry weather conditions when compared to the reductions achieved from defective lateral abatements and sewer relining, wet weather reductions anticipated from the wetland are almost 3 times the dry weather reduction achieved in W-068-04/05.

While fecal coliform contributions from outfall W-068-04/05 have been significantly reduced, this discharge consistently results in fecal coliform concentrations in excess of 3,000 #/100mL at the headwaters of the Monoshone. Sampling conducted downstream on the Monoshone, however, indicates that these concentrations are significantly reduced downstream as a result of die-off and dilution. Fecal coliform concentrations in the Monoshone prior to the confluence with the Wissahickon are consistently under the 2,000 #/100mL DEP non-swimming season standard and occasionally below the 200 #/100mL DEP swimming season standard. Both approaches, the Saylor Grove Storm water Wetland BMP designed to address wet weather fecal coliform contributions as well as TSS and other parameters, and the defective lateral abatement and sewer relining work which directly addresses dry weather fecal contributions, are valuable means of addressing the problem of elevated pathogen concentrations in the Monoshone Creek.

The complete text of this study is provided in a report as Appendix F.

7. End of Pipe Antimicrobial Pilot Study

In FY06, PWD purchased antimicrobial filtration fabric for installation in Monoshone Creek outfall W-068-05 to evaluate the effectiveness of this technology in reducing fecal coliform contributions to the Monoshone from outfalls with defective laterals. This filtration fabric is surface bonded with an antimicrobial agent which kills bacteria upon contact. PWD will install a limited quantity of this product at the end of outfall W-068-05 and will collect water quality samples of the dry weather outfall flow upstream and downstream of the filtration fabric to assess product performance. Based on the results of this sampling, more of product may be added to the installation to achieve the desired removal. If this technology proves effective in reducing fecal coliform concentrations in an outfall containing defective laterals, this same technology could be deployed at outfalls throughout the city which contain high bacteria concentrations as a result of defective laterals. The deployment of this technology has the potential to safeguard and improve the integrity of in-stream water quality during the ongoing effort to locate and abate the sources of dry weather bacteria in the sewershed of a given outfall.

G. Monitor and Control Pollutants from Industrial Sources

1. Inspections

As Title III sites are identified as part of industrial site inspections the City will expand the inspection to include a review of PPC Plan, on-site visual inspection, verify proper operations and maintenance of BMPs, and review any DMRs for compliance with conditions of the individual NPDES permit.

In subsequent annual reports, any identified sites will be listed as having been subjected to the inspection described above.

2. Industrial Waste Inspection Forms

The City has updated its Industrial Waste Inspection Forms used during inspections which take place during enforcement activities as part of its Pretreatment program. The updated Form was faxed to Jennifer Fields, Regional Manager, PADEP on March 29th, 2006.

H. Monitor and Control Storm Water from Construction Activities

1. Introduction

As a result of extensive efforts throughout Pennsylvania to improve and protect overall watershed health the relative condition of streams and rivers has been investigated and classified. Each stream has been identified by the State as whether or not it is attaining its designated use as a swimmable, fishable waterbody. Furthermore, those streams listed as not attaining their designated use were assessed as to which primary pollutants were attributed to the impairments. The majority of stream miles throughout Philadelphia are listed as impaired due to urban runoff. Uncontrolled and untreated urban runoff presents an ongoing negative impact to the receiving streams as a result of increased impervious areas providing a greater rate and volume of runoff reaching the surface waters through the municipal separate storm sewer system.

PWD and watershed partners located within the Darby-Cobbs Creek watershed collaborated under the Act 167 Watershed Management Planning effort led by Delaware County Planning Commission and developed a comprehensive document inclusive of a storm water Ordinance. The storm water Ordinance expanded upon the State model Ordinance by addressing issues identified with respect to the Watershed. PWD committed to enacting the Darby-Cobbs Creek Watershed Management Plan by signing a resolution in August, 2005 followed by adoption of the Storm Water Regulations that became effective as of January 1st 2006. A copy of the resolution along with excerpts of Ordinance and Regulation language were delivered to the State in compliance with the NPDES permit on December 23rd, 2006.

Storm water runoff is a concern both during construction and after construction. Active construction sites are the primary contributor of sediment to our waterways. The role of PWD in the plan review process has provided vastly improved oversight of site controls during earth disturbance activities and will assist in improving water quality. Additionally, post-construction storm water management plan review now extends beyond peak rate control and encompasses water quality and water quantity technical requirements for more frequent storm events. Efforts continue to be focused on improving plan review for both E & S as well as post-construction storm water management. The following discussion documents the progress made so far in terms of storm water runoff from construction activities including the collaborative between City Departments as well as between the City and State agencies.

During Fiscal Year 2006 PWD performed numerous tasks in direct compliance with the NPDES Permit as well as tasks supporting continuance and improvement of a growing storm water management program and Watershed program. Some of the Fiscal Year 2006 activities include the following:

- enacted Storm Water Regulations that are in compliance with the State Model Storm Water Ordinance;
- instituted a development process to incorporate multiple City departments;
- initiated an erosion and sedimentation control inspection program;
- reviewed numerous Storm Water management plans (E & S and post-construction Storm Water management) for compliance with the Regulations;
- coordinated reviews with Pa DEP on NPDES permit applications;
- released the Philadelphia Storm Water Management Guidance Manual;
- conducted storm water workshops for the engineering and development community;
- prepared Fact sheets and pamphlets on topics related to the changes in storm water requirements and the development process;
- launched a website for receiving PWD project submittals online.

The following discussion specifically documents progress made so far in terms of storm water runoff from construction activities including the collaborative between City Departments as well as between the City and State agencies.

2. CONSTRUCTION SITE RUNOFF CONTROL

PWD reviews E & S Plans for sites disturbing between 15,000 square feet (s.f.) and one acre of earth while following policies and practices as provided within the PADEP E & S Control Manual. As a result of plan review and coordination with the State, scheduled site inspections as well as timely responses to active construction site complaints have been incorporated into the storm water management program during Fiscal Year 2006.

During each site visit the inspector communicates with the construction manager and requests to see a copy of the on-site E & S Plan. Photographs are taken documenting site conditions and included as part of the inspection report. The City inspection report form is adapted directly from the DEP form. Copies of the inspection report detailing out-of-compliance items are distributed to the site manager and maintained as part of an electronic project file.

A total 63 E & S Control Plans have been received as of the end of this reporting cycle. This value includes site complaints which were typically not projects subject to PWD review. A total of 51 site inspections were performed for 33 individual sites between January 1st 2006 and June 30th 2006. Of these sites, 10 were visited due to complaints and several were coordinated visits with the Pa DEP designated engineer. Based upon the first six months of inspections the major compliance issues include improper use of silt fences, inadequate or lack of inlet protection, contractor not following the on site E & S Plan and a complete absence of E & S controls. The sites visited cover all of Philadelphia including both separate storm sewer areas and combined sewer areas as depicted in Figure 12.

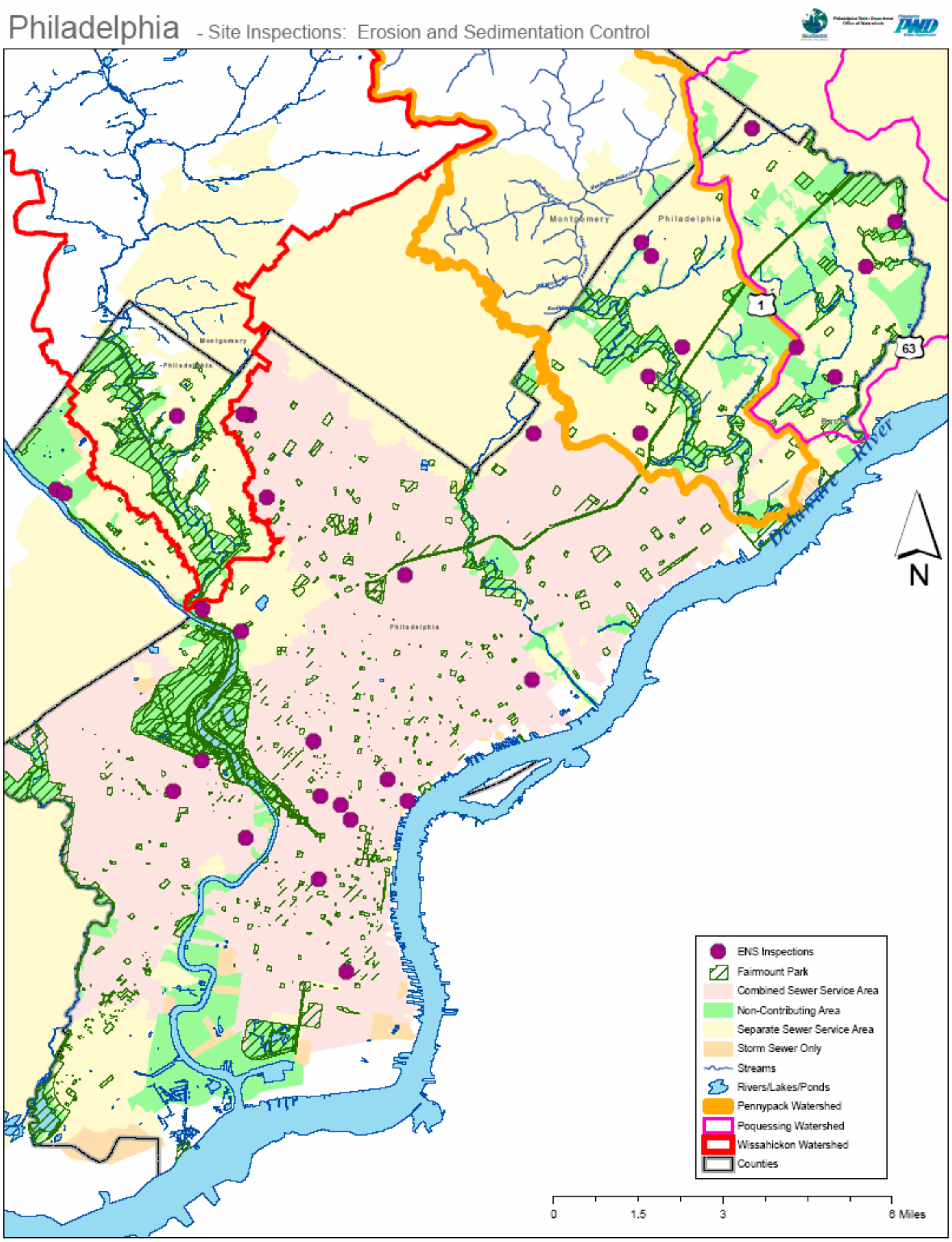


Figure 12 - Construction Site Inspections

As the E & S Control program moves forward, scheduled inspections and responses to complaints will be addressed separately. Plan reviews will continue for projects between 15,000 s.f and one acre of earth disturbance. Coordinated site visits between PWD and PADEP will continue throughout the permit cycle as needed and documented accordingly. The documentation of site visits will be refined through improved data collection which will allow for clear representation of projects located within separate or combined sewersheds. Subsequent annual reports will include compilations and assessments of site visits and improvement in E & S compliance both for the specific reporting year as well as over the course of the permit cycle.

3. Post-Construction Storm water Management in New Development and Redevelopment

The adoption of City wide Storm water Regulations as of January 1st 2006 has enabled Philadelphia to review plans for both new and redevelopment sites ensuring that water quality and quantity are part of the management plan. The Regulations focus on the Post-Construction Storm water Management Plan (PCSMP), which addresses more than the typical peak rate controls previously required. The role of storm water management has been expanded to address smaller more frequent storms in terms of water quality volume and channel protection for all development projects throughout the City. The Philadelphia Storm water Regulations are available online at www.phillyriverinfo.org but are also included within this report as Appendix G.

The Storm Water Regulations have been enacted to address the following technical components:

- *Water quality*: The 1st inch of precipitation over directly connected impervious cover must be recharged. Where recharge is not feasible or limited then any remaining volume is required to be subjected to an acceptable water quality practice.
- *Channel Protection*: The 1-year, 24-hour storm must be detained and slowly released over a minimum of 24-hours and maximum of 72-hours.
- *Flood Control*: Watersheds that have been part of an Act 167 planning effort are to follow the model results for flood management districts. In Philadelphia, Darby and Cobbs creeks watershed are subject to specified management districts. Projects outside of Darby-Cobbs Creeks watershed are currently treated as either a district controlling post-development peaks to pre-development peaks or are considered appropriate for direct discharge.
- *Non-structural Site Design*: Projects are required to maximize the site potential for storm water management through appropriate placement and integration of storm water management practices.

In addition to the technical criteria, storm water management requirements are clearly identified as applying to both new development and redevelopment projects. PWD in collaboration with other City departments recognized the need to appropriately insert PWD into the development process in order to inform the development community of the storm water requirements before extensive investment into the design has been expended. Under this premise PWD divided the Storm water Plan review into two components: the first being a conceptual review tied to the zoning permit; the second being the full technical plan review requiring approval prior to the building permit.

Conceptual plans are submitted online and must receive approval prior to obtaining a Zoning permit from Licenses and Inspections. The conceptual plan review phase enables PWD to clearly inform the applicant of stormwater management requirements applicable to their specific project. Since January 1st the PWD online project submittal system has received 364 conceptual plans for review.

Once conceptual approval has been received then the project can submit a full technical plan set addressing the stormwater regulations and other City plan requirements. PWD has received 105 full technical plan submittals between January 1 and June 30, 2006. It should be noted that this number does not include plans re-submitted for review, some of them multiple times. The distribution of development projects that submitted post-construction stormwater management plans for review is presented in **Error! Reference source not found.**Figure 13 below. Of the 105 plans, 59 are within the combined sewer areas. Of the remaining plans, 44 are located within the MS4: 15 plans within Pennypack watershed, 16 plans within Poquessing watershed and 11 within Wissahickon watershed. The remaining 2 plans are located within areas considered to be non-contributing to either the MS4 or combined system.

Any project exceeding one acre of earth disturbance is required to obtain a Pa DEP NPDES General Permit for control of stormwater runoff during construction activities. The City may not release the building permit until the State NPDES permit has been issued. As a result, a large collaborative effort has been initiated between PWD and Pa DEP in coordinating plan reviews between Departments. Since the beginning of the year there have been 47 coordinated permit applications submitted to the State that are undergoing a joint stormwater management review. In Figure 13 below, sites that are part of a coordinated City and State review are indicated with a blue marker.

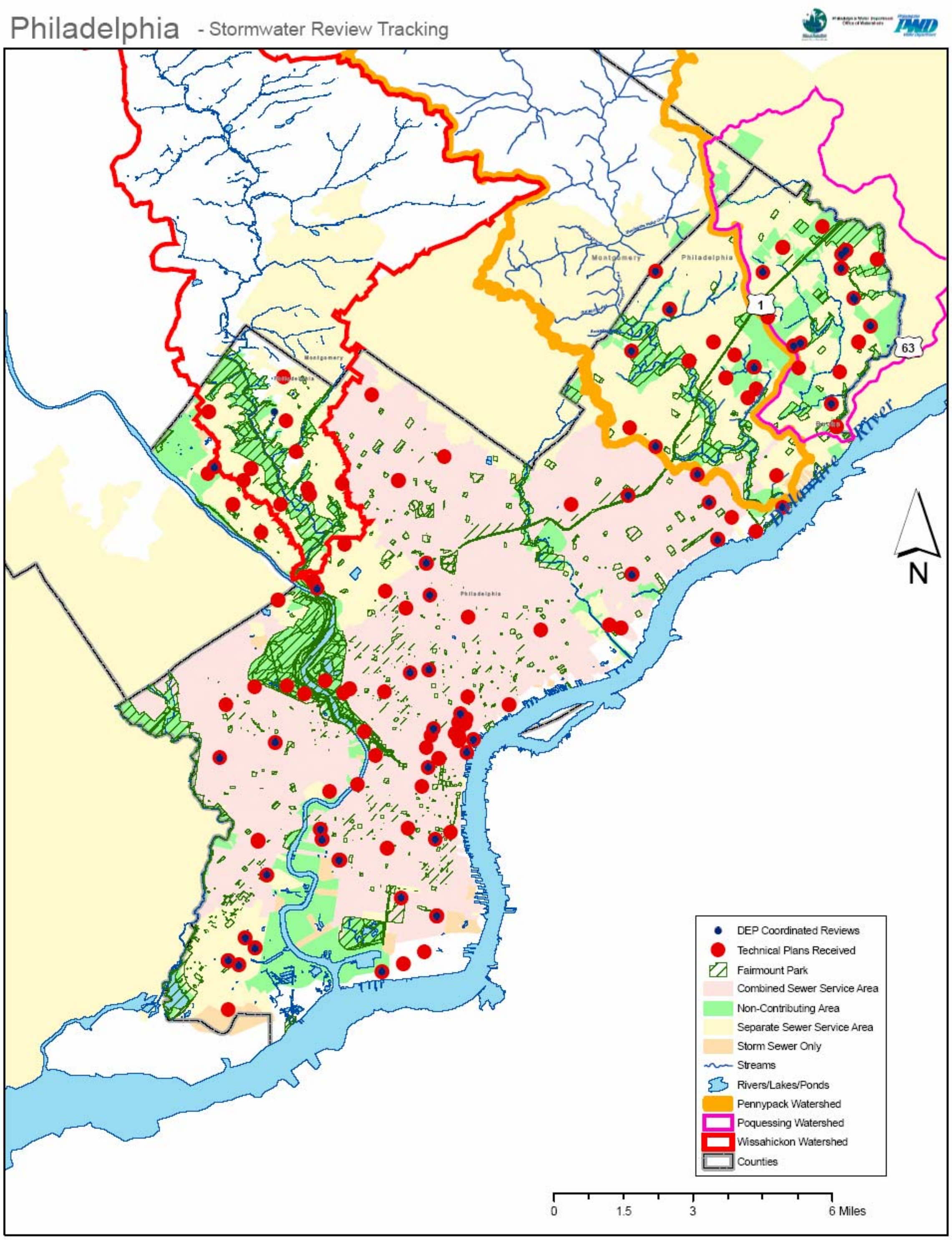


Figure 13 - Locations of Post-Construction Storm water Management Plans Received

Implementation of the Storm water Regulations will continue to improve storm water quality and quantity impacts as redevelopment and development continues across the City. Quantifying the impact of the Regulations in terms of total acres developed, area removed from contributing to the combined sewer system, volume of water quality managed, volume of storm water infiltrated, increase in management approaches (i.e. structural basins, green roofs, porous paving, rain gardens) will be incorporated into reports in upcoming years.

4. APPLICATION/PERMITS

The Department continues to serve as the Conservation District for the City of Philadelphia for NPDES Construction Permitting Requirements and Chapter 102 Regulations relating to Erosion Control. The City receives notifications through Act 14, Municipal Notification, by applicants applying for a permit to discharge storm water from construction activities. The notifications are reviewed and recorded as part of the data collection process for a known development proposal.

Not only does PWD receive notifications but also coordinates review of NPDES application plan sets and calculations. Since a Post-construction storm water management plan must be submitted to both the State and the Municipality for sites disturbing over one acre of earth, the City recognizes the importance of ensuring both municipal and state engineers are reviewing the same plans and are aware of each others technical requirements.

5. STORM WATER BMP HANDBOOK AND EDUCATION MATERIALS

Philadelphia Water Department (PWD) released the Storm Water Management Guidance Manual (Manual) in concert with the Storm water Regulations going into effect as of the first of January 1st 2006. The Manual was created with a focus on urban storm water management and includes Stormwater Management Practice (SMP) details, development processes in the City, calculation worksheets and supporting reference material. The Manual is intended to be a dynamic document allowing updates as needed with the most recent version available for electronic download at www.phillyriverinfo.org. The upcoming Fiscal Year will also include issuance of a checklist and fact sheet specifically geared towards for E & S Controls for Philadelphia.

I. MISCELLANEOUS PROGRAMS AND ACTIVITIES

1. PUBLIC EDUCATION AND AWARENESS

Most of the city ordinances related to this minimum control are housekeeping practices that help to prohibit litter and debris from actually being deposited on the streets and within the watershed area. These include litter ordinances, hazardous waste collection, illegal dumping policies and enforcement, bulk refuse disposal practices, and recycling programs. If these pollutants eventually accumulate within the watershed, practices such as street sweeping and regular maintenance of catch basins can help to reduce the amount of pollutants entering the system and ultimately, the receiving waterbody. Examples of these programs are ongoing and were presented in the NMC document. The City will continue to provide public information about the litter and storm water inlets as part of its implementing this minimum control, as well as continue to develop the following new programs.

From the moment the City of Philadelphia began providing water to its citizens there has been a need to create partnerships to protect the water supply. In our earliest days it was through the creation of Fairmount Park. Today we comply with state and federal regulations that require citizen participation. More importantly however, the Philadelphia Water Department through its Public Education Unit, has for more than 21 years voluntarily reached the public through an aggressive education and community outreach program that serves as a model for utilities across the country. Through these programs, the Water Department raises public awareness and understanding of storm water problems and issues. Educational materials and programs are distributed and hosted at these events and at the Water Department's premier watershed education center – The Fairmount Water Works Interpretive Center. In addition, monthly billstuffers are included with customers' water and sewer bills, reaching over 460,000 households. And, the City continues to facilitate watershed stakeholder meetings to unify public participation in the surrounding counties and to address the issues pertaining to storm water management on a watershed scale.

BILLSTUFFERS

Billstuffers are regularly produced by the Water Department as an educational tool for disseminating information pertaining to customer service and environmental issues. Specific billstuffers are designed on an annual basis for the CSO, Storm water and Watershed Management programs to address the associated educational issues. These billstuffers reach over 470,000 water and wastewater customers. The environmental bill stuffers distributed in 2005/2006 include:

- Waterwheel (April, 2005)
- Streets Department Curbside Recycling Program (May, 2005)
- Streets Recycling (August, 2005)
- In's & Out's of Sewer Inlets (Nov., 2005)
- Trash & Recycling Schedule (Dec., 2005)
- Waterwheel (Jan., 2006)
- Streets Recycling (March, 2006)
- Streets Recycling (May, 2006)
- Water and Sewer Rates (July, 2006)
- Streets Recycling (August, 2006)
- Ins and Outs of Sewer Inlets/Proper Disposal of Grease (Oct., 2006)

WATERWHEEL WATERSHED NEWSLETTERS

The Water Department's watershed newsletters are usually published on a bi-annual basis and target specific information to the residents living within a particular watershed. In this manner, citizens can be kept informed of departmental water pollution control initiatives specific to the watershed in which they live. Issues are sometimes published in the form of billstuffers and sometimes as a brochure (when combined with the annual drinking water quality report). Newsletters issued in FY'06 include:

- Winter '05 Edition – This issue, in the form of a billstuffer, featured PWD's River Conservation Plans, an Update on the Tacony-Frankford River Conservation Plan, and the Poquessing River Conservation Plan

- Spring '05 Edition – This issue, in the form of a mailed newsletter, featured an update on the Pennypack River Conservation Plan, Watershed Events and Seminars, in addition to the department's source water protection plan and its annual drinking water quality data.

- Winter '06 Edition – This issue, in the form of a billstuffer, featured Watershed Improvements and Accomplishments including an update on the Pennypack Watershed Partnership, Goals for Philadelphia's River Conservation Plans, and the Storm water BMP Recognition Program.

COMPREHENSIVE EDUCATION MATERIALS

The following projects were initiated, completed or ongoing in 2006:

- Watershed educational partnerships (continued from 1999) with Bodine High School, Edison-Faira High School, Fairmount Park, Phila. Recreation Dept., Academy of Natural Sciences, Lincoln High School, Turner Middle School, Senior Environmental Corps, and the Schuylkill Center for Environmental Education.

- Completion of the Tookany-Tacony/Frankford (TTF) Watershed Management Plan

- Completion of the Tacony-Frankford River Conservation Plan.

- Establishment of a 501c(3) TTF Partnership Entity to implement the final plan

- Completion of the draft report for the Pennypack Creek River Conservation Plan

- Completion of Year One studies and public outreach for Poquessing Creek River Conservation Plan

- The creation of the Wissahickon Watershed Partnership and the initiative of a number of outreach programs

- The development of a new PWD website (www.phillyriverinfo.org) for the new Storm water Regulations, BMP manuals (developer's and homeowner's versions) and all Office of Watershed programs.

PWD Public Education Outreach

- ***Activity Books***

One of the Water Department's most successful community publications is the student activity book (grades 3 – 8) "Let's Learn About Water." This publication develops the concepts of definition of a watershed, impact of non-point source pollution, and personal responsibility for protecting our water supply. It is in great demand by schools, communities and government officials. This book was developed with the Partnership for the Delaware Estuary and was funded in part through DEP Coastal Zone Management funds. Future editions will include descriptions and activities for various city watersheds. The curriculum has already been used in a number of middle schools to meet state required science-based credits. In 2005, the Activity Booklet was updated and made full color. The Fairmount Water Works Interpretive Center was also highlighted in some of the activities to encourage students to visit with their families.

- ***Public Education Unit in Schools***

PWD's Public Education Unit makes presentations at area schools, organizations and community events, providing information on all topics regarding the urban and natural water cycles and watersheds. Teacher workshops and school-based programs and exhibits are also held daily at the Fairmount Water Works Interpretive Center (FWWIC).

- ***General Education Projects***

General Educational projects in 2005/2006 - A great variety of public information materials concerning the storm water/watershed management in relation to the watershed framework were developed as a result of the watershed partnerships and river conservation plans, including: fact sheets, press releases, tabletop exhibits, brochures, watershed surveys, websites, watershed walks, and presentation materials. Materials developed for a specific watershed are discussed in the Watershed Planning sections as appropriate.

Some of these publications/projects include:

- WaterWheel - Issue included with 2006 Water Quality Report (April/May 2006)
- WaterWheel – Issue included in December 2005 billstuffer.
- 2004 Annual Water Quality Report featuring special supplement on Source Water Assessment and Protection (April/May 2004)
- 2005 Annual Water Quality Report featuring special supplement on Source Water Assessment and Protection (April/May 2005)
- Fairmount Water Works Interpretive Center: Water in Our World (printed several runs 5,000 each time distributed at the Center and other visitor centers and public areas – 2005
- Keeping America's Waterways Beautiful: PWD's Flower Show Exhibit Features Best Management Practices in Landscaping and Gardening – March 2005
- 5th Annual 2006 Southeastern Pennsylvania Coast Day & BYOB Fishing Event (contributed funds for brochure)

- PWD Annual Report Fiscal Year 2005 - annual report features watershed/storm water projects

- Clean Water Begins and Ends with You! Calendar Contest: distribution of calendars and SEPTA car cards featuring winning entries

- Guide for Hydrant Use & Street Water Discharges (best management practices for construction contractors) - in development by Industrial Waste.

- Learn About Your Water from the Comfort of Your Own Home (PWD and Partnership for the Delaware Estuary videos running on Philadelphia's Government Access Channel)

- Another Philadelphia First: Online Forecast System Predicts Schuylkill River Water Quality: RiverCast Unveiled - June 2005

- Southeast Water Pollution Control Plant Employees Receive Platinum Award, Recognizing Environmental Excellence in Wastewater Treatment, National Association of Clean Water Agencies Award - May, 2005

- Pennsylvania Has a Coast? Travelers learn about the Delaware Estuary and the region's premiere ecotourism center (signs on display at the Philadelphia International Airport)

- Know Your Watershed: New Signs Installed in Tookany/Frankford Watershed – July 2005

- You 'Otter' Know: Schuylkill River is Healthier than Ever

- Clean Water Begins and Ends With You! Drawing Calendar Contest - Awards Ceremony at the Fairmount Water Works Interpretive Center; Students' drawings were on display at the Center.

- Fairmount Water Works Interpretive Center – educational brochure for teachers

- First Urban Shad Watch at the Fairmount Water Works Interpretive Center – April 2005. Second annual event held April 2006.

- Catch of the Day – Fish paintings for children

- "Fish don't talk, but what do they tell us?" Aquatic biologist' presentation on how many species of fish have returned to the Schuylkill River

- What's in the River Today? New Exhibit featuring otter caught on tape

- Name the Shad; Name the Otter Activity

- Fish Facts – educational activity booklet, filled to the gills with activities about fish

- ***First Urban Shad Watch at the Fairmount Water Works Interpretive Center***

Season of the Shad Celebration Featuring: Native American Foodways Demonstrations - Fishnet Weaving and Shad Catching, Cooking and Drying Methods

- ***Saturday Morning Family Programs at the Fairmount Water Works Interpretive Center (Spring 2006)***
  The Thirsty Land! Everyone has a Watershed. Where's yours? (April)
  The Dirty Truth: The Scoop on Poop and Pollution (April)
  An Expedition in Time: Explore water pollution now and then during
  Ready? Set. Navigate! (May)
  A Delicate Balance: Exploring the Relationship of Land and Water during
  Choose it. Use it! …Abuse it? Lose it. (June)

- ***Travel Through Time Tours:*** Experience our past, examine our present, explore our future (May{for Drinking Water Week})

- ***Drinking Water Week at the Fairmount Water Works Interpretive Center*** (PWD water treatment engineers and plant managers introduced students to water treatment processes)

- ***Know Your Watershed:*** New Signs Installed in Tookany/Frankford Watershed – July 2005

- ***New Skimmer Vessel Commissioned to Improve Water Quality*** -
  The Water Department, in partnership with the Philadelphia Department of Public Health, the Oliver Evans Chapter of the Society for Industrial Archeology and the Atwater Kent Museum of Philadelphia, is celebrated 200 years' worth of efforts to clean the Schuylkill and Delaware Rivers - July 16, 2005

- ***New PWD pontoon boat commissioned and used to assist with removal of flood debris in the non-tidal Schuylkill*** – June 2006

- ***Clean Water Theater***: videos and DVDs available for public distribution

- ***5th Annual 2006 Southeastern Pennsylvania Coast Day Event*** – September 16, 2006

- ***Return and Rededication of the Fisherman Statue*** - esplanade exhibit at Fairmount Water Works Interpretive Center

- ***PWD Flower Show*** -
  The PWD Public Affairs Division participates in the PA Horticultural Society's annual Flower Show each year to inform citizens of its biosolids products in addition to providing tips on how garden and home water conservation can provide a powerful tool for storm water management at the residential level. The PWD Public Affairs Division participates in the PA Horticultural Society's annual Flower Show each year to inform citizens of its biosolids products in addition to providing tips on how garden and home water conservation can provide a powerful tool for storm water management at the residential level.

- ***PWD Awarded for 2006 Flower Show Exhibit***:

- ***Nature's Solution to Urban Runoff:*** Saylor Grove Storm water Wetland is Featured in PWD's Flower Show Exhibit -
  The Philadelphia Water Department and the Partnership for the Delaware Estuary Inc. are presenting "Saylor Grove Storm water Wetland: Nature's Solution to Urban Runoff" at

the 2006 Philadelphia Flower Show. The exhibit features a genuine storm water wetland project that the Water Department is undertaking at Saylor Grove, located at Lincoln Drive and Wissahickon Avenue in the Northwest section of Philadelphia.

- ***Fairmount Water Works interpretive Center -***
The City's Storm water Management and Source Water Protection programs are inherently linked, as surface water is the source of the city's drinking water supply. Through programs offered at the Interpretive Center, the City provides public education about the urban water cycle and the role of environmental stewardship through tours of the department's drinking and wastewater treatment plants. Students in Philadelphia and surrounding communities learn about storm water pollution prevention through a series of educational activities, most notably the Summer Water Camp and Urban Ecology programs.

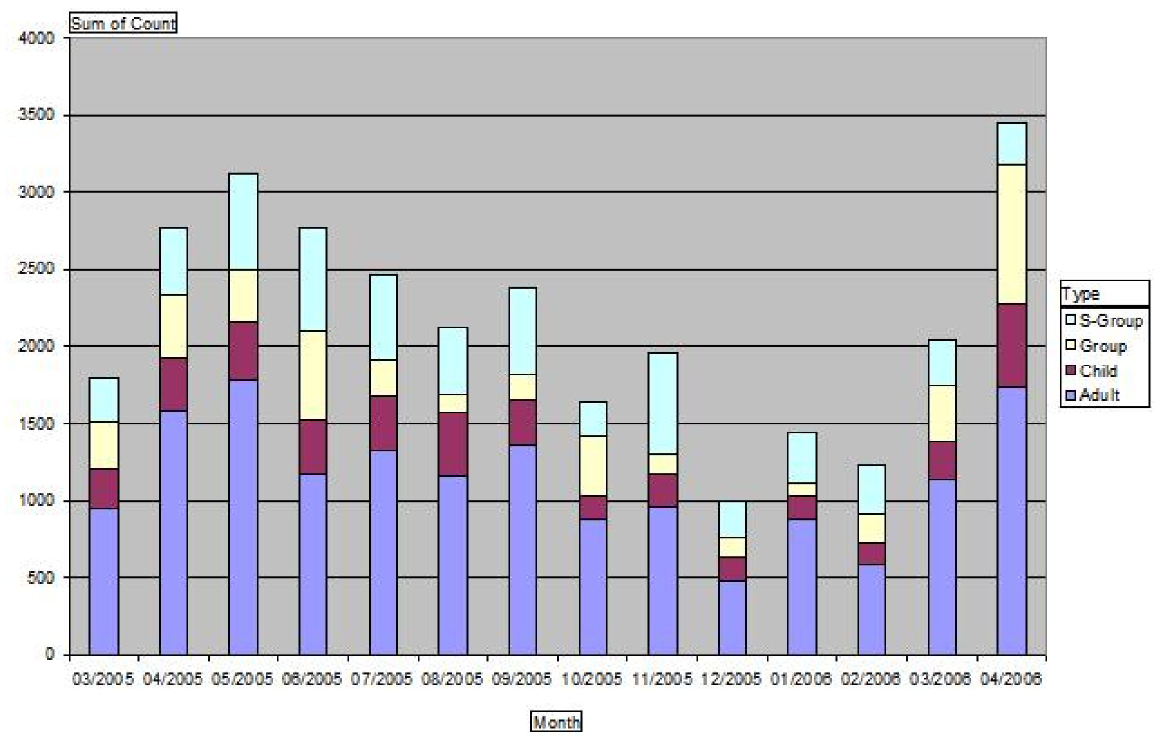


Figure 14 - Attendance at the Fairmount Waterworks Interpretive Center

- ***The Scoop on Poop and Pollution -***
Interpretive Center Educator Brian Rudnick created a novel approach for FWWIC visitors gain a better understand of a common urban watershed problem -- pollution from storm water runoff. As part of his educational program, Brian "introduced" visitors to new students Alice and Sunny, who walked their faithful dog Schnitzel to their new schoolyard. Brian encouraged the visitors to create a short skit, challenging them to give Alice and Sunny, the "scoop on poop" when Schnitzel forgets himself in the schoolyard. Visitors were encouraged to use the exhibits to complete activities in story form.

- ***The Thirsty Land –***
Everybody has a watershed. Where's yours? From Cobbs Creek to the Poquessing, there's a watershed near you. Some watersheds are small, some large. Drew Brown and Jacquelyn Bivins of the Philadelphia Water Department are helping eager Philadelphians explore their local watershed

via The Thirsty Land program at the FWWIC. Participants build a model watershed and learned how to protect their watersheds from storm water runoff pollution. Jackie and Drew explain where Philadelphia is located in the Delaware River Basin Watershed, and how the Delaware and Schuylkill Rivers provide drinking water to nearly 1.5 million people in Philadelphia.

- ***Promoting Clean Water Creatively -***
  The Fairmount Water Works Interpretive Center was proud to host an award ceremony honoring 16 student artists, all winners of a city-wide drawing contest. The contest provides students with a better understanding of how storm water runoff pollution adversely affects our local waterways. The FWWIC was the ideal place to hold the ceremony and serve as the official "art gallery" for the budding artists' work, as the contest's theme is closely aligned with the environmental education messages taught at the Center.

  Philadelphia Mayor John F. Street and other city officials recognized the students and their teachers during the ceremony at the FWWIC in April. The Clean Water Begins and Ends with You! Drawing Contest, sponsored by the Philadelphia Water Department and the Partnership for the Delaware Estuary, was open to Philadelphia public, private and parochial students ranging in age from kindergarten through 12th grade.

- ***Fish don't talk, but what do they tell us? -***
  A lot, actually. Did you know that in the late 1980s, only 11 species of fish were found locally in the Schuylkill River? More recently, aquatic biologists have identified 37 species in the river. What does that tell us? The health of Philadelphia's rivers is better than ever. And that's a good reason to celebrate.

- ***1st Urban Shad Watch -***
  Every, April, the FWWIC sponsors the First Urban Shad Watch. Philadelphia Water Department aquatic biologists Lance Butler and Joe Perillo are on hand to give presentations on the species of fish found in the Schuylkill, and a unique demonstration of the fish ladder at the Fairmount Dam.

  Kids who came to the shad watch are able to take home their fish paintings and a special, educational booklet, that was filled to the gills with activities including a word search puzzle of Pennsylvania Fish and All About Fish, a glossary that helps identify the parts of a fish. The FWWIC partnered with the Pennsylvania Fish and Boat Commission to develop the booklet, and we are grateful to them for their support.

- ***WOW! The Wonder of Water! -***
  Water utilities across the United States, Canada and the United Kingdom celebrated the 30th anniversary of Drinking Water Week in May 2006. The FWWIC hosted two Drinking Water Week events sponsored by the Philadelphia Water Department. Drinking Water Week was established by the American Water Works Association to promote the importance of safe, clean water – a resource whose precious value is often forgotten or taken for granted. The FWWIC is proud to participate in this international celebration. Here's a snapshot of typical Philadelphia events:

- ***Ever wonder about water? -***
  Middle school students from Cornerstone Christian Academy joined several water treatment engineers from the Philadelphia Water Department to celebrate Drinking Water Week at the FWWIC, where they learned about water cycles, water treatment processes and aquatic biology.

- ***Travel Through Time Tours -***
  As any FWWIC Tour Guide knows, Philadelphia was the first major municipal water supplier in the United States. But what came before the Fairmount Water Works and what is the Philadelphia

Water Department doing now to provide safe water to the City? Citizens throughout the watershed, who participated in our Travel Through Time Tours, learn all about Philadelphia's historical, contemporary and future efforts in water treatment and supply. Guests are treated to free bus tours to several former and current water facilities as the Drinking Water Weeks activities continued.

The Travel Through Time Tours starts at City Hall, the former site of the city's first pumping station, Center Square, where Drew Brown, manager of public education, explains the history of water supply in Philadelphia.

From there, guests traveled to the Interpretive Center where FWWIC Tour Guide Ray Finkel explains the vital role the Fairmount Water Works played in the development of the City. At the Center, guests view a video that details the history of water in the 19th century Philadelphia.

Next, our guests continue on to the Belmont Water Treatment Plant by route of West River Drive, giving passengers a scenic view of the Schuylkill River, a source of Philadelphia's drinking water. Here, Ed Grusheski presents a slide presentation on the history of the Belmont plant.

Finally, Nicole Charleton, Pilot Plant Engineer, provids guests with a tour of one of PWD's research plants where they glimpsed future endeavors for water treatment.

- ***Get Out of Bed, Sleepyhead! Learn About Your Watershed.***
  This past spring, our Interpretive Center Educators conducted a series of family-orientated educational programs. The Saturday Morning Family Programs provide fun and interesting ways to learn about Philadelphia's watersheds and how to protect our water resources. The Saturday Morning Family Programs proved to be such a success that the FWWIC staff has decided to continue the series this fall.

- ***Choose it. Use it! …Abuse it? Lose It!***
  Every day, people make choices about how they use the land around them – often without considering how land use will affect the water they drink. In June, visitors to the FWWIC ventured on a scavenger hunt through the exhibits to learn the history of land usage in Philadelphia. They used modern land-use maps to guide them through their journey of discovery, and learned how and why attitudes have changed about using land and protecting the water around us. Interpretive Center Educator Ellen Schultz, creator of Choose It. Uses it!...Abuse it? Lose It! was on hand to help visitors make the important connections during the scavenger hunt.

- ***Citizen Advisory Committee (CAC) and other Partnership Projects***

- ***Water Quality Citizens Advisory Council***
  In 2001, the Water Quality CAC was formed from a merger of the Storm water and the Drinking Water Quality CACs. Over the past few years, source water protection had become more of a concern for drinking water quality. The Drinking Water CACs focus has been drawn naturally toward non-point source pollution, a focus traditionally undertaken by the Storm water CAC. Finally, this merging of the two CACs complemented the PWD's, DEP's and EPA's new approach to looking at and addressing water quality issues on a holistic basis. The Partnership for the Delaware Estuary facilitates CAC meetings. The committee consists of representatives from the following groups: Tookany Creek Watershed, Academy of Natural Sciences, Action AIDS, Bridesburg Civic Association, Bucks County Water & Sewer Authority, Center in the Park Senior Enviromental Corps, Clean Water Action, Cobbs Creek Community Environmental Education Center, Delaware River Basin Commission, Delaware Valley Regional Planning Commission, Drexel University, Eastwick PAC, Fairmount Park Commission, Frankford Group Ministry, Friends of Fox Chase Farm, Friends of High School Park, Friends of Manayunk Canal, Friends of

Pennypack Park, Friends of Poquessing Creek Park, Friends of Tacony Creek Park, MANNA, Mayor's Commission on Literacy, PA DEP Water Supply Division, Partnership for the Delaware Estuary, PA Environmental Council, PennPIRG, PA Horticultural Society, Pennypack Environmental Center, Pennypack Watershed Association, Phila. Health Department, Phila. Corp. for Aging, School District of Philadelphia, Schuylkill Center for Environmental Education, Schuylkill Navy, Schuylkill River Development Corp, Schuylkill River Heritage Corridor, Southhampton Watershed Association, Stroud Water Research Center, US EPA Region III, Wissahickon Charter School.

- ***Clean Water Partners***

  Clean Water Partners is a project designed to reduce non-point source pollution from retail and commercial businesses that will be implemented in several commercial districts in Philadelphia and Chester Counties. In 2005/2006, the Partnership developed and disseminated a brochure to over 2000 groups/individuals, including municipal officials, watershed associations, environmental advisory councils (EACs). The Partnership had 15 resulting responses from groups expressing interest in the Clean Water Partners program. Direct contact was made with 55 groups through a personalized letter and at least one phone call. In total, 41 groups expressed interest in the participating in the Clean Water Partners program, including EACs, watershed groups, business groups, and municipalities. The program coordinator made 33 presentations describing this program and educating 192 individuals about storm water runoff pollution prevention during this partner recruitment phase.

- Program literature and training materials were developed based on the results of the Partnership's Clean Water Partners pilot. Four basic Clean Water Partners educational pieces were developed to support this program, including:

  - Eight-page Good Housekeeping Handbook
  - Clean Water Partners Auto Service Sector Fact Sheet
  - Clean Water Partners Food Service Sector Fact Sheet
  - Clean Water Partners Site Survey Form and Pledge Certificate (Developed to standardize education program, site visit/survey procedures, and facilitate pledges.

- Additional training materials were developed to support program partners and assist with program implementation. These included: Sample Kick-off Letter, Flyers, Sample Press Release, Training Packet and Clean Water Partners Powerpoint Presentation.

  The current seven active program partners in Pennsylvania include: Abington Township EAC, Chester-Ridley-Crum Watersheds Association, Friends of the Wissahickon, Marcus Hook Boro EAC, Norwood Boro, West Goshen Township, and University City. In New Jersey, Gloucester City is the only active program partner. In Delaware, Delaware City is the only active partner.

- ***Annual Earth Day Service Project:***

  Community and watershed volunteers participated in the Water Department- and Storm water CAC-sponsored annual Earth Day service project by installing storm drain curb markers throughout the City. Volunteers used the new curbmarkers developed by PWD and PA Coastal Zone Management Project to stencil the message "Yo!!! No Dumping! Drains to River!" beside a fish. By developing a more durable and easily applied curb marker, volunteers are able to cover more area. In spring and summer 2006, over 15 organizations participated in the storm drain marking activity. Throughout these months, approximately 3,000 storm drains were decaled by the summer in the City of Philadelphia.

- ***"Stormy Weather" Video:***

  The video focuses on individual responsibility as a critical success factor in improving storm water quality. The deleterious effects of storm water pollution on the physical and biological community in aquatic systems are addressed through various anti-litter messages, such as: litter control, responsible household and pet waste management, and the proper use of inlets. The video is distributed to schools, watershed organizations and interested civics. The video has been distributed to over 300 environmental groups on an annual basis, various citizen groups, and schools, and has become a part of the environmental education curriculum for Delaware schools. The City's cable channel is showing the video twice a day.

- ***"Clean Water Begins and Ends with You" Update***

  The Partnership for the Delaware Estuary and the PWD, sponsored its seventh drawing contest for Philadelphia students grades K-12 in January 2005. Students were required to draw an illustration that shows how Philadelphians can help prevent storm water runoff pollution. First prize drawings were used to promote storm water pollution prevention messages on SEPTA buses and in the creation of a "Clean Water Begins and Ends with You" calendar. In 2005, there were almost 1,500 drawings entered into the contest, with 44 schools participating. This year's award ceremony was held in April 2005 at the Fairmount Water Works Interpretive Center.

- ***Clean Water Theatre Update***

  Working in partnership with the Academy of Natural Sciences, the Partnership for the Delaware Estuary, the PWD CAC offered the Clean Water Theatre's "All Washed Up" program which uses local artists and musicians to engage public, private and parochial schools throughout the City of Philadelphia in becoming active and informed stewards of our environment. The setting of the 20 minute play is in an urban park that has a river running through it. The story is built around three characters (an old man who is the caretaker of the park and who had been a vaudeville song and dance man in his youth, and two teenagers – a boy and a girl) that explore the importance of environmental stewardship and clean water. While there were not any live performances of Clean Water Theatre in 2005, many video and DVD copies of the performance was distributed to teachers and local educators.

- ***Senior Citizen Corps (SEC):***

  The Water Department continues to work with the Senior Citizen Corps to address storm water pollution problems and water quality monitoring programs for the Monoshone Creek, a tributary to the Wissahickon Creek and to the Tookany Creek. The SEC performs biomonitoring, collects water samples, and conducts physical assessments of the stream. The Water Department assists SEC efforts through the provision of municipal services, education about storm water runoff and the department's Defective Lateral Program, and mapping services such as GIS. Meetings are held monthly. The Corps has also partnered with PWD on its Saylor Grove Wetland Demonstration Project, assisting with public education and outreach, and providing tours to local students beginning fall 2006.

- ***Safe Boating Program***

  PWD has also initiated an outreach, education, and notification program for marinas and personal watercraft that may be situated near CSO outfalls on the Delaware River. PWD has held meetings with representatives from DEP's Coastal Non-Point Pollution program, the Partnership for the Delaware Estuary and administrators of similar programs in New Jersey to develop a host of educational and environmental management measures. Our proposed approach entails conducting a survey of existing marinas and boat launches and their use profiles (personal, charter, open, closed craft, etc.). We would then initiate meetings with the individual marinas to implement site-specific notification mechanisms (brochure, flags, sign, etc.) that list precautions that should be exercised by those engaging in contact recreation within the marina and/or on the open water. In addition, these meetings would discus how the marina can adopt environmentally responsible operation and maintenance practices for personal and multi-purpose watercraft that are jointly supportive of safe contact recreation and the DEP Coastal Non-Point Pollution goals. Specifically, these would address the measures identified in the Marinas and Recreational Boating section of the DEP document titled Deliverables for Results-Based Funding Coastal Non-point Pollution (CNP) Specialist.

2. PESTICIDES, HERBICIDES, AND FERTILIZER CONTROLS

The City adheres to the Integrated Pest Management protocol in the application of pesticides. Educational materials are made available to private pesticide users through the Department of Health inspectors. More detailed inquiries regarding application of pesticides are referred to the State Department of Agriculture.

The City in conjunction with the Clean Water Action group has developed an Integrated Pest Management (IPM) plan for residents of the City, which proposes alternatives to chemical pesticides. Included in this plan is a resolution adopted by the Board of Health for the use of IPM principles and the developing of literature for the public.

Also, in an effort to encourage better pesticide/herbicide management practices, PWD has begun a program to educate golf course grounds managers on their proper use. Golf courses comprise a major land use within the Schuylkill River watershed. Golf course management techniques, particularly with regard to pesticide application, turf management, and water use significantly impact the quality and quantity of runoff leaving a golf course and entering nearby streams and rivers. To address this concern, the Philadelphia Water Department holds an annual Golf Course Certification workshop through the Audubon Cooperative Sanctuary Program (ACSP). The ACSP is a voluntary education and certification program whose purpose it is to educate, provide conservation assistance to and positively recognize golf course managers for improving environmental management practices and conservation efforts as they pertain to outreach and education, wildlife and habitat management, chemical use reduction and safety, water conservation, and water quality management. The annual workshop introduces golf course managers to the certification program and provides detailed information on key components of the certification process and important principles of environmentally responsible management. To date, PWD has held four annual workshops in different parts of the Schuylkill River watershed.

3. SNOW MANAGEMENT PLAN

The City of Philadelphia, like many other northeastern cities in the US, often faces winter storms that bring potentially dangerous accumulations of ice, sleet, freezing rain, and snow. Such events carry the potential to virtually paralyze the metropolitan area. In order to mitigate the impact of these storms, the Streets Department has prepared a Snow and Ice Removal Operations Plan which provides a detailed outline of the City's response to adverse winter weather conditions. A copy of this Plan has been included on the accompanying CD to this report.

4. Municipal/Hazardous Waste, Storage, Treatment, and Processing Facilities

Over the remaining reporting years the City will collect and assess information regarding municipal facilities (waste treatment, storage and processing) in terms of stormwater runoff. Once preliminary information has been collated priorities and procedures will be developed for inspecting and monitoring such facilities.

J. Best Management Practices (BMPs)

1. Commercial and Residential Source Controls

i. Mingo Creek Surge Basin

The City maintains all city-owned structural controls, which presently consists of the Mingo Creek Surge Basin. Maintenance consists primarily of scheduled preventative maintenance of the pumping station to support its intended purpose of flood control.

In FY 2000, a needs-analysis was completed for the dredging of the Mingo Creek basins. Survey drawings showing the plan and elevation views of the Surge Basin, indicate minimal material deposited in the bed of the basin. In fact there was an indication of basin bed erosion. Based on these findings, dredging of the basin was not recommended. However, additional field investigations reveal pockets of deposition in the basin, suggesting the need for additional study. In June 2001 the basins were dewatered so that visual observations could be made and photos taken of existing conditions.

PWD is considering a study to assess the feasibility retrofitting the basin to improve water quality. It was determined that better methods are needed to determine actual sediment depths within the basins, and research of suitable vegetation survivability in the basin's typical flow regime. PWD investigated a methodology to collect a bathymetric profile of the basin topology in FY 2003.

Currently, PWD is modeling the entire contributing sewer shed to the Mingo Creek Surge Basin in an effort to maximize the capacity of this system.

ii. Enforcement of Storm Sewer Discharge Ordinance

The Water Department continues to enforce its storm water ordinance under the authority delegated 14-1603.1 of the Philadelphia Code and Charter. Please refer to H. Monitor and Control Storm Water from Construction Activities for additional information.

2. DRAINAGE PLAN REVIEW OF DEVELOPMENT

The Water Department and the City Planning Commission provide review of the drainage plans for new development, which addresses both flood control and potential storm water pollutants. under the authority delegated 14-1603.1 of the Philadelphia Code and Charter. Please refer to H MONITOR AND CONTROL STORM WATER FROM CONSTRUCTION ACTIVITIES for additional information.

3. PUBLIC ROADWAYS BMPS

i. DEICING PRACTICES AND SALT STORAGE

The City monitors deicing practices in a manner consistent with its comprehensive snow emergency management procedures. A copy of the procedures was included in the 1996 annual report. On average, the City deices 1,300 street miles per storm.

There are six municipal salt storage areas in the city, all of which have been covered to prevent precipitation from coming in contact with the salt. In Figure 15 below, the relative locations of City salt storage locations have been provided:

- 1st Highway District - 48th & Parkside
- 2nd Highway District - 7th & Pattison
- 3rd Highway District - 21st & York
- 4th Highway District - Stenton & Sylvania
- 5th Highway District - Whitaker & Luzerne
- 6th Highway District - State & Ashburner

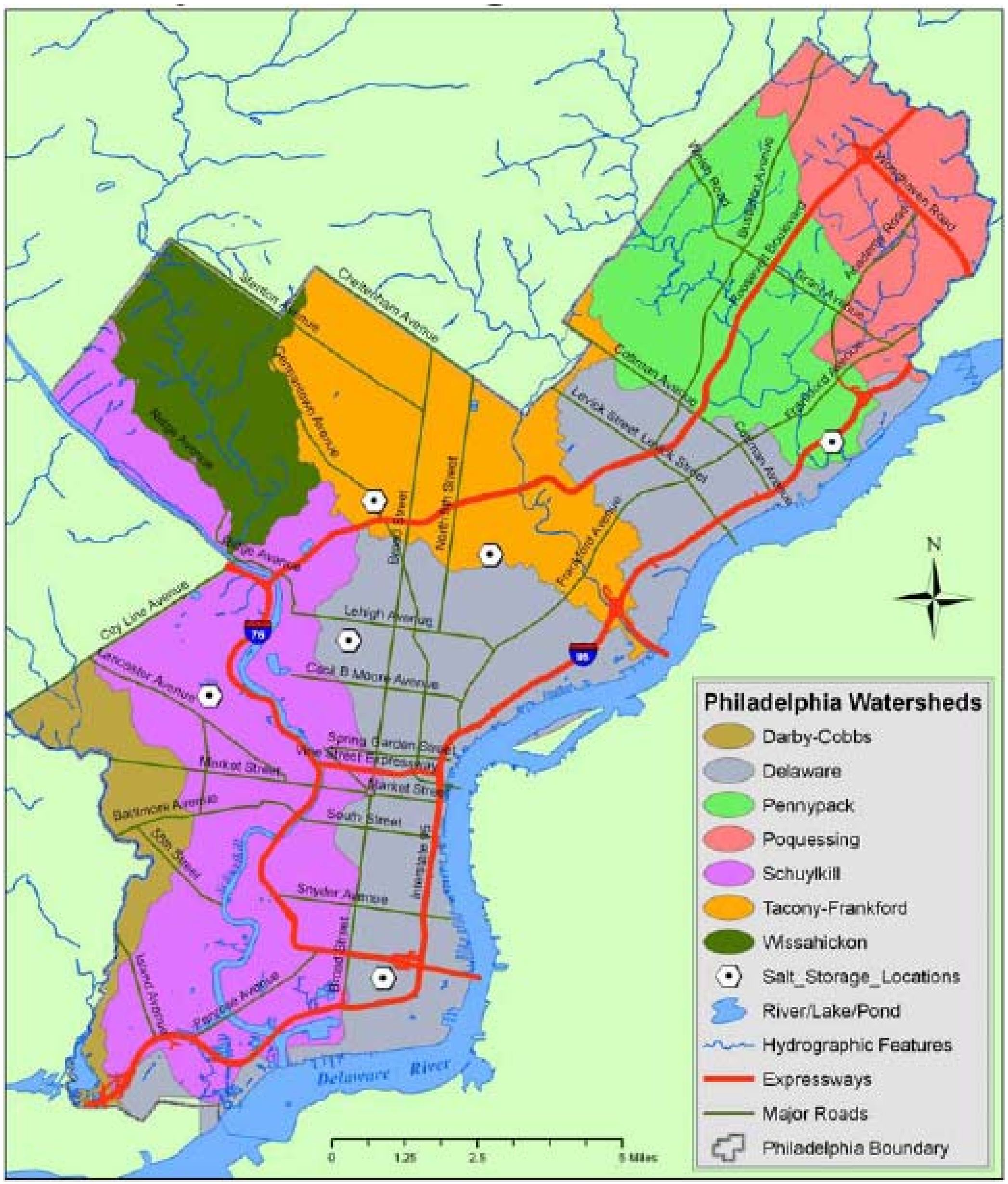


Figure 15 - City of Philadelphia Salt Storage Depots

ii. Street and Inlet Practices

During FY 2006, the City has continued to work toward its goal of daily street cleaning in commercial areas and annual street cleaning in residential areas. Approximately 494 street miles (17% of city streets) are mechanically cleaned daily. The City promotes, develops, and implements litter reduction programs, in an effort to increase public awareness of litter as a source of storm water pollution. There are over 1800 litter baskets throughout the city. The Philadelphia More Beautiful Committee (PMBC), organizes volunteers for 10,000 block clean-ups coordinated through 5,000 volunteer block captains.

iii. MAINTENANCE OF CITY-OWNED INLETS

The Inlet Cleaning Section of PWD, under the direct jurisdiction of the Chief of the Collector Systems is primarily responsible for the inspection and cleaning of 78,136 storm water inlets within the City. This section is also charged with the responsibility of the following: Retrieving and installing inlet covers, installing original replacement covers that are missing, installing locking covers, unclogging choked inlet traps and outlet piping so that inlets can take water; alleviating flooded streets and intersections when hydrants are opened, broken water mains, rain storm and other weather related problems. Inlet Cleaning is also charged with answering flood complaints at the Philadelphia Business Center.

To insure the efficient and effective operation of the City's inlets and connecting stormwater sewers, it has been found necessary to use specialized inlet cleaning equipment to work along with the various units of the PWD as well as various government agencies and the private sector. We also cleaned inlets on PWD properties.

The Inlet Cleaning Sections five (5) highway crews, whose duties are to clean high volume traffic areas during the night hours, 11 P.M. - 7 A.M. have been very effective. Besides cleaning areas throughout the city, these crews cleaned the entire Roosevelt Blvd. at least once during the 2006 Fiscal Year. We attempt to clean the Center lanes two (2) times a year and the service lane four (4) times a year. Seven (7) of our goals for Fiscal Year 2007 are:

1. To get unit Personnel to proposed staffing numbers (108).
2. One (1) Permanent manual crew.
3. To replace the air conditioning unit in the Fox St. building.
4. To further work to replace footage I.D.'s with numbered posts at locations such as Roosevelt Blvd., Bartram Ave., Columbus Blvd., and other semi and non-residential areas.
5. Establish a crew to maintain the Inlet I.D. posts or stencil markers on the above locations.
6. To install on board computers in a few select vehicles.
7. To add a vactor for purposes of cleaning the night shift areas, i.e. Roosevelt Blvd., Bartram Ave., Columbus Blvd., and other semi and non-residential areas.

A statistical summary of PWD's inlet cleaning work during FY06 is provided in Table 21.

Table 21 - Inlet Cleaning Statistical Summary

STATISTICAL SUMMARY

The following represents a summary of work performed by the Water Department/Inlet Cleaning Section from July 1, 2005 to June 30, 2006.

Total Work Orders Received	**88,890**
Inlets Cleaned Mechanically	**74,850**
Inlets Cleaned Manually	**2,753**
Total Inlets Cleaned	**77,603**
No Cleaning Required (NCR)	**516**
Parked Vehicles (PV)	**11,198**
Inlets Bled	**6,535**
Traffic	**2,010**
Referrals	**7,524****
Missing Cover Replacement	**2,202**
Locking Cover Installed	**3,877**
None Needed (NN)	**274**
(NI)	**1,455**
Total Job Output	**106,128**
Ton of Debris Disposed	**20,234.62*****
Total Cubic Feet Debris	**1,054,663.3**

****These figures have not been included in the total job output.**
***** Do not include days when scale was broken.**

4. ANIMAL WASTE AND CODE ENFORCEMENT

The City of Philadelphia actively enforces code which covers the regulation of animal waste. The Philadelphia Code and Charter Chapter 10.100 – Animals and Chapter 10.700 – Refuse and Littering addresses the proper clean-up of pet waste and applicable fines and penalties. In addition, signs advertising the said penalties are displayed city-wide in any effort to prevent residents from violating this statute. The City of Philadelphia also provides the text of this code online at http://municipalcodes.lexisnexis.com/codes/philadelphia/.

5. Spill Prevention and Response

The City's response plan to respond to and contain harmful spills that may discharge to the municipal separate storm sewer system is managed by the Philadelphia Local Emergency Planning Committee. PWD is represented by the Industrial Waste Unit, whose personnel are charged with response to such events.

In order to protect the Philadelphia Water Department's structures and treatment processes, IWU personnel respond to oil and chemical spills and other incidents that have the potential to threaten the water supply or impact the sewer system, twenty-four hours per day, seven days per week. They supervise cleanup activities and assess environmental impact. The inspectors also investigate various other types of complaints. In FY 2006, there were 213 incidents that required an IWU response.

i. Public Reporting of Illicit Discharges, Improper Disposal

The City vigorously encourages public citizens to report the occurrence of illicit discharges that may impact the sewer system and water bodies. To facilitate the timely reporting of such events, PWD operates a 24 Hour/Day, 7 Day/Week Municipal Dispatcher to handle reports from the public. The direct numbers for the Dispatcher are (215) 686-4514 or (215) 686-4515. In addition, a customer service hotline is also operated that provides the ability to connect to the Dispatcher. This information is distributed in mailings, as well as online at http://www.phila.gov/water/contact_us.html.

Upon the reporting of such an incident, a PWD inspector is immediately dispatched to the site to investigate and determine the source of the discharge, as well as the extent of impact on the receiving water body. Each incident is logged into an electronic database that enables tracking of the details of each occurrence.

ii. Used Oil and Toxic Material Disposal

The City continues to facilitate the proper disposal of used oil and other toxic materials. This program includes collections events, distribution of educational materials, the operation of a website, and a hotline accessible to the public. Please reference page 56, HOUSEHOLD HAZARDOUS WASTE COLLECTIONS for a more detailed discussion of this topic.

K. Fiscal Resources

The Storm water Management Program is funded from the City's Water Fund, supported by revenue from water and sewer rates. The Water and Wastewater Funds are required under the General Ordinance to be held separate and apart from all other funds and accounts of the City. The Fiscal Agent and the funds and accounts therein shall not be commingled with, loaned or transferred among themselves or to any other City funds or accounts except as expressly permitted by the General Ordinance. During the reporting period, the City provided fiscal resources needed to support operation and maintenance of the Storm water Management Program as outlined in Table 22 below. The table presents fiscal year budgets for both the reporting year as well as the upcoming fiscal year.

Table 22 - Fiscal Resources

Program	**FY 2006 Budget**	**FY 2007 Budget**
Office of Watersheds	5.97 million	7.26 million
Collector Systems Support	1.34 million	1.42 million
Sewer Maintenance and Flow Control	15.9 million	18.6 million
Inlet Cleaning	5.45 million	4.38 million
Abatement of Nuisances	5.73 million	6.49 million
Sewer Reconstruction	22.7 million	22.5 million
Public Affairs and Education	4.09 million	4.09 million
TOTAL	**$ 60.8 million**	**$ 64.7 million**

The conditions of the NPDES permit are able to be achieved through appropriate budget planning supporting the projects and assessments critical to a successful program. Any funding changes will be included as part of subsequent annual reports.

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Title:	STORM WATER MANAGEMENT PROGRAM
Subject:	
Author:	pwd
Keywords:	
Comments:	
Creation Date:	9/29/2006 11:19 AM
Change Number:	6
Last Saved On:	9/29/2006 12:28 PM
Last Saved By:	pwd
Total Editing Time:	58 Minutes
Last Printed On:	9/29/2006 12:29 PM

As of Last Complete Printing

Number of Pages: 118

Number of Words: 37,388 (approx.)

Number of Characters: 213,115 (approx.)

APPENDIX A – SEDIMENT TOTAL MAXIMUM DAILY LOAD (TMDL) FOR WISSAHICKON CREEK – FEASIBILITY STUDY & MONITORING PLAN

1. STORMWATER FLOW AND LOAD ESTIMATES BY OUTFALL

Methods used to develop stormwater outfall flows and loads are described in detail in the Wissahickon Comprehensive Characterization Report. In Appendix A, Table 1 drainage area and estimated mean annual runoff volume are reported for each outfall. In Appendix A, Table 2 estimated mean annual pollutant loads are reported for each outfall. A summary of the total number of outfalls per tributary is reported in Appendix A, Table 3 along with a summary of discharge and estimated loads for all of the outfalls found in each tributary.

Appendix A, Table 1 - Philadelphia Stormwater Outfall Runoff

Outfall	Tributary/Stream	Drainage Area (acres)	Runoff 4/93-3/01 (in/yr)
W-084-01	Bells Mill	62.8	7.74
W-084-02	Bells Mill	106	9.26
W-084-03	Bells Mill	4.94	10.4
W-084-04	Bells Mill	12.2	11.9
W-076-01	Cathedral Road Run	90.3	6.01
W-076-02	Cathedral Road Run	38.3	6.12
W-076-08	Cresheim Creek	5.94	12.4
W-076-11	Cresheim Creek	10.6	7.31
W-076-12	Cresheim Creek	47.5	9.97
W-077-01	Cresheim Creek	46.2	8.93
W-077-02	Cresheim Creek	239	10.0
W-086-01	Cresheim Creek	270	14.8
W-086-02	Cresheim Creek	76.7	12.6
W-086-03	Cresheim Creek	35.3	13.2
W-086-04	Cresheim Creek	31.6	18.8
W-086-05	Cresheim Creek	47.7	11.7
W-086-06	Cresheim Creek	85.3	11.6
W-086-07	Cresheim Creek	23.6	17.2
W-067-01	Gorgas Run	392	12.2
W-067-02	Gorgas Run	41.3	14.9
W-067-03	Gorgas Run	29.5	13.3
W-076-07	Hartwell Run	48.0	9.30
W-076-14	Hartwell Run	67.6	10.4
W-095-01	Hill Crest Run	99.7	11.3
W-095-03	Hill Crest Run	51.3	12.4
W-068-01	Kitchen's Lane	16.0	12.2
W-068-02	Kitchen's Lane	10.7	15.7
W-068-03	Kitchen's Lane	4.07	13.0
W-068-06	Kitchen's Lane	23.2	10.3
W-068-08E	Kitchen's Lane	25.9	9.38
W-068-08W	Kitchen's Lane	33.8	9.85
W-060-04	Monoshone Creek	12.7	4.83

W-060-08	Monoshone Creek	16.3	6.43
W-060-09	Monoshone Creek	17.0	4.65
W-060-10	Monoshone Creek	163	6.28
W-060-11	Monoshone Creek	39.2	4.35
W-068-04	Monoshone Creek	628	5.26
W-068-05	Monoshone Creek	76.4	5.72
W-095-02	Paper Mill Run	6.07	9.10
W-095-04	Paper Mill Run	6.82	15.4
W-095-05	Paper Mill Run, Trib B	20.7	14.8
W-076-09	Valley Green Run	62.8	9.96
W-076-10	Valley Green Run	46.0	10.7
W-075-01	Wise's Mill Run	154	14.5
W-075-02	Wise's Mill Run	9.88	8.18
W-076-04	Wise's Mill Run	9.02	8.40
W-076-05	Wise's Mill Run	3.82	10.4
W-076-06	Wise's Mill Run	9.62	11.5
W-076-13	Wise's Mill Run	92.0	13.2
W-076-X	Wise's Mill Run	9.47	1.72
W-052-01	Wissahickon Creek	12.4	11.3
W-052-02	Wissahickon Creek	15.5	12.8
W-060-01	Wissahickon Creek	111	12.5
W-060-02	Wissahickon Creek	25.5	14.0
W-060-03	Wissahickon Creek	63.2	13.8
W-060-05	Wissahickon Creek	96.7	8.39
W-060-06	Wissahickon Creek	2.58	16.7
W-060-07	Wissahickon Creek	22.0	12.4
W-067-04	Wissahickon Creek	23.8	13.9
W-067-05	Wissahickon Creek	10.0	14.1
W-067-06	Wissahickon Creek	41.5	10.8
W-068-07	Wissahickon Creek	24.9	9.39
W-076-03	Wissahickon Creek	9.21	11.7
W-085-01	Wissahickon Creek	83.9	12.3
W-085-02	Wissahickon Creek, Trib I	57.4	11.4

Appendix A, Table 2 - Wissahickon Outfall Load Summary

Outfall	Tributary/Stream	BOD5 (lbs/yr)	TSS (lbs/yr)	COD (lbs/yr)	TP (lbs/yr)	Cu (lbs/yr)	Zn (lbs/yr)	Fe (lbs/yr)	TN (lbs/yr)	Fecal (#/yr)	Pb (lbs/yr)
W-084-01	Bells Mill	892	7,395	5,397	29.2	1.51	11.5	129	198	2.92E+12	1.86
W-084-02	Bells Mill	1,759	14,084	10,743	57.3	2.99	22.9	262	385	5.77E+12	3.70
W-084-03	Bells Mill	104	731	653	3.29	0.177	1.39	17.0	21.6	3.41E+11	0.222
W-084-04	Bells Mill	297	2,123	1,989	9.36	0.549	4.18	55.4	57.4	9.34E+11	0.656
W-076-01	Cathedral Road Run	985	8,370	6,030	32.4	1.71	12.8	146	217	3.19E+12	2.07
W-076-02	Cathedral Road Run	490	3,247	3,123	15.4	0.834	6.62	83.2	100	1.61E+12	1.06
W-076-08	Cresheim Creek	141	1,084	872	4.56	0.240	1.86	21.8	30.4	4.64E+11	0.299
W-076-11	Cresheim Creek	134	1,221	791	4.49	0.228	1.69	17.8	31.0	4.39E+11	0.276
W-076-12	Cresheim Creek	975	6,648	6,180	30.8	1.66	13.1	163	201	3.20E+12	2.10
W-077-01	Cresheim Creek	665	6,819	3,861	22.8	1.16	8.27	81.6	159	2.15E+12	1.35
W-077-02	Cresheim Creek	4,632	35,467	29,705	149	8.25	62.8	778	955	1.48E+13	10.0
W-086-01	Cresheim Creek	7,939	58,607	51,631	253	14.2	109	1,384	1,602	2.54E+13	17.3
W-086-02	Cresheim Creek	1,411	16,888	7,885	50.4	2.51	17.0	146	358	4.50E+12	2.79
W-086-03	Cresheim Creek	953	6,595	6,120	30.1	1.66	12.9	163	193	3.10E+12	2.06
W-086-04	Cresheim Creek	1,163	9,531	8,702	36.9	2.54	18.0	265	196	3.29E+12	2.71
W-086-05	Cresheim Creek	1,143	7,876	7,235	36.1	1.95	15.3	190	236	3.75E+12	2.46
W-086-06	Cresheim Creek	1,482	16,878	8,242	52.4	2.56	17.8	154	374	4.80E+12	2.93
W-086-07	Cresheim Creek	739	7,133	5,998	23.9	1.84	12.2	191	112	1.87E+12	1.79
W-067-01	Gorgas Run	8,705	74,863	55,682	285	16.0	118	1,421	1,833	2.74E+13	18.7
W-067-02	Gorgas Run	1,280	8,604	8,141	40.3	2.18	17.3	216	262	4.20E+12	2.76
W-067-03	Gorgas Run	774	5,849	5,049	24.7	1.40	10.6	135	156	2.46E+12	1.68
W-076-07	Hartwell Run	803	6,882	4,820	26.5	1.36	10.3	113	181	2.63E+12	1.67
W-076-14	Hartwell Run	1,088	11,798	6,249	37.9	1.91	13.4	127	265	3.49E+12	2.19
W-095-01	Hill Crest Run	2,029	17,529	12,447	66.9	3.55	26.5	300	447	6.55E+12	4.26
W-095-03	Hill Crest Run	1,191	9,722	7,658	38.6	2.17	16.2	199	247	3.77E+12	2.57
W-068-01	Kitchen's Lane	395	2,771	2,490	12.5	0.672	5.28	64.8	82.2	1.30E+12	0.848
W-068-02	Kitchen's Lane	334	2,403	2,089	10.6	0.567	4.44	53.8	70.1	1.10E+12	0.713
W-068-03	Kitchen's Lane	101	785	620	3.26	0.171	1.32	15.4	21.8	3.31E+11	0.213
W-068-06	Kitchen's Lane	491	3,397	3,099	15.5	0.835	6.57	81.1	102	1.61E+12	1.05
W-068-08E	Kitchen's Lane	426	3,802	2,528	14.2	0.723	5.40	57.6	97.6	1.40E+12	0.879
W-068-08W	Kitchen's Lane	676	4,711	4,267	21.4	1.15	9.05	111	140	2.22E+12	1.45
W-060-04	Monoshone Creek	100	1,017	602	3.40	0.181	1.28	13.6	22.9	3.14E+11	0.206
W-060-08	Monoshone Creek	213	1,486	1,342	6.74	0.362	2.85	35.0	44.2	6.99E+11	0.457
W-060-09	Monoshone Creek	144	1,214	865	4.73	0.244	1.85	20.4	32.1	4.71E+11	0.299
W-060-10	Monoshone Creek	1,910	16,134	12,860	62.0	3.71	27.0	350	377	5.83E+12	4.21
W-060-11	Monoshone Creek	304	2,656	1,838	10.1	0.524	3.92	43.3	68.1	9.89E+11	0.634
W-068-04	Monoshone Creek	6,613	47,570	42,041	210	11.5	89.1	1,102	1,365	2.15E+13	14.2
W-068-05	Monoshone Creek	854	6,523	5,559	27.3	1.55	11.7	148	173	2.71E+12	1.86
W-095-02	Paper Mill Run	77.1	970	403	2.81	0.130	0.877	6.18	20.8	2.52E+11	0.147
W-095-04	Paper Mill Run	208	1,539	1,335	6.63	0.367	2.82	35.2	42.6	6.69E+11	0.449
W-095-05	Paper Mill Run, Trib B	635	4,452	4,334	19.9	1.19	9.08	123	120	1.98E+12	1.42
W-076-09	Valley Green Run	800	11,580	4,291	30.2	1.49	9.27	64.1	218	2.48E+12	1.53
W-076-10	Valley Green Run	989	7,079	6,199	31.5	1.68	13.2	160	207	3.25E+12	2.11

W-075-01	Wise's Mill Run	4,086	36,479	28,767	133	8.50	59.9	813	768	1.19E+13	9.19
W-075-02	Wise's Mill Run	139	1,279	817	4.66	0.236	1.75	18.2	32.3	4.55E+11	0.285
W-076-04	Wise's Mill Run	137	1,162	826	4.52	0.233	1.76	19.5	30.7	4.50E+11	0.286
W-076-05	Wise's Mill Run	83.0	554	531	2.60	0.142	1.12	14.2	16.8	2.72E+11	0.180
W-076-06	Wise's Mill Run	224	1,621	1,472	7.09	0.405	3.10	40.1	44.4	7.11E+11	0.490
W-076-13	Wise's Mill Run	2,436	18,295	16,673	77.2	4.68	34.9	471	462	7.50E+12	5.43
W-076-X	Wise's Mill Run	20.9	295	103	0.790	0.035	0.227	1.20	5.99	6.83E+10	0.039
W-052-01	Wissahickon Creek	201	2,517	1,220	7.21	0.397	2.59	25.8	48.0	6.05E+11	0.412
W-052-02	Wissahickon Creek	341	3,411	2,433	11.3	0.744	5.05	68.3	64.4	9.62E+11	0.768
W-060-01	Wissahickon Creek	2,376	22,846	15,121	79.7	4.49	31.9	374	513	7.35E+12	5.06
W-060-02	Wissahickon Creek	705	5,161	4,401	22.5	1.20	9.35	112	149	2.32E+12	1.50
W-060-03	Wissahickon Creek	1,456	14,497	9,260	49.2	2.78	19.5	227	317	4.48E+12	3.09
W-060-05	Wissahickon Creek	1,202	13,898	6,518	42.7	2.04	14.1	115	310	3.93E+12	2.35
W-060-06	Wissahickon Creek	46.4	829	195	1.90	0.078	0.439	0.00	15.2	1.50E+11	0.078
W-060-07	Wissahickon Creek	397	4,906	2,472	14.1	0.802	5.22	55.0	91.9	1.17E+12	0.824
W-067-04	Wissahickon Creek	605	5,233	3,963	19.8	1.14	8.34	104	124	1.87E+12	1.31
W-067-05	Wissahickon Creek	265	2,209	1,756	8.61	0.503	3.69	47.0	53.5	8.22E+11	0.580
W-067-06	Wissahickon Creek	808	6,903	4,851	26.7	1.37	10.4	114	182	2.65E+12	1.68
W-068-07	Wissahickon Creek	477	3,295	3,016	15.1	0.812	6.40	79.0	98.6	1.57E+12	1.03
W-076-03	Wissahickon Creek	214	1,548	1,336	6.81	0.363	2.84	34.3	45.0	7.01E+11	0.456
W-085-01	Wissahickon Creek	1,741	16,604	10,267	58.8	3.00	22.0	228	405	5.66E+12	3.57
W-085-02	Wissahickon Creek, Trib I	1,289	9,638	8,237	41.2	2.27	17.4	216	266	4.16E+12	2.78

Appendix A, Table 3 - Wissahickon Tributary Load Summary

Tributary/Stream	Outfalls	Total Discharge (cfs)	BOD5 (lbs/yr)	TSS (lbs/yr)	COD (lbs/yr)	TP (lbs/yr)	Cu (lbs/yr)	Zn (lbs/yr)	Fe (lbs/yr)	TN (lbs/yr)	Fecal (#/yr)	Pb (lbs/yr)
Bells Mill	4	0.060	3,051	2.43E+04	1.88E+04	99.2	5.23	40.0	463	662	9.97E+12	6.44
Cathedral Road Run	2	0.028	1,475	1.16E+04	9.15E+03	47.8	2.54	19.4	229	317	4.80E+12	3.13
Cresheim Creek	12	0.523	21,378	1.75E+05	1.37E+05	694	38.8	290	3,554	4,448	6.78E+13	46.0
Gorgas Run	3	0.255	10,759	8.93E+04	6.89E+04	350	19.6	146	1,772	2,251	3.41E+13	23.1
Hartwell Run	2	0.028	1,891	1.87E+04	1.11E+04	64.4	3.28	23.7	240	446	6.13E+12	3.86
Hill Crest Run	2	0.053	3,220	2.73E+04	2.01E+04	106	5.72	42.6	499	694	1.03E+13	6.83
Kitchen's Lane	6	0.038	2,423	1.79E+04	1.51E+04	77.6	4.12	32.1	384	513	7.95E+12	5.16
Monoshone Creek	7	0.259	10,136	7.66E+04	6.51E+04	324	18.0	138	1,713	2,082	3.25E+13	21.9
Paper Mill Run	3	0.020	920	6.96E+03	6.07E+03	29.3	1.69	12.8	165	183	2.90E+12	2.01
Valley Green Run	2	0.030	1,789	1.87E+04	1.05E+04	61.6	3.17	22.4	224	425	5.73E+12	3.64
Wise's Mill Run	7	0.195	7,126	5.97E+04	4.92E+04	230	14.2	103	1,378	1,361	2.14E+13	15.9
Wissahickon Creek	14	0.250	10,835	1.04E+05	6.68E+04	365	19.7	142	1,582	2,416	3.42E+13	22.7
Wissahickon Creek Trib 1	1	0.021	1,289	9.64E+03	8.24E+03	41.2	2.27	17.4	216	266	4.16E+12	2.78

2. STREAMBANK EROSION LOAD FIELD METHODS

In conjunction with Section D (*Sediment Total Maximum Daily Load (TMDL) For Wissahickon Creek*) of the City's stormwater permit, PWD has initiated a monitoring plan that addresses the adverse impacts to in-stream habitats as a result of the transport of

sediment and/or streambank erosion. Baseline data from 13 perennial tributaries that originate in the City will be monitored to define their contribution of sediment loading.

There are two elements to the monitoring program. The first estimates the sediment load originating from streambanks. The second estimates the total sediment load being carried by the stream. Data collection is ongoing for both parts.

i. BEHI/NBS ASSESSMENTS

PWD employed the Bank Erosion Hazard Index (BEHI) and Near Bank Stress (NBS) as defined by Rosgen (1996) to predict erosion rates and classify the erosion potential of the tributaries. An example of bank erosion can be seen in Figure Appendix A, Figure 1 where much of a bank pin is exposed. Three hundred and sixty eight reaches in 13 tributaries have been assessed using BEHI and NBS criteria. Reaches were assessed based on visual inspection of obvious signs of erosion. BEHI and NBS scores were grouped as very low, low, moderate, high or very high. Table 4 summarizes the portion of each tributary that was assessed using the BEHI/NBS method.

Appendix A, Figure 1 - PWD staff digging out eroded bank sediment in order to accurately measure bank pin exposure

Appendix A, Table 4 - Portion of Each Tributary Assessed Using BEHI/NBS Method

Site	BEHI/NBS Assessed (ft)	Channelized (ft)	Visually Assessed - Low Erosion (ft)
Monoshone	147	3,074	9,537
Kitchens Ln	1,250	0.00	12,946
Cresheim	1,835	1,062	29,143
Valley Green Run	270	277	3,859
Hartwell	340	0.00	6,358

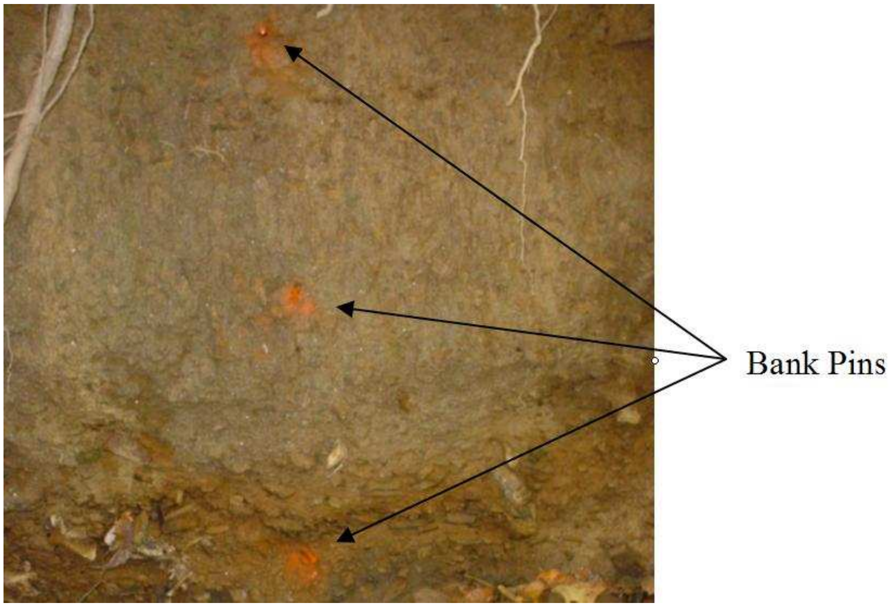
Rex Ave	270	0.00	2,982
Thomas Mill	625	0.00	6,895
Hill Crest	75.0	2,128	6,929
Paper Mill	2,640	8,576	48,298
Gorgas Ln	350	325	3,261
Wises Mill	1,042	1,057	11,301
Cathedral	1,135	0.00	4,227
Bells Mill	1,759	0.00	7,781

ii. Bank Profile Measurements

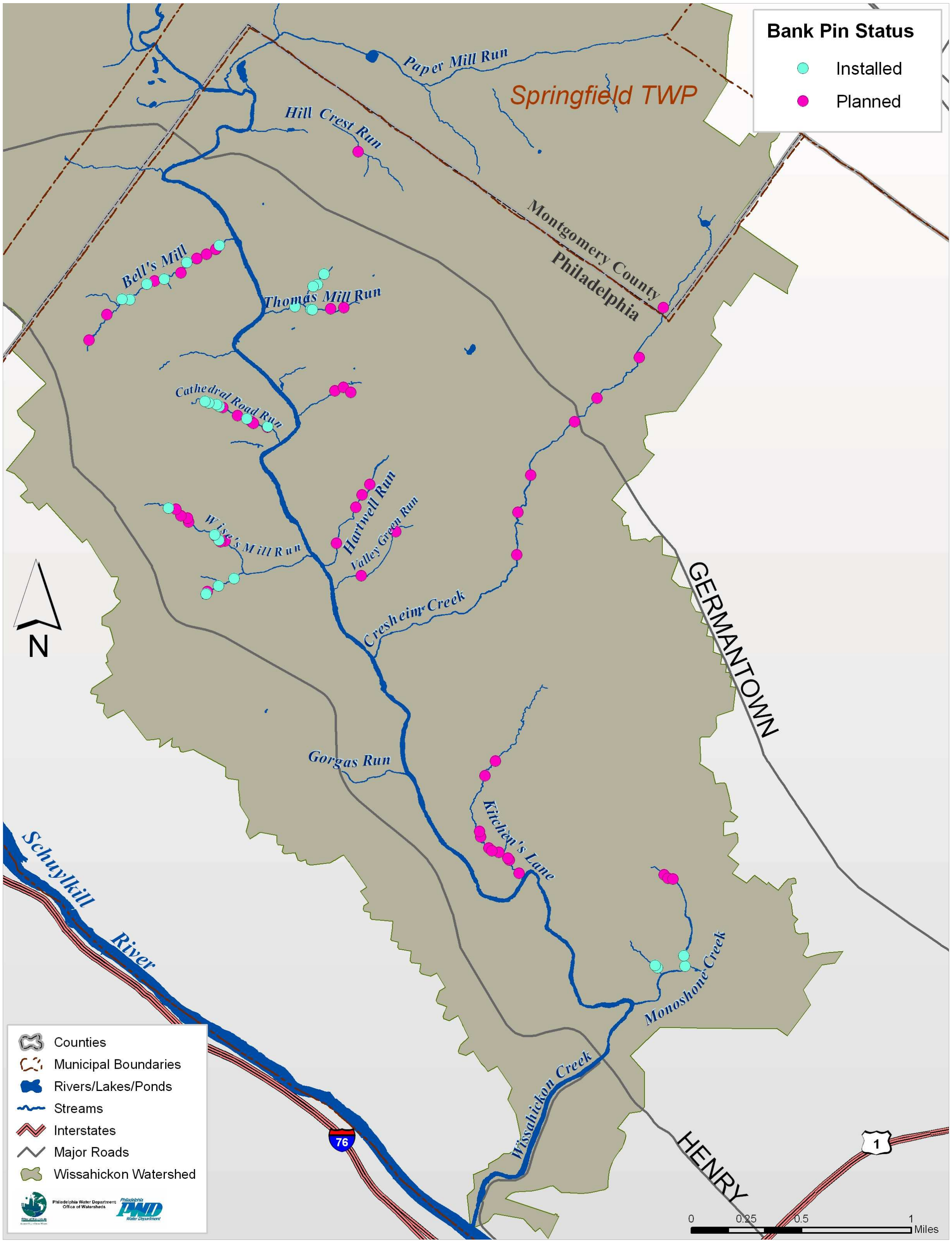
Bank pins were installed in Bells Mill, Cathedral Run, Wises Mill and Monoshone tributaries in October and November 2005. Nine bank pin sites were chosen in each of the tributaries listed with the exception of Monoshone. Only four bank pin sites were chosen in Monoshone because much of the tributary is channelized. Bank pins were installed in reaches with varying BEHI and NBS scores in order to validate and calibrate the prediction model. Three of the 9 sites were in reaches visually assessed to have low erosion rates. Additional bank pin sites in these tributaries and others are planned for the future. The current bank pin installation locations and planned bank pin installation locations can be seen on the map in Appendix A, Figure 4.

Bank pins were installed where the bend in the bank was greatest. At least one bank pin was put in below bankfull height and they were spaced no closer than 1 ft. The number of bank pins at a site was dependent on bank height and ranged from one to three. An example of bank pin installation can be seen in Appendix A, Figure 2, and an example of bank pin spacing can be seen in Appendix A, Figure 3.

Appendix A, Figure 2 - PWD staff installing a bank pin into the bank along the Wises Mill tributary. Bank pins are driven horizontally into streambanks at positions corresponding to bank erosion locations.

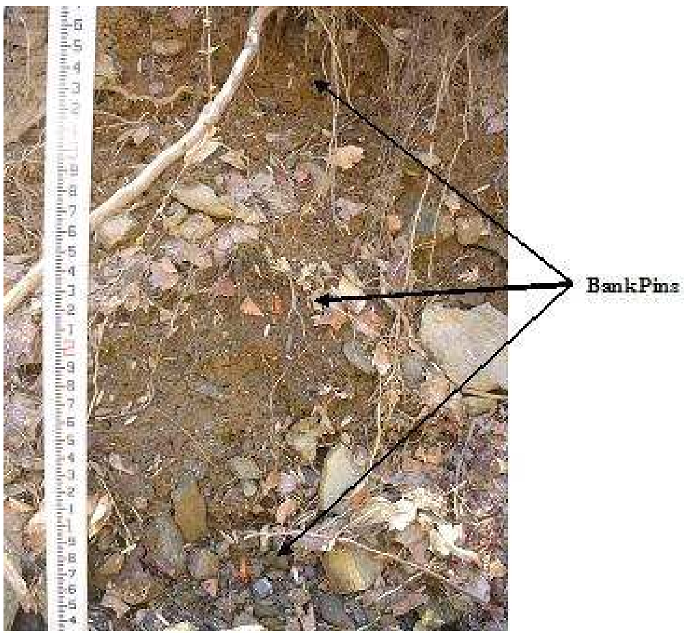


Appendix A, Figure 3 - After bank pin installation, the exposed ends were spray painted to make more visible



Appendix A, Figure 4 - Current and Planned Bank Pin Locations

Measurements were made using a survey rod, a Keson pocket rod and two levels. The survey rod was placed on the edge of the toe pin and kept straight using a level. The pocket rod was placed over the bank pin up against the bank and kept straight by a level. The distance from the bank to the edge of the survey rod closest to the bank was recorded on the field data sheet. Toe pins are bank offset pins driven vertically into the bed surface in order to "profile" the streambank with vertical measurements from the survey rod to the bank. The toe pin offers a permanent location with which to determine lateral erosion per unit time between surveys. The survey rod can be seen in Appendix A, Figure 5 where the bank pins are being measured in relation to the toe pin position. Lateral erosion or aggrading of the streambank is determined by measuring changes in bank pin distance from the toe pin (Appendix A, Figure 6).



Appendix A, Figure 5 - The survey rod measures the amount of exposed pin as the amount of lateral erosion upon re-survey.

Appendix A, Figure 6 - The toe pin is a permanent reference point for determining lateral erosion.

iii. Channel Stability

Bar samples, sub-pavement samples and pebble counts were collected at 9 sites in 5 tributaries to Wissahickon Creek in order to gather information on channel stability. Bar and sub-pavement samples as well as pebble counts were collected following methods described on EPA's Watershed Assessment of River Stability and Sediment Supply (WARSSS) website. An example of bar sampling is depicted in Figures 7 and 8. Additionally, Riffle Stability Index (RSI) Assessments and pebble counts were completed at 14 sites in the same 5 tributaries. RSI methods are described in Kappesser (1994). RSI assessments were done in place of bar samples in cases where sediment bars were not prominent due to high slope. In some cases RSI assessments were done in close proximity to bar or sub-pavement samples in order to compare results from the two methods. All samples were collected in April and May 2006.

Appendix A, Figure 7 - PWD staff collected a bar sample representing the size gradation of bedload at the bankfull stage.

Appendix A, Figure 8 - PWD staff draining water from the bar sample.

iv. Total Suspended Sediment Load

Automated water collection devices (ISCO model no. 6712) were used to collect water samples during wet weather events in the Wissahickon Creek tributaries. An example of the automated sampler being set up by PWD staff is shown in Appendix A, Figure 9. In the attempt to characterize an entire storm event, automated samplers were triggered by a 0.2 ft elevation change in stream height and collected samples every 20 minutes for the first hour. Following this step, samples were then collected every 2-4 hours until discharge returned to base flow conditions. Suspended sediment loads were related to the discharge at which they were collected to create a suspended sediment rating curve. Four tributaries were selected based on visual inspection of obvious signs of erosion to

estimate sediment loads and calibrate methods used in other tributaries. The location of installed samplers can be seen in Figure 10.

Total suspended sediment samples were collected from Monoshone Creek (5/20/2005 and 7/8/2005), Wises Mill (11/16/2005), Cathedral Run (11/10/2005 and 11/16/2005) and Bells Mill (9/15/2005, 9/26/2005 and 10/8/2005). Samples were collected using an ISCO automated sampler and followed methods described in wet weather monitoring. Water level is recorded during the sample period allowing a sediment discharge rating curve to be established. Additional sample collections are planned for these 4 tributaries as well as other tributaries.

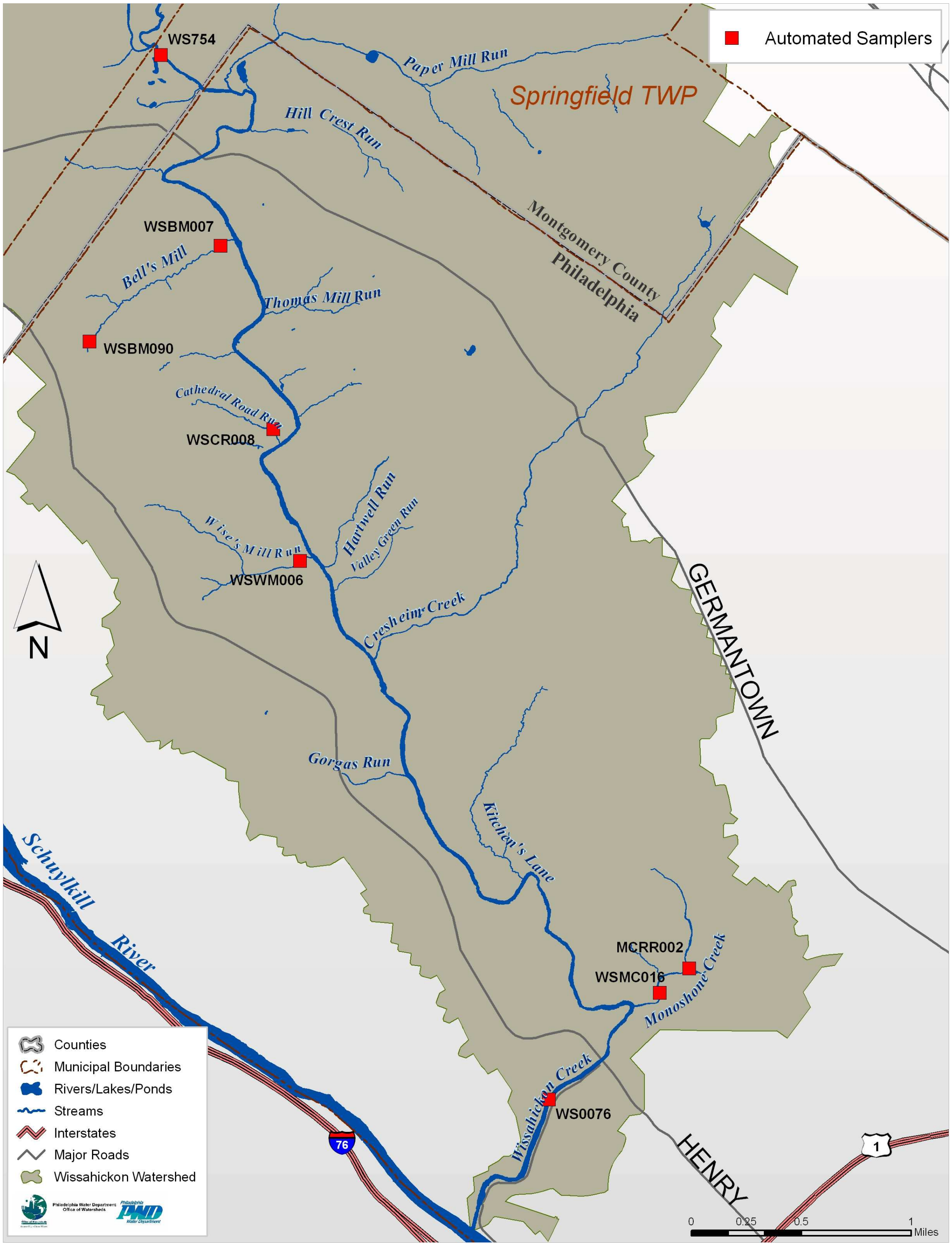
Appendix A, Figure 9 - PWD staff setting up the automated water sampler for wet weather monitoring

Stage data from Bells Mill, Cathedral Run, Wises Mill and Monoshone were recorded near the Wissahickon confluence downstream of all stormwater outfalls. Stage was measured every six minutes by either an ultrasonic down-looking water level sensor or a pressure transducer and recorded on a Sigma620. The ultrasonic down-looking sensor and pressure transducer are shown in Figures 11 and 12. PWD staff periodically downloaded stage data and performed quality assurance. Any data determined to be incorrect was removed and saved in another location.

Dates of ultrasonic down-looking sensor installation in Bells Mill, Cathedral Run and Wises Mill are May 2005, September 2005 and August 2005 respectively. Pressure transducers were installed in Monoshone in July 2005 and Bells Mill in November 2005. Stage data will continue to be recorded at these sites and additional sites will be added.

Appendix A, Figure 10 - An ultrasonic down-looking acoustic water level sensor for water level measurement as it was installed above the Cathedral Run tributary

Appendix A, Figure 11 - A pressure transducer for redundant water level measurement as it was installed in the Cathedral Run tributary.



Appendix A, Figure 12 - Automatic Sampler Locations

v. STAGE-DISCHARGE RATING CURVES

Staff gages were installed in Monoshone, Wises Mill and Bells Mill concurrent with ultrasonic downlooker or pressure transducer installation. Staff gauges are located next to the stage recording device in culverts with concrete floors to ensure that the cross section will not change over time. The staff gage along with the ultrasonic down-looking sensor and pressure transducer are shown in Appendix A, Figure 13.

Discharge rating curves were established in Monoshone, Wises Mill and Bells Mill following a modified version of the USGS protocol (Buchanan and Somers 1969). Discharge was measured in a cross section close to the staff gage using a SonTek Flowtraker Handheld ADV and plotted against the stage it was recorded at. Due to lack of a suitable monitoring location, the discharge rating curve in Cathedral Run will be mathematically modeled instead of measured in the field.

Appendix A, Figure 13 - Staff Gage for the Bells Mill tributary pictured with a pressure transducer and ultrasonic down-looking sensor.

3. Preliminary Streambank Erosion Load Estimates

Results of preliminary BEHI, NBS, erosion rate measurements at a reference site, and sediment-flow correlations were analyzed to produce several independent estimates of sediment load in the system. These results are useful for long-term planning but may change substantially as more data are collected and analyzed in the future. Appendix A, Table 5 includes useful summary information for the watershed. Appendix A, Table 6 through Appendix A, Table 8 include estimates of sediment load. The various methods and references used to derive these estimates are discussed below.

Appendix A, Table 5 - Wissahickon Watershed Information

System		
Philadelphia tributary stream length =	81,964	ft
Philadelphia main stem stream length =	40,712	ft
Philadelphia Trib Drainage Area =	4,963	ac
Philadelphia Drainage Area =	6,711	ac

Appendix A, Table 6 - Streambank Erosion Estimates

System	Streambank TSS Load (lb/yr)	Streambank TSS Load (ton/sq. mi/yr)	Streambank TSS Load (lb/ft/yr)	Calculation Method
Philadelphia Tributaries Only	3,142,358	203	38.3	BEHI/NBS Analysis with Colorado Reference Stream
Philadelphia Tributaries and Main Stem	3,685,717	176	30.0	Instream TSS-Flow Regression

Appendix A, Table 7 - Total Sediment Load from Historical Studies

Study	Total Sediment Load (lb/yr)	Total Sediment Load (ton/sq. mi/yr)
RSRI, 1973	8,388,391	400
USGS, 1985	3,271,472	156

Appendix A, Table 8 - Estimated Tributary Loads based on BEHI/NBS and Colorado Reference Stream

System	Drainage Area (acres)	Stream Length (ft)	Total TSS Load (lb/yr)	Total TSS Load (lb/acre/yr)
Bells Mill	323	4,770	414,592	1,285
Cathedral	160	2,681	332,015	2,073
Creshiem	1,218	16,020	731,882	601
Gorgas Lane	499	1,968	183,082	367
Hill Crest	217	4,860	77,581	358
Hartwell	144	3,350	166,226	1,157
Kitchens Lane	234	7,098	279,594	1,194
Monoshone	1,056	6,379	246,101	233
Paper Mill Run	297	29,757	931,999	3,142
Thomas Mill	104	3,760	188,382	1,804
Tributary I	137	1,626	94,361	688
Wises Mill	446	6,980	351,120	788
Valley Green	128	2,203	77,423	604

i. BEHI/NBS AND OBSERVED EROSION IN COLORADO REFERENCE STREAM

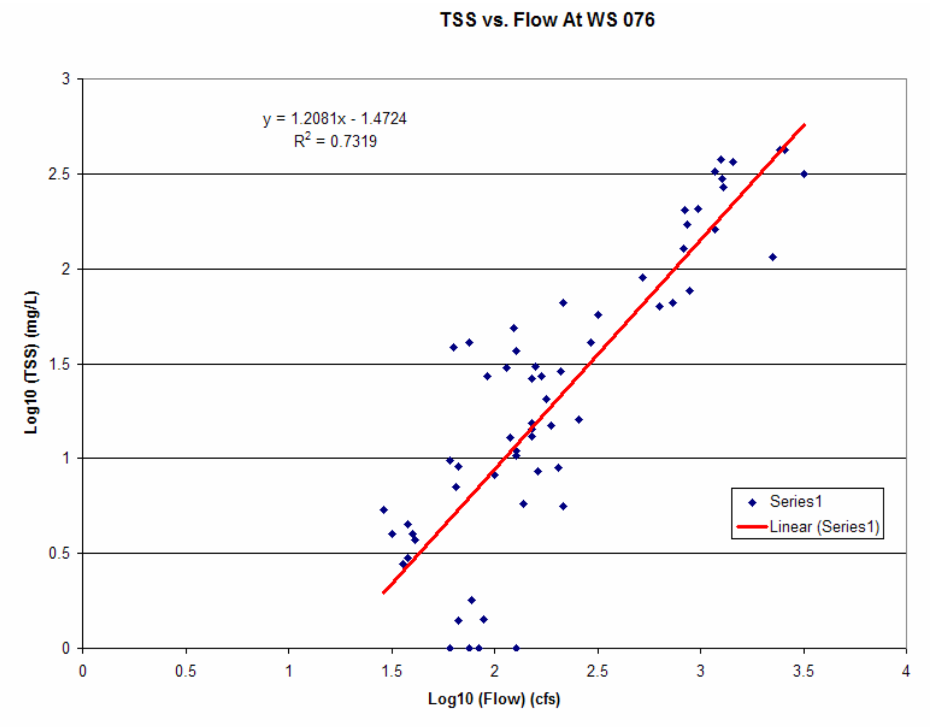
Predicted streambank erosion rates were calculated based on a relationship between these scores and measured streambank erosion rates in a reference stream in Colorado (Rosgen, 1996). The predicted rate is multiplied by the bank height and length as well as a conversion factor to get a sediment load in tons/year.

Streambank erosion estimates were determined using the data from the methods discussed above. For streambanks that were visually assessed to be low-erosion, a background erosion rate was applied. This rate corresponds to a low BEHI and low NBS score. These banks were assumed to have a bank height of the average of that particular tributary. For planning purposes, these low BEHI/NBS erosion rates are assumed to represent relatively stable conditions.

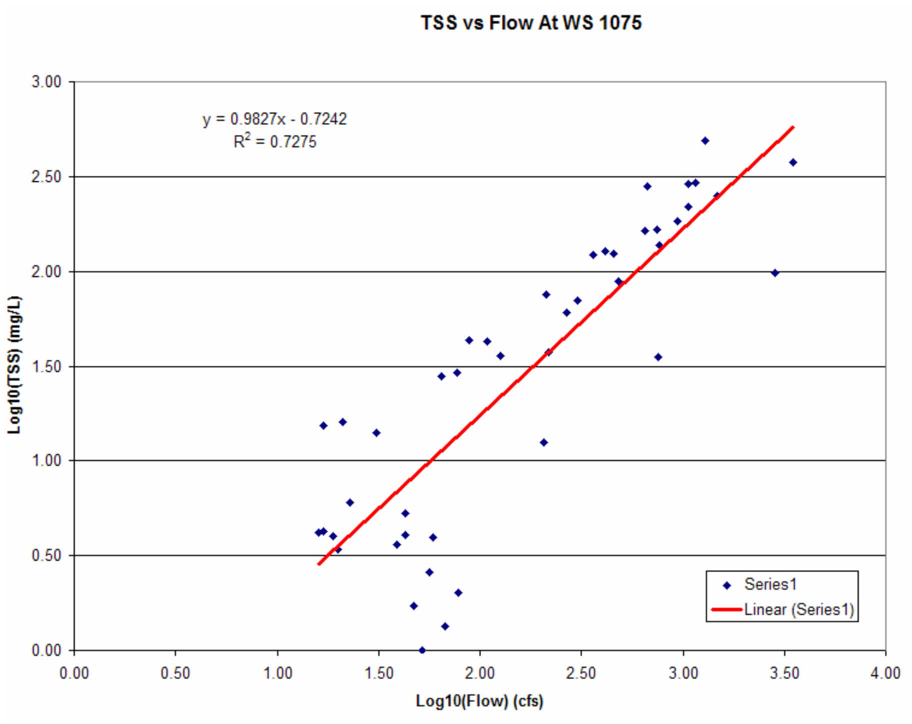
ii. INSTREAM TSS-FLOW REGRESSION

A TSS-flow regression was performed by matching instream TSS measurements at or near USGS gauging stations to the flow recorded closest to sampling time. The USGS gage located near the mouth of the main stem provided results for the regression shown in Appendix A, Figure 14. Similarly, a gage located in Fort Washington provided data for the regression in Appendix A, Figure 15. Once the regression was created for the two sites on the main stem, Fort Washington and the mouth at Philadelphia, an annual load could be determined by area weighting measured sediment loads at each station and

estimating sediment input between stations. Regression results were not extrapolated to estimate TSS concentrations at flows outside the range used for the regression. Instead, TSS concentration corresponding to the maximum measured flow was applied to all flows greater than the maximum. For the gage station at Philadelphia, this concentration was 572.3 mg/L and for Fort Washington this concentration was calculated at 570.3 mg/L. The streambank portion of this total sediment load was then estimated by removing estimated runoff sediment load. An estimated 3,685,717 lb/yr of streambank sediment load is contributed by the city of Philadelphia based on this load estimation method.



Appendix A, Figure 14 - TSS-Flow Regression at USGS Gage 01474000 (mouth at Philadelphia) using WS076 TSS data



Appendix A, Figure 15 - TSS-Flow Regression at USGS Gage 01473900 (Fort Washington) using WS1075 TSS data

iii. ENVIRONMENTAL STUDY OF THE WISSAHICKON WATERSHED WITHIN THE CITY OF PHILADELPHIA

A study performed by the Regional Science Research Institute (RSRI) in 1973 estimated a sediment load for the Wissahickon watershed (Appendix A, Table 7). The city of Philadelphia contributes an estimated 8,388,391 lb/yr of sediment based on this study. This amount represents a total sediment load, but the report does not distinguish between the proportion of the load contributed by streambank erosion and stormwater runoff. This study is important because it provides an independent estimate to compare with estimates based on PWD and USGS monitoring.

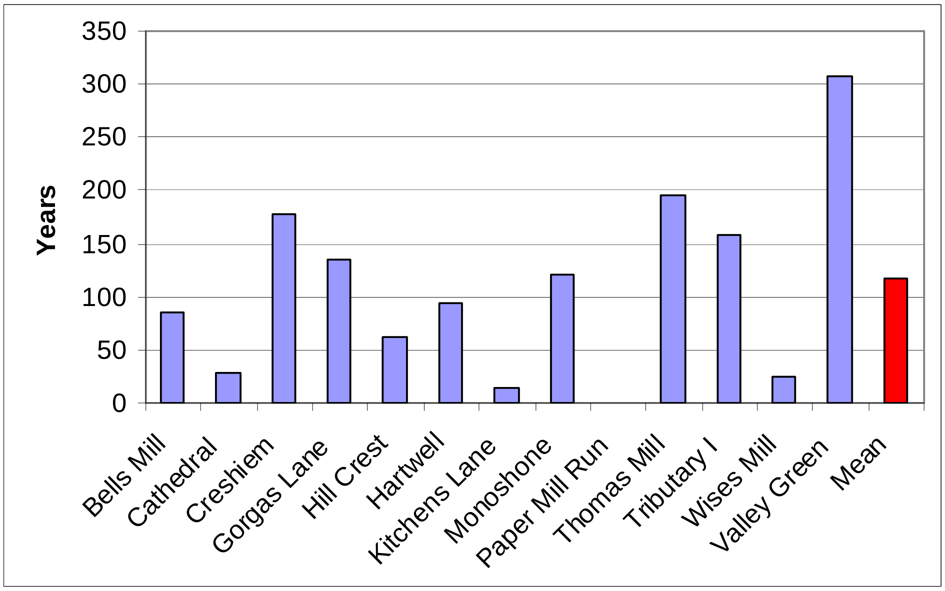
iv. EFFECTS OF LOW LEVEL DAMS ON THE DISTRIBUTION OF SEDIMENT, METALS, AND ORGANIC SUBSTANCES IN THE LOWER SCHUYLKILL RIVER BASIN, PENNSYLVANIA

A study performed by the United States Geologic Survey (USGS) in 1985 also estimated a total sediment load for the Wissahickon watershed (Appendix A, Table 7). The city of Philadelphia contributes an estimated 3,271,472 lb/yr of sediment based on this study. Similar to the RSRI study, no distinction between runoff and streambank load was provided. Again, this study is important because it provides another independent estimate to compare with estimated sediment loads based on PWD monitoring data.

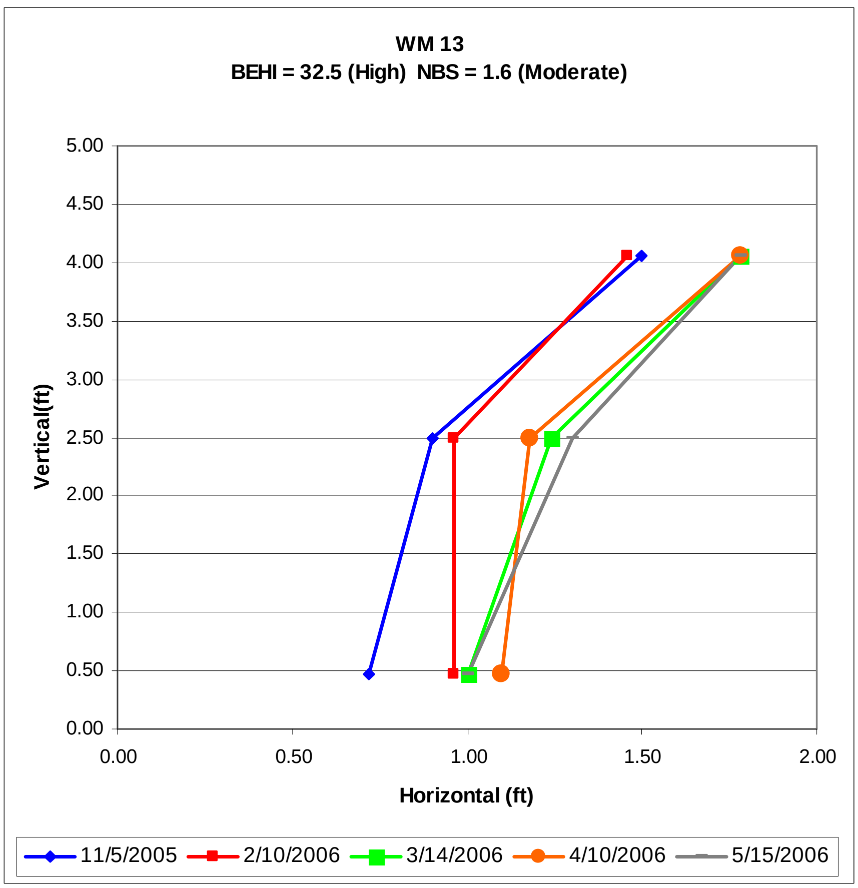
v. Verification and Comparison Studies

Two additional analyses were performed to verify that preliminary estimates are within a reasonable range. The first method involved determining the amount of time it would take for erosion to produce present stream cross sections, using estimated erosion rates based on BEHI/NBS and the Colorado reference stream. Estimates ranged from 14 to 307 years with a mean of 120 years for individual tributaries, and a mean of 155 years using the total tributary loads and rates (Appendix A, Figure 16). This period of time is reasonable considering the history of natural, agricultural, and urban uses in the watershed.

The other method used to verify BEHI erosion prediction methods was installation of bank pins to measure erosion rates. As of September 2006, data collected so far are insufficient to draw conclusions. The bank pin program is being expanded significantly as discussed in a later section. An example of bank profile measurements at one site over several dates is shown in Appendix A, Figure 17.



Appendix A, Figure 16 - Estimated erosion rate based on BEHI/NBS from current cross section data.



Appendix A, Figure 17 - Example of Bank Pin Measurement

4. Tributary Restoration Potential Ranking

i. Multi-Criteria Evaluation (EVAMIX)

EVAMIX has been chosen to rank the restoration potential of tributaries and stream reaches. EVAMIX is a matrix-based, multi-criteria evaluation program that makes use of both quantitative and qualitative criteria within the same evaluation; regardless of the units of measure. The algorithm behind EVAMIX is unique in that it maintains the essential characteristics of quantitative and qualitative criteria, yet is designed to eventually combine the results into a single appraisal score. This critical feature gives the program much greater flexibility than most other matrix-based evaluation programs, and allows the evaluation team to make use of all data available to them in its original form.

EVAMIX makes a pair by pair comparison of all options under evaluation across all evaluation criteria, resulting in thousands of computations. The computations eventually result in an overall appraisal score. This is a single number, attached to a single alternative, and represents the overall worth of that alternative relative to the other alternatives based on the criteria selected, and the weights attached to the criteria. This number is used to determine the final ranking of alternatives from best to worst, or most important to least important.

EVAMIX offers several important advantages when used in planning studies:

- The alternatives under consideration are clearly defined
- The criteria used in evaluating the alternatives are explicit and measurable
- The algorithm can handle both quantitative and qualitative data, utilizing all available data to the highest degree of measurability possible
- The priorities underlying the evaluation are made explicit, and can be flexibly applied to highlight the effect that weighting has on the final ranking
- The technique is flexible enough to handle new data as it becomes available
- The technique is applied using widely available software (Excel spreadsheets)

The use of EVAMIX requires the development of a two dimensional matrix consisting of the options to be evaluated (columns) and a set of evaluation criteria (rows). For every combination of options and criteria, a score is assigned. The choice of the criteria is governed, in part, by the need for the scoring to be as objective as possible. By objective, we mean that the scores should represent impartial data and information useful in making decisions. The criteria must be clear and unambiguously defined, and can be set up as either quantitative criteria (e.g. threshold concentration in percent, time of travel in hours), or qualitative criteria (e.g. discharge frequency, location, etc.).

The other input variable required for the evaluation procedure is the selection of weighting factors for each of the criteria. While the scoring process strives to be as objective as possible and is carried out by the project team, the selection of weights is inherently subjective and should be done by the decision-makers, planner, or

stakeholders. Unlike the matrix of scores, numerous possible weight sets are possible, and all are equally “valid”.

Criteria chosen to evaluate restoration potential are summarized in Appendix A, Table 9 and discussed in more detail below.

Appendix A, Table 9 - Ranking Criteria

		Need for Restoration				Potential for Restoration	
Criterion	Unit	Sediment Reduction	Habitat	Riparian	Infrastructure	Channel	Riparian
estimated streambank erosion load	lb/ft/yr	XX	X	N/A	N/A	N/A	N/A
habitat index	% ref. cond.	N/A	XX	N/A	N/A	N/A	N/A
benthic macroinvertebrate index	# species	N/A	XX	N/A	N/A	N/A	N/A
construction difficulty and disturbance	TBD	N/A	N/A	X	N/A	XX	XX
Fairmount Park projects	number	N/A	N/A	N/A	N/A	XX	XX
identified sanitary sewer problems	number	N/A	N/A	N/A	XX	N/A	N/A

XX - need or potential for restoration is highly related to the criterion
X - need or potential for restoration is somewhat related to the criterion

ESTIMATED STREAMBANK EROSION LOAD

Units: lb/ft/yr
Derivation: Sediment loads due to streambank erosion have been estimated using the Rosgen BEHI/NBS method and Colorado reference stream.

- The reach containing each BEHI/NBS assessment site was identified.
- The sediment load contributed by the BEHI/NBS site (and associated length) was estimates. Details of these calculations are discussed earlier in this document.
- Sediment load contributed by the portion of the reach not assessed using the BEHI/NBS method was not considered in the ranking.

HABITAT INDEX

Units: % of reference condition
Derivation: Habitat monitoring was conducted by USEPA in 2005. For each reach, the nearest habitat monitoring site was determined. The habitat quality score assigned by EPA at the nearest site was assigned to the reach. Habitat assessments are discussed in detail in the Comprehensive Characterization Report.

BENTHIC MACROINVERTEBRATE INDEX (TAXA RICHNESS)

Units: number of species present
Derivation: Benthic macroinvertebrate monitoring was conducted by USEPA in 2005. For each reach, the nearest macroinvertebrate monitoring site was determined. The species richness score assigned by EPA at the nearest site was assigned to the reach. Macroinvertebrate assessments are discussed in detail in the Comprehensive Characterization Report.

CONSTRUCTION DIFFICULTY AND DISTURBANCE
Units: qualitative (low/medium/high)

Derivation: Factors were not determined quantitatively. Instead, PWD staff with extensive field experience in the Philadelphia portion of the watershed were asked to provide their impressions.

DEFINITION OF LOW DIFFICULTY/DISTURBANCE (INCLUDING MAIN STEM)

- low-slope stream channel and corridor
- wide stream channel can accommodate heavy equipment
- wide paths or low-slope grassy areas suitable for heavy equipment (e.g., Forbidden Drive)
- public ownership (e.g., Fairmount Park)

DEFINITION OF MEDIUM DIFFICULTY/DISTURBANCE

- channel and corridor slope intermediate between Low and High
- some access but not ideal for heavy equipment, some disturbance to forest
- small number of receptive institutional or private owners
- combination of low and high factors

DEFINITION OF HIGH DIFFICULTY/DISTURBANCE

- stream channel and corridor are steep
- stream channel is too small for heavy equipment
- forested riparian area with no paths or low-slope grassy areas for heavy equipment
- multiple private residential/commercial owners

FAIRMOUNT PARK PROJECTS
Units: number of projects in vicinity of each reach
Derivation: Fairmount Park's ES&ED division provided a spreadsheet showing medium and high priority projects. For a small number of projects, the location was not clear from the spreadsheet; these projects were not included in the analysis. For other projects, a point was placed in a GIS layer using the best judgment of GIS staff.

IDENTIFIED SANITARY SEWER PROBLEMS
Units: number of problems identified along each reach
Derivation: A sanitary infrastructure problem was defined as follows:

- The infrastructure feature may be leaking sanitary sewage to the stream, or high stream flows may be infiltrating the infrastructure feature.
- The feature is in good condition, but is exposed in the channel or bank and subject to damage by high flows.

DETERMINATION OF CONDITION OF MANHOLES AND PIPES

- Condition was noted as "poor" by the field team (no instances identified).

- The photo taken by the field team shows at least one of the following:
  - The feature is broken, cracked, leaking, or has exposed joints.
  - The feature is exposed in the channel or bank and subject to high flows.

DETERMINATION OF CONDITION OF DAMS

- If sanitary infrastructure is visible in the photo taken by the field team, the checklist for manholes and pipes above was followed.

USE OF THERMAL IMAGING STUDY RESULTS (NO INSTANCES IDENTIFIED)

- The point was noted as a "suspected leak" by the thermal imaging team.
- Ground truthing notes indicate that the point is associated with sanitary infrastructure (not a stormwater outfall) and that evidence of sewage is present.

RESTORATION PRIORITY RESULTS

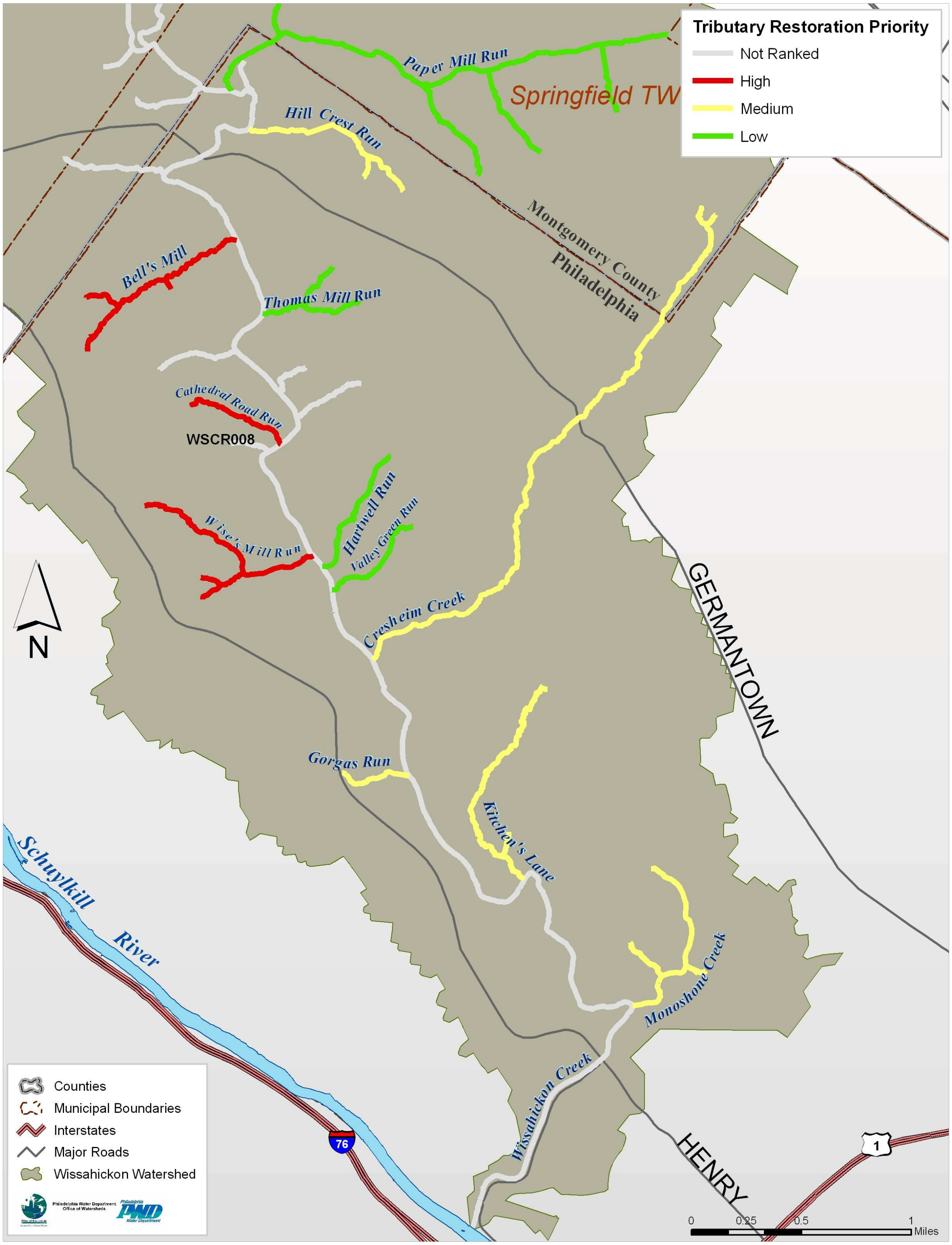
Ranking analyses were performed with several sets of criteria weights. One set of weights for the restoration project are shown in Appendix A, Table 10. The results obtained with that weight set are presented in Appendix A, Table 11. Also shown in Appendix A, Table 11 is the sum of all the reach lengths for each category identified as low, medium, and high priority within each tributary. The tributary restoration ranking is graphically represented in Appendix A, Figure 18; and reach restoration ranking is graphically represented in Appendix A, Figure 19.

Appendix A, Table 10 – Criteria Weights

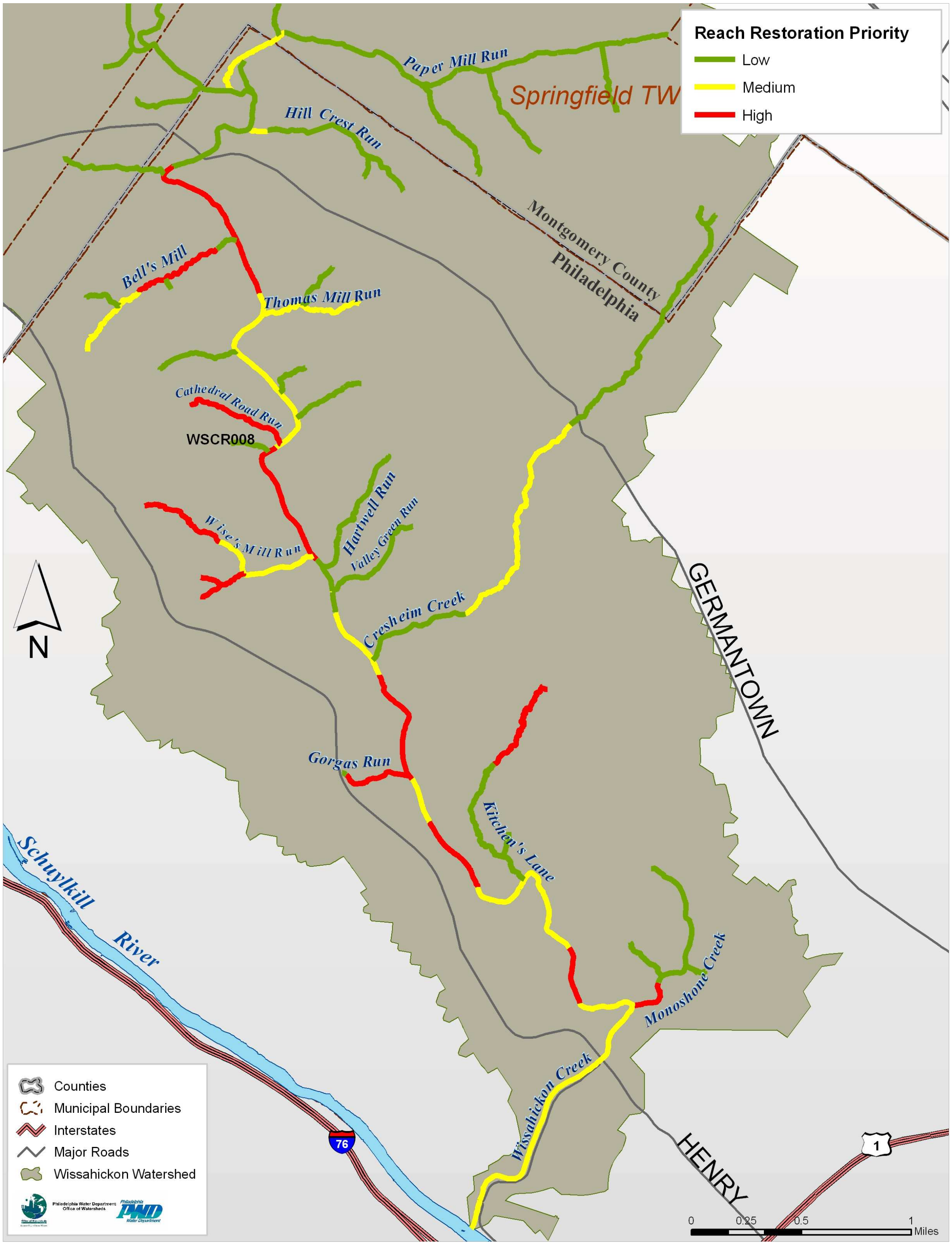
	Weight
Criteria	**0<wt<1**
estimated streambank erosion load	0.300
habitat index	0.100
benthic macroinvertebrate index	0.100
Fairmount Park projects	0.100
identified sanitary sewer problems	0.100
construction difficulty/disturbance index	0.300

Appendix A, Table 11 – Tributary Ranking Results

			Total Reach Length (ft)		
Options	**Ranking**	**Mean Rank**	**low**	**medium**	**high**
Cathedral Road Run	High	1.0	0	0	2771
Bell's Mill	High	3.0	1834	1078	1846
Wise's Mill	High	4.0	0	1507	4052
Cresheim Creek	Medium	5.0	9997	5383	0
Gorgas Run	Medium	5.5	0	0	1750
Hill Crest Run	Medium	5.5	2035	1781	0
Monoshone Creek	Medium	6.0	3236	0	1658
Kitchen's Lane	Medium	8.5	4720	0	2019
Paper Mill Run	Low	8.5	788	4653	0
Valley Green Run	Low	10.5	2868	0	0
Thomas Mill Run	Low	11.0	0	2689	0
Hartwell Run	Low	11.5	3423	0	0



Appendix A, Figure 18 – Tributary Restoration Ranking



Appendix A, Figure 19 – Reach Restoration Ranking

5. Future Sampling

In efforts to comply with the Wissahickon Creek Sediment TMDL and the continuing goal of reducing sediment load from tributaries within City boundaries, PWD has developed a five-year strategy (Appendix A, Table 12).

Appendix A, Table 12 - Time Line Strategy for Monitoring Components of the Wissahickon TMDL.

Monitoring Program	2005				2006				2007				2008				2009				2010			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Tributary Prioritization																								
BEHI/NBS Studies			■	■	■	■																		
Bank Profile Measurements				■	■	■	■	■	■	■	■	■	■	■	■	■	■	■						
Stream Modelling			■	■	■	■	■																	
Flow Monitoring																								
Discharge Rating Curve		■	■	■	■	■	■	■	■	■	■	■	■	■	■									
Continuous Stage Recording		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■								
Sediment Transport Rates																								
TSS Rating Curve				■	■	■	■	■	■	■	■	■	■	■	■									
Bedload Sediment Rating Curve						■	■	■	■	■	■	■	■	■	■	■								
BMP Monitoring																								
Post Construction TSS Monitoring															■	■	■	■	■	■	■	■	■	■
Post Construction Bank Profile Measurements															■	■	■	■	■	■	■	■	■	■
Post Construction Stream Modelling															■	■	■	■	■	■	■	■	■	■

i. Expanded Bank Pin Program

The program of installing bank pins to measure actual erosion rates is being greatly expanded. The objective of this program is to define a local relationship between measured streambank erosion and qualitative streambank erosion (using Rosgen's BEHI/NBS method).

Sampling Design

The sampling design below is recommended based on EPA (2002).

- stratified sampling design: stream length broken up into categories (strata), each representing one combination of BEHI and NBS score observed in Wissahickon.
- total number of sampling sites allocated in each strata according to the estimated load contributed by each BEHI/NBS combination (Appendix A, Table 13)
- total number of sampling sites determined by acceptable margin of error and available budget/staff (more discussion below)
- random site selection within each stratum

As of April 2006, bank pins were installed at 21 sites, and erosion was measured at 11 of these. The most recent measurements included in this study were taken April 24, 2006. Mean erosion rates at the 11 sites with measured erosion are shown in Appendix A, Table 13. A summary of the BEHI ratings are shown in Appendix A, Table 14. The fraction of total load contributed by reaches with each combination of BEHI and NBS score are shown in Appendix A, Table 15. Shown in Appendix A, Figure 20 is a comparison of high and moderate BEHI from local study results. No trend is apparent from data collected so far, but it is hoped a trend will emerge in the future as more data points are added.

Appendix A, Table 13 - Preliminary Bank Pin Data

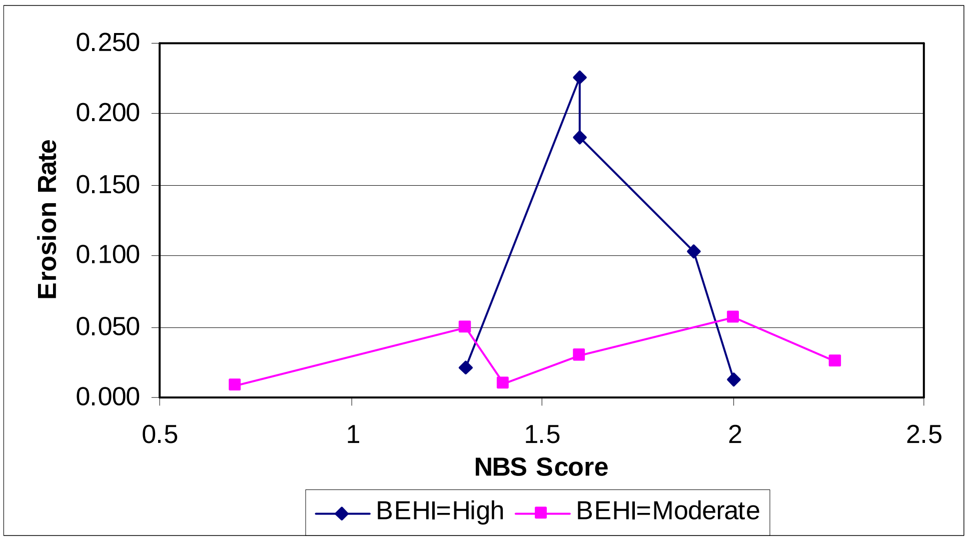
Site	First	Last	Days Monitored	BEHI Rating	NBS Rating	Measured Erosion to top bank pin (ton/ft/yr)	Measured Erosion to top of bank (ton/ft/yr)
MN1	11/2/2005	4/24/2006	173	Moderate	Very Low	0.006	0.016
MN4	11/2/2005	4/24/2006	173	Moderate	Low	0.004	0.009
WM29	11/5/2005	4/24/2006	170	Moderate	Low	0.022	0.074
BM25	11/7/2005	4/24/2006	168	Moderate	Moderate	0.020	0.046
BM21	11/7/2005	4/24/2006	168	Moderate	High	0.012	0.040
CR16	10/31/2005	4/24/2006	175	Moderate	High	0.036	0.090
CR13	10/31/2005	4/24/2006	175	High	Low	0.014	0.041
BM35	11/7/2005	4/24/2006	168	High	Moderate	0.154	0.379
WM13	11/5/2005	4/24/2006	170	High	Moderate	0.122	0.326
MN3	11/2/2005	4/24/2006	173	High	High	0.066	0.275
CR7	10/31/2005	4/24/2006	175	High	High	0.008	0.042

Appendix A, Table 14 - Bank Pin Erosion Summary

		To Top Bank Pin		To Top of Bank	
BEHI Rating	No. Sites	Mean (ton/ft/yr)	St. Deviation (ton/ft/yr)	Mean (ton/ft/yr)	St. Deviation (ton/ft/yr)
Moderate	6	0.017	0.012	0.046	0.032
High	5	0.073	0.065	0.213	0.161

Appendix A, Table 15 - Fraction of Load Contributed by each BEHI/NBS Combination

BEHI	NBS	Sites	Erosion (ton/yr/ft)	Length (ft)	Erosion (ton/yr)	Erosion (% of total)	New Bank Pin Sites
Low	Low	Unassessed*	0.009	153,552	1,367	68.4	60
Low	High	1	0.043	30	1.30	0.065	1
Moderate	Very Low	17	0.020	647	12.9	0.645	1
Moderate	Low	96	0.025	3,008	74.6	3.73	4
Moderate	Moderate	11	0.042	379	15.8	0.791	1
Moderate	High	9	0.056	341	19.1	0.956	1
Moderate	Very High	2	0.096	75	7.21	0.361	1
High	Very Low	15	0.045	370	16.5	0.824	1
High	Low	136	0.059	5,040	299	15.0	15
High	Moderate	9	0.133	388	51.6	2.59	3
High	High	12	0.134	566	75.7	3.79	4
High	Very High	1	0.143	15	2.15	0.107	1
High	Extreme	1	0.107	25	2.68	0.134	1
Very High	Very Low	5	0.069	160	11.0	0.550	1
Very High	Low	21	0.067	455	30.6	1.53	2
Very High	Moderate	1	0.062	10	0.616	0.031	1
Very High	High	1	0.144	20	2.89	0.145	1
Extreme	Low	1	0.289	25	7.22	0.362	1
All Measurements		339		165,106	1997	100	100



Appendix A, Figure 20 - BEHI/NBS Local Study Results

<u>NUMBER OF SITES</u>

The number of sites needed can be estimated based on observed variability in measurements and the acceptable uncertainty in the estimate:

$$n = \frac{z_{\alpha}^2 \sigma^2}{L^2}$$

where n = sample size (number of sites, rounded up to nearest integer)
z = standard normal cumulative probability for a 2-tailed 95% confidence interval = 1.96
σ = standard deviation of measured erosion rates so far = 0.0439 ton/yr/ft
L = acceptable uncertainty, 1/2 width of confidence interval (ton/yr/ft)

The number of BEHI sites for each rating, required to achieve a given confidence interval, are listed in Appendix A, Table 16 (erosion measured from top bank pin) and Appendix A, Table 17 (erosion measured from top of bank). Low and Moderate BEHI sites were assigned the standard deviation measured at Moderate BEHI sites. High BEHI sites were assigned the standard deviation measured at High BEHI sites. The results suggest that a sampling program to achieve a confidence interval of 100 ton/yr/sq.mi. or less may not be feasible. However, it is important to note that the standard deviations are based on a very small sample size. Collecting more samples may result in a lower estimate of standard deviation. Even if a statistically meaningful measure of error cannot be established, additional sites will allow better management decisions.

Appendix A, Table 16 - The number of sites required to achieve a given Confidence Interval

	St. Dev.	1/2 C.I. (ton/yr/sq.mi.)				
BEHI	(ton/yr/ft)	10	50	100	150	200
Low/Moderate	0.012	1,320	53	14	6	4
High	0.065	38,717	1,549	388	173	97
Total		40,037	1,602	402	179	101

Based on erosion to top bank pin

Appendix A, Table 17 - The number of sites required to achieve a given Confidence Interval

	St. Dev.	1/2 C.I. (ton/yr/sq.mi.)				
BEHI	(ton/yr/ft)	10	50	100	150	200
Low/Moderate	0.032	9,384	376	94	42	24
High	0.161	237,530	9,502	2,376	1,056	594
Total		246,914	9,878	2,470	1,098	618

Based on erosion to top of bank

NEXT STEPS

PWD plans to establish approximately 100 new sites to better estimate the true standard deviations. If these are lower than current estimates, the number of sites needed for a statistically meaningful estimate will also decrease.

ii. BANK EROSION HAZARD INDEX AND NEAR BANK STRESS

Total sediment yields are composed of sediment derived from overland runoff and from that originating in the creek. To determine the relative importance of these two components, PWD is conducting an expanded Bank Erosion Hazard Index (BEHI) and Near Bank Stress (NBS) study as defined by Rosgen (1996) to predict streambank erosion rates.

Additional reaches of the thirteen tributaries (Appendix A, Figure 19) within Philadelphia will be assessed by PWD staff and sections of streambank will be scored based on the BEHI and NBS criteria. This study will be combined with the expanded bank pin program to develop a local relationship between these indices and measured erosion.

iii. BANK EROSION HAZARD INDEX AND NEAR BANK STRESS

Additional discharge rating curves will be established and existing ones will be refined as necessary for the tributaries within Philadelphia County limits following a modified version of the USGS protocol (Buchanan and Somers 1969). Currently, discharge rating curves have been completed on three tributaries (Bells Mill, Monoshone, and Wises Mill). Discharge will be measured using a SonTek Flowtraker during low and medium flow events and a Gurley pygmy meter during high flow events.

iv. CONTINUOUS STAGE RECORDING

Discharge characterization on the thirteen tributaries within Philadelphia County limits will be completed based on the aforementioned prioritization ranking. Stage data will be recorded at the designated monitoring site using a fixed Sigma ultrasonic sensor and/or pressure transducer. Stage data will be downloaded bimonthly and QA/QC will be performed by PWD staff.

v. TSS RATING CURVE

Automated water collection devices (ISCO model no. 6712) will be used to collect water samples during additional wet weather events as needed in the Wissahickon Creek tributaries. In the attempt to characterize an entire storm event, automated samplers are triggered by a 0.2 ft elevation change in stream height and will continue to collect samples every 20 minutes for the first hour. Following this step, samples are then collected every 2-4 hours until discharge has returned to base flow conditions. Suspended sediment loads will be related to the discharge at which they were collected to create a suspended sediment rating curve. To date, two wet weather events have been captured on Monoshone Creek, Wises Mill and Cathedral Run, and three runoff producing events have been captured on Bells Mill. Wet weather monitoring will continue through 2006-2007 in attempt to characterize TSS in relation to discharge.

vi. BEDLOAD SEDIMENT RATING CURVE

In order to estimate a total sediment load, bedload sediment samples will be collected in addition to suspended sediment samples. Bedload sediment samples will be collected at different stages according to a modified version of USGS protocol (Edwards and Glysson 1999). Samples will be collected using a Helley-Smith handheld sampler with a 15cm orifice. Samples will be dried, sieved and weighed in order to determine a rate of transport as well as a particle size distribution.

vii. POST-CONSTRUCTION MONIITORING

The final objective of the TMDL monitoring program is to measure (i.e., quantify) the efficacy of Best Management Practices (BMPs) and their benefit in terms of sediment reduction in the Wissahickon drainage. In 2005, PWD conducted extensive wet-weather monitoring on three tributaries where various stormwater BMPs have been proposed or are currently under construction.

APPENDIX A – SEDIMENT TOTAL MAXIMUM DAILY LOAD (TMDL) FOR WISSAHICKON CREEK – FEASIBILITY STUDY & MONITORING PLAN

1. STORMWATER FLOW AND LOAD ESTIMATES BY OUTFALL

Methods used to develop stormwater outfall flows and loads are described in detail in the Wissahickon Comprehensive Characterization Report. In Appendix A, Table 1 drainage area and estimated mean annual runoff volume are reported for each outfall. In Appendix A, Table 2 estimated mean annual pollutant loads are reported for each outfall. A summary of the total number of outfalls per tributary is reported in Appendix A, Table 3 along with a summary of discharge and estimated loads for all of the outfalls found in each tributary.

Appendix A, Table 1 - Philadelphia Stormwater Outfall Runoff

Outfall	Tributary/Stream	Drainage Area (acres)	Runoff 4/93-3/01 (in/yr)
W-084-01	Bells Mill	62.8	7.74
W-084-02	Bells Mill	106	9.26
W-084-03	Bells Mill	4.94	10.4
W-084-04	Bells Mill	12.2	11.9
W-076-01	Cathedral Road Run	90.3	6.01
W-076-02	Cathedral Road Run	38.3	6.12
W-076-08	Cresheim Creek	5.94	12.4
W-076-11	Cresheim Creek	10.6	7.31
W-076-12	Cresheim Creek	47.5	9.97
W-077-01	Cresheim Creek	46.2	8.93
W-077-02	Cresheim Creek	239	10.0
W-086-01	Cresheim Creek	270	14.8
W-086-02	Cresheim Creek	76.7	12.6
W-086-03	Cresheim Creek	35.3	13.2
W-086-04	Cresheim Creek	31.6	18.8
W-086-05	Cresheim Creek	47.7	11.7
W-086-06	Cresheim Creek	85.3	11.6
W-086-07	Cresheim Creek	23.6	17.2
W-067-01	Gorgas Run	392	12.2
W-067-02	Gorgas Run	41.3	14.9
W-067-03	Gorgas Run	29.5	13.3
W-076-07	Hartwell Run	48.0	9.30
W-076-14	Hartwell Run	67.6	10.4
W-095-01	Hill Crest Run	99.7	11.3
W-095-03	Hill Crest Run	51.3	12.4
W-068-01	Kitchen's Lane	16.0	12.2
W-068-02	Kitchen's Lane	10.7	15.7
W-068-03	Kitchen's Lane	4.07	13.0
W-068-06	Kitchen's Lane	23.2	10.3
W-068-08E	Kitchen's Lane	25.9	9.38
W-068-08W	Kitchen's Lane	33.8	9.85
W-060-04	Monoshone Creek	12.7	4.83

W-060-08	Monoshone Creek	16.3	6.43
W-060-09	Monoshone Creek	17.0	4.65
W-060-10	Monoshone Creek	163	6.28
W-060-11	Monoshone Creek	39.2	4.35
W-068-04	Monoshone Creek	628	5.26
W-068-05	Monoshone Creek	76.4	5.72
W-095-02	Paper Mill Run	6.07	9.10
W-095-04	Paper Mill Run	6.82	15.4
W-095-05	Paper Mill Run, Trib B	20.7	14.8
W-076-09	Valley Green Run	62.8	9.96
W-076-10	Valley Green Run	46.0	10.7
W-075-01	Wise's Mill Run	154	14.5
W-075-02	Wise's Mill Run	9.88	8.18
W-076-04	Wise's Mill Run	9.02	8.40
W-076-05	Wise's Mill Run	3.82	10.4
W-076-06	Wise's Mill Run	9.62	11.5
W-076-13	Wise's Mill Run	92.0	13.2
W-076-X	Wise's Mill Run	9.47	1.72
W-052-01	Wissahickon Creek	12.4	11.3
W-052-02	Wissahickon Creek	15.5	12.8
W-060-01	Wissahickon Creek	111	12.5
W-060-02	Wissahickon Creek	25.5	14.0
W-060-03	Wissahickon Creek	63.2	13.8
W-060-05	Wissahickon Creek	96.7	8.39
W-060-06	Wissahickon Creek	2.58	16.7
W-060-07	Wissahickon Creek	22.0	12.4
W-067-04	Wissahickon Creek	23.8	13.9
W-067-05	Wissahickon Creek	10.0	14.1
W-067-06	Wissahickon Creek	41.5	10.8
W-068-07	Wissahickon Creek	24.9	9.39
W-076-03	Wissahickon Creek	9.21	11.7
W-085-01	Wissahickon Creek	83.9	12.3
W-085-02	Wissahickon Creek, Trib I	57.4	11.4

Appendix A, Table 2 - Wissahickon Outfall Load Summary

Outfall	Tributary/Stream	BOD5 (lbs/yr)	TSS (lbs/yr)	COD (lbs/yr)	TP (lbs/yr)	Cu (lbs/yr)	Zn (lbs/yr)	Fe (lbs/yr)	TN (lbs/yr)	Fecal (#/yr)	Pb (lbs/yr)
W-084-01	Bells Mill	892	7,395	5,397	29.2	1.51	11.5	129	198	2.92E+12	1.86
W-084-02	Bells Mill	1,759	14,084	10,743	57.3	2.99	22.9	262	385	5.77E+12	3.70
W-084-03	Bells Mill	104	731	653	3.29	0.177	1.39	17.0	21.6	3.41E+11	0.222
W-084-04	Bells Mill	297	2,123	1,989	9.36	0.549	4.18	55.4	57.4	9.34E+11	0.656
W-076-01	Cathedral Road Run	985	8,370	6,030	32.4	1.71	12.8	146	217	3.19E+12	2.07
W-076-02	Cathedral Road Run	490	3,247	3,123	15.4	0.834	6.62	83.2	100	1.61E+12	1.06
W-076-08	Cresheim Creek	141	1,084	872	4.56	0.240	1.86	21.8	30.4	4.64E+11	0.299
W-076-11	Cresheim Creek	134	1,221	791	4.49	0.228	1.69	17.8	31.0	4.39E+11	0.276
W-076-12	Cresheim Creek	975	6,648	6,180	30.8	1.66	13.1	163	201	3.20E+12	2.10
W-077-01	Cresheim Creek	665	6,819	3,861	22.8	1.16	8.27	81.6	159	2.15E+12	1.35
W-077-02	Cresheim Creek	4,632	35,467	29,705	149	8.25	62.8	778	955	1.48E+13	10.0
W-086-01	Cresheim Creek	7,939	58,607	51,631	253	14.2	109	1,384	1,602	2.54E+13	17.3
W-086-02	Cresheim Creek	1,411	16,888	7,885	50.4	2.51	17.0	146	358	4.50E+12	2.79
W-086-03	Cresheim Creek	953	6,595	6,120	30.1	1.66	12.9	163	193	3.10E+12	2.06
W-086-04	Cresheim Creek	1,163	9,531	8,702	36.9	2.54	18.0	265	196	3.29E+12	2.71
W-086-05	Cresheim Creek	1,143	7,876	7,235	36.1	1.95	15.3	190	236	3.75E+12	2.46
W-086-06	Cresheim Creek	1,482	16,878	8,242	52.4	2.56	17.8	154	374	4.80E+12	2.93
W-086-07	Cresheim Creek	739	7,133	5,998	23.9	1.84	12.2	191	112	1.87E+12	1.79
W-067-01	Gorgas Run	8,705	74,863	55,682	285	16.0	118	1,421	1,833	2.74E+13	18.7
W-067-02	Gorgas Run	1,280	8,604	8,141	40.3	2.18	17.3	216	262	4.20E+12	2.76
W-067-03	Gorgas Run	774	5,849	5,049	24.7	1.40	10.6	135	156	2.46E+12	1.68
W-076-07	Hartwell Run	803	6,882	4,820	26.5	1.36	10.3	113	181	2.63E+12	1.67
W-076-14	Hartwell Run	1,088	11,798	6,249	37.9	1.91	13.4	127	265	3.49E+12	2.19
W-095-01	Hill Crest Run	2,029	17,529	12,447	66.9	3.55	26.5	300	447	6.55E+12	4.26
W-095-03	Hill Crest Run	1,191	9,722	7,658	38.6	2.17	16.2	199	247	3.77E+12	2.57
W-068-01	Kitchen's Lane	395	2,771	2,490	12.5	0.672	5.28	64.8	82.2	1.30E+12	0.848
W-068-02	Kitchen's Lane	334	2,403	2,089	10.6	0.567	4.44	53.8	70.1	1.10E+12	0.713
W-068-03	Kitchen's Lane	101	785	620	3.26	0.171	1.32	15.4	21.8	3.31E+11	0.213
W-068-06	Kitchen's Lane	491	3,397	3,099	15.5	0.835	6.57	81.1	102	1.61E+12	1.05
W-068-08E	Kitchen's Lane	426	3,802	2,528	14.2	0.723	5.40	57.6	97.6	1.40E+12	0.879
W-068-08W	Kitchen's Lane	676	4,711	4,267	21.4	1.15	9.05	111	140	2.22E+12	1.45
W-060-04	Monoshone Creek	100	1,017	602	3.40	0.181	1.28	13.6	22.9	3.14E+11	0.206
W-060-08	Monoshone Creek	213	1,486	1,342	6.74	0.362	2.85	35.0	44.2	6.99E+11	0.457
W-060-09	Monoshone Creek	144	1,214	865	4.73	0.244	1.85	20.4	32.1	4.71E+11	0.299
W-060-10	Monoshone Creek	1,910	16,134	12,860	62.0	3.71	27.0	350	377	5.83E+12	4.21
W-060-11	Monoshone Creek	304	2,656	1,838	10.1	0.524	3.92	43.3	68.1	9.89E+11	0.634
W-068-04	Monoshone Creek	6,613	47,570	42,041	210	11.5	89.1	1,102	1,365	2.15E+13	14.2
W-068-05	Monoshone Creek	854	6,523	5,559	27.3	1.55	11.7	148	173	2.71E+12	1.86
W-095-02	Paper Mill Run	77.1	970	403	2.81	0.130	0.877	6.18	20.8	2.52E+11	0.147
W-095-04	Paper Mill Run	208	1,539	1,335	6.63	0.367	2.82	35.2	42.6	6.69E+11	0.449
W-095-05	Paper Mill Run, Trib B	635	4,452	4,334	19.9	1.19	9.08	123	120	1.98E+12	1.42
W-076-09	Valley Green Run	800	11,580	4,291	30.2	1.49	9.27	64.1	218	2.48E+12	1.53
W-076-10	Valley Green Run	989	7,079	6,199	31.5	1.68	13.2	160	207	3.25E+12	2.11

W-075-01	Wise's Mill Run	4,086	36,479	28,767	133	8.50	59.9	813	768	1.19E+13	9.19
W-075-02	Wise's Mill Run	139	1,279	817	4.66	0.236	1.75	18.2	32.3	4.55E+11	0.285
W-076-04	Wise's Mill Run	137	1,162	826	4.52	0.233	1.76	19.5	30.7	4.50E+11	0.286
W-076-05	Wise's Mill Run	83.0	554	531	2.60	0.142	1.12	14.2	16.8	2.72E+11	0.180
W-076-06	Wise's Mill Run	224	1,621	1,472	7.09	0.405	3.10	40.1	44.4	7.11E+11	0.490
W-076-13	Wise's Mill Run	2,436	18,295	16,673	77.2	4.68	34.9	471	462	7.50E+12	5.43
W-076-X	Wise's Mill Run	20.9	295	103	0.790	0.035	0.227	1.20	5.99	6.83E+10	0.039
W-052-01	Wissahickon Creek	201	2,517	1,220	7.21	0.397	2.59	25.8	48.0	6.05E+11	0.412
W-052-02	Wissahickon Creek	341	3,411	2,433	11.3	0.744	5.05	68.3	64.4	9.62E+11	0.768
W-060-01	Wissahickon Creek	2,376	22,846	15,121	79.7	4.49	31.9	374	513	7.35E+12	5.06
W-060-02	Wissahickon Creek	705	5,161	4,401	22.5	1.20	9.35	112	149	2.32E+12	1.50
W-060-03	Wissahickon Creek	1,456	14,497	9,260	49.2	2.78	19.5	227	317	4.48E+12	3.09
W-060-05	Wissahickon Creek	1,202	13,898	6,518	42.7	2.04	14.1	115	310	3.93E+12	2.35
W-060-06	Wissahickon Creek	46.4	829	195	1.90	0.078	0.439	0.00	15.2	1.50E+11	0.078
W-060-07	Wissahickon Creek	397	4,906	2,472	14.1	0.802	5.22	55.0	91.9	1.17E+12	0.824
W-067-04	Wissahickon Creek	605	5,233	3,963	19.8	1.14	8.34	104	124	1.87E+12	1.31
W-067-05	Wissahickon Creek	265	2,209	1,756	8.61	0.503	3.69	47.0	53.5	8.22E+11	0.580
W-067-06	Wissahickon Creek	808	6,903	4,851	26.7	1.37	10.4	114	182	2.65E+12	1.68
W-068-07	Wissahickon Creek	477	3,295	3,016	15.1	0.812	6.40	79.0	98.6	1.57E+12	1.03
W-076-03	Wissahickon Creek	214	1,548	1,336	6.81	0.363	2.84	34.3	45.0	7.01E+11	0.456
W-085-01	Wissahickon Creek	1,741	16,604	10,267	58.8	3.00	22.0	228	405	5.66E+12	3.57
W-085-02	Wissahickon Creek, Trib I	1,289	9,638	8,237	41.2	2.27	17.4	216	266	4.16E+12	2.78

Appendix A, Table 3 - Wissahickon Tributary Load Summary

Tributary/Stream	Outfalls	Total Discharge (cfs)	BOD5 (lbs/yr)	TSS (lbs/yr)	COD (lbs/yr)	TP (lbs/yr)	Cu (lbs/yr)	Zn (lbs/yr)	Fe (lbs/yr)	TN (lbs/yr)	Fecal (#/yr)	Pb (lbs/yr)
Bells Mill	4	0.060	3,051	2.43E+04	1.88E+04	99.2	5.23	40.0	463	662	9.97E+12	6.44
Cathedral Road Run	2	0.028	1,475	1.16E+04	9.15E+03	47.8	2.54	19.4	229	317	4.80E+12	3.13
Cresheim Creek	12	0.523	21,378	1.75E+05	1.37E+05	694	38.8	290	3,554	4,448	6.78E+13	46.0
Gorgas Run	3	0.255	10,759	8.93E+04	6.89E+04	350	19.6	146	1,772	2,251	3.41E+13	23.1
Hartwell Run	2	0.028	1,891	1.87E+04	1.11E+04	64.4	3.28	23.7	240	446	6.13E+12	3.86
Hill Crest Run	2	0.053	3,220	2.73E+04	2.01E+04	106	5.72	42.6	499	694	1.03E+13	6.83
Kitchen's Lane	6	0.038	2,423	1.79E+04	1.51E+04	77.6	4.12	32.1	384	513	7.95E+12	5.16
Monoshone Creek	7	0.259	10,136	7.66E+04	6.51E+04	324	18.0	138	1,713	2,082	3.25E+13	21.9
Paper Mill Run	3	0.020	920	6.96E+03	6.07E+03	29.3	1.69	12.8	165	183	2.90E+12	2.01
Valley Green Run	2	0.030	1,789	1.87E+04	1.05E+04	61.6	3.17	22.4	224	425	5.73E+12	3.64
Wise's Mill Run	7	0.195	7,126	5.97E+04	4.92E+04	230	14.2	103	1,378	1,361	2.14E+13	15.9
Wissahickon Creek	14	0.250	10,835	1.04E+05	6.68E+04	365	19.7	142	1,582	2,416	3.42E+13	22.7
Wissahickon Creek Trib 1	1	0.021	1,289	9.64E+03	8.24E+03	41.2	2.27	17.4	216	266	4.16E+12	2.78

2. STREAMBANK EROSION LOAD FIELD METHODS

In conjunction with Section D (*Sediment Total Maximum Daily Load (TMDL) For Wissahickon Creek*) of the City's stormwater permit, PWD has initiated a monitoring plan that addresses the adverse impacts to in-stream habitats as a result of the transport of

sediment and/or streambank erosion. Baseline data from 13 perennial tributaries that originate in the City will be monitored to define their contribution of sediment loading.

There are two elements to the monitoring program. The first estimates the sediment load originating from streambanks. The second estimates the total sediment load being carried by the stream. Data collection is ongoing for both parts.

i. BEHI/NBS Assessments

PWD employed the Bank Erosion Hazard Index (BEHI) and Near Bank Stress (NBS) as defined by Rosgen (1996) to predict erosion rates and classify the erosion potential of the tributaries. An example of bank erosion can be seen in Figure Appendix A, Figure 1 where much of a bank pin is exposed. Three hundred and sixty eight reaches in 13 tributaries have been assessed using BEHI and NBS criteria. Reaches were assessed based on visual inspection of obvious signs of erosion. BEHI and NBS scores were grouped as very low, low, moderate, high or very high. Table 4 summarizes the portion of each tributary that was assessed using the BEHI/NBS method.

Appendix A, Figure 1 - PWD staff digging out eroded bank sediment in order to accurately measure bank pin exposure

Appendix A, Table 4 - Portion of Each Tributary Assessed Using BEHI/NBS Method

Site	BEHI/NBS Assessed (ft)	Channelized (ft)	Visually Assessed - Low Erosion (ft)
Monoshone	147	3,074	9,537
Kitchens Ln	1,250	0.00	12,946
Cresheim	1,835	1,062	29,143
Valley Green Run	270	277	3,859
Hartwell	340	0.00	6,358

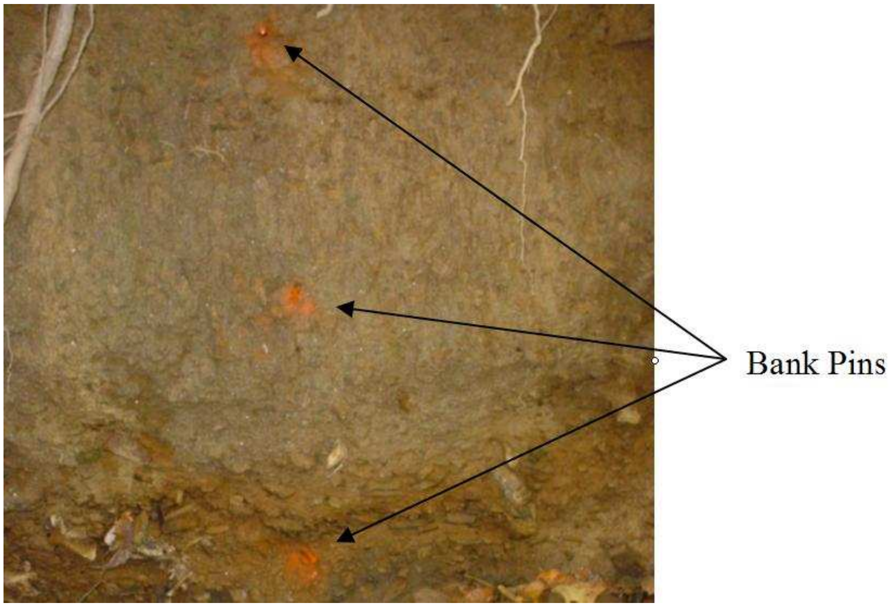
Rex Ave	270	0.00	2,982
Thomas Mill	625	0.00	6,895
Hill Crest	75.0	2,128	6,929
Paper Mill	2,640	8,576	48,298
Gorgas Ln	350	325	3,261
Wises Mill	1,042	1,057	11,301
Cathedral	1,135	0.00	4,227
Bells Mill	1,759	0.00	7,781

ii. Bank Profile Measurements

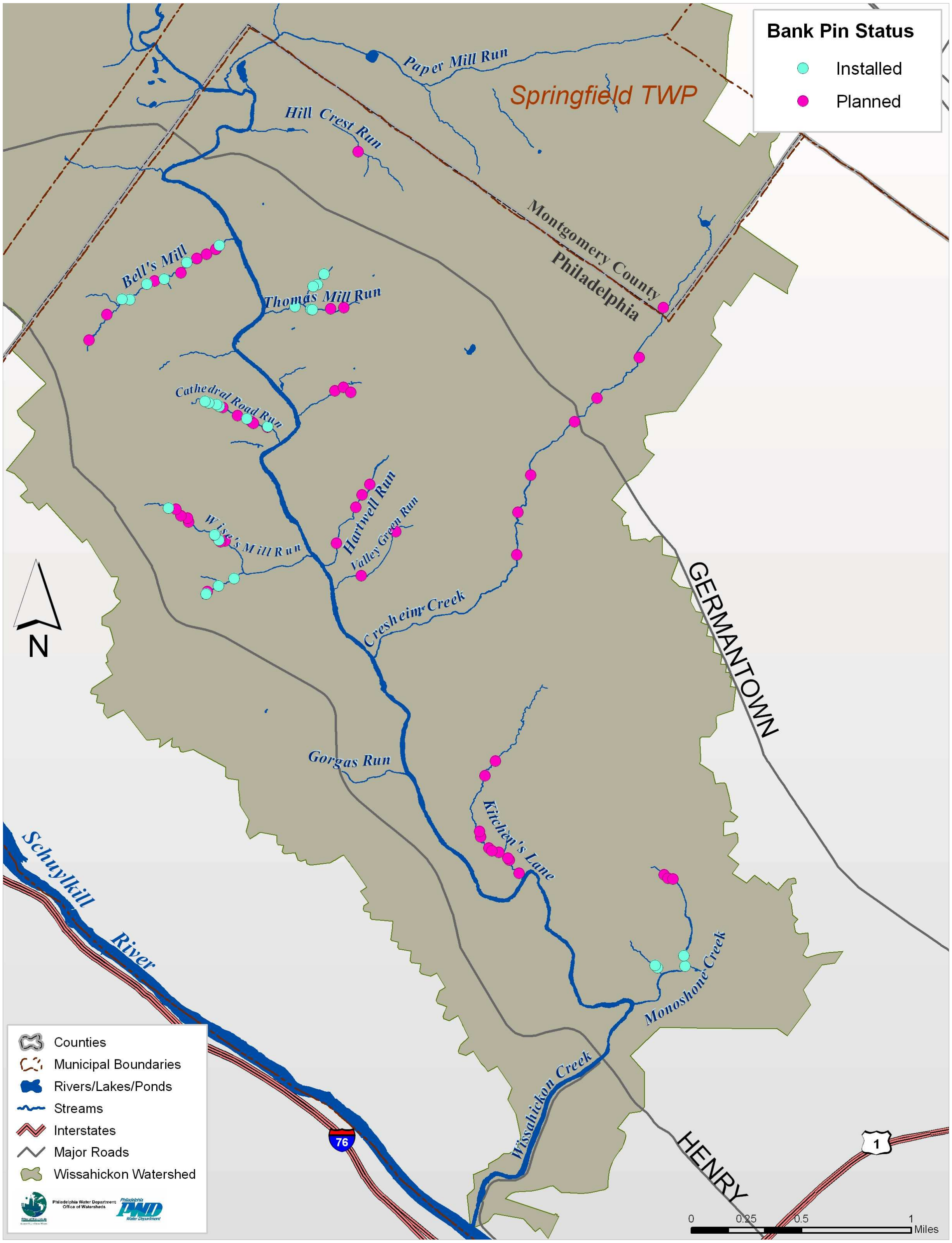
Bank pins were installed in Bells Mill, Cathedral Run, Wises Mill and Monoshone tributaries in October and November 2005. Nine bank pin sites were chosen in each of the tributaries listed with the exception of Monoshone. Only four bank pin sites were chosen in Monoshone because much of the tributary is channelized. Bank pins were installed in reaches with varying BEHI and NBS scores in order to validate and calibrate the prediction model. Three of the 9 sites were in reaches visually assessed to have low erosion rates. Additional bank pin sites in these tributaries and others are planned for the future. The current bank pin installation locations and planned bank pin installation locations can be seen on the map in Appendix A, Figure 4.

Bank pins were installed where the bend in the bank was greatest. At least one bank pin was put in below bankfull height and they were spaced no closer than 1 ft. The number of bank pins at a site was dependent on bank height and ranged from one to three. An example of bank pin installation can be seen in Appendix A, Figure 2, and an example of bank pin spacing can be seen in Appendix A, Figure 3.

Appendix A, Figure 2 - PWD staff installing a bank pin into the bank along the Wises Mill tributary. Bank pins are driven horizontally into streambanks at positions corresponding to bank erosion locations.

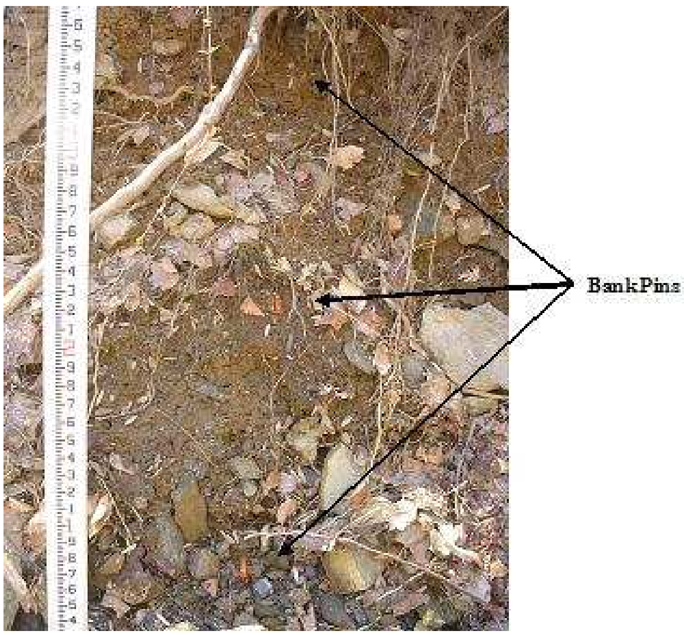


Appendix A, Figure 3 - After bank pin installation, the exposed ends were spray painted to make more visible



Appendix A, Figure 4 - Current and Planned Bank Pin Locations

Measurements were made using a survey rod, a Keson pocket rod and two levels. The survey rod was placed on the edge of the toe pin and kept straight using a level. The pocket rod was placed over the bank pin up against the bank and kept straight by a level. The distance from the bank to the edge of the survey rod closest to the bank was recorded on the field data sheet. Toe pins are bank offset pins driven vertically into the bed surface in order to "profile" the streambank with vertical measurements from the survey rod to the bank. The toe pin offers a permanent location with which to determine lateral erosion per unit time between surveys. The survey rod can be seen in Appendix A, Figure 5 where the bank pins are being measured in relation to the toe pin position. Lateral erosion or aggrading of the streambank is determined by measuring changes in bank pin distance from the toe pin (Appendix A, Figure 6).



Appendix A, Figure 5 - The survey rod measures the amount of exposed pin as the amount of lateral erosion upon re-survey.

Appendix A, Figure 6 - The toe pin is a permanent reference point for determining lateral erosion.

iii. CHANNEL STABILITY

Bar samples, sub-pavement samples and pebble counts were collected at 9 sites in 5 tributaries to Wissahickon Creek in order to gather information on channel stability. Bar and sub-pavement samples as well as pebble counts were collected following methods described on EPA's Watershed Assessment of River Stability and Sediment Supply (WARSSS) website. An example of bar sampling is depicted in Figures 7 and 8. Additionally, Riffle Stability Index (RSI) Assessments and pebble counts were completed at 14 sites in the same 5 tributaries. RSI methods are described in Kappesser (1994). RSI assessments were done in place of bar samples in cases where sediment bars were not prominent due to high slope. In some cases RSI assessments were done in close proximity to bar or sub-pavement samples in order to compare results from the two methods. All samples were collected in April and May 2006.

Appendix A, Figure 7 - PWD staff collected a bar sample representing the size gradation of bedload at the bankfull stage.

Appendix A, Figure 8 - PWD staff draining water from the bar sample.

iv. TOTAL SUSPENDED SEDIMENT LOAD

Automated water collection devices (ISCO model no. 6712) were used to collect water samples during wet weather events in the Wissahickon Creek tributaries. An example of the automated sampler being set up by PWD staff is shown in Appendix A, Figure 9. In the attempt to characterize an entire storm event, automated samplers were triggered by a 0.2 ft elevation change in stream height and collected samples every 20 minutes for the first hour. Following this step, samples were then collected every 2-4 hours until discharge returned to base flow conditions. Suspended sediment loads were related to the discharge at which they were collected to create a suspended sediment rating curve. Four tributaries were selected based on visual inspection of obvious signs of erosion to

estimate sediment loads and calibrate methods used in other tributaries. The location of installed samplers can be seen in Figure 10.

Total suspended sediment samples were collected from Monoshone Creek (5/20/2005 and 7/8/2005), Wises Mill (11/16/2005), Cathedral Run (11/10/2005 and 11/16/2005) and Bells Mill (9/15/2005, 9/26/2005 and 10/8/2005). Samples were collected using an ISCO automated sampler and followed methods described in wet weather monitoring. Water level is recorded during the sample period allowing a sediment discharge rating curve to be established. Additional sample collections are planned for these 4 tributaries as well as other tributaries.

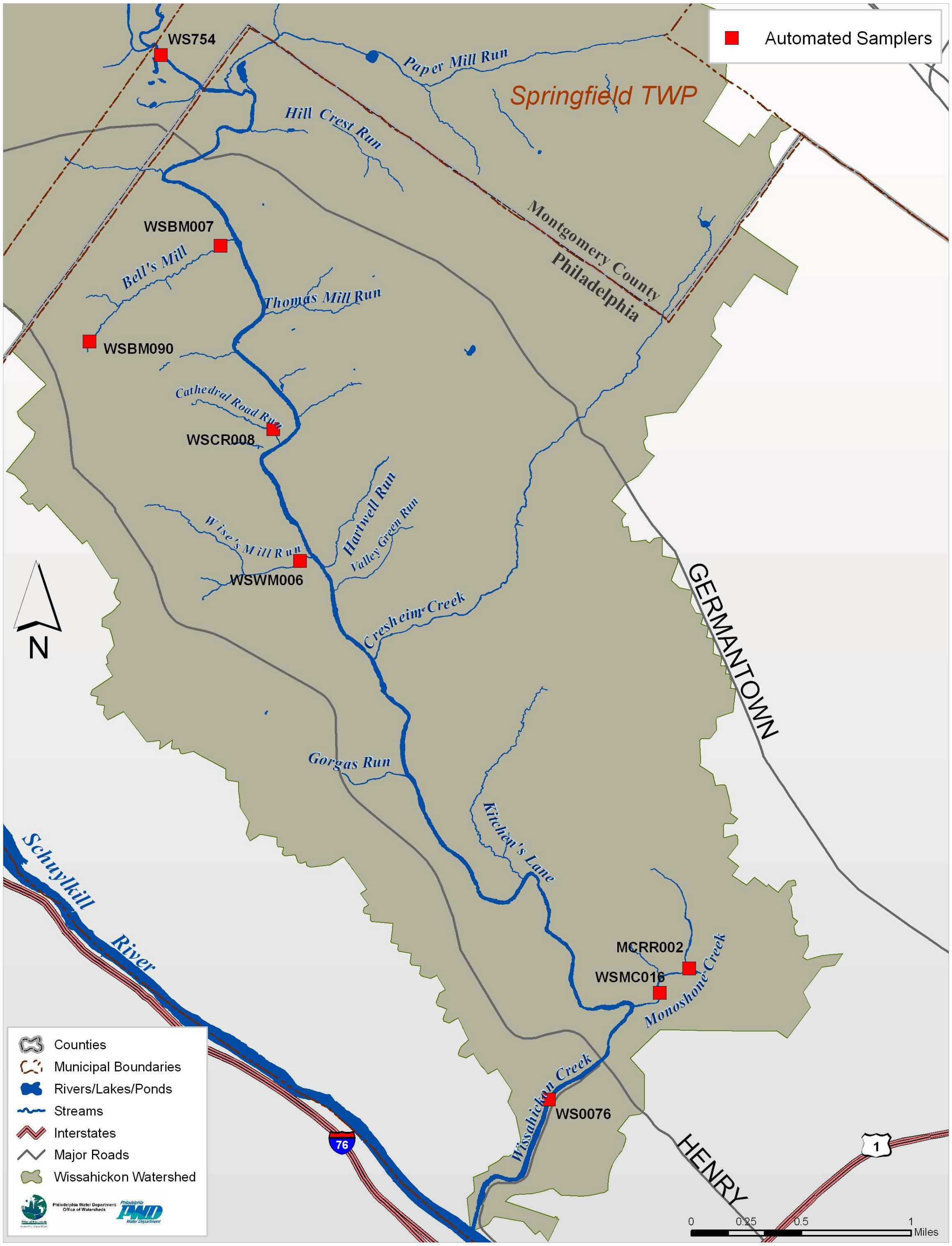
Appendix A, Figure 9 - PWD staff setting up the automated water sampler for wet weather monitoring

Stage data from Bells Mill, Cathedral Run, Wises Mill and Monoshone were recorded near the Wissahickon confluence downstream of all stormwater outfalls. Stage was measured every six minutes by either an ultrasonic down-looking water level sensor or a pressure transducer and recorded on a Sigma620. The ultrasonic down-looking sensor and pressure transducer are shown in Figures 11 and 12. PWD staff periodically downloaded stage data and performed quality assurance. Any data determined to be incorrect was removed and saved in another location.

Dates of ultrasonic down-looking sensor installation in Bells Mill, Cathedral Run and Wises Mill are May 2005, September 2005 and August 2005 respectively. Pressure transducers were installed in Monoshone in July 2005 and Bells Mill in November 2005. Stage data will continue to be recorded at these sites and additional sites will be added.

Appendix A, Figure 10 - An ultrasonic down-looking acoustic water level sensor for water level measurement as it was installed above the Cathedral Run tributary

Appendix A, Figure 11 - A pressure transducer for redundant water level measurement as it was installed in the Cathedral Run tributary.



Appendix A, Figure 12 - Automatic Sampler Locations

v. STAGE-DISCHARGE RATING CURVES

Staff gages were installed in Monoshone, Wises Mill and Bells Mill concurrent with ultrasonic downlooker or pressure transducer installation. Staff gauges are located next to the stage recording device in culverts with concrete floors to ensure that the cross section will not change over time. The staff gage along with the ultrasonic down-looking sensor and pressure transducer are shown in Appendix A, Figure 13.

Discharge rating curves were established in Monoshone, Wises Mill and Bells Mill following a modified version of the USGS protocol (Buchanan and Somers 1969). Discharge was measured in a cross section close to the staff gage using a SonTek Flowtraker Handheld ADV and plotted against the stage it was recorded at. Due to lack of a suitable monitoring location, the discharge rating curve in Cathedral Run will be mathematically modeled instead of measured in the field.

Appendix A, Figure 13 - Staff Gage for the Bells Mill tributary pictured with a pressure transducer and ultrasonic down-looking sensor.

3. PRELIMINARY STREAMBANK EROSION LOAD ESTIMATES

Results of preliminary BEHI, NBS, erosion rate measurements at a reference site, and sediment-flow correlations were analyzed to produce several independent estimates of sediment load in the system. These results are useful for long-term planning but may change substantially as more data are collected and analyzed in the future. Appendix A, Table 5 includes useful summary information for the watershed. Appendix A, Table 6 through Appendix A, Table 8 include estimates of sediment load. The various methods and references used to derive these estimates are discussed below.

Appendix A, Table 5 - Wissahickon Watershed Information

System		
Philadelphia tributary stream length =	81,964	ft
Philadelphia main stem stream length =	40,712	ft
Philadelphia Trib Drainage Area =	4,963	ac
Philadelphia Drainage Area =	6,711	ac

Appendix A, Table 6 - Streambank Erosion Estimates

System	Streambank TSS Load (lb/yr)	Streambank TSS Load (ton/sq. mi/yr)	Streambank TSS Load (lb/ft/yr)	Calculation Method
Philadelphia Tributaries Only	3,142,358	203	38.3	BEHI/NBS Analysis with Colorado Reference Stream
Philadelphia Tributaries and Main Stem	3,685,717	176	30.0	Instream TSS-Flow Regression

Appendix A, Table 7 - Total Sediment Load from Historical Studies

Study	Total Sediment Load (lb/yr)	Total Sediment Load (ton/sq. mi/yr)
RSRI, 1973	8,388,391	400
USGS, 1985	3,271,472	156

Appendix A, Table 8 - Estimated Tributary Loads based on BEHI/NBS and Colorado Reference Stream

System	Drainage Area (acres)	Stream Length (ft)	Total TSS Load (lb/yr)	Total TSS Load (lb/acre/yr)
Bells Mill	323	4,770	414,592	1,285
Cathedral	160	2,681	332,015	2,073
Creshiem	1,218	16,020	731,882	601
Gorgas Lane	499	1,968	183,082	367
Hill Crest	217	4,860	77,581	358
Hartwell	144	3,350	166,226	1,157
Kitchens Lane	234	7,098	279,594	1,194
Monoshone	1,056	6,379	246,101	233
Paper Mill Run	297	29,757	931,999	3,142
Thomas Mill	104	3,760	188,382	1,804
Tributary I	137	1,626	94,361	688
Wises Mill	446	6,980	351,120	788
Valley Green	128	2,203	77,423	604

i. BEHI/NBS and Observed Erosion in Colorado Reference Stream

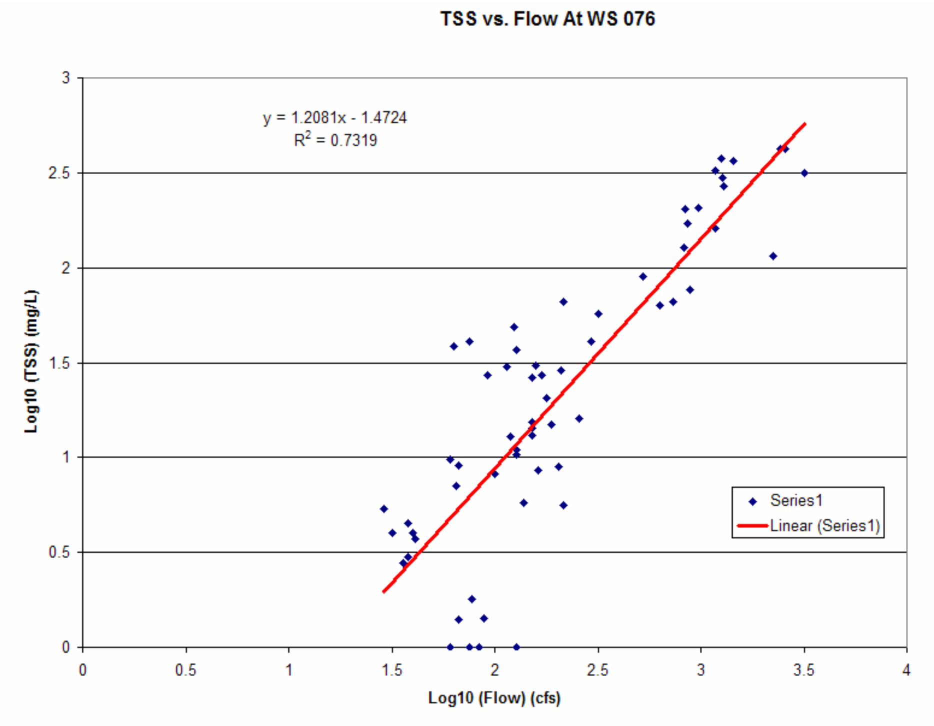
Predicted streambank erosion rates were calculated based on a relationship between these scores and measured streambank erosion rates in a reference stream in Colorado (Rosgen, 1996). The predicted rate is multiplied by the bank height and length as well as a conversion factor to get a sediment load in tons/year.

Streambank erosion estimates were determined using the data from the methods discussed above. For streambanks that were visually assessed to be low-erosion, a background erosion rate was applied. This rate corresponds to a low BEHI and low NBS score. These banks were assumed to have a bank height of the average of that particular tributary. For planning purposes, these low BEHI/NBS erosion rates are assumed to represent relatively stable conditions.

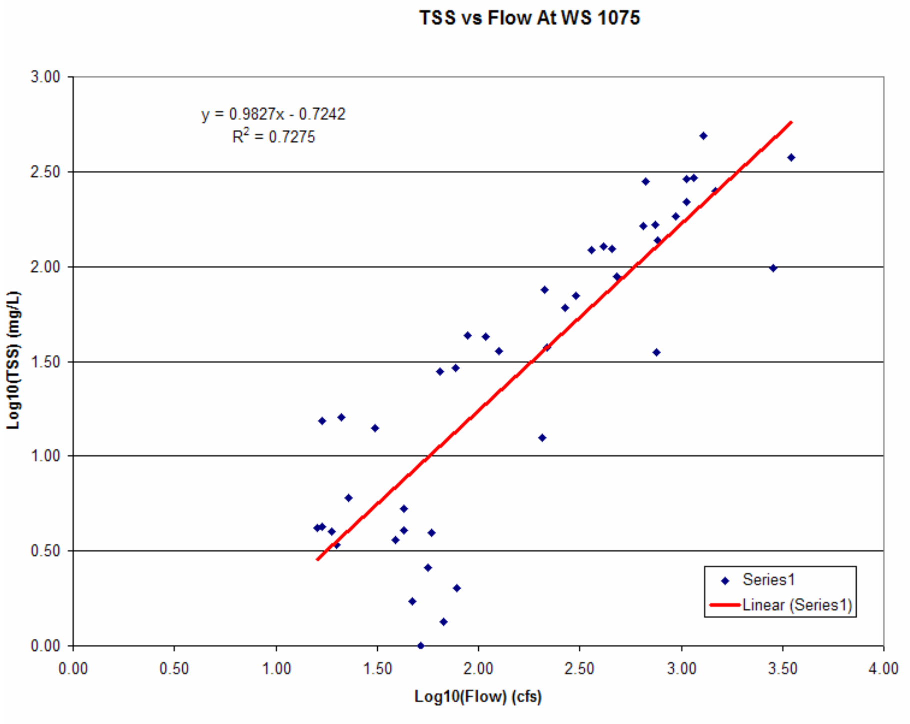
ii. Instream TSS-Flow Regression

A TSS-flow regression was performed by matching instream TSS measurements at or near USGS gauging stations to the flow recorded closest to sampling time. The USGS gage located near the mouth of the main stem provided results for the regression shown in Appendix A, Figure 14. Similarly, a gage located in Fort Washington provided data for the regression in Appendix A, Figure 15. Once the regression was created for the two sites on the main stem, Fort Washington and the mouth at Philadelphia, an annual load could be determined by area weighting measured sediment loads at each station and

estimating sediment input between stations. Regression results were not extrapolated to estimate TSS concentrations at flows outside the range used for the regression. Instead, TSS concentration corresponding to the maximum measured flow was applied to all flows greater than the maximum. For the gage station at Philadelphia, this concentration was 572.3 mg/L and for Fort Washington this concentration was calculated at 570.3 mg/L. The streambank portion of this total sediment load was then estimated by removing estimated runoff sediment load. An estimated 3,685,717 lb/yr of streambank sediment load is contributed by the city of Philadelphia based on this load estimation method.



Appendix A, Figure 14 - TSS-Flow Regression at USGS Gage 01474000 (mouth at Philadelphia) using WS076 TSS data



Appendix A, Figure 15 - TSS-Flow Regression at USGS Gage 01473900 (Fort Washington) using WS1075 TSS data

iii. ENVIRONMENTAL STUDY OF THE WISSAHICKON WATERSHED WITHIN THE CITY OF PHILADELPHIA

A study performed by the Regional Science Research Institute (RSRI) in 1973 estimated a sediment load for the Wissahickon watershed (Appendix A, Table 7). The city of Philadelphia contributes an estimated 8,388,391 lb/yr of sediment based on this study. This amount represents a total sediment load, but the report does not distinguish between the proportion of the load contributed by streambank erosion and stormwater runoff. This study is important because it provides an independent estimate to compare with estimates based on PWD and USGS monitoring.

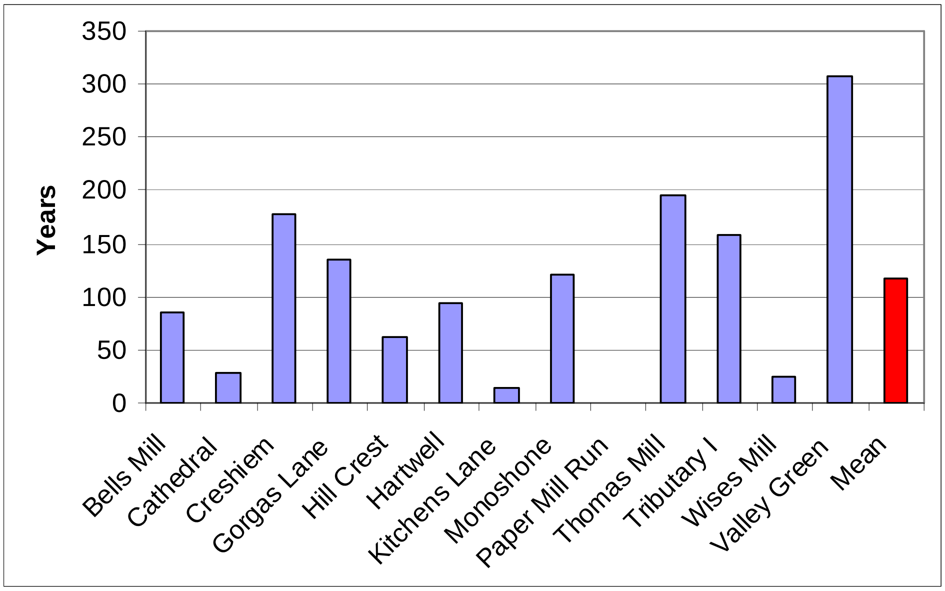
iv. EFFECTS OF LOW LEVEL DAMS ON THE DISTRIBUTION OF SEDIMENT, METALS, AND ORGANIC SUBSTANCES IN THE LOWER SCHUYLKILL RIVER BASIN, PENNSYLVANIA

A study performed by the United States Geologic Survey (USGS) in 1985 also estimated a total sediment load for the Wissahickon watershed (Appendix A, Table 7). The city of Philadelphia contributes an estimated 3,271,472 lb/yr of sediment based on this study. Similar to the RSRI study, no distinction between runoff and streambank load was provided. Again, this study is important because it provides another independent estimate to compare with estimated sediment loads based on PWD monitoring data.

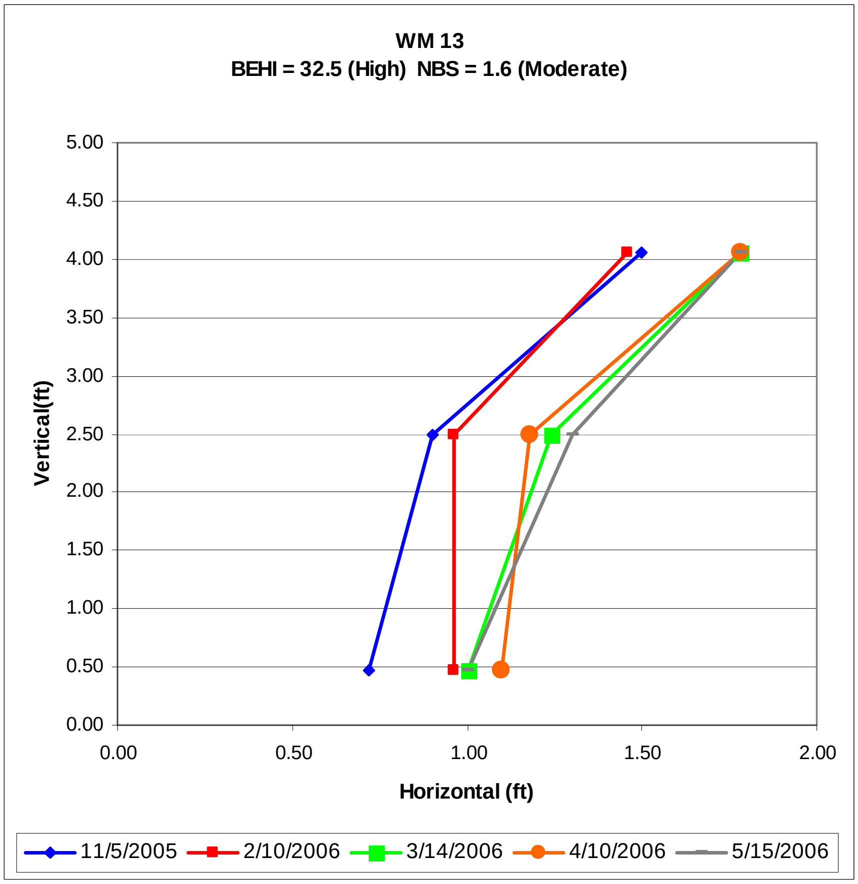
v. VERIFICATION AND COMPARISON STUDIES

Two additional analyses were performed to verify that preliminary estimates are within a reasonable range. The first method involved determining the amount of time it would take for erosion to produce present stream cross sections, using estimated erosion rates based on BEHI/NBS and the Colorado reference stream. Estimates ranged from 14 to 307 years with a mean of 120 years for individual tributaries, and a mean of 155 years using the total tributary loads and rates (Appendix A, Figure 16). This period of time is reasonable considering the history of natural, agricultural, and urban uses in the watershed.

The other method used to verify BEHI erosion prediction methods was installation of bank pins to measure erosion rates. As of September 2006, data collected so far are insufficient to draw conclusions. The bank pin program is being expanded significantly as discussed in a later section. An example of bank profile measurements at one site over several dates is shown in Appendix A, Figure 17.



Appendix A, Figure 16 - Estimated erosion rate based on BEHI/NBS from current cross section data.



Appendix A, Figure 17 - Example of Bank Pin Measurement

4. TRIBUTARY RESTORATION POTENTIAL RANKING

i. MULTI-CRITERIA EVALUATION (EVAMIX)

EVAMIX has been chosen to rank the restoration potential of tributaries and stream reaches. EVAMIX is a matrix-based, multi-criteria evaluation program that makes use of both quantitative and qualitative criteria within the same evaluation; regardless of the units of measure. The algorithm behind EVAMIX is unique in that it maintains the essential characteristics of quantitative and qualitative criteria, yet is designed to eventually combine the results into a single appraisal score. This critical feature gives the program much greater flexibility than most other matrix-based evaluation programs, and allows the evaluation team to make use of all data available to them in its original form.

EVAMIX makes a pair by pair comparison of all options under evaluation across all evaluation criteria, resulting in thousands of computations. The computations eventually result in an overall appraisal score. This is a single number, attached to a single alternative, and represents the overall worth of that alternative relative to the other alternatives based on the criteria selected, and the weights attached to the criteria. This number is used to determine the final ranking of alternatives from best to worst, or most important to least important.

EVAMIX offers several important advantages when used in planning studies:

- The alternatives under consideration are clearly defined
- The criteria used in evaluating the alternatives are explicit and measurable
- The algorithm can handle both quantitative and qualitative data, utilizing all available data to the highest degree of measurability possible
- The priorities underlying the evaluation are made explicit, and can be flexibly applied to highlight the effect that weighting has on the final ranking
- The technique is flexible enough to handle new data as it becomes available
- The technique is applied using widely available software (Excel spreadsheets)

The use of EVAMIX requires the development of a two dimensional matrix consisting of the options to be evaluated (columns) and a set of evaluation criteria (rows). For every combination of options and criteria, a score is assigned. The choice of the criteria is governed, in part, by the need for the scoring to be as objective as possible. By objective, we mean that the scores should represent impartial data and information useful in making decisions. The criteria must be clear and unambiguously defined, and can be set up as either quantitative criteria (e.g. threshold concentration in percent, time of travel in hours), or qualitative criteria (e.g. discharge frequency, location, etc.).

The other input variable required for the evaluation procedure is the selection of weighting factors for each of the criteria. While the scoring process strives to be as objective as possible and is carried out by the project team, the selection of weights is inherently subjective and should be done by the decision-makers, planner, or

stakeholders. Unlike the matrix of scores, numerous possible weight sets are possible, and all are equally "valid".

Criteria chosen to evaluate restoration potential are summarized in Appendix A, Table 9 and discussed in more detail below.

Appendix A, Table 9 - Ranking Criteria

		Need for Restoration				Potential for Restoration	
Criterion	Unit	Sediment Reduction	Habitat	Riparian	Infrastructure	Channel	Riparian
estimated streambank erosion load	lb/ft/yr	XX	X	N/A	N/A	N/A	N/A
habitat index	% ref. cond.	N/A	XX	N/A	N/A	N/A	N/A
benthic macroinvertebrate index	# species	N/A	XX	N/A	N/A	N/A	N/A
construction difficulty and disturbance	TBD	N/A	N/A	X	N/A	XX	XX
Fairmount Park projects	number	N/A	N/A	N/A	N/A	XX	XX
identified sanitary sewer problems	number	N/A	N/A	N/A	XX	N/A	N/A

XX - need or potential for restoration is highly related to the criterion
X - need or potential for restoration is somewhat related to the criterion

<u>ESTIMATED STREAMBANK EROSION LOAD</u>
Units: lb/ft/yr
Derivation: Sediment loads due to streambank erosion have been estimated using the Rosgen BEHI/NBS method and Colorado reference stream.

- The reach containing each BEHI/NBS assessment site was identified.
- The sediment load contributed by the BEHI/NBS site (and associated length) was estimates. Details of these calculations are discussed earlier in this document.
- Sediment load contributed by the portion of the reach not assessed using the BEHI/NBS method was not considered in the ranking.

<u>HABITAT INDEX</u>
Units: % of reference condition
Derivation: Habitat monitoring was conducted by USEPA in 2005. For each reach, the nearest habitat monitoring site was determined. The habitat quality score assigned by EPA at the nearest site was assigned to the reach. Habitat assessments are discussed in detail in the Comprehensive Characterization Report.

<u>BENTHIC MACROINVERTEBRATE INDEX (TAXA RICHNESS)</u>
Units: number of species present
Derivation: Benthic macroinvertebrate monitoring was conducted by USEPA in 2005. For each reach, the nearest macroinvertebrate monitoring site was determined. The species richness score assigned by EPA at the nearest site was assigned to the reach. Macroinvertebrate assessments are discussed in detail in the Comprehensive Characterization Report.

CONSTRUCTION DIFFICULTY AND DISTURBANCE
Units: qualitative (low/medium/high)

Derivation: Factors were not determined quantitatively. Instead, PWD staff with extensive field experience in the Philadelphia portion of the watershed were asked to provide their impressions.

DEFINITION OF LOW DIFFICULTY/DISTURBANCE (INCLUDING MAIN STEM)
- low-slope stream channel and corridor
- wide stream channel can accommodate heavy equipment
- wide paths or low-slope grassy areas suitable for heavy equipment (e.g., Forbidden Drive)
- public ownership (e.g., Fairmount Park)

DEFINITION OF MEDIUM DIFFICULTY/DISTURBANCE
- channel and corridor slope intermediate between Low and High
- some access but not ideal for heavy equipment, some disturbance to forest
- small number of receptive institutional or private owners
- combination of low and high factors

DEFINITION OF HIGH DIFFICULTY/DISTURBANCE
- stream channel and corridor are steep
- stream channel is too small for heavy equipment
- forested riparian area with no paths or low-slope grassy areas for heavy equipment
- multiple private residential/commercial owners

FAIRMOUNT PARK PROJECTS
Units: number of projects in vicinity of each reach
Derivation: Fairmount Park's ES&ED division provided a spreadsheet showing medium and high priority projects. For a small number of projects, the location was not clear from the spreadsheet; these projects were not included in the analysis. For other projects, a point was placed in a GIS layer using the best judgment of GIS staff.

IDENTIFIED SANITARY SEWER PROBLEMS
Units: number of problems identified along each reach
Derivation: A sanitary infrastructure problem was defined as follows:

- The infrastructure feature may be leaking sanitary sewage to the stream, or high stream flows may be infiltrating the infrastructure feature.
- The feature is in good condition, but is exposed in the channel or bank and subject to damage by high flows.

DETERMINATION OF CONDITION OF MANHOLES AND PIPES
- Condition was noted as "poor" by the field team (no instances identified).

- The photo taken by the field team shows at least one of the following:
  - o The feature is broken, cracked, leaking, or has exposed joints.
  - o The feature is exposed in the channel or bank and subject to high flows.

DETERMINATION OF CONDITION OF DAMS

- If sanitary infrastructure is visible in the photo taken by the field team, the checklist for manholes and pipes above was followed.

USE OF THERMAL IMAGING STUDY RESULTS (NO INSTANCES IDENTIFIED)

- The point was noted as a "suspected leak" by the thermal imaging team.
- Ground truthing notes indicate that the point is associated with sanitary infrastructure (not a stormwater outfall) and that evidence of sewage is present.

RESTORATION PRIORITY RESULTS

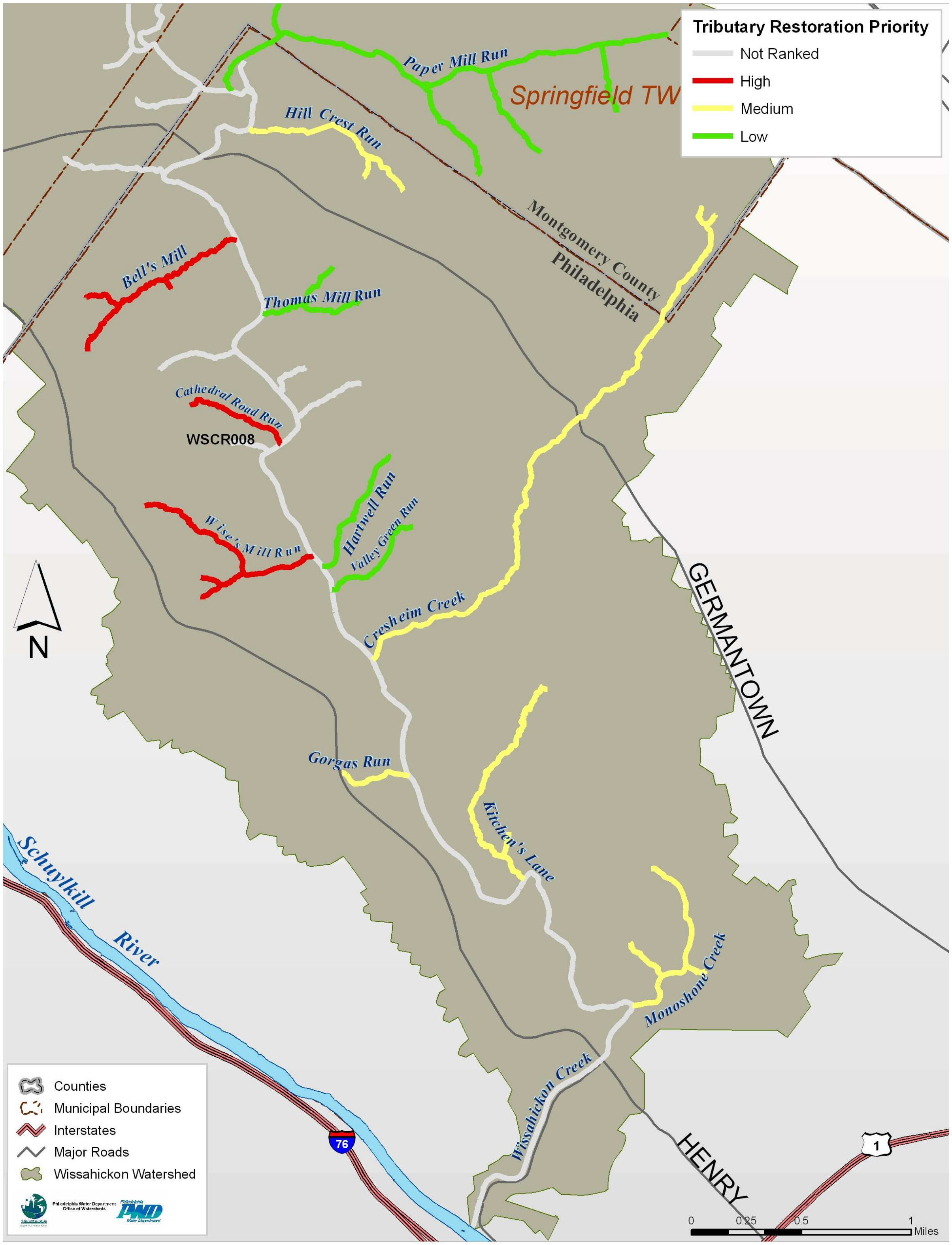
Ranking analyses were performed with several sets of criteria weights. One set of weights for the restoration project are shown in Appendix A, Table 10. The results obtained with that weight set are presented in Appendix A, Table 11. Also shown in Appendix A, Table 11 is the sum of all the reach lengths for each category identified as low, medium, and high priority within each tributary. The tributary restoration ranking is graphically represented in Appendix A, Figure 18; and reach restoration ranking is graphically represented in Appendix A, Figure 19.

Appendix A, Table 10 – Criteria Weights

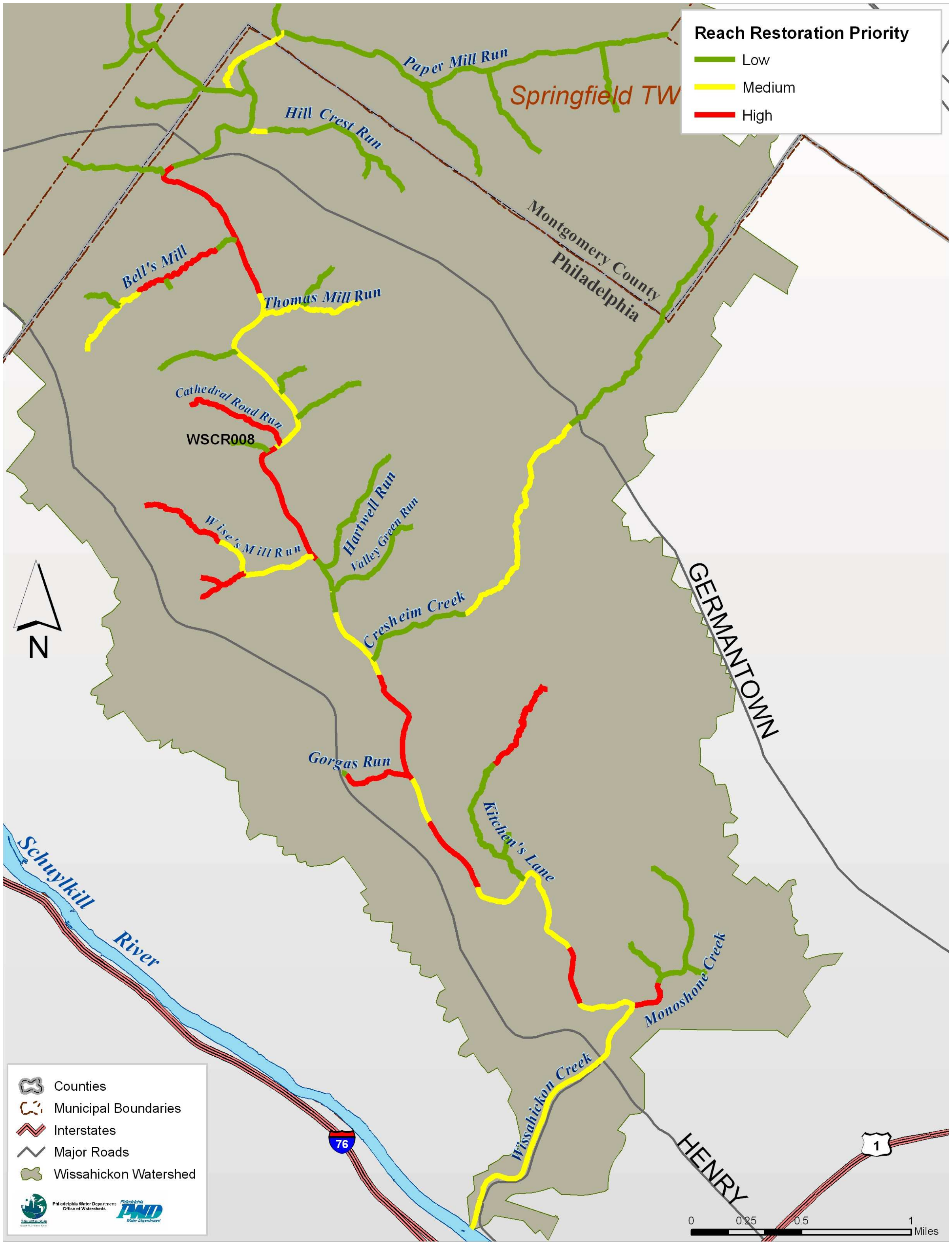
	Weight
Criteria	**0<wt<1**
estimated streambank erosion load	0.300
habitat index	0.100
benthic macroinvertebrate index	0.100
Fairmount Park projects	0.100
identified sanitary sewer problems	0.100
construction difficulty/disturbance index	0.300

Appendix A, Table 11 – Tributary Ranking Results

			Total Reach Length (ft)		
Options	**Ranking**	**Mean Rank**	**low**	**medium**	**high**
Cathedral Road Run	High	1.0	0	0	2771
Bell's Mill	High	3.0	1834	1078	1846
Wise's Mill	High	4.0	0	1507	4052
Cresheim Creek	Medium	5.0	9997	5383	0
Gorgas Run	Medium	5.5	0	0	1750
Hill Crest Run	Medium	5.5	2035	1781	0
Monoshone Creek	Medium	6.0	3236	0	1658
Kitchen's Lane	Medium	8.5	4720	0	2019
Paper Mill Run	Low	8.5	788	4653	0
Valley Green Run	Low	10.5	2868	0	0
Thomas Mill Run	Low	11.0	0	2689	0
Hartwell Run	Low	11.5	3423	0	0



Appendix A, Figure 18 – Tributary Restoration Ranking

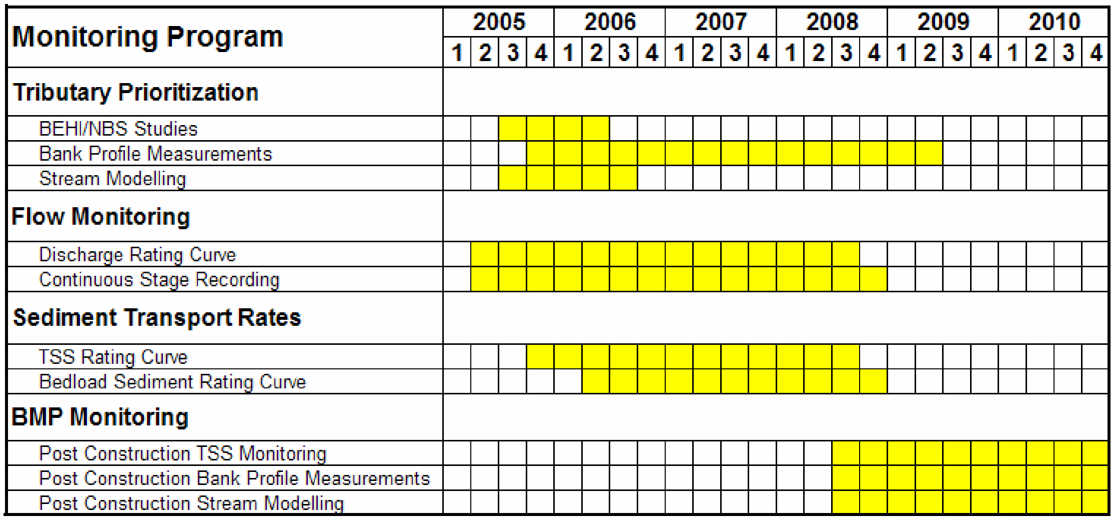


Appendix A, Figure 19 – Reach Restoration Ranking

5. Future Sampling

In efforts to comply with the Wissahickon Creek Sediment TMDL and the continuing goal of reducing sediment load from tributaries within City boundaries, PWD has developed a five-year strategy (Appendix A, Table 12).

Appendix A, Table 12 - Time Line Strategy for Monitoring Components of the Wissahickon TMDL.



i. Expanded Bank Pin Program

The program of installing bank pins to measure actual erosion rates is being greatly expanded. The objective of this program is to define a local relationship between measured streambank erosion and qualitative streambank erosion (using Rosgen's BEHI/NBS method).

Sampling Design

The sampling design below is recommended based on EPA (2002).

- stratified sampling design: stream length broken up into categories (strata), each representing one combination of BEHI and NBS score observed in Wissahickon.
- total number of sampling sites allocated in each strata according to the estimated load contributed by each BEHI/NBS combination (Appendix A, Table 13)
- total number of sampling sites determined by acceptable margin of error and available budget/staff (more discussion below)
- random site selection within each stratum

As of April 2006, bank pins were installed at 21 sites, and erosion was measured at 11 of these. The most recent measurements included in this study were taken April 24, 2006. Mean erosion rates at the 11 sites with measured erosion are shown in Appendix A, Table 13. A summary of the BEHI ratings are shown in Appendix A, Table 14. The fraction of total load contributed by reaches with each combination of BEHI and NBS score are shown in Appendix A, Table 15. Shown in Appendix A, Figure 20 is a comparison of high and moderate BEHI from local study results. No trend is apparent from data collected so far, but it is hoped a trend will emerge in the future as more data points are added.

Appendix A, Table 13 - Preliminary Bank Pin Data

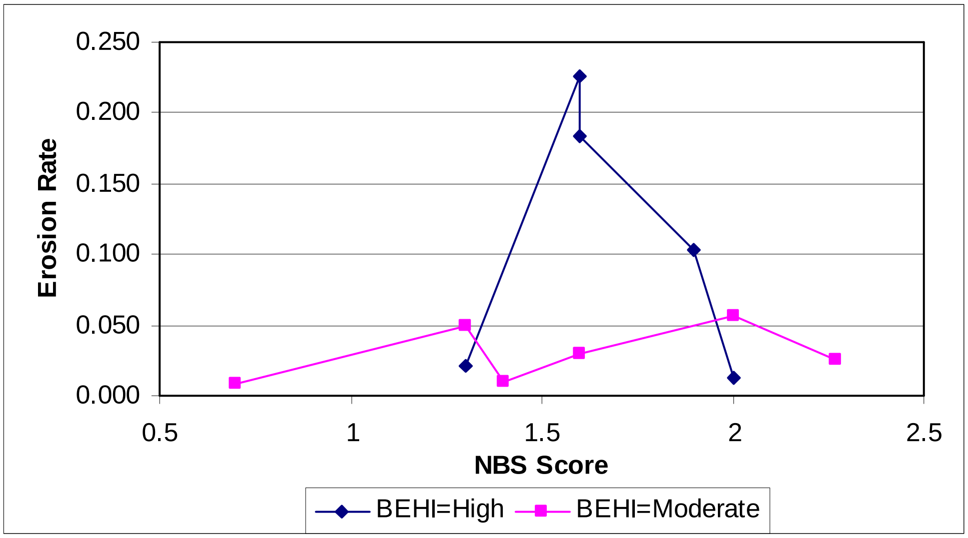
Site	First	Last	Days Monitored	BEHI Rating	NBS Rating	Measured Erosion to top bank pin (ton/ft/yr)	Measured Erosion to top of bank (ton/ft/yr)
MN1	11/2/2005	4/24/2006	173	Moderate	Very Low	0.006	0.016
MN4	11/2/2005	4/24/2006	173	Moderate	Low	0.004	0.009
WM29	11/5/2005	4/24/2006	170	Moderate	Low	0.022	0.074
BM25	11/7/2005	4/24/2006	168	Moderate	Moderate	0.020	0.046
BM21	11/7/2005	4/24/2006	168	Moderate	High	0.012	0.040
CR16	10/31/2005	4/24/2006	175	Moderate	High	0.036	0.090
CR13	10/31/2005	4/24/2006	175	High	Low	0.014	0.041
BM35	11/7/2005	4/24/2006	168	High	Moderate	0.154	0.379
WM13	11/5/2005	4/24/2006	170	High	Moderate	0.122	0.326
MN3	11/2/2005	4/24/2006	173	High	High	0.066	0.275
CR7	10/31/2005	4/24/2006	175	High	High	0.008	0.042

Appendix A, Table 14 - Bank Pin Erosion Summary

BEHI Rating	No. Sites	To Top Bank Pin Mean (ton/ft/yr)	To Top Bank Pin St. Deviation (ton/ft/yr)	To Top of Bank Mean (ton/ft/yr)	To Top of Bank St. Deviation (ton/ft/yr)
Moderate	6	0.017	0.012	0.046	0.032
High	5	0.073	0.065	0.213	0.161

Appendix A, Table 15 - Fraction of Load Contributed by each BEHI/NBS Combination

BEHI	NBS	Sites	Erosion (ton/yr/ft)	Length (ft)	Erosion (ton/yr)	Erosion (% of total)	New Bank Pin Sites
Low	Low	Unassessed*	0.009	153,552	1,367	68.4	60
Low	High	1	0.043	30	1.30	0.065	1
Moderate	Very Low	17	0.020	647	12.9	0.645	1
Moderate	Low	96	0.025	3,008	74.6	3.73	4
Moderate	Moderate	11	0.042	379	15.8	0.791	1
Moderate	High	9	0.056	341	19.1	0.956	1
Moderate	Very High	2	0.096	75	7.21	0.361	1
High	Very Low	15	0.045	370	16.5	0.824	1
High	Low	136	0.059	5,040	299	15.0	15
High	Moderate	9	0.133	388	51.6	2.59	3
High	High	12	0.134	566	75.7	3.79	4
High	Very High	1	0.143	15	2.15	0.107	1
High	Extreme	1	0.107	25	2.68	0.134	1
Very High	Very Low	5	0.069	160	11.0	0.550	1
Very High	Low	21	0.067	455	30.6	1.53	2
Very High	Moderate	1	0.062	10	0.616	0.031	1
Very High	High	1	0.144	20	2.89	0.145	1
Extreme	Low	1	0.289	25	7.22	0.362	1
All Measurements		339		165,106	1997	100	100



Appendix A, Figure 20 - BEHI/NBS Local Study Results

<u>NUMBER OF SITES</u>

The number of sites needed can be estimated based on observed variability in measurements and the acceptable uncertainty in the estimate:

$$n = \frac{z_{\alpha}^2 \sigma^2}{L^2}$$

where n = sample size (number of sites, rounded up to nearest integer)
z = standard normal cumulative probability for a 2-tailed 95% confidence interval = 1.96
σ = standard deviation of measured erosion rates so far = 0.0439 ton/yr/ft
L = acceptable uncertainty, 1/2 width of confidence interval (ton/yr/ft)

The number of BEHI sites for each rating, required to achieve a given confidence interval, are listed in Appendix A, Table 16 (erosion measured from top bank pin) and Appendix A, Table 17 (erosion measured from top of bank). Low and Moderate BEHI sites were assigned the standard deviation measured at Moderate BEHI sites. High BEHI sites were assigned the standard deviation measured at High BEHI sites. The results suggest that a sampling program to achieve a confidence interval of 100 ton/yr/sq.mi. or less may not be feasible. However, it is important to note that the standard deviations are based on a very small sample size. Collecting more samples may result in a lower estimate of standard deviation. Even if a statistically meaningful measure of error cannot be established, additional sites will allow better management decisions.

Appendix A, Table 16 - The number of sites required to achieve a given Confidence Interval

	St. Dev.	1/2 C.I. (ton/yr/sq.mi.)				
BEHI	(ton/yr/ft)	10	50	100	150	200
Low/Moderate	0.012	1,320	53	14	6	4
High	0.065	38,717	1,549	388	173	97
Total		40,037	1,602	402	179	101

Based on erosion to top bank pin

Appendix A, Table 17 - The number of sites required to achieve a given Confidence Interval

	St. Dev.	1/2 C.I. (ton/yr/sq.mi.)				
BEHI	(ton/yr/ft)	10	50	100	150	200
Low/Moderate	0.032	9,384	376	94	42	24
High	0.161	237,530	9,502	2,376	1,056	594
Total		246,914	9,878	2,470	1,098	618

Based on erosion to top of bank

NEXT STEPS

PWD plans to establish approximately 100 new sites to better estimate the true standard deviations. If these are lower than current estimates, the number of sites needed for a statistically meaningful estimate will also decrease.

ii. BANK EROSION HAZARD INDEX AND NEAR BANK STRESS

Total sediment yields are composed of sediment derived from overland runoff and from that originating in the creek. To determine the relative importance of these two components, PWD is conducting an expanded Bank Erosion Hazard Index (BEHI) and Near Bank Stress (NBS) study as defined by Rosgen (1996) to predict streambank erosion rates.

Additional reaches of the thirteen tributaries (Appendix A, Figure 19) within Philadelphia will be assessed by PWD staff and sections of streambank will be scored based on the BEHI and NBS criteria. This study will be combined with the expanded bank pin program to develop a local relationship between these indices and measured erosion.

iii. Bank Erosion Hazard Index and Near Bank Stress

Additional discharge rating curves will be established and existing ones will be refined as necessary for the tributaries within Philadelphia County limits following a modified version of the USGS protocol (Buchanan and Somers 1969). Currently, discharge rating curves have been completed on three tributaries (Bells Mill, Monoshone, and Wises Mill). Discharge will be measured using a SonTek Flowtraker during low and medium flow events and a Gurley pygmy meter during high flow events.

iv. Continuous Stage Recording

Discharge characterization on the thirteen tributaries within Philadelphia County limits will be completed based on the aforementioned prioritization ranking. Stage data will be recorded at the designated monitoring site using a fixed Sigma ultrasonic sensor and/or pressure transducer. Stage data will be downloaded bimonthly and QA/QC will be performed by PWD staff.

v. TSS Rating Curve

Automated water collection devices (ISCO model no. 6712) will be used to collect water samples during additional wet weather events as needed in the Wissahickon Creek tributaries. In the attempt to characterize an entire storm event, automated samplers are triggered by a 0.2 ft elevation change in stream height and will continue to collect samples every 20 minutes for the first hour. Following this step, samples are then collected every 2-4 hours until discharge has returned to base flow conditions. Suspended sediment loads will be related to the discharge at which they were collected to create a suspended sediment rating curve. To date, two wet weather events have been captured on Monoshone Creek, Wises Mill and Cathedral Run, and three runoff producing events have been captured on Bells Mill. Wet weather monitoring will continue through 2006-2007 in attempt to characterize TSS in relation to discharge.

vi. Bedload Sediment Rating Curve

In order to estimate a total sediment load, bedload sediment samples will be collected in addition to suspended sediment samples. Bedload sediment samples will be collected at different stages according to a modified version of USGS protocol (Edwards and Glysson 1999). Samples will be collected using a Helley-Smith handheld sampler with a 15cm orifice. Samples will be dried, sieved and weighed in order to determine a rate of transport as well as a particle size distribution.

vii. POST-CONSTRUCTION MONIITORING

The final objective of the TMDL monitoring program is to measure (i.e., quantify) the efficacy of Best Management Practices (BMPs) and their benefit in terms of sediment reduction in the Wissahickon drainage. In 2005, PWD conducted extensive wet-weather monitoring on three tributaries where various stormwater BMPs have been proposed or are currently under construction.

APPENDIX A – SEDIMENT TOTAL MAXIMUM DAILY LOAD (TMDL) FOR WISSAHICKON CREEK – FEASIBILITY STUDY & MONITORING PLAN

1. STORMWATER FLOW AND LOAD ESTIMATES BY OUTFALL

Methods used to develop stormwater outfall flows and loads are described in detail in the Wissahickon Comprehensive Characterization Report. In Appendix A, Table 1 drainage area and estimated mean annual runoff volume are reported for each outfall. In Appendix A, Table 2 estimated mean annual pollutant loads are reported for each outfall. A summary of the total number of outfalls per tributary is reported in Appendix A, Table 3 along with a summary of discharge and estimated loads for all of the outfalls found in each tributary.

Appendix A, Table 1 - Philadelphia Stormwater Outfall Runoff

Outfall	Tributary/Stream	Drainage Area (acres)	Runoff 4/93-3/01 (in/yr)
W-084-01	Bells Mill	62.8	7.74
W-084-02	Bells Mill	106	9.26
W-084-03	Bells Mill	4.94	10.4
W-084-04	Bells Mill	12.2	11.9
W-076-01	Cathedral Road Run	90.3	6.01
W-076-02	Cathedral Road Run	38.3	6.12
W-076-08	Cresheim Creek	5.94	12.4
W-076-11	Cresheim Creek	10.6	7.31
W-076-12	Cresheim Creek	47.5	9.97
W-077-01	Cresheim Creek	46.2	8.93
W-077-02	Cresheim Creek	239	10.0
W-086-01	Cresheim Creek	270	14.8
W-086-02	Cresheim Creek	76.7	12.6
W-086-03	Cresheim Creek	35.3	13.2
W-086-04	Cresheim Creek	31.6	18.8
W-086-05	Cresheim Creek	47.7	11.7
W-086-06	Cresheim Creek	85.3	11.6
W-086-07	Cresheim Creek	23.6	17.2
W-067-01	Gorgas Run	392	12.2
W-067-02	Gorgas Run	41.3	14.9
W-067-03	Gorgas Run	29.5	13.3
W-076-07	Hartwell Run	48.0	9.30
W-076-14	Hartwell Run	67.6	10.4
W-095-01	Hill Crest Run	99.7	11.3
W-095-03	Hill Crest Run	51.3	12.4
W-068-01	Kitchen's Lane	16.0	12.2
W-068-02	Kitchen's Lane	10.7	15.7
W-068-03	Kitchen's Lane	4.07	13.0
W-068-06	Kitchen's Lane	23.2	10.3
W-068-08E	Kitchen's Lane	25.9	9.38
W-068-08W	Kitchen's Lane	33.8	9.85
W-060-04	Monoshone Creek	12.7	4.83

W-060-08	Monoshone Creek	16.3	6.43
W-060-09	Monoshone Creek	17.0	4.65
W-060-10	Monoshone Creek	163	6.28
W-060-11	Monoshone Creek	39.2	4.35
W-068-04	Monoshone Creek	628	5.26
W-068-05	Monoshone Creek	76.4	5.72
W-095-02	Paper Mill Run	6.07	9.10
W-095-04	Paper Mill Run	6.82	15.4
W-095-05	Paper Mill Run, Trib B	20.7	14.8
W-076-09	Valley Green Run	62.8	9.96
W-076-10	Valley Green Run	46.0	10.7
W-075-01	Wise's Mill Run	154	14.5
W-075-02	Wise's Mill Run	9.88	8.18
W-076-04	Wise's Mill Run	9.02	8.40
W-076-05	Wise's Mill Run	3.82	10.4
W-076-06	Wise's Mill Run	9.62	11.5
W-076-13	Wise's Mill Run	92.0	13.2
W-076-X	Wise's Mill Run	9.47	1.72
W-052-01	Wissahickon Creek	12.4	11.3
W-052-02	Wissahickon Creek	15.5	12.8
W-060-01	Wissahickon Creek	111	12.5
W-060-02	Wissahickon Creek	25.5	14.0
W-060-03	Wissahickon Creek	63.2	13.8
W-060-05	Wissahickon Creek	96.7	8.39
W-060-06	Wissahickon Creek	2.58	16.7
W-060-07	Wissahickon Creek	22.0	12.4
W-067-04	Wissahickon Creek	23.8	13.9
W-067-05	Wissahickon Creek	10.0	14.1
W-067-06	Wissahickon Creek	41.5	10.8
W-068-07	Wissahickon Creek	24.9	9.39
W-076-03	Wissahickon Creek	9.21	11.7
W-085-01	Wissahickon Creek	83.9	12.3
W-085-02	Wissahickon Creek, Trib I	57.4	11.4

Appendix A, Table 2 - Wissahickon Outfall Load Summary

Outfall	Tributary/Stream	BOD5 (lbs/yr)	TSS (lbs/yr)	COD (lbs/yr)	TP (lbs/yr)	Cu (lbs/yr)	Zn (lbs/yr)	Fe (lbs/yr)	TN (lbs/yr)	Fecal (#/yr)	Pb (lbs/yr)
W-084-01	Bells Mill	892	7,395	5,397	29.2	1.51	11.5	129	198	2.92E+12	1.86
W-084-02	Bells Mill	1,759	14,084	10,743	57.3	2.99	22.9	262	385	5.77E+12	3.70
W-084-03	Bells Mill	104	731	653	3.29	0.177	1.39	17.0	21.6	3.41E+11	0.222
W-084-04	Bells Mill	297	2,123	1,989	9.36	0.549	4.18	55.4	57.4	9.34E+11	0.656
W-076-01	Cathedral Road Run	985	8,370	6,030	32.4	1.71	12.8	146	217	3.19E+12	2.07
W-076-02	Cathedral Road Run	490	3,247	3,123	15.4	0.834	6.62	83.2	100	1.61E+12	1.06
W-076-08	Cresheim Creek	141	1,084	872	4.56	0.240	1.86	21.8	30.4	4.64E+11	0.299
W-076-11	Cresheim Creek	134	1,221	791	4.49	0.228	1.69	17.8	31.0	4.39E+11	0.276
W-076-12	Cresheim Creek	975	6,648	6,180	30.8	1.66	13.1	163	201	3.20E+12	2.10
W-077-01	Cresheim Creek	665	6,819	3,861	22.8	1.16	8.27	81.6	159	2.15E+12	1.35
W-077-02	Cresheim Creek	4,632	35,467	29,705	149	8.25	62.8	778	955	1.48E+13	10.0
W-086-01	Cresheim Creek	7,939	58,607	51,631	253	14.2	109	1,384	1,602	2.54E+13	17.3
W-086-02	Cresheim Creek	1,411	16,888	7,885	50.4	2.51	17.0	146	358	4.50E+12	2.79
W-086-03	Cresheim Creek	953	6,595	6,120	30.1	1.66	12.9	163	193	3.10E+12	2.06
W-086-04	Cresheim Creek	1,163	9,531	8,702	36.9	2.54	18.0	265	196	3.29E+12	2.71
W-086-05	Cresheim Creek	1,143	7,876	7,235	36.1	1.95	15.3	190	236	3.75E+12	2.46
W-086-06	Cresheim Creek	1,482	16,878	8,242	52.4	2.56	17.8	154	374	4.80E+12	2.93
W-086-07	Cresheim Creek	739	7,133	5,998	23.9	1.84	12.2	191	112	1.87E+12	1.79
W-067-01	Gorgas Run	8,705	74,863	55,682	285	16.0	118	1,421	1,833	2.74E+13	18.7
W-067-02	Gorgas Run	1,280	8,604	8,141	40.3	2.18	17.3	216	262	4.20E+12	2.76
W-067-03	Gorgas Run	774	5,849	5,049	24.7	1.40	10.6	135	156	2.46E+12	1.68
W-076-07	Hartwell Run	803	6,882	4,820	26.5	1.36	10.3	113	181	2.63E+12	1.67
W-076-14	Hartwell Run	1,088	11,798	6,249	37.9	1.91	13.4	127	265	3.49E+12	2.19
W-095-01	Hill Crest Run	2,029	17,529	12,447	66.9	3.55	26.5	300	447	6.55E+12	4.26
W-095-03	Hill Crest Run	1,191	9,722	7,658	38.6	2.17	16.2	199	247	3.77E+12	2.57
W-068-01	Kitchen's Lane	395	2,771	2,490	12.5	0.672	5.28	64.8	82.2	1.30E+12	0.848
W-068-02	Kitchen's Lane	334	2,403	2,089	10.6	0.567	4.44	53.8	70.1	1.10E+12	0.713
W-068-03	Kitchen's Lane	101	785	620	3.26	0.171	1.32	15.4	21.8	3.31E+11	0.213
W-068-06	Kitchen's Lane	491	3,397	3,099	15.5	0.835	6.57	81.1	102	1.61E+12	1.05
W-068-08E	Kitchen's Lane	426	3,802	2,528	14.2	0.723	5.40	57.6	97.6	1.40E+12	0.879
W-068-08W	Kitchen's Lane	676	4,711	4,267	21.4	1.15	9.05	111	140	2.22E+12	1.45
W-060-04	Monoshone Creek	100	1,017	602	3.40	0.181	1.28	13.6	22.9	3.14E+11	0.206
W-060-08	Monoshone Creek	213	1,486	1,342	6.74	0.362	2.85	35.0	44.2	6.99E+11	0.457
W-060-09	Monoshone Creek	144	1,214	865	4.73	0.244	1.85	20.4	32.1	4.71E+11	0.299
W-060-10	Monoshone Creek	1,910	16,134	12,860	62.0	3.71	27.0	350	377	5.83E+12	4.21
W-060-11	Monoshone Creek	304	2,656	1,838	10.1	0.524	3.92	43.3	68.1	9.89E+11	0.634
W-068-04	Monoshone Creek	6,613	47,570	42,041	210	11.5	89.1	1,102	1,365	2.15E+13	14.2
W-068-05	Monoshone Creek	854	6,523	5,559	27.3	1.55	11.7	148	173	2.71E+12	1.86
W-095-02	Paper Mill Run	77.1	970	403	2.81	0.130	0.877	6.18	20.8	2.52E+11	0.147
W-095-04	Paper Mill Run	208	1,539	1,335	6.63	0.367	2.82	35.2	42.6	6.69E+11	0.449
W-095-05	Paper Mill Run, Trib B	635	4,452	4,334	19.9	1.19	9.08	123	120	1.98E+12	1.42
W-076-09	Valley Green Run	800	11,580	4,291	30.2	1.49	9.27	64.1	218	2.48E+12	1.53
W-076-10	Valley Green Run	989	7,079	6,199	31.5	1.68	13.2	160	207	3.25E+12	2.11

W-075-01	Wise's Mill Run	4,086	36,479	28,767	133	8.50	59.9	813	768	1.19E+13	9.19
W-075-02	Wise's Mill Run	139	1,279	817	4.66	0.236	1.75	18.2	32.3	4.55E+11	0.285
W-076-04	Wise's Mill Run	137	1,162	826	4.52	0.233	1.76	19.5	30.7	4.50E+11	0.286
W-076-05	Wise's Mill Run	83.0	554	531	2.60	0.142	1.12	14.2	16.8	2.72E+11	0.180
W-076-06	Wise's Mill Run	224	1,621	1,472	7.09	0.405	3.10	40.1	44.4	7.11E+11	0.490
W-076-13	Wise's Mill Run	2,436	18,295	16,673	77.2	4.68	34.9	471	462	7.50E+12	5.43
W-076-X	Wise's Mill Run	20.9	295	103	0.790	0.035	0.227	1.20	5.99	6.83E+10	0.039
W-052-01	Wissahickon Creek	201	2,517	1,220	7.21	0.397	2.59	25.8	48.0	6.05E+11	0.412
W-052-02	Wissahickon Creek	341	3,411	2,433	11.3	0.744	5.05	68.3	64.4	9.62E+11	0.768
W-060-01	Wissahickon Creek	2,376	22,846	15,121	79.7	4.49	31.9	374	513	7.35E+12	5.06
W-060-02	Wissahickon Creek	705	5,161	4,401	22.5	1.20	9.35	112	149	2.32E+12	1.50
W-060-03	Wissahickon Creek	1,456	14,497	9,260	49.2	2.78	19.5	227	317	4.48E+12	3.09
W-060-05	Wissahickon Creek	1,202	13,898	6,518	42.7	2.04	14.1	115	310	3.93E+12	2.35
W-060-06	Wissahickon Creek	46.4	829	195	1.90	0.078	0.439	0.00	15.2	1.50E+11	0.078
W-060-07	Wissahickon Creek	397	4,906	2,472	14.1	0.802	5.22	55.0	91.9	1.17E+12	0.824
W-067-04	Wissahickon Creek	605	5,233	3,963	19.8	1.14	8.34	104	124	1.87E+12	1.31
W-067-05	Wissahickon Creek	265	2,209	1,756	8.61	0.503	3.69	47.0	53.5	8.22E+11	0.580
W-067-06	Wissahickon Creek	808	6,903	4,851	26.7	1.37	10.4	114	182	2.65E+12	1.68
W-068-07	Wissahickon Creek	477	3,295	3,016	15.1	0.812	6.40	79.0	98.6	1.57E+12	1.03
W-076-03	Wissahickon Creek	214	1,548	1,336	6.81	0.363	2.84	34.3	45.0	7.01E+11	0.456
W-085-01	Wissahickon Creek	1,741	16,604	10,267	58.8	3.00	22.0	228	405	5.66E+12	3.57
W-085-02	Wissahickon Creek, Trib I	1,289	9,638	8,237	41.2	2.27	17.4	216	266	4.16E+12	2.78

Appendix A, Table 3 - Wissahickon Tributary Load Summary

Tributary/Stream	Outfalls	Total Discharge (cfs)	BOD5 (lbs/yr)	TSS (lbs/yr)	COD (lbs/yr)	TP (lbs/yr)	Cu (lbs/yr)	Zn (lbs/yr)	Fe (lbs/yr)	TN (lbs/yr)	Fecal (#/yr)	Pb (lbs/yr)
Bells Mill	4	0.060	3,051	2.43E+04	1.88E+04	99.2	5.23	40.0	463	662	9.97E+12	6.44
Cathedral Road Run	2	0.028	1,475	1.16E+04	9.15E+03	47.8	2.54	19.4	229	317	4.80E+12	3.13
Cresheim Creek	12	0.523	21,378	1.75E+05	1.37E+05	694	38.8	290	3,554	4,448	6.78E+13	46.0
Gorgas Run	3	0.255	10,759	8.93E+04	6.89E+04	350	19.6	146	1,772	2,251	3.41E+13	23.1
Hartwell Run	2	0.028	1,891	1.87E+04	1.11E+04	64.4	3.28	23.7	240	446	6.13E+12	3.86
Hill Crest Run	2	0.053	3,220	2.73E+04	2.01E+04	106	5.72	42.6	499	694	1.03E+13	6.83
Kitchen's Lane	6	0.038	2,423	1.79E+04	1.51E+04	77.6	4.12	32.1	384	513	7.95E+12	5.16
Monoshone Creek	7	0.259	10,136	7.66E+04	6.51E+04	324	18.0	138	1,713	2,082	3.25E+13	21.9
Paper Mill Run	3	0.020	920	6.96E+03	6.07E+03	29.3	1.69	12.8	165	183	2.90E+12	2.01
Valley Green Run	2	0.030	1,789	1.87E+04	1.05E+04	61.6	3.17	22.4	224	425	5.73E+12	3.64
Wise's Mill Run	7	0.195	7,126	5.97E+04	4.92E+04	230	14.2	103	1,378	1,361	2.14E+13	15.9
Wissahickon Creek	14	0.250	10,835	1.04E+05	6.68E+04	365	19.7	142	1,582	2,416	3.42E+13	22.7
Wissahickon Creek Trib 1	1	0.021	1,289	9.64E+03	8.24E+03	41.2	2.27	17.4	216	266	4.16E+12	2.78

2. STREAMBANK EROSION LOAD FIELD METHODS

In conjunction with Section D (*Sediment Total Maximum Daily Load (TMDL) For Wissahickon Creek*) of the City's stormwater permit, PWD has initiated a monitoring plan that addresses the adverse impacts to in-stream habitats as a result of the transport of

sediment and/or streambank erosion. Baseline data from 13 perennial tributaries that originate in the City will be monitored to define their contribution of sediment loading.

There are two elements to the monitoring program. The first estimates the sediment load originating from streambanks. The second estimates the total sediment load being carried by the stream. Data collection is ongoing for both parts.

i. BEHI/NBS ASSESSMENTS

PWD employed the Bank Erosion Hazard Index (BEHI) and Near Bank Stress (NBS) as defined by Rosgen (1996) to predict erosion rates and classify the erosion potential of the tributaries. An example of bank erosion can be seen in Figure Appendix A, Figure 1 where much of a bank pin is exposed. Three hundred and sixty eight reaches in 13 tributaries have been assessed using BEHI and NBS criteria. Reaches were assessed based on visual inspection of obvious signs of erosion. BEHI and NBS scores were grouped as very low, low, moderate, high or very high. Table 4 summarizes the portion of each tributary that was assessed using the BEHI/NBS method.

Appendix A, Figure 1 - PWD staff digging out eroded bank sediment in order to accurately measure bank pin exposure

Appendix A, Table 4 - Portion of Each Tributary Assessed Using BEHI/NBS Method

Site	BEHI/NBS Assessed (ft)	Channelized (ft)	Visually Assessed - Low Erosion (ft)
Monoshone	147	3,074	9,537
Kitchens Ln	1,250	0.00	12,946
Cresheim	1,835	1,062	29,143
Valley Green Run	270	277	3,859
Hartwell	340	0.00	6,358

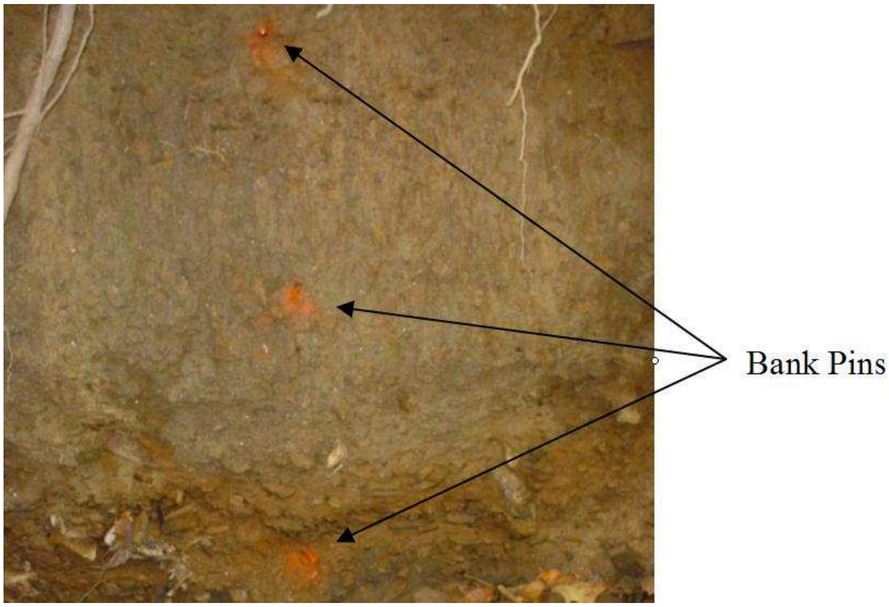
Rex Ave	270	0.00	2,982
Thomas Mill	625	0.00	6,895
Hill Crest	75.0	2,128	6,929
Paper Mill	2,640	8,576	48,298
Gorgas Ln	350	325	3,261
Wises Mill	1,042	1,057	11,301
Cathedral	1,135	0.00	4,227
Bells Mill	1,759	0.00	7,781

ii. Bank Profile Measurements

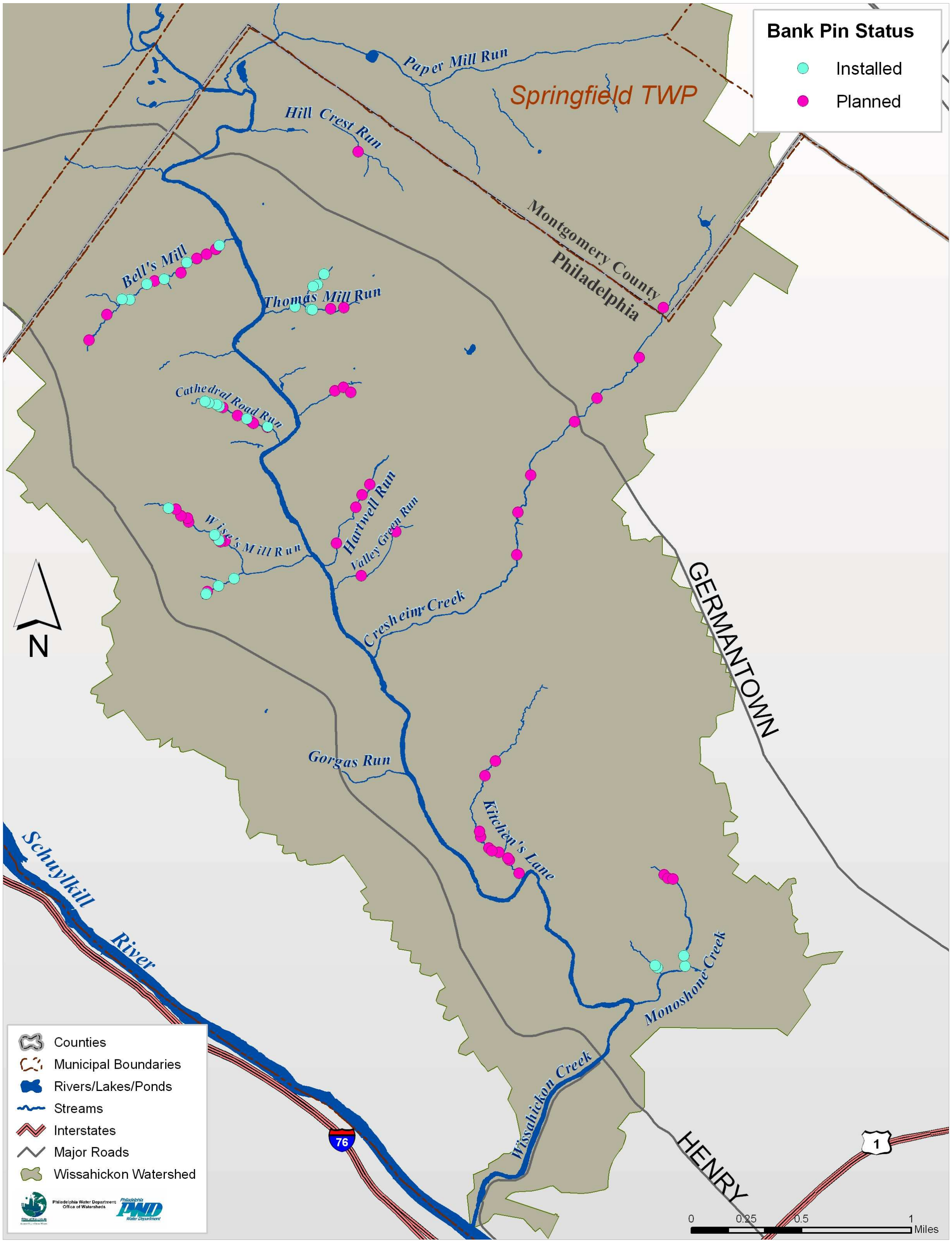
Bank pins were installed in Bells Mill, Cathedral Run, Wises Mill and Monoshone tributaries in October and November 2005. Nine bank pin sites were chosen in each of the tributaries listed with the exception of Monoshone. Only four bank pin sites were chosen in Monoshone because much of the tributary is channelized. Bank pins were installed in reaches with varying BEHI and NBS scores in order to validate and calibrate the prediction model. Three of the 9 sites were in reaches visually assessed to have low erosion rates. Additional bank pin sites in these tributaries and others are planned for the future. The current bank pin installation locations and planned bank pin installation locations can be seen on the map in Appendix A, Figure 4.

Bank pins were installed where the bend in the bank was greatest. At least one bank pin was put in below bankfull height and they were spaced no closer than 1 ft. The number of bank pins at a site was dependent on bank height and ranged from one to three. An example of bank pin installation can be seen in Appendix A, Figure 2, and an example of bank pin spacing can be seen in Appendix A, Figure 3.

Appendix A, Figure 2 - PWD staff installing a bank pin into the bank along the Wises Mill tributary. Bank pins are driven horizontally into streambanks at positions corresponding to bank erosion locations.

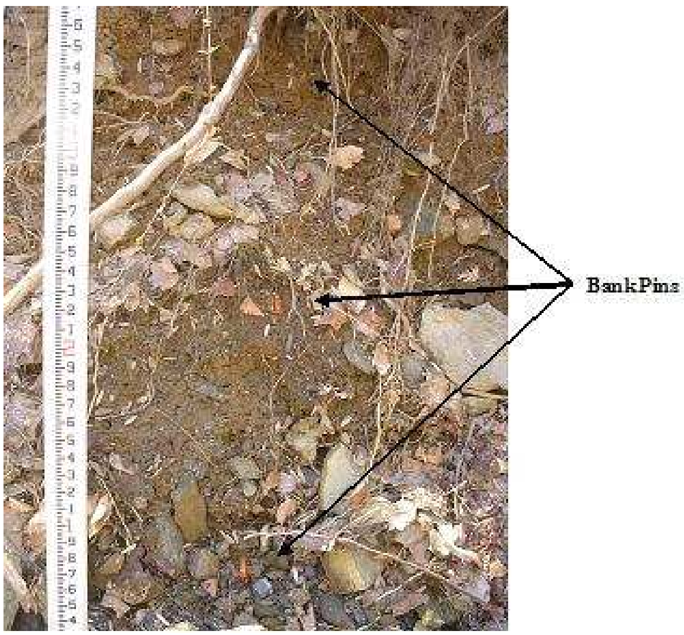


Appendix A, Figure 3 - After bank pin installation, the exposed ends were spray painted to make more visible



Appendix A, Figure 4 - Current and Planned Bank Pin Locations

Measurements were made using a survey rod, a Keson pocket rod and two levels. The survey rod was placed on the edge of the toe pin and kept straight using a level. The pocket rod was placed over the bank pin up against the bank and kept straight by a level. The distance from the bank to the edge of the survey rod closest to the bank was recorded on the field data sheet. Toe pins are bank offset pins driven vertically into the bed surface in order to "profile" the streambank with vertical measurements from the survey rod to the bank. The toe pin offers a permanent location with which to determine lateral erosion per unit time between surveys. The survey rod can be seen in Appendix A, Figure 5 where the bank pins are being measured in relation to the toe pin position. Lateral erosion or aggrading of the streambank is determined by measuring changes in bank pin distance from the toe pin (Appendix A, Figure 6).



Appendix A, Figure 5 - The survey rod measures the amount of exposed pin as the amount of lateral erosion upon re-survey.

Appendix A, Figure 6 - The toe pin is a permanent reference point for determining lateral erosion.

iii. Channel Stability

Bar samples, sub-pavement samples and pebble counts were collected at 9 sites in 5 tributaries to Wissahickon Creek in order to gather information on channel stability. Bar and sub-pavement samples as well as pebble counts were collected following methods described on EPA's Watershed Assessment of River Stability and Sediment Supply (WARSSS) website. An example of bar sampling is depicted in Figures 7 and 8. Additionally, Riffle Stability Index (RSI) Assessments and pebble counts were completed at 14 sites in the same 5 tributaries. RSI methods are described in Kappesser (1994). RSI assessments were done in place of bar samples in cases where sediment bars were not prominent due to high slope. In some cases RSI assessments were done in close proximity to bar or sub-pavement samples in order to compare results from the two methods. All samples were collected in April and May 2006.

Appendix A, Figure 7 - PWD staff collected a bar sample representing the size gradation of bedload at the bankfull stage.

Appendix A, Figure 8 - PWD staff draining water from the bar sample.

iv. Total Suspended Sediment Load

Automated water collection devices (ISCO model no. 6712) were used to collect water samples during wet weather events in the Wissahickon Creek tributaries. An example of the automated sampler being set up by PWD staff is shown in Appendix A, Figure 9. In the attempt to characterize an entire storm event, automated samplers were triggered by a 0.2 ft elevation change in stream height and collected samples every 20 minutes for the first hour. Following this step, samples were then collected every 2-4 hours until discharge returned to base flow conditions. Suspended sediment loads were related to the discharge at which they were collected to create a suspended sediment rating curve. Four tributaries were selected based on visual inspection of obvious signs of erosion to

estimate sediment loads and calibrate methods used in other tributaries. The location of installed samplers can be seen in Figure 10.

Total suspended sediment samples were collected from Monoshone Creek (5/20/2005 and 7/8/2005), Wises Mill (11/16/2005), Cathedral Run (11/10/2005 and 11/16/2005) and Bells Mill (9/15/2005, 9/26/2005 and 10/8/2005). Samples were collected using an ISCO automated sampler and followed methods described in wet weather monitoring. Water level is recorded during the sample period allowing a sediment discharge rating curve to be established. Additional sample collections are planned for these 4 tributaries as well as other tributaries.

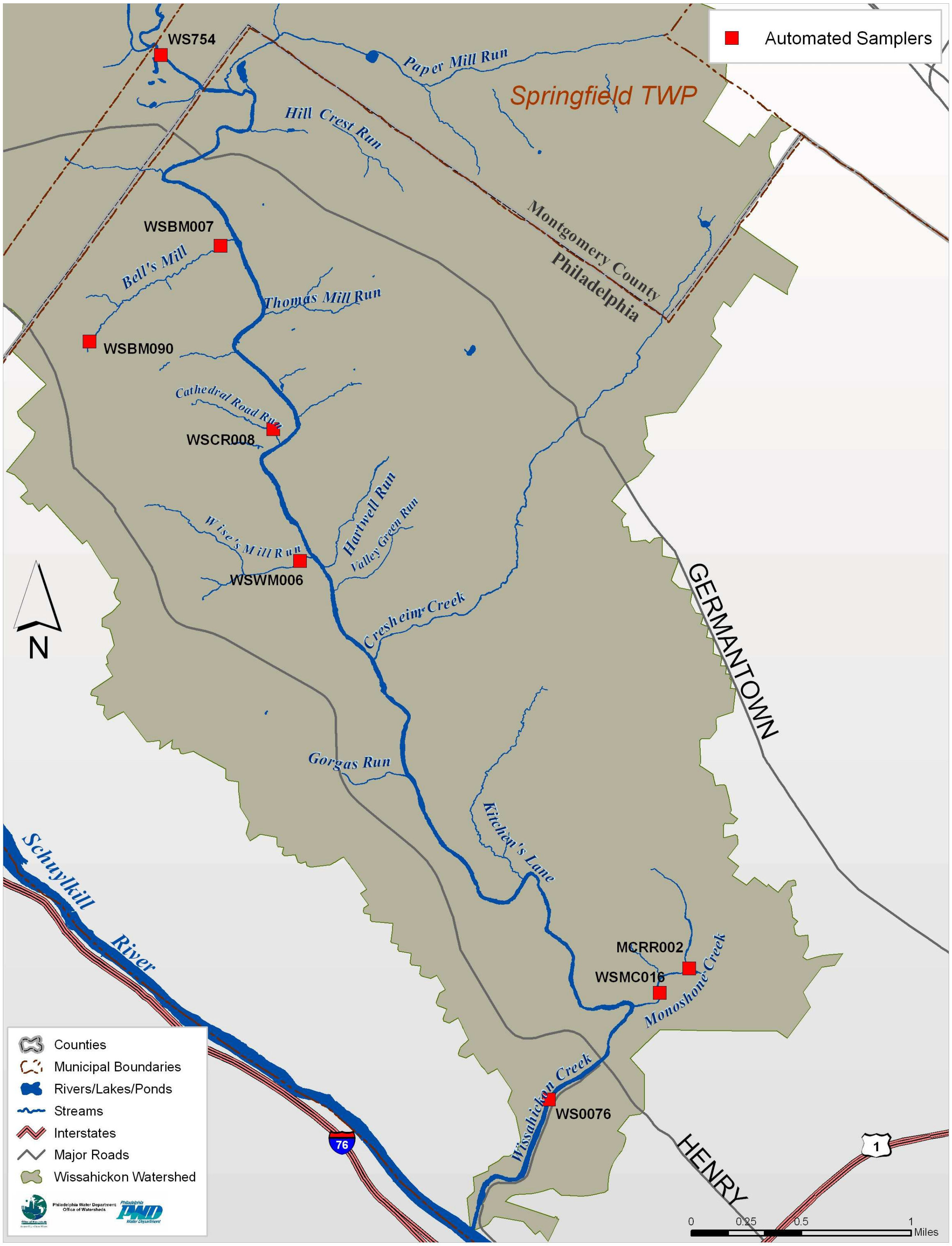
Appendix A, Figure 9 - PWD staff setting up the automated water sampler for wet weather monitoring

Stage data from Bells Mill, Cathedral Run, Wises Mill and Monoshone were recorded near the Wissahickon confluence downstream of all stormwater outfalls. Stage was measured every six minutes by either an ultrasonic down-looking water level sensor or a pressure transducer and recorded on a Sigma620. The ultrasonic down-looking sensor and pressure transducer are shown in Figures 11 and 12. PWD staff periodically downloaded stage data and performed quality assurance. Any data determined to be incorrect was removed and saved in another location.

Dates of ultrasonic down-looking sensor installation in Bells Mill, Cathedral Run and Wises Mill are May 2005, September 2005 and August 2005 respectively. Pressure transducers were installed in Monoshone in July 2005 and Bells Mill in November 2005. Stage data will continue to be recorded at these sites and additional sites will be added.

Appendix A, Figure 10 - An ultrasonic down-looking acoustic water level sensor for water level measurement as it was installed above the Cathedral Run tributary

Appendix A, Figure 11 - A pressure transducer for redundant water level measurement as it was installed in the Cathedral Run tributary.



Appendix A, Figure 12 - Automatic Sampler Locations

v. Stage-Discharge Rating Curves

Staff gages were installed in Monoshone, Wises Mill and Bells Mill concurrent with ultrasonic downlooker or pressure transducer installation. Staff gauges are located next to the stage recording device in culverts with concrete floors to ensure that the cross section will not change over time. The staff gage along with the ultrasonic down-looking sensor and pressure transducer are shown in Appendix A, Figure 13.

Discharge rating curves were established in Monoshone, Wises Mill and Bells Mill following a modified version of the USGS protocol (Buchanan and Somers 1969). Discharge was measured in a cross section close to the staff gage using a SonTek Flowtraker Handheld ADV and plotted against the stage it was recorded at. Due to lack of a suitable monitoring location, the discharge rating curve in Cathedral Run will be mathematically modeled instead of measured in the field.

Appendix A, Figure 13 - Staff Gage for the Bells Mill tributary pictured with a pressure transducer and ultrasonic down-looking sensor.

3. PRELIMINARY STREAMBANK EROSION LOAD ESTIMATES

Results of preliminary BEHI, NBS, erosion rate measurements at a reference site, and sediment-flow correlations were analyzed to produce several independent estimates of sediment load in the system. These results are useful for long-term planning but may change substantially as more data are collected and analyzed in the future. Appendix A, Table 5 includes useful summary information for the watershed. Appendix A, Table 6 through Appendix A, Table 8 include estimates of sediment load. The various methods and references used to derive these estimates are discussed below.

Appendix A, Table 5 - Wissahickon Watershed Information

System		
Philadelphia tributary stream length =	81,964	ft
Philadelphia main stem stream length =	40,712	ft
Philadelphia Trib Drainage Area =	4,963	ac
Philadelphia Drainage Area =	6,711	ac

Appendix A, Table 6 - Streambank Erosion Estimates

System	Streambank TSS Load (lb/yr)	Streambank TSS Load (ton/sq. mi/yr)	Streambank TSS Load (lb/ft/yr)	Calculation Method
Philadelphia Tributaries Only	3,142,358	203	38.3	BEHI/NBS Analysis with Colorado Reference Stream
Philadelphia Tributaries and Main Stem	3,685,717	176	30.0	Instream TSS-Flow Regression

Appendix A, Table 7 - Total Sediment Load from Historical Studies

Study	Total Sediment Load (lb/yr)	Total Sediment Load (ton/sq. mi/yr)
RSRI, 1973	8,388,391	400
USGS, 1985	3,271,472	156

Appendix A, Table 8 - Estimated Tributary Loads based on BEHI/NBS and Colorado Reference Stream

System	Drainage Area (acres)	Stream Length (ft)	Total TSS Load (lb/yr)	Total TSS Load (lb/acre/yr)
Bells Mill	323	4,770	414,592	1,285
Cathedral	160	2,681	332,015	2,073
Creshiem	1,218	16,020	731,882	601
Gorgas Lane	499	1,968	183,082	367
Hill Crest	217	4,860	77,581	358
Hartwell	144	3,350	166,226	1,157
Kitchens Lane	234	7,098	279,594	1,194
Monoshone	1,056	6,379	246,101	233
Paper Mill Run	297	29,757	931,999	3,142
Thomas Mill	104	3,760	188,382	1,804
Tributary I	137	1,626	94,361	688
Wises Mill	446	6,980	351,120	788
Valley Green	128	2,203	77,423	604

i. BEHI/NBS AND OBSERVED EROSION IN COLORADO REFERENCE STREAM

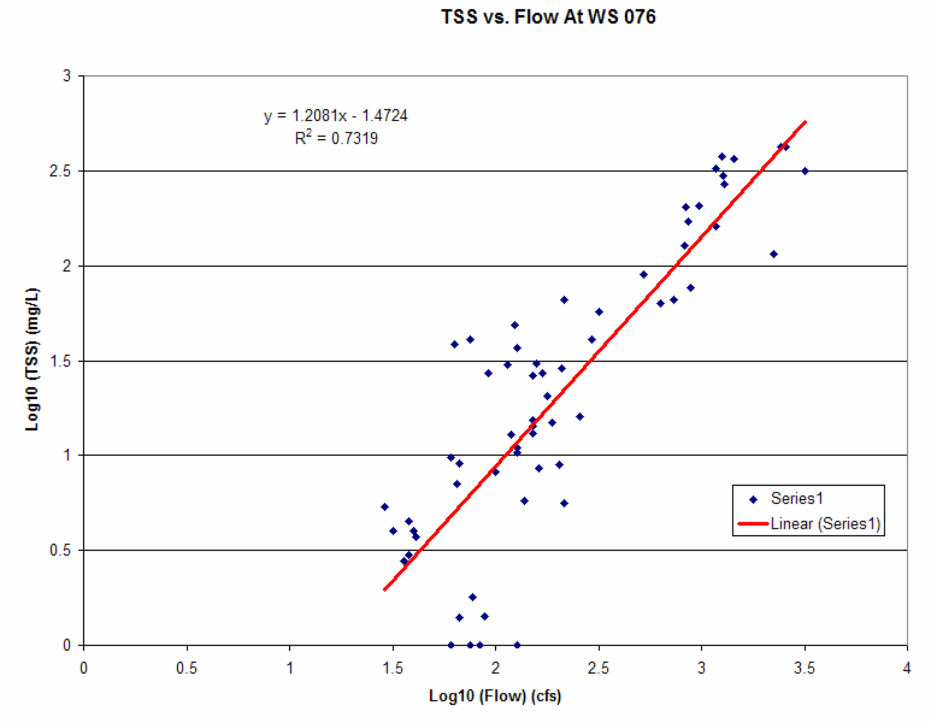
Predicted streambank erosion rates were calculated based on a relationship between these scores and measured streambank erosion rates in a reference stream in Colorado (Rosgen, 1996). The predicted rate is multiplied by the bank height and length as well as a conversion factor to get a sediment load in tons/year.

Streambank erosion estimates were determined using the data from the methods discussed above. For streambanks that were visually assessed to be low-erosion, a background erosion rate was applied. This rate corresponds to a low BEHI and low NBS score. These banks were assumed to have a bank height of the average of that particular tributary. For planning purposes, these low BEHI/NBS erosion rates are assumed to represent relatively stable conditions.

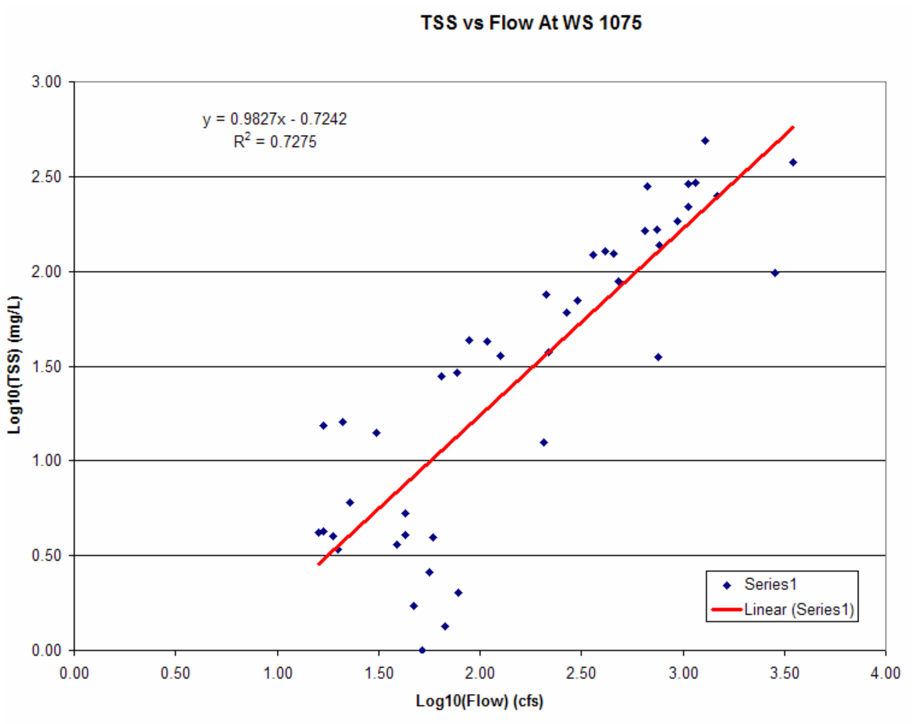
ii. INSTREAM TSS-FLOW REGRESSION

A TSS-flow regression was performed by matching instream TSS measurements at or near USGS gauging stations to the flow recorded closest to sampling time. The USGS gage located near the mouth of the main stem provided results for the regression shown in Appendix A, Figure 14. Similarly, a gage located in Fort Washington provided data for the regression in Appendix A, Figure 15. Once the regression was created for the two sites on the main stem, Fort Washington and the mouth at Philadelphia, an annual load could be determined by area weighting measured sediment loads at each station and

estimating sediment input between stations. Regression results were not extrapolated to estimate TSS concentrations at flows outside the range used for the regression. Instead, TSS concentration corresponding to the maximum measured flow was applied to all flows greater than the maximum. For the gage station at Philadelphia, this concentration was 572.3 mg/L and for Fort Washington this concentration was calculated at 570.3 mg/L. The streambank portion of this total sediment load was then estimated by removing estimated runoff sediment load. An estimated 3,685,717 lb/yr of streambank sediment load is contributed by the city of Philadelphia based on this load estimation method.



Appendix A, Figure 14 - TSS-Flow Regression at USGS Gage 01474000 (mouth at Philadelphia) using WS076 TSS data



Appendix A, Figure 15 - TSS-Flow Regression at USGS Gage 01473900 (Fort Washington) using WS1075 TSS data

iii. Environmental Study of the Wissahickon Watershed within the City of Philadelphia

A study performed by the Regional Science Research Institute (RSRI) in 1973 estimated a sediment load for the Wissahickon watershed (Appendix A, Table 7). The city of Philadelphia contributes an estimated 8,388,391 lb/yr of sediment based on this study. This amount represents a total sediment load, but the report does not distinguish between the proportion of the load contributed by streambank erosion and stormwater runoff. This study is important because it provides an independent estimate to compare with estimates based on PWD and USGS monitoring.

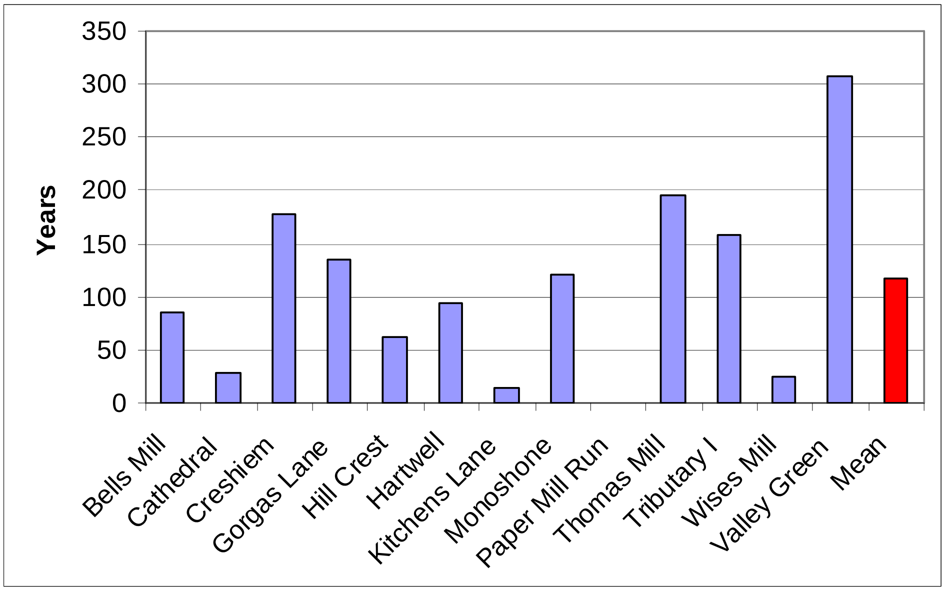
iv. Effects of Low Level Dams on the Distribution of Sediment, Metals, and Organic Substances in the Lower Schuylkill River Basin, Pennsylvania

A study performed by the United States Geologic Survey (USGS) in 1985 also estimated a total sediment load for the Wissahickon watershed (Appendix A, Table 7). The city of Philadelphia contributes an estimated 3,271,472 lb/yr of sediment based on this study. Similar to the RSRI study, no distinction between runoff and streambank load was provided. Again, this study is important because it provides another independent estimate to compare with estimated sediment loads based on PWD monitoring data.

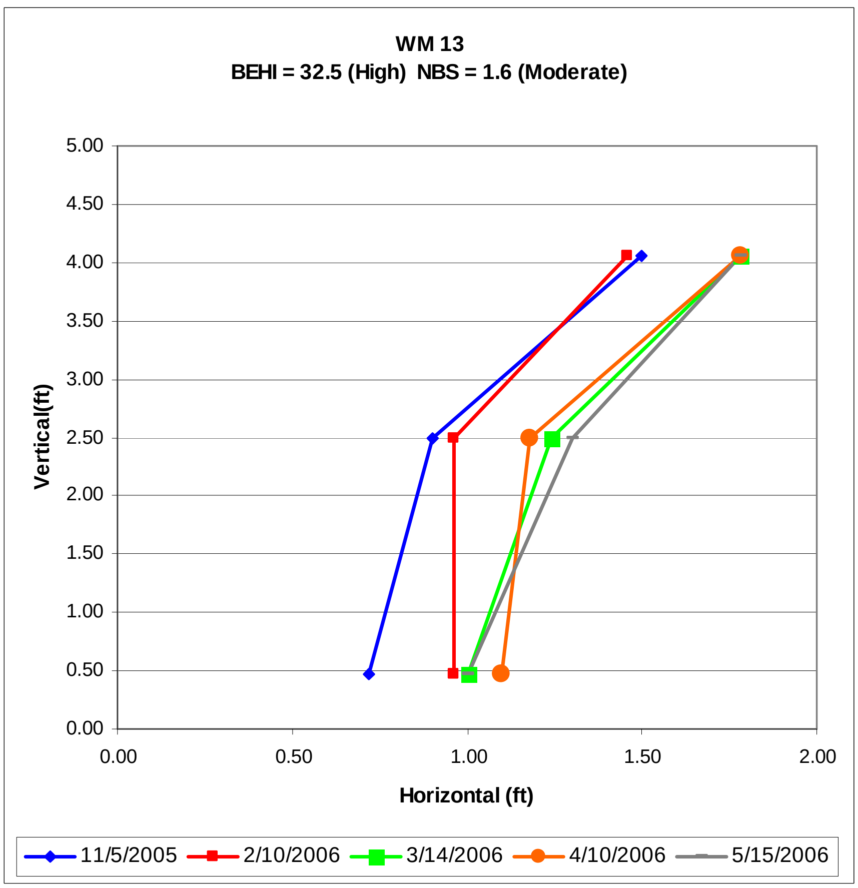
v. VERIFICATION AND COMPARISON STUDIES

Two additional analyses were performed to verify that preliminary estimates are within a reasonable range. The first method involved determining the amount of time it would take for erosion to produce present stream cross sections, using estimated erosion rates based on BEHI/NBS and the Colorado reference stream. Estimates ranged from 14 to 307 years with a mean of 120 years for individual tributaries, and a mean of 155 years using the total tributary loads and rates (Appendix A, Figure 16). This period of time is reasonable considering the history of natural, agricultural, and urban uses in the watershed.

The other method used to verify BEHI erosion prediction methods was installation of bank pins to measure erosion rates. As of September 2006, data collected so far are insufficient to draw conclusions. The bank pin program is being expanded significantly as discussed in a later section. An example of bank profile measurements at one site over several dates is shown in Appendix A, Figure 17.



Appendix A, Figure 16 - Estimated erosion rate based on BEHI/NBS from current cross section data.



Appendix A, Figure 17 - Example of Bank Pin Measurement

4. Tributary Restoration Potential Ranking

i. Multi-Criteria Evaluation (EVAMIX)

EVAMIX has been chosen to rank the restoration potential of tributaries and stream reaches. EVAMIX is a matrix-based, multi-criteria evaluation program that makes use of both quantitative and qualitative criteria within the same evaluation; regardless of the units of measure. The algorithm behind EVAMIX is unique in that it maintains the essential characteristics of quantitative and qualitative criteria, yet is designed to eventually combine the results into a single appraisal score. This critical feature gives the program much greater flexibility than most other matrix-based evaluation programs, and allows the evaluation team to make use of all data available to them in its original form.

EVAMIX makes a pair by pair comparison of all options under evaluation across all evaluation criteria, resulting in thousands of computations. The computations eventually result in an overall appraisal score. This is a single number, attached to a single alternative, and represents the overall worth of that alternative relative to the other alternatives based on the criteria selected, and the weights attached to the criteria. This number is used to determine the final ranking of alternatives from best to worst, or most important to least important.

EVAMIX offers several important advantages when used in planning studies:

- The alternatives under consideration are clearly defined
- The criteria used in evaluating the alternatives are explicit and measurable
- The algorithm can handle both quantitative and qualitative data, utilizing all available data to the highest degree of measurability possible
- The priorities underlying the evaluation are made explicit, and can be flexibly applied to highlight the effect that weighting has on the final ranking
- The technique is flexible enough to handle new data as it becomes available
- The technique is applied using widely available software (Excel spreadsheets)

The use of EVAMIX requires the development of a two dimensional matrix consisting of the options to be evaluated (columns) and a set of evaluation criteria (rows). For every combination of options and criteria, a score is assigned. The choice of the criteria is governed, in part, by the need for the scoring to be as objective as possible. By objective, we mean that the scores should represent impartial data and information useful in making decisions. The criteria must be clear and unambiguously defined, and can be set up as either quantitative criteria (e.g. threshold concentration in percent, time of travel in hours), or qualitative criteria (e.g. discharge frequency, location, etc.).

The other input variable required for the evaluation procedure is the selection of weighting factors for each of the criteria. While the scoring process strives to be as objective as possible and is carried out by the project team, the selection of weights is inherently subjective and should be done by the decision-makers, planner, or

stakeholders. Unlike the matrix of scores, numerous possible weight sets are possible, and all are equally "valid".

Criteria chosen to evaluate restoration potential are summarized in Appendix A, Table 9 and discussed in more detail below.

Appendix A, Table 9 - Ranking Criteria

		Need for Restoration				Potential for Restoration	
Criterion	Unit	Sediment Reduction	Habitat	Riparian	Infrastructure	Channel	Riparian
estimated streambank erosion load	lb/ft/yr	XX	X	N/A	N/A	N/A	N/A
habitat index	% ref. cond.	N/A	XX	N/A	N/A	N/A	N/A
benthic macroinvertebrate index	# species	N/A	XX	N/A	N/A	N/A	N/A
construction difficulty and disturbance	TBD	N/A	N/A	X	N/A	XX	XX
Fairmount Park projects	number	N/A	N/A	N/A	N/A	XX	XX
identified sanitary sewer problems	number	N/A	N/A	N/A	XX	N/A	N/A

XX - need or potential for restoration is highly related to the criterion
X - need or potential for restoration is somewhat related to the criterion

ESTIMATED STREAMBANK EROSION LOAD

Units: lb/ft/yr
Derivation: Sediment loads due to streambank erosion have been estimated using the Rosgen BEHI/NBS method and Colorado reference stream.

- The reach containing each BEHI/NBS assessment site was identified.
- The sediment load contributed by the BEHI/NBS site (and associated length) was estimates. Details of these calculations are discussed earlier in this document.
- Sediment load contributed by the portion of the reach not assessed using the BEHI/NBS method was not considered in the ranking.

HABITAT INDEX

Units: % of reference condition
Derivation: Habitat monitoring was conducted by USEPA in 2005. For each reach, the nearest habitat monitoring site was determined. The habitat quality score assigned by EPA at the nearest site was assigned to the reach. Habitat assessments are discussed in detail in the Comprehensive Characterization Report.

BENTHIC MACROINVERTEBRATE INDEX (TAXA RICHNESS)

Units: number of species present
Derivation: Benthic macroinvertebrate monitoring was conducted by USEPA in 2005. For each reach, the nearest macroinvertebrate monitoring site was determined. The species richness score assigned by EPA at the nearest site was assigned to the reach. Macroinvertebrate assessments are discussed in detail in the Comprehensive Characterization Report.

CONSTRUCTION DIFFICULTY AND DISTURBANCE

Units: qualitative (low/medium/high)

Derivation: Factors were not determined quantitatively. Instead, PWD staff with extensive field experience in the Philadelphia portion of the watershed were asked to provide their impressions.

DEFINITION OF LOW DIFFICULTY/DISTURBANCE (INCLUDING MAIN STEM)

- low-slope stream channel and corridor
- wide stream channel can accommodate heavy equipment
- wide paths or low-slope grassy areas suitable for heavy equipment (e.g., Forbidden Drive)
- public ownership (e.g., Fairmount Park)

DEFINITION OF MEDIUM DIFFICULTY/DISTURBANCE

- channel and corridor slope intermediate between Low and High
- some access but not ideal for heavy equipment, some disturbance to forest
- small number of receptive institutional or private owners
- combination of low and high factors

DEFINITION OF HIGH DIFFICULTY/DISTURBANCE

- stream channel and corridor are steep
- stream channel is too small for heavy equipment
- forested riparian area with no paths or low-slope grassy areas for heavy equipment
- multiple private residential/commercial owners

FAIRMOUNT PARK PROJECTS

Units: number of projects in vicinity of each reach
Derivation: Fairmount Park's ES&ED division provided a spreadsheet showing medium and high priority projects. For a small number of projects, the location was not clear from the spreadsheet; these projects were not included in the analysis. For other projects, a point was placed in a GIS layer using the best judgment of GIS staff.

IDENTIFIED SANITARY SEWER PROBLEMS

Units: number of problems identified along each reach
Derivation: A sanitary infrastructure problem was defined as follows:

- The infrastructure feature may be leaking sanitary sewage to the stream, or high stream flows may be infiltrating the infrastructure feature.
- The feature is in good condition, but is exposed in the channel or bank and subject to damage by high flows.

DETERMINATION OF CONDITION OF MANHOLES AND PIPES

- Condition was noted as "poor" by the field team (no instances identified).

- The photo taken by the field team shows at least one of the following:
  - The feature is broken, cracked, leaking, or has exposed joints.
  - The feature is exposed in the channel or bank and subject to high flows.

DETERMINATION OF CONDITION OF DAMS

- If sanitary infrastructure is visible in the photo taken by the field team, the checklist for manholes and pipes above was followed.

USE OF THERMAL IMAGING STUDY RESULTS (NO INSTANCES IDENTIFIED)

- The point was noted as a "suspected leak" by the thermal imaging team.
- Ground truthing notes indicate that the point is associated with sanitary infrastructure (not a stormwater outfall) and that evidence of sewage is present.

RESTORATION PRIORITY RESULTS

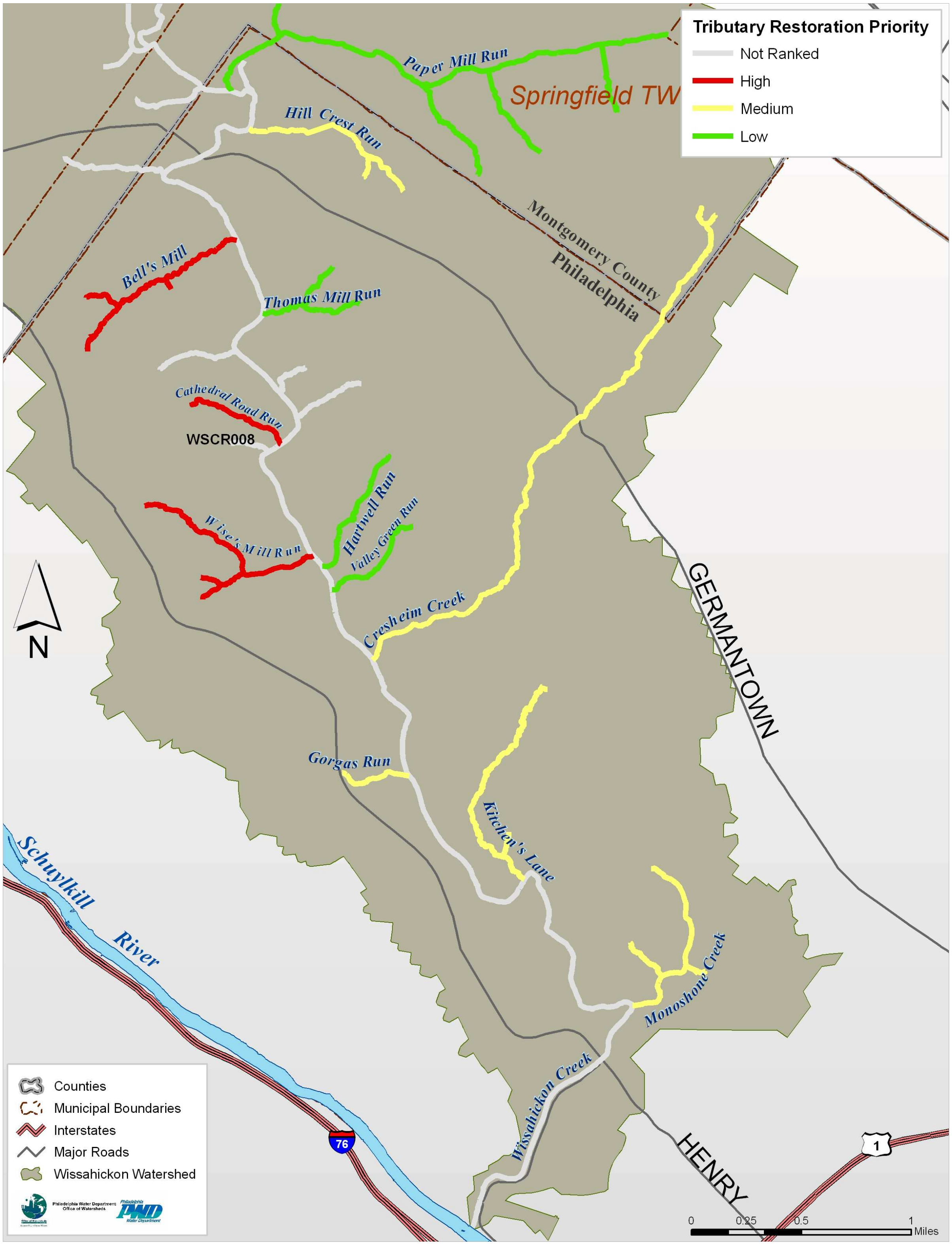
Ranking analyses were performed with several sets of criteria weights. One set of weights for the restoration project are shown in Appendix A, Table 10. The results obtained with that weight set are presented in Appendix A, Table 11. Also shown in Appendix A, Table 11 is the sum of all the reach lengths for each category identified as low, medium, and high priority within each tributary. The tributary restoration ranking is graphically represented in Appendix A, Figure 18; and reach restoration ranking is graphically represented in Appendix A, Figure 19.

Appendix A, Table 10 – Criteria Weights

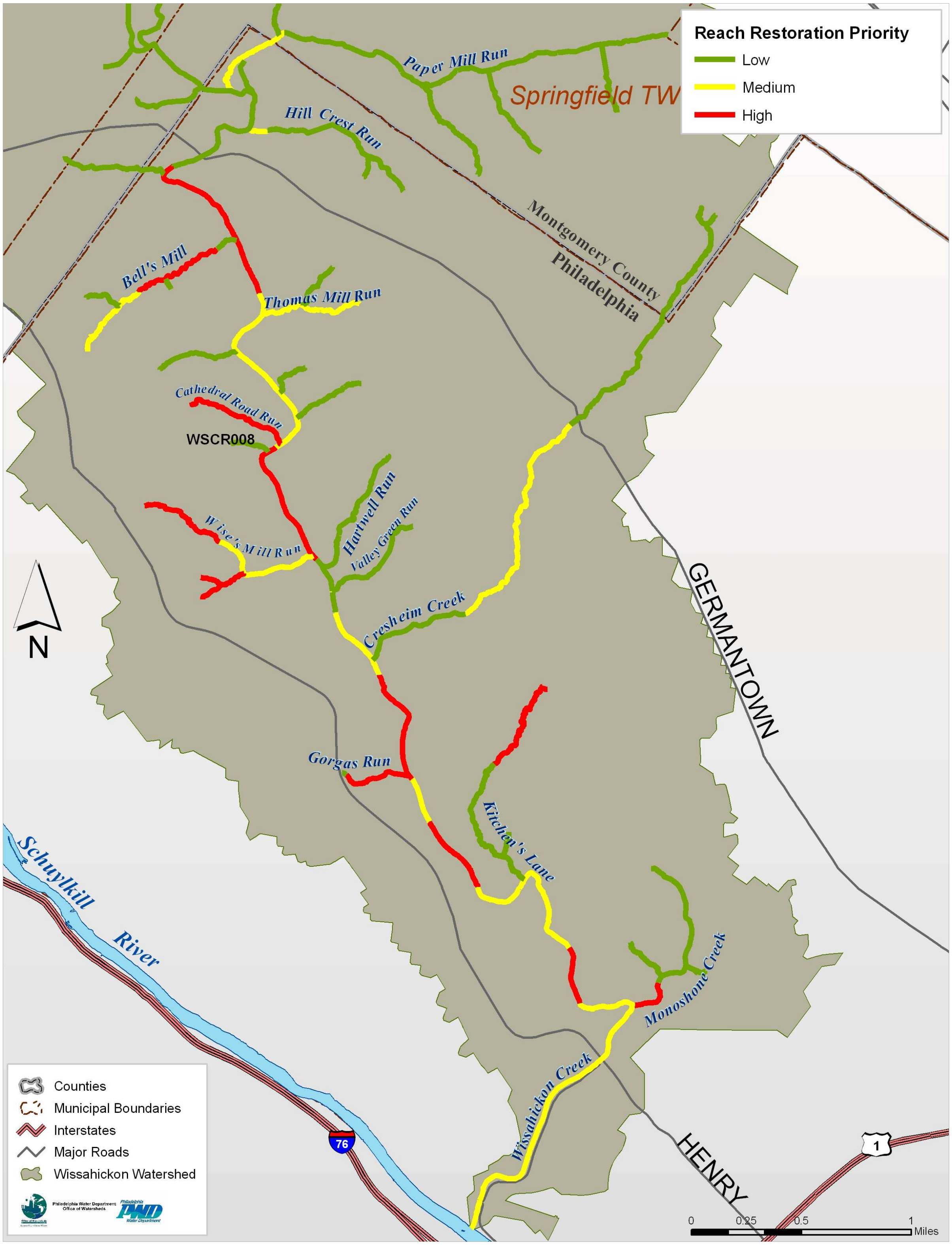
	Weight
Criteria	**0<wt<1**
estimated streambank erosion load	0.300
habitat index	0.100
benthic macroinvertebrate index	0.100
Fairmount Park projects	0.100
identified sanitary sewer problems	0.100
construction difficulty/disturbance index	0.300

Appendix A, Table 11 – Tributary Ranking Results

			Total Reach Length (ft)		
Options	**Ranking**	**Mean Rank**	**low**	**medium**	**high**
Cathedral Road Run	High	1.0	0	0	2771
Bell’s Mill	High	3.0	1834	1078	1846
Wise’s Mill	High	4.0	0	1507	4052
Cresheim Creek	Medium	5.0	9997	5383	0
Gorgas Run	Medium	5.5	0	0	1750
Hill Crest Run	Medium	5.5	2035	1781	0
Monoshone Creek	Medium	6.0	3236	0	1658
Kitchen’s Lane	Medium	8.5	4720	0	2019
Paper Mill Run	Low	8.5	788	4653	0
Valley Green Run	Low	10.5	2868	0	0
Thomas Mill Run	Low	11.0	0	2689	0
Hartwell Run	Low	11.5	3423	0	0



Appendix A, Figure 18 – Tributary Restoration Ranking



Appendix A, Figure 19 – Reach Restoration Ranking

5. Future Sampling

In efforts to comply with the Wissahickon Creek Sediment TMDL and the continuing goal of reducing sediment load from tributaries within City boundaries, PWD has developed a five-year strategy (Appendix A, Table 12).

Appendix A, Table 12 - Time Line Strategy for Monitoring Components of the Wissahickon TMDL.

Monitoring Program	2005				2006				2007				2008				2009				2010			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Tributary Prioritization																								
BEHI/NBS Studies																								
Bank Profile Measurements																								
Stream Modelling																								
Flow Monitoring																								
Discharge Rating Curve																								
Continuous Stage Recording																								
Sediment Transport Rates																								
TSS Rating Curve																								
Bedload Sediment Rating Curve																								
BMP Monitoring																								
Post Construction TSS Monitoring																								
Post Construction Bank Profile Measurements																								
Post Construction Stream Modelling																								

i. Expanded Bank Pin Program

The program of installing bank pins to measure actual erosion rates is being greatly expanded. The objective of this program is to define a local relationship between measured streambank erosion and qualitative streambank erosion (using Rosgen's BEHI/NBS method).

<u>Sampling Design</u>

The sampling design below is recommended based on EPA (2002).

- stratified sampling design: stream length broken up into categories (strata), each representing one combination of BEHI and NBS score observed in Wissahickon.
- total number of sampling sites allocated in each strata according to the estimated load contributed by each BEHI/NBS combination (Appendix A, Table 13)
- total number of sampling sites determined by acceptable margin of error and available budget/staff (more discussion below)
- random site selection within each stratum

As of April 2006, bank pins were installed at 21 sites, and erosion was measured at 11 of these. The most recent measurements included in this study were taken April 24, 2006. Mean erosion rates at the 11 sites with measured erosion are shown in Appendix A, Table 13. A summary of the BEHI ratings are shown in Appendix A, Table 14. The fraction of total load contributed by reaches with each combination of BEHI and NBS score are shown in Appendix A, Table 15. Shown in Appendix A, Figure 20 is a comparison of high and moderate BEHI from local study results. No trend is apparent from data collected so far, but it is hoped a trend will emerge in the future as more data points are added.

Appendix A, Table 13 - Preliminary Bank Pin Data

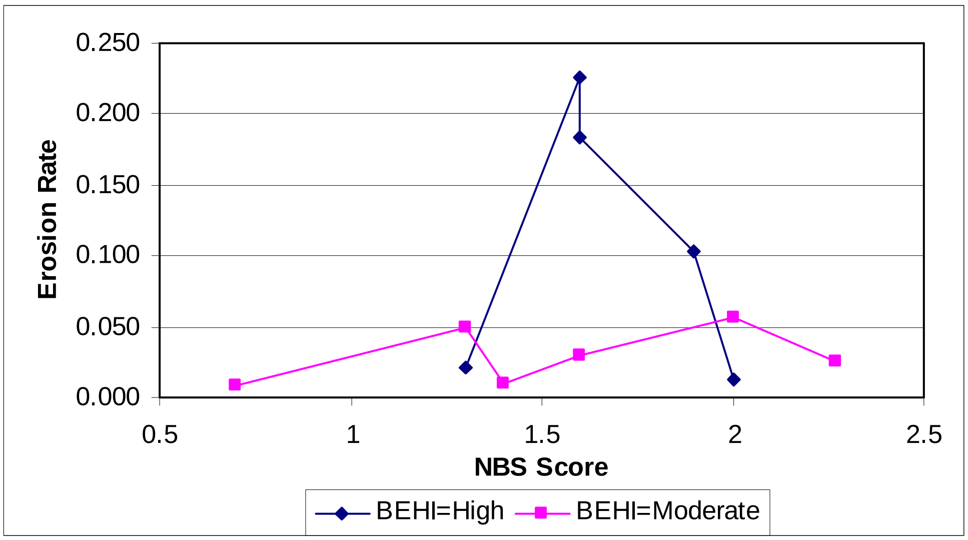
Site	First	Last	Days Monitored	BEHI Rating	NBS Rating	Measured Erosion to top bank pin (ton/ft/yr)	Measured Erosion to top of bank (ton/ft/yr)
MN1	11/2/2005	4/24/2006	173	Moderate	Very Low	0.006	0.016
MN4	11/2/2005	4/24/2006	173	Moderate	Low	0.004	0.009
WM29	11/5/2005	4/24/2006	170	Moderate	Low	0.022	0.074
BM25	11/7/2005	4/24/2006	168	Moderate	Moderate	0.020	0.046
BM21	11/7/2005	4/24/2006	168	Moderate	High	0.012	0.040
CR16	10/31/2005	4/24/2006	175	Moderate	High	0.036	0.090
CR13	10/31/2005	4/24/2006	175	High	Low	0.014	0.041
BM35	11/7/2005	4/24/2006	168	High	Moderate	0.154	0.379
WM13	11/5/2005	4/24/2006	170	High	Moderate	0.122	0.326
MN3	11/2/2005	4/24/2006	173	High	High	0.066	0.275
CR7	10/31/2005	4/24/2006	175	High	High	0.008	0.042

Appendix A, Table 14 - Bank Pin Erosion Summary

BEHI Rating	No. Sites	To Top Bank Pin Mean (ton/ft/yr)	To Top Bank Pin St. Deviation (ton/ft/yr)	To Top of Bank Mean (ton/ft/yr)	To Top of Bank St. Deviation (ton/ft/yr)
Moderate	6	0.017	0.012	0.046	0.032
High	5	0.073	0.065	0.213	0.161

Appendix A, Table 15 - Fraction of Load Contributed by each BEHI/NBS Combination

BEHI	NBS	Sites	Erosion (ton/yr/ft)	Length (ft)	Erosion (ton/yr)	Erosion (% of total)	New Bank Pin Sites
Low	Low	Unassessed*	0.009	153,552	1,367	68.4	60
Low	High	1	0.043	30	1.30	0.065	1
Moderate	Very Low	17	0.020	647	12.9	0.645	1
Moderate	Low	96	0.025	3,008	74.6	3.73	4
Moderate	Moderate	11	0.042	379	15.8	0.791	1
Moderate	High	9	0.056	341	19.1	0.956	1
Moderate	Very High	2	0.096	75	7.21	0.361	1
High	Very Low	15	0.045	370	16.5	0.824	1
High	Low	136	0.059	5,040	299	15.0	15
High	Moderate	9	0.133	388	51.6	2.59	3
High	High	12	0.134	566	75.7	3.79	4
High	Very High	1	0.143	15	2.15	0.107	1
High	Extreme	1	0.107	25	2.68	0.134	1
Very High	Very Low	5	0.069	160	11.0	0.550	1
Very High	Low	21	0.067	455	30.6	1.53	2
Very High	Moderate	1	0.062	10	0.616	0.031	1
Very High	High	1	0.144	20	2.89	0.145	1
Extreme	Low	1	0.289	25	7.22	0.362	1
All Measurements		339		165,106	1997	100	100



Appendix A, Figure 20 - BEHI/NBS Local Study Results

<u>NUMBER OF SITES</u>

The number of sites needed can be estimated based on observed variability in measurements and the acceptable uncertainty in the estimate:

$$n = \frac{z_\alpha^2 \sigma^2}{L^2}$$

where n = sample size (number of sites, rounded up to nearest integer)
z = standard normal cumulative probability for a 2-tailed 95% confidence interval = 1.96
σ = standard deviation of measured erosion rates so far = 0.0439 ton/yr/ft
L = acceptable uncertainty, 1/2 width of confidence interval (ton/yr/ft)

The number of BEHI sites for each rating, required to achieve a given confidence interval, are listed in Appendix A, Table 16 (erosion measured from top bank pin) and Appendix A, Table 17 (erosion measured from top of bank). Low and Moderate BEHI sites were assigned the standard deviation measured at Moderate BEHI sites. High BEHI sites were assigned the standard deviation measured at High BEHI sites. The results suggest that a sampling program to achieve a confidence interval of 100 ton/yr/sq.mi. or less may not be feasible. However, it is important to note that the standard deviations are based on a very small sample size. Collecting more samples may result in a lower estimate of standard deviation. Even if a statistically meaningful measure of error cannot be established, additional sites will allow better management decisions.

Appendix A, Table 16 - The number of sites required to achieve a given Confidence Interval

	St. Dev.	1/2 C.I. (ton/yr/sq.mi.)				
BEHI	(ton/yr/ft)	10	50	100	150	200
Low/Moderate	0.012	1,320	53	14	6	4
High	0.065	38,717	1,549	388	173	97
Total		40,037	1,602	402	179	101

Based on erosion to top bank pin

Appendix A, Table 17 - The number of sites required to achieve a given Confidence Interval

	St. Dev.	1/2 C.I. (ton/yr/sq.mi.)				
BEHI	(ton/yr/ft)	10	50	100	150	200
Low/Moderate	0.032	9,384	376	94	42	24
High	0.161	237,530	9,502	2,376	1,056	594
Total		246,914	9,878	2,470	1,098	618

Based on erosion to top of bank

NEXT STEPS

PWD plans to establish approximately 100 new sites to better estimate the true standard deviations. If these are lower than current estimates, the number of sites needed for a statistically meaningful estimate will also decrease.

ii. BANK EROSION HAZARD INDEX AND NEAR BANK STRESS

Total sediment yields are composed of sediment derived from overland runoff and from that originating in the creek. To determine the relative importance of these two components, PWD is conducting an expanded Bank Erosion Hazard Index (BEHI) and Near Bank Stress (NBS) study as defined by Rosgen (1996) to predict streambank erosion rates.

Additional reaches of the thirteen tributaries (Appendix A, Figure 19) within Philadelphia will be assessed by PWD staff and sections of streambank will be scored based on the BEHI and NBS criteria. This study will be combined with the expanded bank pin program to develop a local relationship between these indices and measured erosion.

iii. BANK EROSION HAZARD INDEX AND NEAR BANK STRESS

Additional discharge rating curves will be established and existing ones will be refined as necessary for the tributaries within Philadelphia County limits following a modified version of the USGS protocol (Buchanan and Somers 1969). Currently, discharge rating curves have been completed on three tributaries (Bells Mill, Monoshone, and Wises Mill). Discharge will be measured using a SonTek Flowtraker during low and medium flow events and a Gurley pygmy meter during high flow events.

iv. CONTINUOUS STAGE RECORDING

Discharge characterization on the thirteen tributaries within Philadelphia County limits will be completed based on the aforementioned prioritization ranking. Stage data will be recorded at the designated monitoring site using a fixed Sigma ultrasonic sensor and/or pressure transducer. Stage data will be downloaded bimonthly and QA/QC will be performed by PWD staff.

v. TSS RATING CURVE

Automated water collection devices (ISCO model no. 6712) will be used to collect water samples during additional wet weather events as needed in the Wissahickon Creek tributaries. In the attempt to characterize an entire storm event, automated samplers are triggered by a 0.2 ft elevation change in stream height and will continue to collect samples every 20 minutes for the first hour. Following this step, samples are then collected every 2-4 hours until discharge has returned to base flow conditions. Suspended sediment loads will be related to the discharge at which they were collected to create a suspended sediment rating curve. To date, two wet weather events have been captured on Monoshone Creek, Wises Mill and Cathedral Run, and three runoff producing events have been captured on Bells Mill. Wet weather monitoring will continue through 2006-2007 in attempt to characterize TSS in relation to discharge.

vi. BEDLOAD SEDIMENT RATING CURVE

In order to estimate a total sediment load, bedload sediment samples will be collected in addition to suspended sediment samples. Bedload sediment samples will be collected at different stages according to a modified version of USGS protocol (Edwards and Glysson 1999). Samples will be collected using a Helley-Smith handheld sampler with a 15cm orifice. Samples will be dried, sieved and weighed in order to determine a rate of transport as well as a particle size distribution.

vii. POST-CONSTRUCTION MONIITORING

The final objective of the TMDL monitoring program is to measure (i.e., quantify) the efficacy of Best Management Practices (BMPs) and their benefit in terms of sediment reduction in the Wissahickon drainage. In 2005, PWD conducted extensive wet-weather monitoring on three tributaries where various stormwater BMPs have been proposed or are currently under construction.

APPENDIX A – SEDIMENT TOTAL MAXIMUM DAILY LOAD (TMDL) FOR WISSAHICKON CREEK – FEASIBILITY STUDY & MONITORING PLAN

1. STORMWATER FLOW AND LOAD ESTIMATES BY OUTFALL

Methods used to develop stormwater outfall flows and loads are described in detail in the Wissahickon Comprehensive Characterization Report. In Appendix A, Table 1 drainage area and estimated mean annual runoff volume are reported for each outfall. In Appendix A, Table 2 estimated mean annual pollutant loads are reported for each outfall. A summary of the total number of outfalls per tributary is reported in Appendix A, Table 3 along with a summary of discharge and estimated loads for all of the outfalls found in each tributary.

Appendix A, Table 1 - Philadelphia Stormwater Outfall Runoff

Outfall	Tributary/Stream	Drainage Area (acres)	Runoff 4/93-3/01 (in/yr)
W-084-01	Bells Mill	62.8	7.74
W-084-02	Bells Mill	106	9.26
W-084-03	Bells Mill	4.94	10.4
W-084-04	Bells Mill	12.2	11.9
W-076-01	Cathedral Road Run	90.3	6.01
W-076-02	Cathedral Road Run	38.3	6.12
W-076-08	Cresheim Creek	5.94	12.4
W-076-11	Cresheim Creek	10.6	7.31
W-076-12	Cresheim Creek	47.5	9.97
W-077-01	Cresheim Creek	46.2	8.93
W-077-02	Cresheim Creek	239	10.0
W-086-01	Cresheim Creek	270	14.8
W-086-02	Cresheim Creek	76.7	12.6
W-086-03	Cresheim Creek	35.3	13.2
W-086-04	Cresheim Creek	31.6	18.8
W-086-05	Cresheim Creek	47.7	11.7
W-086-06	Cresheim Creek	85.3	11.6
W-086-07	Cresheim Creek	23.6	17.2
W-067-01	Gorgas Run	392	12.2
W-067-02	Gorgas Run	41.3	14.9
W-067-03	Gorgas Run	29.5	13.3
W-076-07	Hartwell Run	48.0	9.30
W-076-14	Hartwell Run	67.6	10.4
W-095-01	Hill Crest Run	99.7	11.3
W-095-03	Hill Crest Run	51.3	12.4
W-068-01	Kitchen's Lane	16.0	12.2
W-068-02	Kitchen's Lane	10.7	15.7
W-068-03	Kitchen's Lane	4.07	13.0
W-068-06	Kitchen's Lane	23.2	10.3
W-068-08E	Kitchen's Lane	25.9	9.38
W-068-08W	Kitchen's Lane	33.8	9.85
W-060-04	Monoshone Creek	12.7	4.83

W-060-08	Monoshone Creek	16.3	6.43
W-060-09	Monoshone Creek	17.0	4.65
W-060-10	Monoshone Creek	163	6.28
W-060-11	Monoshone Creek	39.2	4.35
W-068-04	Monoshone Creek	628	5.26
W-068-05	Monoshone Creek	76.4	5.72
W-095-02	Paper Mill Run	6.07	9.10
W-095-04	Paper Mill Run	6.82	15.4
W-095-05	Paper Mill Run, Trib B	20.7	14.8
W-076-09	Valley Green Run	62.8	9.96
W-076-10	Valley Green Run	46.0	10.7
W-075-01	Wise's Mill Run	154	14.5
W-075-02	Wise's Mill Run	9.88	8.18
W-076-04	Wise's Mill Run	9.02	8.40
W-076-05	Wise's Mill Run	3.82	10.4
W-076-06	Wise's Mill Run	9.62	11.5
W-076-13	Wise's Mill Run	92.0	13.2
W-076-X	Wise's Mill Run	9.47	1.72
W-052-01	Wissahickon Creek	12.4	11.3
W-052-02	Wissahickon Creek	15.5	12.8
W-060-01	Wissahickon Creek	111	12.5
W-060-02	Wissahickon Creek	25.5	14.0
W-060-03	Wissahickon Creek	63.2	13.8
W-060-05	Wissahickon Creek	96.7	8.39
W-060-06	Wissahickon Creek	2.58	16.7
W-060-07	Wissahickon Creek	22.0	12.4
W-067-04	Wissahickon Creek	23.8	13.9
W-067-05	Wissahickon Creek	10.0	14.1
W-067-06	Wissahickon Creek	41.5	10.8
W-068-07	Wissahickon Creek	24.9	9.39
W-076-03	Wissahickon Creek	9.21	11.7
W-085-01	Wissahickon Creek	83.9	12.3
W-085-02	Wissahickon Creek, Trib I	57.4	11.4

Appendix A, Table 2 - Wissahickon Outfall Load Summary

Outfall	Tributary/Stream	BOD5 (lbs/yr)	TSS (lbs/yr)	COD (lbs/yr)	TP (lbs/yr)	Cu (lbs/yr)	Zn (lbs/yr)	Fe (lbs/yr)	TN (lbs/yr)	Fecal (#/yr)	Pb (lbs/yr)
W-084-01	Bells Mill	892	7,395	5,397	29.2	1.51	11.5	129	198	2.92E+12	1.86
W-084-02	Bells Mill	1,759	14,084	10,743	57.3	2.99	22.9	262	385	5.77E+12	3.70
W-084-03	Bells Mill	104	731	653	3.29	0.177	1.39	17.0	21.6	3.41E+11	0.222
W-084-04	Bells Mill	297	2,123	1,989	9.36	0.549	4.18	55.4	57.4	9.34E+11	0.656
W-076-01	Cathedral Road Run	985	8,370	6,030	32.4	1.71	12.8	146	217	3.19E+12	2.07
W-076-02	Cathedral Road Run	490	3,247	3,123	15.4	0.834	6.62	83.2	100	1.61E+12	1.06
W-076-08	Cresheim Creek	141	1,084	872	4.56	0.240	1.86	21.8	30.4	4.64E+11	0.299
W-076-11	Cresheim Creek	134	1,221	791	4.49	0.228	1.69	17.8	31.0	4.39E+11	0.276
W-076-12	Cresheim Creek	975	6,648	6,180	30.8	1.66	13.1	163	201	3.20E+12	2.10
W-077-01	Cresheim Creek	665	6,819	3,861	22.8	1.16	8.27	81.6	159	2.15E+12	1.35
W-077-02	Cresheim Creek	4,632	35,467	29,705	149	8.25	62.8	778	955	1.48E+13	10.0
W-086-01	Cresheim Creek	7,939	58,607	51,631	253	14.2	109	1,384	1,602	2.54E+13	17.3
W-086-02	Cresheim Creek	1,411	16,888	7,885	50.4	2.51	17.0	146	358	4.50E+12	2.79
W-086-03	Cresheim Creek	953	6,595	6,120	30.1	1.66	12.9	163	193	3.10E+12	2.06
W-086-04	Cresheim Creek	1,163	9,531	8,702	36.9	2.54	18.0	265	196	3.29E+12	2.71
W-086-05	Cresheim Creek	1,143	7,876	7,235	36.1	1.95	15.3	190	236	3.75E+12	2.46
W-086-06	Cresheim Creek	1,482	16,878	8,242	52.4	2.56	17.8	154	374	4.80E+12	2.93
W-086-07	Cresheim Creek	739	7,133	5,998	23.9	1.84	12.2	191	112	1.87E+12	1.79
W-067-01	Gorgas Run	8,705	74,863	55,682	285	16.0	118	1,421	1,833	2.74E+13	18.7
W-067-02	Gorgas Run	1,280	8,604	8,141	40.3	2.18	17.3	216	262	4.20E+12	2.76
W-067-03	Gorgas Run	774	5,849	5,049	24.7	1.40	10.6	135	156	2.46E+12	1.68
W-076-07	Hartwell Run	803	6,882	4,820	26.5	1.36	10.3	113	181	2.63E+12	1.67
W-076-14	Hartwell Run	1,088	11,798	6,249	37.9	1.91	13.4	127	265	3.49E+12	2.19
W-095-01	Hill Crest Run	2,029	17,529	12,447	66.9	3.55	26.5	300	447	6.55E+12	4.26
W-095-03	Hill Crest Run	1,191	9,722	7,658	38.6	2.17	16.2	199	247	3.77E+12	2.57
W-068-01	Kitchen's Lane	395	2,771	2,490	12.5	0.672	5.28	64.8	82.2	1.30E+12	0.848
W-068-02	Kitchen's Lane	334	2,403	2,089	10.6	0.567	4.44	53.8	70.1	1.10E+12	0.713
W-068-03	Kitchen's Lane	101	785	620	3.26	0.171	1.32	15.4	21.8	3.31E+11	0.213
W-068-06	Kitchen's Lane	491	3,397	3,099	15.5	0.835	6.57	81.1	102	1.61E+12	1.05
W-068-08E	Kitchen's Lane	426	3,802	2,528	14.2	0.723	5.40	57.6	97.6	1.40E+12	0.879
W-068-08W	Kitchen's Lane	676	4,711	4,267	21.4	1.15	9.05	111	140	2.22E+12	1.45
W-060-04	Monoshone Creek	100	1,017	602	3.40	0.181	1.28	13.6	22.9	3.14E+11	0.206
W-060-08	Monoshone Creek	213	1,486	1,342	6.74	0.362	2.85	35.0	44.2	6.99E+11	0.457
W-060-09	Monoshone Creek	144	1,214	865	4.73	0.244	1.85	20.4	32.1	4.71E+11	0.299
W-060-10	Monoshone Creek	1,910	16,134	12,860	62.0	3.71	27.0	350	377	5.83E+12	4.21
W-060-11	Monoshone Creek	304	2,656	1,838	10.1	0.524	3.92	43.3	68.1	9.89E+11	0.634
W-068-04	Monoshone Creek	6,613	47,570	42,041	210	11.5	89.1	1,102	1,365	2.15E+13	14.2
W-068-05	Monoshone Creek	854	6,523	5,559	27.3	1.55	11.7	148	173	2.71E+12	1.86
W-095-02	Paper Mill Run	77.1	970	403	2.81	0.130	0.877	6.18	20.8	2.52E+11	0.147
W-095-04	Paper Mill Run	208	1,539	1,335	6.63	0.367	2.82	35.2	42.6	6.69E+11	0.449
W-095-05	Paper Mill Run, Trib B	635	4,452	4,334	19.9	1.19	9.08	123	120	1.98E+12	1.42
W-076-09	Valley Green Run	800	11,580	4,291	30.2	1.49	9.27	64.1	218	2.48E+12	1.53
W-076-10	Valley Green Run	989	7,079	6,199	31.5	1.68	13.2	160	207	3.25E+12	2.11

W-075-01	Wise's Mill Run	4,086	36,479	28,767	133	8.50	59.9	813	768	1.19E+13	9.19
W-075-02	Wise's Mill Run	139	1,279	817	4.66	0.236	1.75	18.2	32.3	4.55E+11	0.285
W-076-04	Wise's Mill Run	137	1,162	826	4.52	0.233	1.76	19.5	30.7	4.50E+11	0.286
W-076-05	Wise's Mill Run	83.0	554	531	2.60	0.142	1.12	14.2	16.8	2.72E+11	0.180
W-076-06	Wise's Mill Run	224	1,621	1,472	7.09	0.405	3.10	40.1	44.4	7.11E+11	0.490
W-076-13	Wise's Mill Run	2,436	18,295	16,673	77.2	4.68	34.9	471	462	7.50E+12	5.43
W-076-X	Wise's Mill Run	20.9	295	103	0.790	0.035	0.227	1.20	5.99	6.83E+10	0.039
W-052-01	Wissahickon Creek	201	2,517	1,220	7.21	0.397	2.59	25.8	48.0	6.05E+11	0.412
W-052-02	Wissahickon Creek	341	3,411	2,433	11.3	0.744	5.05	68.3	64.4	9.62E+11	0.768
W-060-01	Wissahickon Creek	2,376	22,846	15,121	79.7	4.49	31.9	374	513	7.35E+12	5.06
W-060-02	Wissahickon Creek	705	5,161	4,401	22.5	1.20	9.35	112	149	2.32E+12	1.50
W-060-03	Wissahickon Creek	1,456	14,497	9,260	49.2	2.78	19.5	227	317	4.48E+12	3.09
W-060-05	Wissahickon Creek	1,202	13,898	6,518	42.7	2.04	14.1	115	310	3.93E+12	2.35
W-060-06	Wissahickon Creek	46.4	829	195	1.90	0.078	0.439	0.00	15.2	1.50E+11	0.078
W-060-07	Wissahickon Creek	397	4,906	2,472	14.1	0.802	5.22	55.0	91.9	1.17E+12	0.824
W-067-04	Wissahickon Creek	605	5,233	3,963	19.8	1.14	8.34	104	124	1.87E+12	1.31
W-067-05	Wissahickon Creek	265	2,209	1,756	8.61	0.503	3.69	47.0	53.5	8.22E+11	0.580
W-067-06	Wissahickon Creek	808	6,903	4,851	26.7	1.37	10.4	114	182	2.65E+12	1.68
W-068-07	Wissahickon Creek	477	3,295	3,016	15.1	0.812	6.40	79.0	98.6	1.57E+12	1.03
W-076-03	Wissahickon Creek	214	1,548	1,336	6.81	0.363	2.84	34.3	45.0	7.01E+11	0.456
W-085-01	Wissahickon Creek	1,741	16,604	10,267	58.8	3.00	22.0	228	405	5.66E+12	3.57
W-085-02	Wissahickon Creek, Trib I	1,289	9,638	8,237	41.2	2.27	17.4	216	266	4.16E+12	2.78

Appendix A, Table 3 - Wissahickon Tributary Load Summary

Tributary/Stream	Outfalls	Total Discharge (cfs)	BOD5 (lbs/yr)	TSS (lbs/yr)	COD (lbs/yr)	TP (lbs/yr)	Cu (lbs/yr)	Zn (lbs/yr)	Fe (lbs/yr)	TN (lbs/yr)	Fecal (#/yr)	Pb (lbs/yr)
Bells Mill	4	0.060	3,051	2.43E+04	1.88E+04	99.2	5.23	40.0	463	662	9.97E+12	6.44
Cathedral Road Run	2	0.028	1,475	1.16E+04	9.15E+03	47.8	2.54	19.4	229	317	4.80E+12	3.13
Cresheim Creek	12	0.523	21,378	1.75E+05	1.37E+05	694	38.8	290	3,554	4,448	6.78E+13	46.0
Gorgas Run	3	0.255	10,759	8.93E+04	6.89E+04	350	19.6	146	1,772	2,251	3.41E+13	23.1
Hartwell Run	2	0.028	1,891	1.87E+04	1.11E+04	64.4	3.28	23.7	240	446	6.13E+12	3.86
Hill Crest Run	2	0.053	3,220	2.73E+04	2.01E+04	106	5.72	42.6	499	694	1.03E+13	6.83
Kitchen's Lane	6	0.038	2,423	1.79E+04	1.51E+04	77.6	4.12	32.1	384	513	7.95E+12	5.16
Monoshone Creek	7	0.259	10,136	7.66E+04	6.51E+04	324	18.0	138	1,713	2,082	3.25E+13	21.9
Paper Mill Run	3	0.020	920	6.96E+03	6.07E+03	29.3	1.69	12.8	165	183	2.90E+12	2.01
Valley Green Run	2	0.030	1,789	1.87E+04	1.05E+04	61.6	3.17	22.4	224	425	5.73E+12	3.64
Wise's Mill Run	7	0.195	7,126	5.97E+04	4.92E+04	230	14.2	103	1,378	1,361	2.14E+13	15.9
Wissahickon Creek	14	0.250	10,835	1.04E+05	6.68E+04	365	19.7	142	1,582	2,416	3.42E+13	22.7
Wissahickon Creek Trib 1	1	0.021	1,289	9.64E+03	8.24E+03	41.2	2.27	17.4	216	266	4.16E+12	2.78

2. STREAMBANK EROSION LOAD FIELD METHODS

In conjunction with Section D (*Sediment Total Maximum Daily Load (TMDL) For Wissahickon Creek*) of the City's stormwater permit, PWD has initiated a monitoring plan that addresses the adverse impacts to in-stream habitats as a result of the transport of

sediment and/or streambank erosion. Baseline data from 13 perennial tributaries that originate in the City will be monitored to define their contribution of sediment loading.

There are two elements to the monitoring program. The first estimates the sediment load originating from streambanks. The second estimates the total sediment load being carried by the stream. Data collection is ongoing for both parts.

i. BEHI/NBS Assessments

PWD employed the Bank Erosion Hazard Index (BEHI) and Near Bank Stress (NBS) as defined by Rosgen (1996) to predict erosion rates and classify the erosion potential of the tributaries. An example of bank erosion can be seen in Figure Appendix A, Figure 1 where much of a bank pin is exposed. Three hundred and sixty eight reaches in 13 tributaries have been assessed using BEHI and NBS criteria. Reaches were assessed based on visual inspection of obvious signs of erosion. BEHI and NBS scores were grouped as very low, low, moderate, high or very high. Table 4 summarizes the portion of each tributary that was assessed using the BEHI/NBS method.

Appendix A, Figure 1 - PWD staff digging out eroded bank sediment in order to accurately measure bank pin exposure

Appendix A, Table 4 - Portion of Each Tributary Assessed Using BEHI/NBS Method

Site	BEHI/NBS Assessed (ft)	Channelized (ft)	Visually Assessed - Low Erosion (ft)
Monoshone	147	3,074	9,537
Kitchens Ln	1,250	0.00	12,946
Cresheim	1,835	1,062	29,143
Valley Green Run	270	277	3,859
Hartwell	340	0.00	6,358

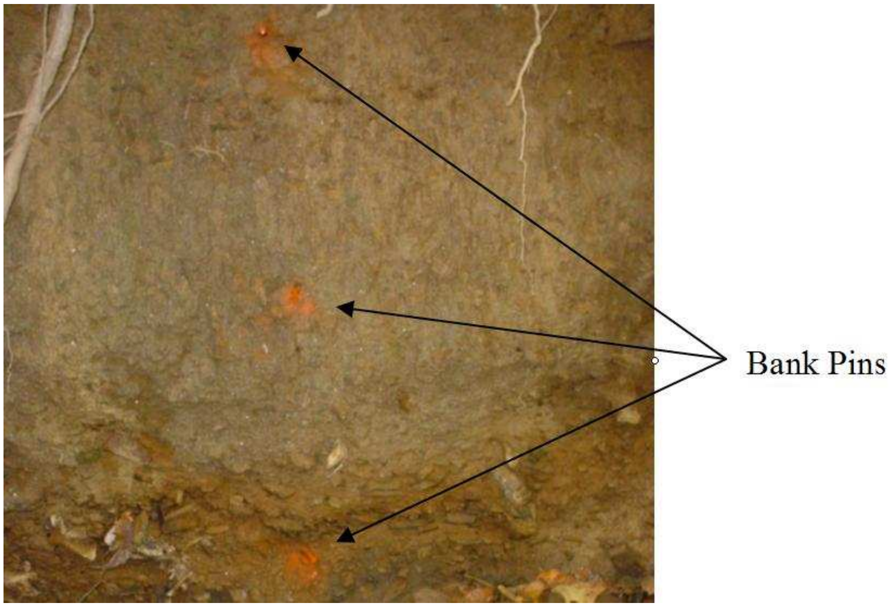
Rex Ave	270	0.00	2,982
Thomas Mill	625	0.00	6,895
Hill Crest	75.0	2,128	6,929
Paper Mill	2,640	8,576	48,298
Gorgas Ln	350	325	3,261
Wises Mill	1,042	1,057	11,301
Cathedral	1,135	0.00	4,227
Bells Mill	1,759	0.00	7,781

ii. Bank Profile Measurements

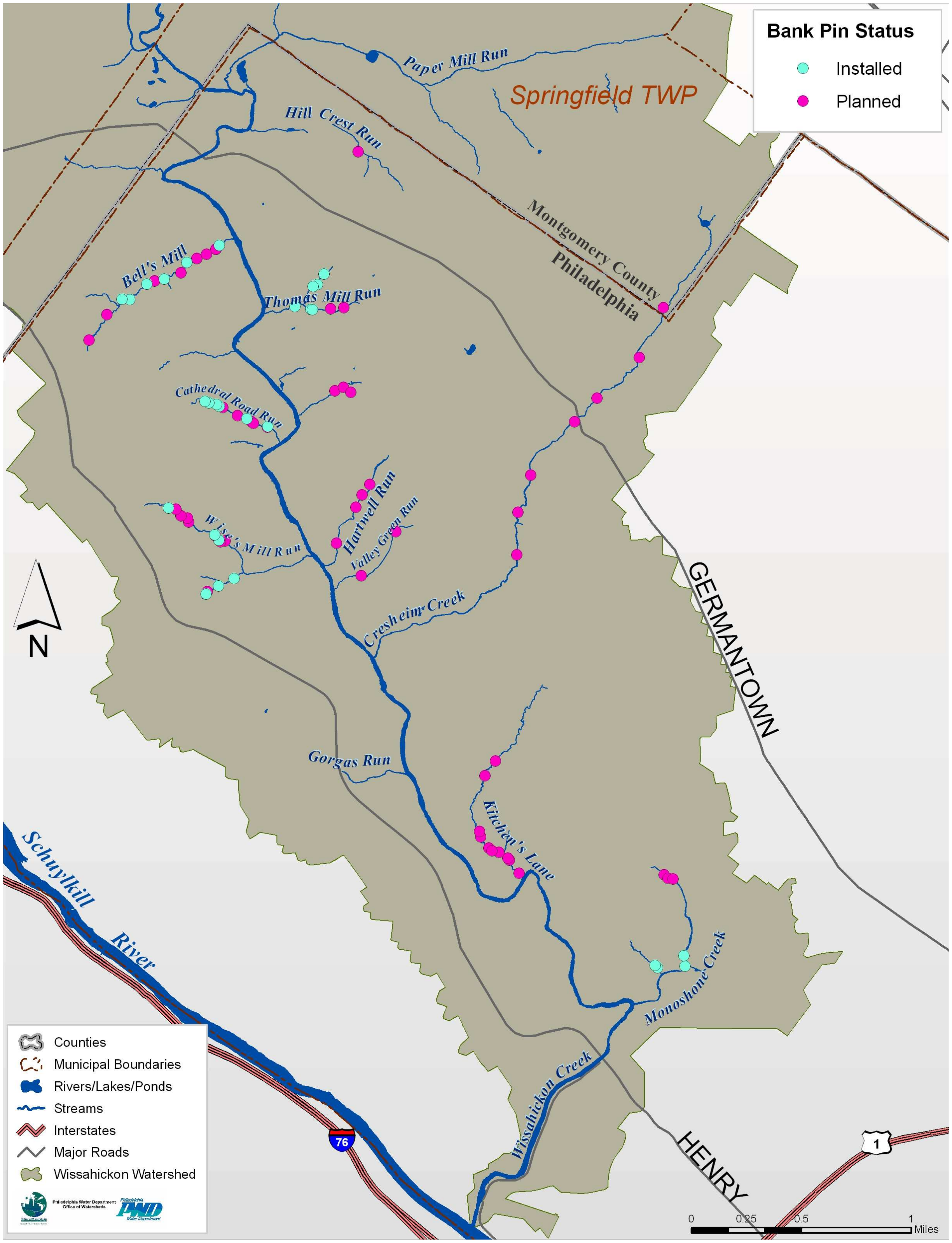
Bank pins were installed in Bells Mill, Cathedral Run, Wises Mill and Monoshone tributaries in October and November 2005. Nine bank pin sites were chosen in each of the tributaries listed with the exception of Monoshone. Only four bank pin sites were chosen in Monoshone because much of the tributary is channelized. Bank pins were installed in reaches with varying BEHI and NBS scores in order to validate and calibrate the prediction model. Three of the 9 sites were in reaches visually assessed to have low erosion rates. Additional bank pin sites in these tributaries and others are planned for the future. The current bank pin installation locations and planned bank pin installation locations can be seen on the map in Appendix A, Figure 4.

Bank pins were installed where the bend in the bank was greatest. At least one bank pin was put in below bankfull height and they were spaced no closer than 1 ft. The number of bank pins at a site was dependent on bank height and ranged from one to three. An example of bank pin installation can be seen in Appendix A, Figure 2, and an example of bank pin spacing can be seen in Appendix A, Figure 3.

Appendix A, Figure 2 - PWD staff installing a bank pin into the bank along the Wises Mill tributary. Bank pins are driven horizontally into streambanks at positions corresponding to bank erosion locations.

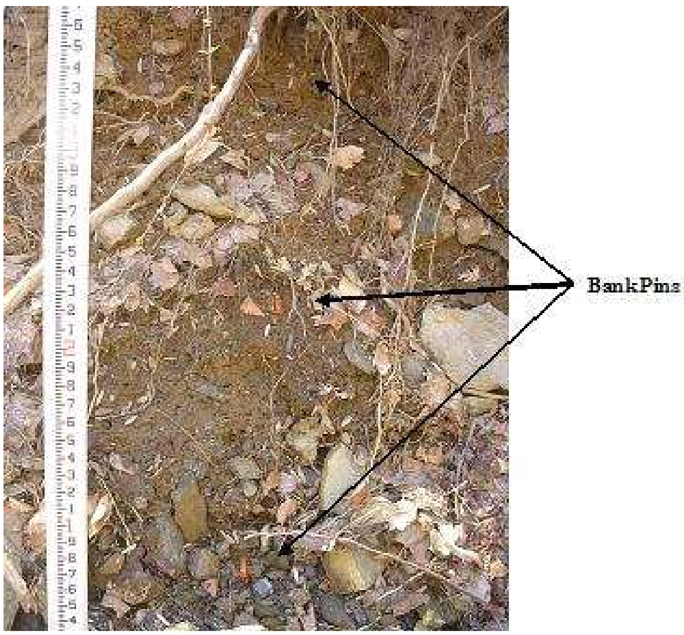


Appendix A, Figure 3 - After bank pin installation, the exposed ends were spray painted to make more visible



Appendix A, Figure 4 - Current and Planned Bank Pin Locations

Measurements were made using a survey rod, a Keson pocket rod and two levels. The survey rod was placed on the edge of the toe pin and kept straight using a level. The pocket rod was placed over the bank pin up against the bank and kept straight by a level. The distance from the bank to the edge of the survey rod closest to the bank was recorded on the field data sheet. Toe pins are bank offset pins driven vertically into the bed surface in order to "profile" the streambank with vertical measurements from the survey rod to the bank. The toe pin offers a permanent location with which to determine lateral erosion per unit time between surveys. The survey rod can be seen in Appendix A, Figure 5 where the bank pins are being measured in relation to the toe pin position. Lateral erosion or aggrading of the streambank is determined by measuring changes in bank pin distance from the toe pin (Appendix A, Figure 6).



Appendix A, Figure 5 - The survey rod measures the amount of exposed pin as the amount of lateral erosion upon re-survey.

Appendix A, Figure 6 - The toe pin is a permanent reference point for determining lateral erosion.

iii. CHANNEL STABILITY

Bar samples, sub-pavement samples and pebble counts were collected at 9 sites in 5 tributaries to Wissahickon Creek in order to gather information on channel stability. Bar and sub-pavement samples as well as pebble counts were collected following methods described on EPA's Watershed Assessment of River Stability and Sediment Supply (WARSSS) website. An example of bar sampling is depicted in Figures 7 and 8. Additionally, Riffle Stability Index (RSI) Assessments and pebble counts were completed at 14 sites in the same 5 tributaries. RSI methods are described in Kappesser (1994). RSI assessments were done in place of bar samples in cases where sediment bars were not prominent due to high slope. In some cases RSI assessments were done in close proximity to bar or sub-pavement samples in order to compare results from the two methods. All samples were collected in April and May 2006.

Appendix A, Figure 7 - PWD staff collected a bar sample representing the size gradation of bedload at the bankfull stage.

Appendix A, Figure 8 - PWD staff draining water from the bar sample.

iv. TOTAL SUSPENDED SEDIMENT LOAD

Automated water collection devices (ISCO model no. 6712) were used to collect water samples during wet weather events in the Wissahickon Creek tributaries. An example of the automated sampler being set up by PWD staff is shown in Appendix A, Figure 9. In the attempt to characterize an entire storm event, automated samplers were triggered by a 0.2 ft elevation change in stream height and collected samples every 20 minutes for the first hour. Following this step, samples were then collected every 2-4 hours until discharge returned to base flow conditions. Suspended sediment loads were related to the discharge at which they were collected to create a suspended sediment rating curve. Four tributaries were selected based on visual inspection of obvious signs of erosion to

estimate sediment loads and calibrate methods used in other tributaries. The location of installed samplers can be seen in Figure 10.

Total suspended sediment samples were collected from Monoshone Creek (5/20/2005 and 7/8/2005), Wises Mill (11/16/2005), Cathedral Run (11/10/2005 and 11/16/2005) and Bells Mill (9/15/2005, 9/26/2005 and 10/8/2005). Samples were collected using an ISCO automated sampler and followed methods described in wet weather monitoring. Water level is recorded during the sample period allowing a sediment discharge rating curve to be established. Additional sample collections are planned for these 4 tributaries as well as other tributaries.

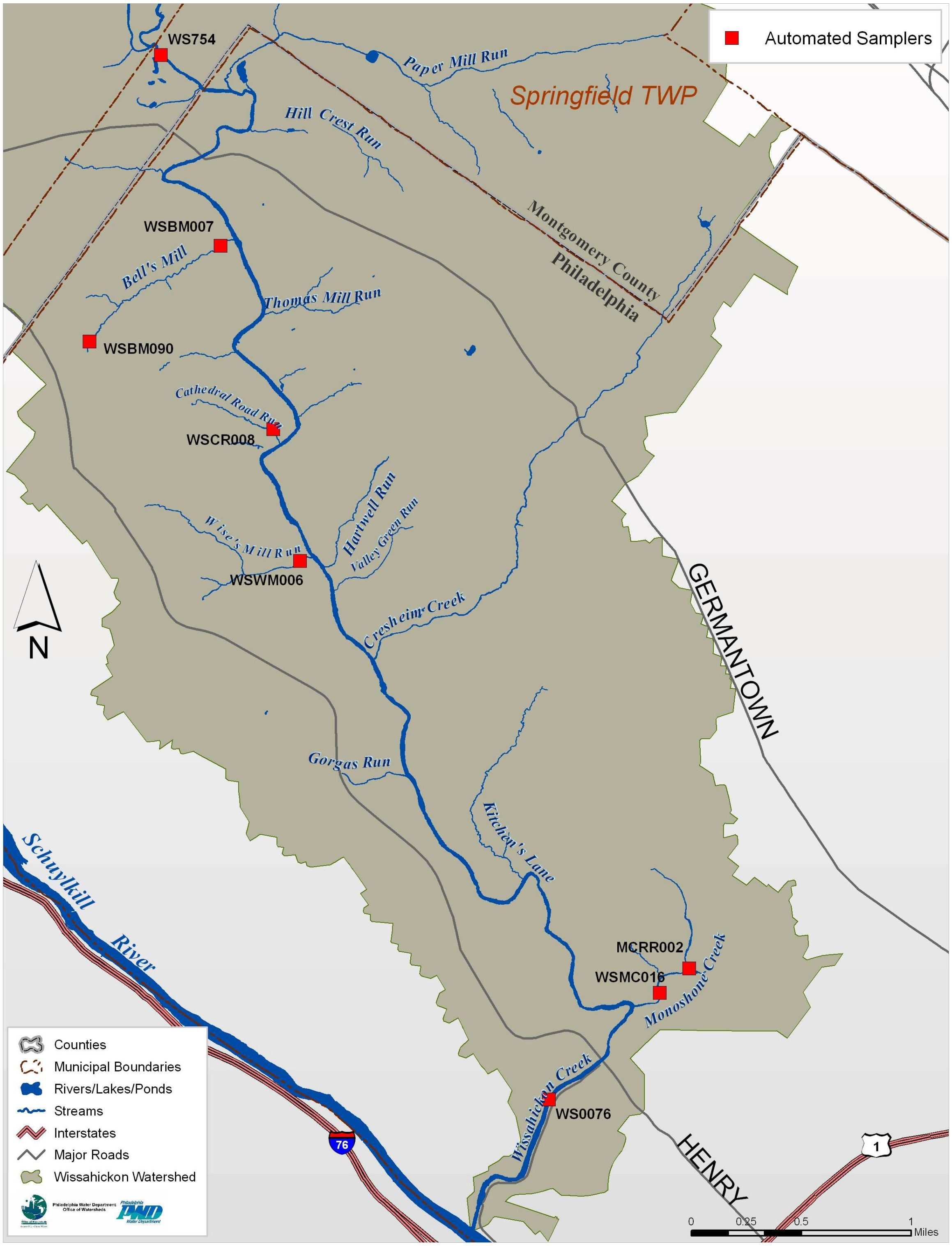
Appendix A, Figure 9 - PWD staff setting up the automated water sampler for wet weather monitoring

Stage data from Bells Mill, Cathedral Run, Wises Mill and Monoshone were recorded near the Wissahickon confluence downstream of all stormwater outfalls. Stage was measured every six minutes by either an ultrasonic down-looking water level sensor or a pressure transducer and recorded on a Sigma620. The ultrasonic down-looking sensor and pressure transducer are shown in Figures 11 and 12. PWD staff periodically downloaded stage data and performed quality assurance. Any data determined to be incorrect was removed and saved in another location.

Dates of ultrasonic down-looking sensor installation in Bells Mill, Cathedral Run and Wises Mill are May 2005, September 2005 and August 2005 respectively. Pressure transducers were installed in Monoshone in July 2005 and Bells Mill in November 2005. Stage data will continue to be recorded at these sites and additional sites will be added.

Appendix A, Figure 10 - An ultrasonic down-looking acoustic water level sensor for water level measurement as it was installed above the Cathedral Run tributary

Appendix A, Figure 11 - A pressure transducer for redundant water level measurement as it was installed in the Cathedral Run tributary.



Appendix A, Figure 12 - Automatic Sampler Locations

v. STAGE-DISCHARGE RATING CURVES

Staff gages were installed in Monoshone, Wises Mill and Bells Mill concurrent with ultrasonic downlooker or pressure transducer installation. Staff gauges are located next to the stage recording device in culverts with concrete floors to ensure that the cross section will not change over time. The staff gage along with the ultrasonic down-looking sensor and pressure transducer are shown in Appendix A, Figure 13.

Discharge rating curves were established in Monoshone, Wises Mill and Bells Mill following a modified version of the USGS protocol (Buchanan and Somers 1969). Discharge was measured in a cross section close to the staff gage using a SonTek Flowtraker Handheld ADV and plotted against the stage it was recorded at. Due to lack of a suitable monitoring location, the discharge rating curve in Cathedral Run will be mathematically modeled instead of measured in the field.

Appendix A, Figure 13 - Staff Gage for the Bells Mill tributary pictured with a pressure transducer and ultrasonic down-looking sensor.

3. Preliminary Streambank Erosion Load Estimates

Results of preliminary BEHI, NBS, erosion rate measurements at a reference site, and sediment-flow correlations were analyzed to produce several independent estimates of sediment load in the system. These results are useful for long-term planning but may change substantially as more data are collected and analyzed in the future. Appendix A, Table 5 includes useful summary information for the watershed. Appendix A, Table 6 through Appendix A, Table 8 include estimates of sediment load. The various methods and references used to derive these estimates are discussed below.

Appendix A, Table 5 - Wissahickon Watershed Information

System		
Philadelphia tributary stream length =	81,964	ft
Philadelphia main stem stream length =	40,712	ft
Philadelphia Trib Drainage Area =	4,963	ac
Philadelphia Drainage Area =	6,711	ac

Appendix A, Table 6 - Streambank Erosion Estimates

System	Streambank TSS Load (lb/yr)	Streambank TSS Load (ton/sq. mi/yr)	Streambank TSS Load (lb/ft/yr)	Calculation Method
Philadelphia Tributaries Only	3,142,358	203	38.3	BEHI/NBS Analysis with Colorado Reference Stream
Philadelphia Tributaries and Main Stem	3,685,717	176	30.0	Instream TSS-Flow Regression

Appendix A, Table 7 - Total Sediment Load from Historical Studies

Study	Total Sediment Load (lb/yr)	Total Sediment Load (ton/sq. mi/yr)
RSRI, 1973	8,388,391	400
USGS, 1985	3,271,472	156

Appendix A, Table 8 - Estimated Tributary Loads based on BEHI/NBS and Colorado Reference Stream

System	Drainage Area (acres)	Stream Length (ft)	Total TSS Load (lb/yr)	Total TSS Load (lb/acre/yr)
Bells Mill	323	4,770	414,592	1,285
Cathedral	160	2,681	332,015	2,073
Creshiem	1,218	16,020	731,882	601
Gorgas Lane	499	1,968	183,082	367
Hill Crest	217	4,860	77,581	358
Hartwell	144	3,350	166,226	1,157
Kitchens Lane	234	7,098	279,594	1,194
Monoshone	1,056	6,379	246,101	233
Paper Mill Run	297	29,757	931,999	3,142
Thomas Mill	104	3,760	188,382	1,804
Tributary I	137	1,626	94,361	688
Wises Mill	446	6,980	351,120	788
Valley Green	128	2,203	77,423	604

i. BEHI/NBS and Observed Erosion in Colorado Reference Stream

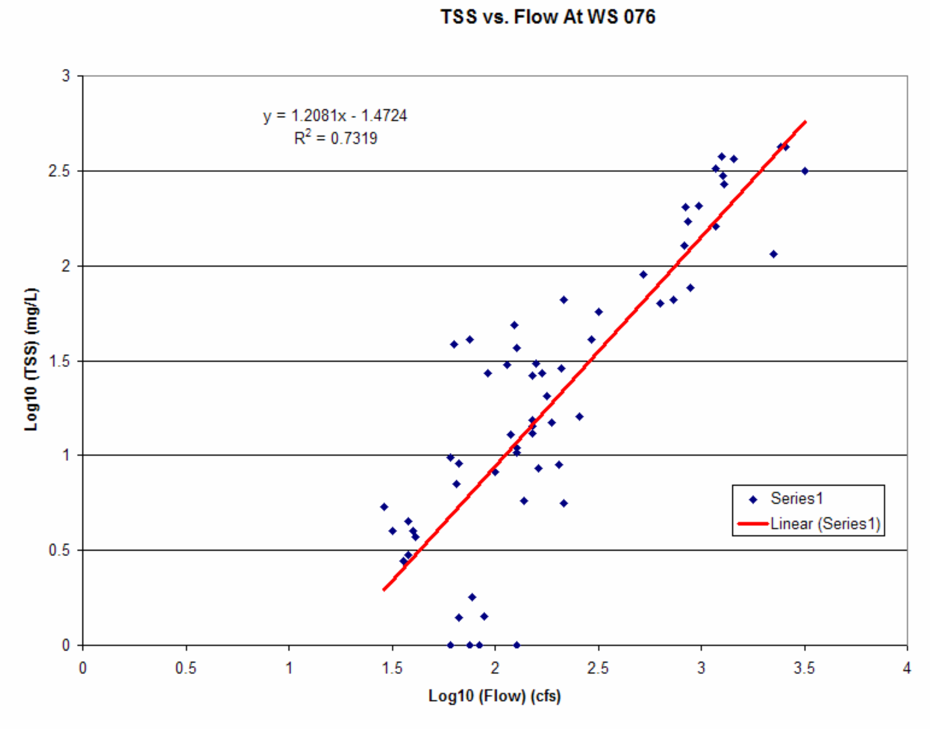
Predicted streambank erosion rates were calculated based on a relationship between these scores and measured streambank erosion rates in a reference stream in Colorado (Rosgen, 1996). The predicted rate is multiplied by the bank height and length as well as a conversion factor to get a sediment load in tons/year.

Streambank erosion estimates were determined using the data from the methods discussed above. For streambanks that were visually assessed to be low-erosion, a background erosion rate was applied. This rate corresponds to a low BEHI and low NBS score. These banks were assumed to have a bank height of the average of that particular tributary. For planning purposes, these low BEHI/NBS erosion rates are assumed to represent relatively stable conditions.

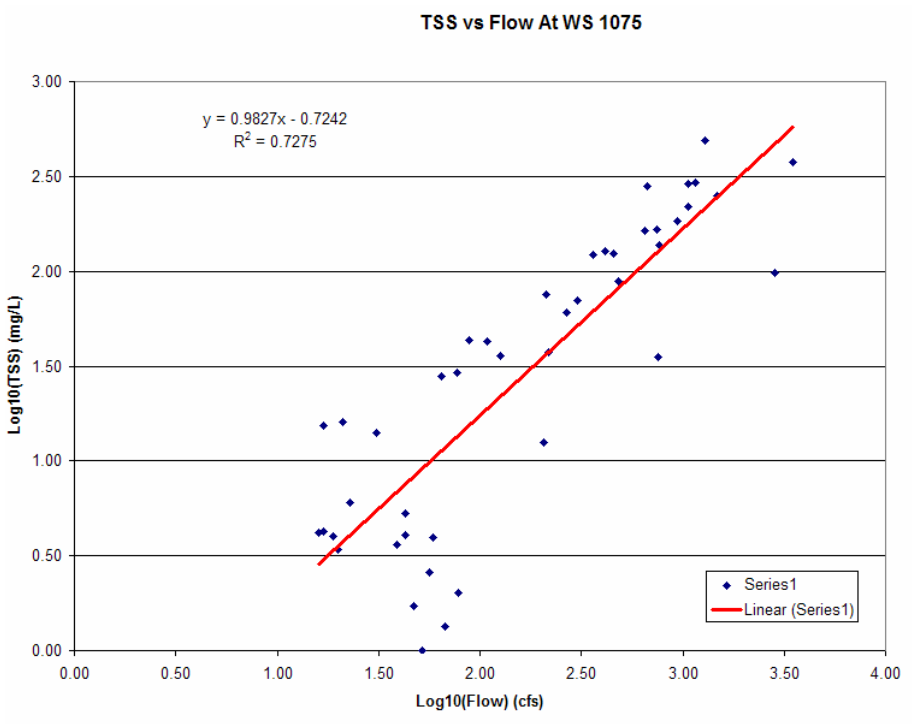
ii. Instream TSS-Flow Regression

A TSS-flow regression was performed by matching instream TSS measurements at or near USGS gauging stations to the flow recorded closest to sampling time. The USGS gage located near the mouth of the main stem provided results for the regression shown in Appendix A, Figure 14. Similarly, a gage located in Fort Washington provided data for the regression in Appendix A, Figure 15. Once the regression was created for the two sites on the main stem, Fort Washington and the mouth at Philadelphia, an annual load could be determined by area weighting measured sediment loads at each station and

estimating sediment input between stations. Regression results were not extrapolated to estimate TSS concentrations at flows outside the range used for the regression. Instead, TSS concentration corresponding to the maximum measured flow was applied to all flows greater than the maximum. For the gage station at Philadelphia, this concentration was 572.3 mg/L and for Fort Washington this concentration was calculated at 570.3 mg/L. The streambank portion of this total sediment load was then estimated by removing estimated runoff sediment load. An estimated 3,685,717 lb/yr of streambank sediment load is contributed by the city of Philadelphia based on this load estimation method.



Appendix A, Figure 14 - TSS-Flow Regression at USGS Gage 01474000 (mouth at Philadelphia) using WS076 TSS data



Appendix A, Figure 15 - TSS-Flow Regression at USGS Gage 01473900 (Fort Washington) using WS1075 TSS data

iii. Environmental Study of the Wissahickon Watershed within the City of Philadelphia

A study performed by the Regional Science Research Institute (RSRI) in 1973 estimated a sediment load for the Wissahickon watershed (Appendix A, Table 7). The city of Philadelphia contributes an estimated 8,388,391 lb/yr of sediment based on this study. This amount represents a total sediment load, but the report does not distinguish between the proportion of the load contributed by streambank erosion and stormwater runoff. This study is important because it provides an independent estimate to compare with estimates based on PWD and USGS monitoring.

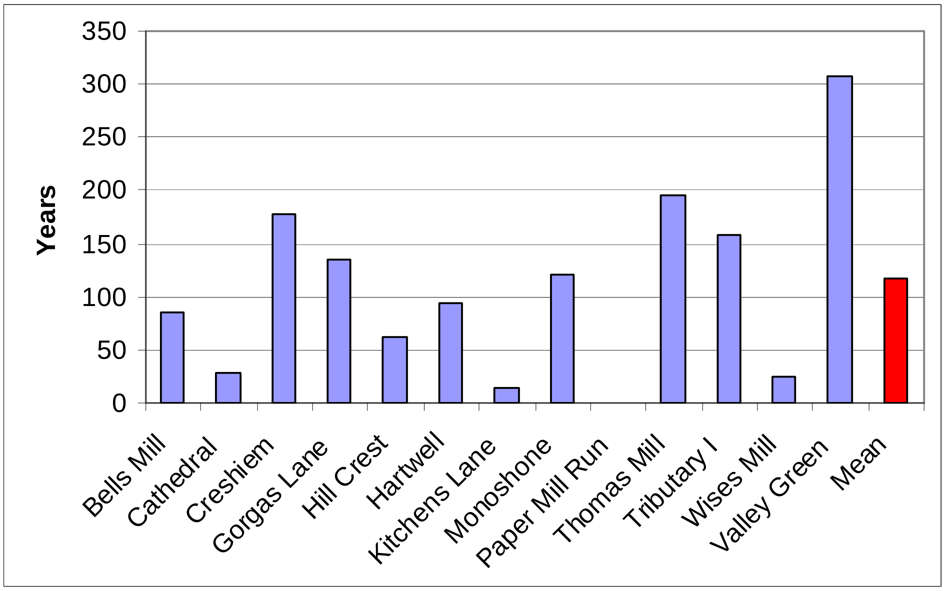
iv. Effects of Low Level Dams on the Distribution of Sediment, Metals, and Organic Substances in the Lower Schuylkill River Basin, Pennsylvania

A study performed by the United States Geologic Survey (USGS) in 1985 also estimated a total sediment load for the Wissahickon watershed (Appendix A, Table 7). The city of Philadelphia contributes an estimated 3,271,472 lb/yr of sediment based on this study. Similar to the RSRI study, no distinction between runoff and streambank load was provided. Again, this study is important because it provides another independent estimate to compare with estimated sediment loads based on PWD monitoring data.

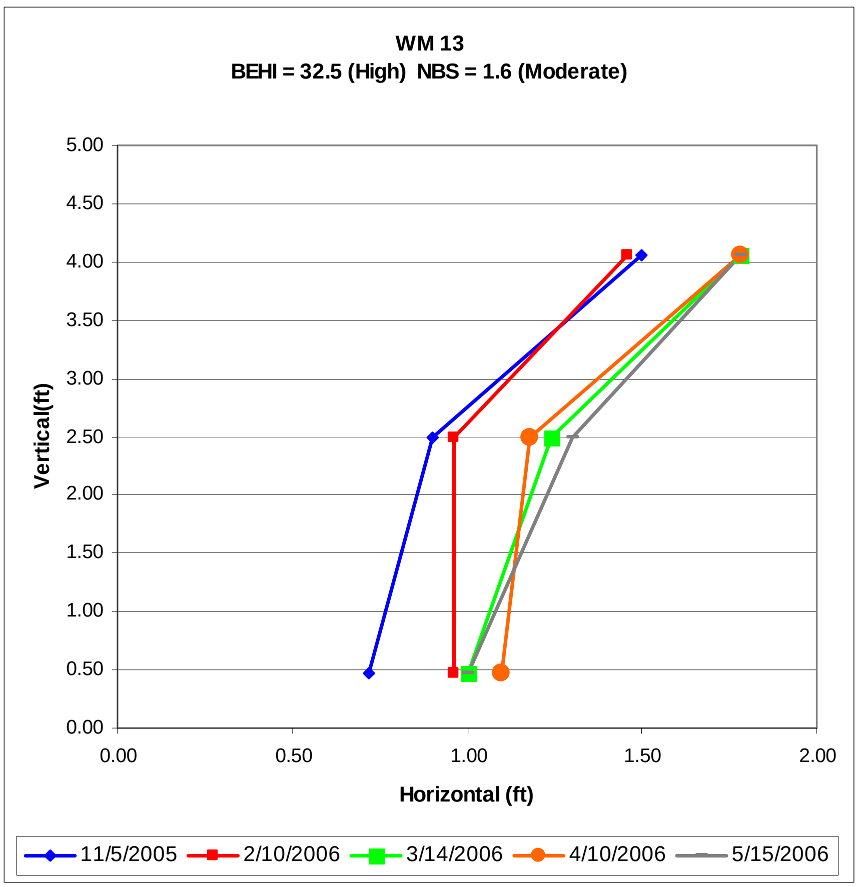
v. VERIFICATION AND COMPARISON STUDIES

Two additional analyses were performed to verify that preliminary estimates are within a reasonable range. The first method involved determining the amount of time it would take for erosion to produce present stream cross sections, using estimated erosion rates based on BEHI/NBS and the Colorado reference stream. Estimates ranged from 14 to 307 years with a mean of 120 years for individual tributaries, and a mean of 155 years using the total tributary loads and rates (Appendix A, Figure 16). This period of time is reasonable considering the history of natural, agricultural, and urban uses in the watershed.

The other method used to verify BEHI erosion prediction methods was installation of bank pins to measure erosion rates. As of September 2006, data collected so far are insufficient to draw conclusions. The bank pin program is being expanded significantly as discussed in a later section. An example of bank profile measurements at one site over several dates is shown in Appendix A, Figure 17.



Appendix A, Figure 16 - Estimated erosion rate based on BEHI/NBS from current cross section data.



Appendix A, Figure 17 - Example of Bank Pin Measurement

4. TRIBUTARY RESTORATION POTENTIAL RANKING

i. MULTI-CRITERIA EVALUATION (EVAMIX)

EVAMIX has been chosen to rank the restoration potential of tributaries and stream reaches. EVAMIX is a matrix-based, multi-criteria evaluation program that makes use of both quantitative and qualitative criteria within the same evaluation; regardless of the units of measure. The algorithm behind EVAMIX is unique in that it maintains the essential characteristics of quantitative and qualitative criteria, yet is designed to eventually combine the results into a single appraisal score. This critical feature gives the program much greater flexibility than most other matrix-based evaluation programs, and allows the evaluation team to make use of all data available to them in its original form.

EVAMIX makes a pair by pair comparison of all options under evaluation across all evaluation criteria, resulting in thousands of computations. The computations eventually result in an overall appraisal score. This is a single number, attached to a single alternative, and represents the overall worth of that alternative relative to the other alternatives based on the criteria selected, and the weights attached to the criteria. This number is used to determine the final ranking of alternatives from best to worst, or most important to least important.

EVAMIX offers several important advantages when used in planning studies:

- The alternatives under consideration are clearly defined
- The criteria used in evaluating the alternatives are explicit and measurable
- The algorithm can handle both quantitative and qualitative data, utilizing all available data to the highest degree of measurability possible
- The priorities underlying the evaluation are made explicit, and can be flexibly applied to highlight the effect that weighting has on the final ranking
- The technique is flexible enough to handle new data as it becomes available
- The technique is applied using widely available software (Excel spreadsheets)

The use of EVAMIX requires the development of a two dimensional matrix consisting of the options to be evaluated (columns) and a set of evaluation criteria (rows). For every combination of options and criteria, a score is assigned. The choice of the criteria is governed, in part, by the need for the scoring to be as objective as possible. By objective, we mean that the scores should represent impartial data and information useful in making decisions. The criteria must be clear and unambiguously defined, and can be set up as either quantitative criteria (e.g. threshold concentration in percent, time of travel in hours), or qualitative criteria (e.g. discharge frequency, location, etc.).

The other input variable required for the evaluation procedure is the selection of weighting factors for each of the criteria. While the scoring process strives to be as objective as possible and is carried out by the project team, the selection of weights is inherently subjective and should be done by the decision-makers, planner, or

stakeholders. Unlike the matrix of scores, numerous possible weight sets are possible, and all are equally “valid”.

Criteria chosen to evaluate restoration potential are summarized in Appendix A, Table 9 and discussed in more detail below.

Appendix A, Table 9 - Ranking Criteria

		Need for Restoration				Potential for Restoration	
Criterion	Unit	Sediment Reduction	Habitat	Riparian	Infrastructure	Channel	Riparian
estimated streambank erosion load	lb/ft/yr	XX	X	N/A	N/A	N/A	N/A
habitat index	% ref. cond.	N/A	XX	N/A	N/A	N/A	N/A
benthic macroinvertebrate index	# species	N/A	XX	N/A	N/A	N/A	N/A
construction difficulty and disturbance	TBD	N/A	N/A	X	N/A	XX	XX
Fairmount Park projects	number	N/A	N/A	N/A	N/A	XX	XX
identified sanitary sewer problems	number	N/A	N/A	N/A	XX	N/A	N/A

XX - need or potential for restoration is highly related to the criterion
X - need or potential for restoration is somewhat related to the criterion

ESTIMATED STREAMBANK EROSION LOAD

Units: lb/ft/yr
Derivation: Sediment loads due to streambank erosion have been estimated using the Rosgen BEHI/NBS method and Colorado reference stream.

- The reach containing each BEHI/NBS assessment site was identified.
- The sediment load contributed by the BEHI/NBS site (and associated length) was estimates. Details of these calculations are discussed earlier in this document.
- Sediment load contributed by the portion of the reach not assessed using the BEHI/NBS method was not considered in the ranking.

HABITAT INDEX

Units: % of reference condition
Derivation: Habitat monitoring was conducted by USEPA in 2005. For each reach, the nearest habitat monitoring site was determined. The habitat quality score assigned by EPA at the nearest site was assigned to the reach. Habitat assessments are discussed in detail in the Comprehensive Characterization Report.

BENTHIC MACROINVERTEBRATE INDEX (TAXA RICHNESS)

Units: number of species present
Derivation: Benthic macroinvertebrate monitoring was conducted by USEPA in 2005. For each reach, the nearest macroinvertebrate monitoring site was determined. The species richness score assigned by EPA at the nearest site was assigned to the reach. Macroinvertebrate assessments are discussed in detail in the Comprehensive Characterization Report.

CONSTRUCTION DIFFICULTY AND DISTURBANCE

Units: qualitative (low/medium/high)

Derivation: Factors were not determined quantitatively. Instead, PWD staff with extensive field experience in the Philadelphia portion of the watershed were asked to provide their impressions.

DEFINITION OF LOW DIFFICULTY/DISTURBANCE (INCLUDING MAIN STEM)

- low-slope stream channel and corridor
- wide stream channel can accommodate heavy equipment
- wide paths or low-slope grassy areas suitable for heavy equipment (e.g., Forbidden Drive)
- public ownership (e.g., Fairmount Park)

DEFINITION OF MEDIUM DIFFICULTY/DISTURBANCE

- channel and corridor slope intermediate between Low and High
- some access but not ideal for heavy equipment, some disturbance to forest
- small number of receptive institutional or private owners
- combination of low and high factors

DEFINITION OF HIGH DIFFICULTY/DISTURBANCE

- stream channel and corridor are steep
- stream channel is too small for heavy equipment
- forested riparian area with no paths or low-slope grassy areas for heavy equipment
- multiple private residential/commercial owners

FAIRMOUNT PARK PROJECTS

Units: number of projects in vicinity of each reach
Derivation: Fairmount Park's ES&ED division provided a spreadsheet showing medium and high priority projects. For a small number of projects, the location was not clear from the spreadsheet; these projects were not included in the analysis. For other projects, a point was placed in a GIS layer using the best judgment of GIS staff.

IDENTIFIED SANITARY SEWER PROBLEMS

Units: number of problems identified along each reach
Derivation: A sanitary infrastructure problem was defined as follows:

- The infrastructure feature may be leaking sanitary sewage to the stream, or high stream flows may be infiltrating the infrastructure feature.
- The feature is in good condition, but is exposed in the channel or bank and subject to damage by high flows.

DETERMINATION OF CONDITION OF MANHOLES AND PIPES

- Condition was noted as "poor" by the field team (no instances identified).

- The photo taken by the field team shows at least one of the following:
    - The feature is broken, cracked, leaking, or has exposed joints.
    - The feature is exposed in the channel or bank and subject to high flows.

DETERMINATION OF CONDITION OF DAMS

- If sanitary infrastructure is visible in the photo taken by the field team, the checklist for manholes and pipes above was followed.

USE OF THERMAL IMAGING STUDY RESULTS (NO INSTANCES IDENTIFIED)

- The point was noted as a "suspected leak" by the thermal imaging team.
- Ground truthing notes indicate that the point is associated with sanitary infrastructure (not a stormwater outfall) and that evidence of sewage is present.

RESTORATION PRIORITY RESULTS

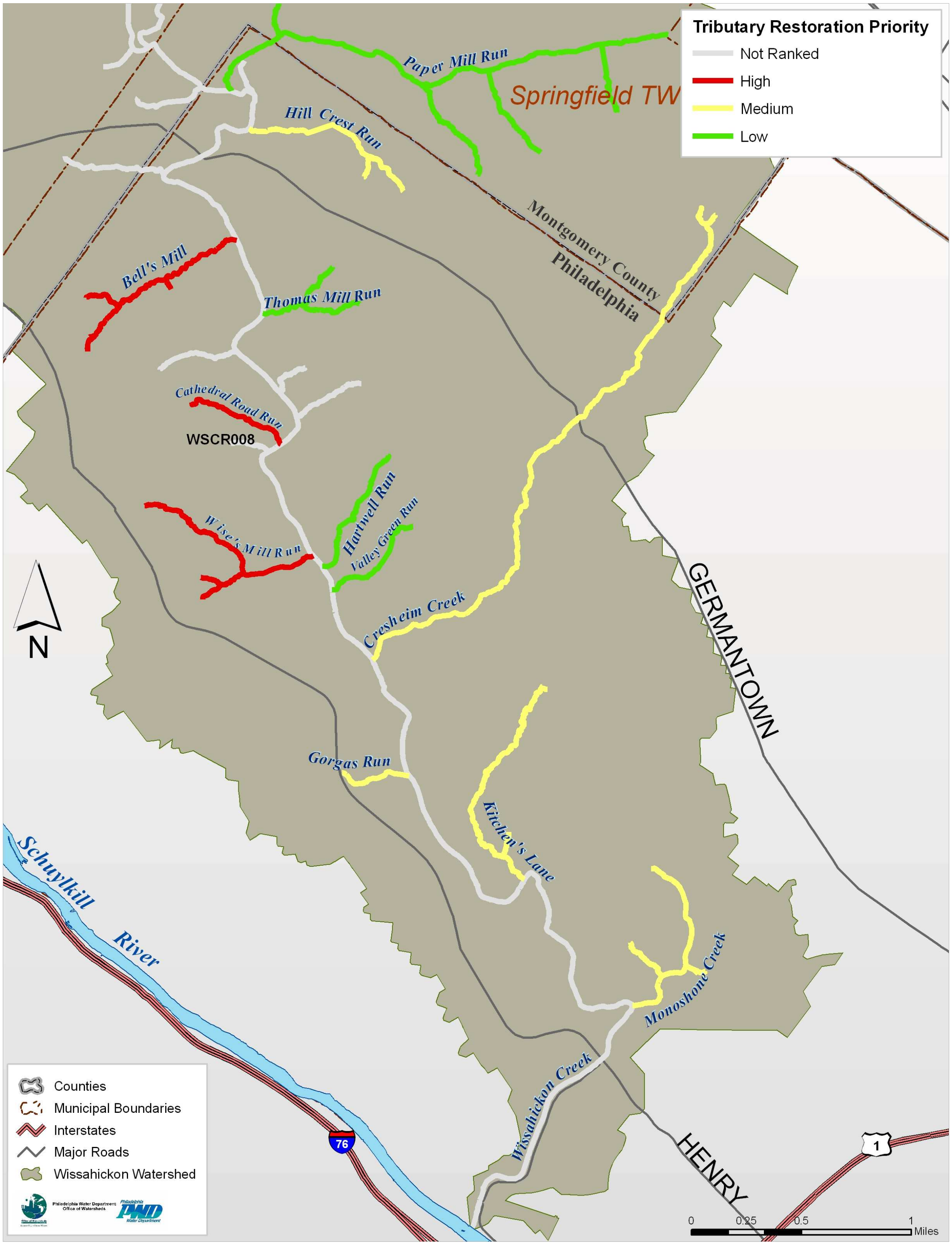
Ranking analyses were performed with several sets of criteria weights. One set of weights for the restoration project are shown in Appendix A, Table 10. The results obtained with that weight set are presented in Appendix A, Table 11. Also shown in Appendix A, Table 11 is the sum of all the reach lengths for each category identified as low, medium, and high priority within each tributary. The tributary restoration ranking is graphically represented in Appendix A, Figure 18; and reach restoration ranking is graphically represented in Appendix A, Figure 19.

Appendix A, Table 10 – Criteria Weights

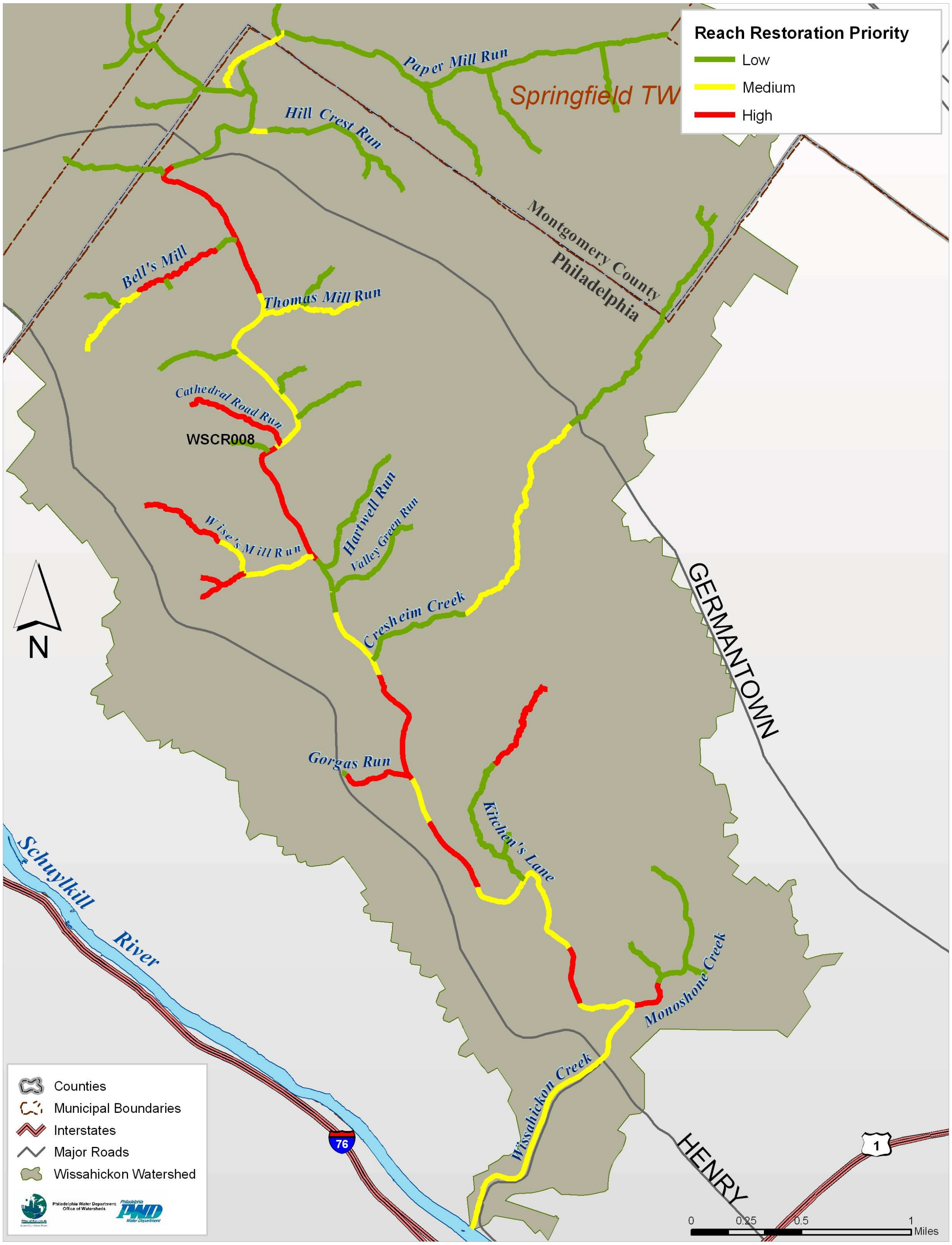
	Weight
Criteria	**0<wt<1**
estimated streambank erosion load	0.300
habitat index	0.100
benthic macroinvertebrate index	0.100
Fairmount Park projects	0.100
identified sanitary sewer problems	0.100
construction difficulty/disturbance index	0.300

Appendix A, Table 11 – Tributary Ranking Results

			Total Reach Length (ft)		
Options	**Ranking**	**Mean Rank**	**low**	**medium**	**high**
Cathedral Road Run	High	1.0	0	0	2771
Bell's Mill	High	3.0	1834	1078	1846
Wise's Mill	High	4.0	0	1507	4052
Cresheim Creek	Medium	5.0	9997	5383	0
Gorgas Run	Medium	5.5	0	0	1750
Hill Crest Run	Medium	5.5	2035	1781	0
Monoshone Creek	Medium	6.0	3236	0	1658
Kitchen's Lane	Medium	8.5	4720	0	2019
Paper Mill Run	Low	8.5	788	4653	0
Valley Green Run	Low	10.5	2868	0	0
Thomas Mill Run	Low	11.0	0	2689	0
Hartwell Run	Low	11.5	3423	0	0



Appendix A, Figure 18 – Tributary Restoration Ranking

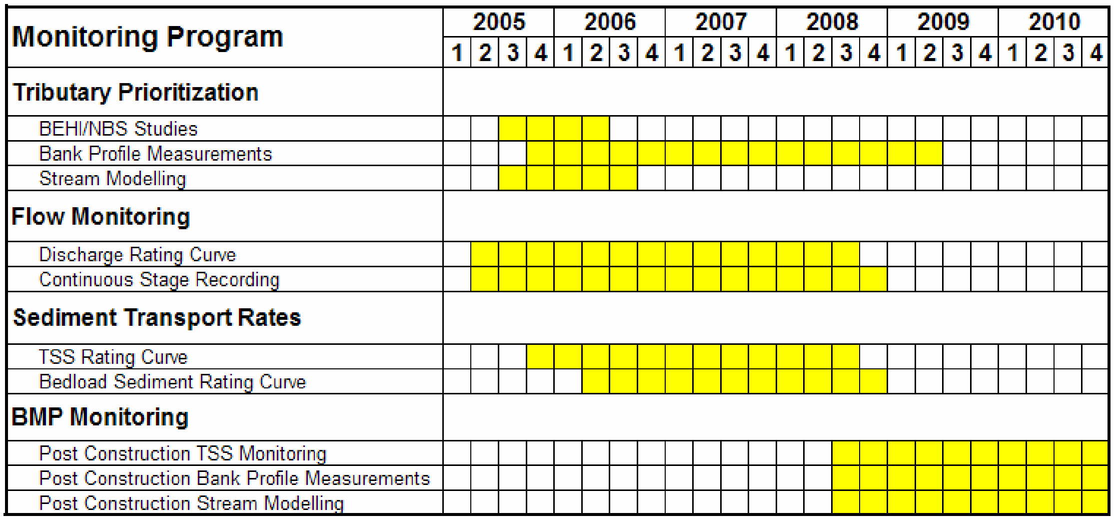


Appendix A, Figure 19 – Reach Restoration Ranking

5. FUTURE SAMPLING

In efforts to comply with the Wissahickon Creek Sediment TMDL and the continuing goal of reducing sediment load from tributaries within City boundaries, PWD has developed a five-year strategy (Appendix A, Table 12).

Appendix A, Table 12 - Time Line Strategy for Monitoring Components of the Wissahickon TMDL.



i. EXPANDED BANK PIN PROGRAM

The program of installing bank pins to measure actual erosion rates is being greatly expanded. The objective of this program is to define a local relationship between measured streambank erosion and qualitative streambank erosion (using Rosgen's BEHI/NBS method).

SAMPLING DESIGN

The sampling design below is recommended based on EPA (2002).

- stratified sampling design: stream length broken up into categories (strata), each representing one combination of BEHI and NBS score observed in Wissahickon.
- total number of sampling sites allocated in each strata according to the estimated load contributed by each BEHI/NBS combination (Appendix A, Table 13)
- total number of sampling sites determined by acceptable margin of error and available budget/staff (more discussion below)
- random site selection within each stratum

As of April 2006, bank pins were installed at 21 sites, and erosion was measured at 11 of these. The most recent measurements included in this study were taken April 24, 2006. Mean erosion rates at the 11 sites with measured erosion are shown in Appendix A, Table 13. A summary of the BEHI ratings are shown in Appendix A, Table 14. The fraction of total load contributed by reaches with each combination of BEHI and NBS score are shown in Appendix A, Table 15. Shown in Appendix A, Figure 20 is a comparison of high and moderate BEHI from local study results. No trend is apparent from data collected so far, but it is hoped a trend will emerge in the future as more data points are added.

Appendix A, Table 13 - Preliminary Bank Pin Data

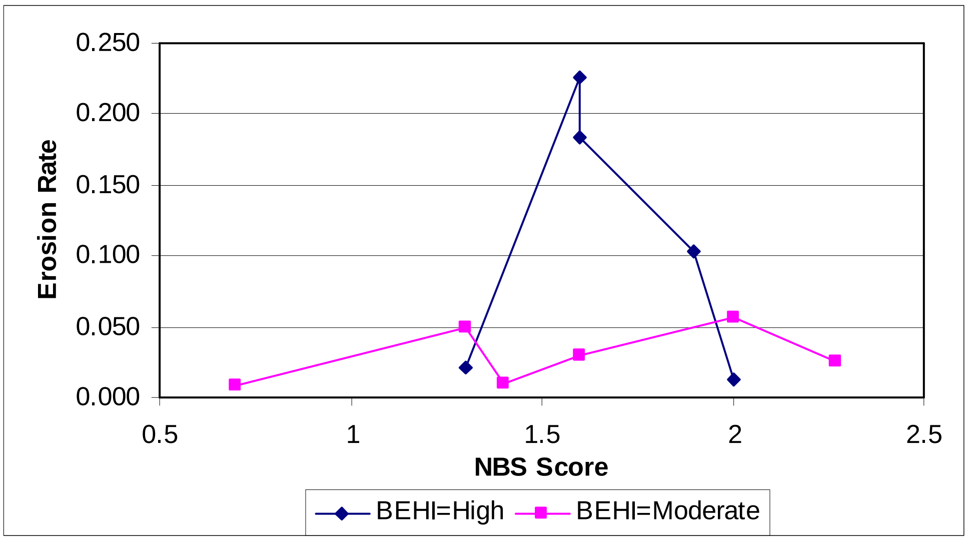
Site	First	Last	Days Monitored	BEHI Rating	NBS Rating	Measured Erosion to top bank pin (ton/ft/yr)	Measured Erosion to top of bank (ton/ft/yr)
MN1	11/2/2005	4/24/2006	173	Moderate	Very Low	0.006	0.016
MN4	11/2/2005	4/24/2006	173	Moderate	Low	0.004	0.009
WM29	11/5/2005	4/24/2006	170	Moderate	Low	0.022	0.074
BM25	11/7/2005	4/24/2006	168	Moderate	Moderate	0.020	0.046
BM21	11/7/2005	4/24/2006	168	Moderate	High	0.012	0.040
CR16	10/31/2005	4/24/2006	175	Moderate	High	0.036	0.090
CR13	10/31/2005	4/24/2006	175	High	Low	0.014	0.041
BM35	11/7/2005	4/24/2006	168	High	Moderate	0.154	0.379
WM13	11/5/2005	4/24/2006	170	High	Moderate	0.122	0.326
MN3	11/2/2005	4/24/2006	173	High	High	0.066	0.275
CR7	10/31/2005	4/24/2006	175	High	High	0.008	0.042

Appendix A, Table 14 - Bank Pin Erosion Summary

BEHI Rating	No. Sites	To Top Bank Pin Mean (ton/ft/yr)	To Top Bank Pin St. Deviation (ton/ft/yr)	To Top of Bank Mean (ton/ft/yr)	To Top of Bank St. Deviation (ton/ft/yr)
Moderate	6	0.017	0.012	0.046	0.032
High	5	0.073	0.065	0.213	0.161

Appendix A, Table 15 - Fraction of Load Contributed by each BEHI/NBS Combination

BEHI	NBS	Sites	Erosion (ton/yr/ft)	Length (ft)	Erosion (ton/yr)	Erosion (% of total)	New Bank Pin Sites
Low	Low	Unassessed*	0.009	153,552	1,367	68.4	60
Low	High	1	0.043	30	1.30	0.065	1
Moderate	Very Low	17	0.020	647	12.9	0.645	1
Moderate	Low	96	0.025	3,008	74.6	3.73	4
Moderate	Moderate	11	0.042	379	15.8	0.791	1
Moderate	High	9	0.056	341	19.1	0.956	1
Moderate	Very High	2	0.096	75	7.21	0.361	1
High	Very Low	15	0.045	370	16.5	0.824	1
High	Low	136	0.059	5,040	299	15.0	15
High	Moderate	9	0.133	388	51.6	2.59	3
High	High	12	0.134	566	75.7	3.79	4
High	Very High	1	0.143	15	2.15	0.107	1
High	Extreme	1	0.107	25	2.68	0.134	1
Very High	Very Low	5	0.069	160	11.0	0.550	1
Very High	Low	21	0.067	455	30.6	1.53	2
Very High	Moderate	1	0.062	10	0.616	0.031	1
Very High	High	1	0.144	20	2.89	0.145	1
Extreme	Low	1	0.289	25	7.22	0.362	1
All Measurements		339		165,106	1997	100	100



Appendix A, Figure 20 - BEHI/NBS Local Study Results

<u>NUMBER OF SITES</u>

The number of sites needed can be estimated based on observed variability in measurements and the acceptable uncertainty in the estimate:

$$n = \frac{z_{\alpha}^2 \sigma^2}{L^2}$$

where n = sample size (number of sites, rounded up to nearest integer)
z = standard normal cumulative probability for a 2-tailed 95% confidence interval = 1.96
σ = standard deviation of measured erosion rates so far = 0.0439 ton/yr/ft
L = acceptable uncertainty, 1/2 width of confidence interval (ton/yr/ft)

The number of BEHI sites for each rating, required to achieve a given confidence interval, are listed in Appendix A, Table 16 (erosion measured from top bank pin) and Appendix A, Table 17 (erosion measured from top of bank). Low and Moderate BEHI sites were assigned the standard deviation measured at Moderate BEHI sites. High BEHI sites were assigned the standard deviation measured at High BEHI sites. The results suggest that a sampling program to achieve a confidence interval of 100 ton/yr/sq.mi. or less may not be feasible. However, it is important to note that the standard deviations are based on a very small sample size. Collecting more samples may result in a lower estimate of standard deviation. Even if a statistically meaningful measure of error cannot be established, additional sites will allow better management decisions.

Appendix A, Table 16 - The number of sites required to achieve a given Confidence Interval

	St. Dev.	1/2 C.I. (ton/yr/sq.mi.)				
BEHI	(ton/yr/ft)	10	50	100	150	200
Low/Moderate	0.012	1,320	53	14	6	4
High	0.065	38,717	1,549	388	173	97
Total		40,037	1,602	402	179	101

Based on erosion to top bank pin

Appendix A, Table 17 - The number of sites required to achieve a given Confidence Interval

	St. Dev.	1/2 C.I. (ton/yr/sq.mi.)				
BEHI	(ton/yr/ft)	10	50	100	150	200
Low/Moderate	0.032	9,384	376	94	42	24
High	0.161	237,530	9,502	2,376	1,056	594
Total		246,914	9,878	2,470	1,098	618

Based on erosion to top of bank

NEXT STEPS

PWD plans to establish approximately 100 new sites to better estimate the true standard deviations. If these are lower than current estimates, the number of sites needed for a statistically meaningful estimate will also decrease.

ii. BANK EROSION HAZARD INDEX AND NEAR BANK STRESS

Total sediment yields are composed of sediment derived from overland runoff and from that originating in the creek. To determine the relative importance of these two components, PWD is conducting an expanded Bank Erosion Hazard Index (BEHI) and Near Bank Stress (NBS) study as defined by Rosgen (1996) to predict streambank erosion rates.

Additional reaches of the thirteen tributaries (Appendix A, Figure 19) within Philadelphia will be assessed by PWD staff and sections of streambank will be scored based on the BEHI and NBS criteria. This study will be combined with the expanded bank pin program to develop a local relationship between these indices and measured erosion.

iii. Bank Erosion Hazard Index and Near Bank Stress

Additional discharge rating curves will be established and existing ones will be refined as necessary for the tributaries within Philadelphia County limits following a modified version of the USGS protocol (Buchanan and Somers 1969). Currently, discharge rating curves have been completed on three tributaries (Bells Mill, Monoshone, and Wises Mill). Discharge will be measured using a SonTek Flowtraker during low and medium flow events and a Gurley pygmy meter during high flow events.

iv. Continuous Stage Recording

Discharge characterization on the thirteen tributaries within Philadelphia County limits will be completed based on the aforementioned prioritization ranking. Stage data will be recorded at the designated monitoring site using a fixed Sigma ultrasonic sensor and/or pressure transducer. Stage data will be downloaded bimonthly and QA/QC will be performed by PWD staff.

v. TSS Rating Curve

Automated water collection devices (ISCO model no. 6712) will be used to collect water samples during additional wet weather events as needed in the Wissahickon Creek tributaries. In the attempt to characterize an entire storm event, automated samplers are triggered by a 0.2 ft elevation change in stream height and will continue to collect samples every 20 minutes for the first hour. Following this step, samples are then collected every 2-4 hours until discharge has returned to base flow conditions. Suspended sediment loads will be related to the discharge at which they were collected to create a suspended sediment rating curve. To date, two wet weather events have been captured on Monoshone Creek, Wises Mill and Cathedral Run, and three runoff producing events have been captured on Bells Mill. Wet weather monitoring will continue through 2006-2007 in attempt to characterize TSS in relation to discharge.

vi. Bedload Sediment Rating Curve

In order to estimate a total sediment load, bedload sediment samples will be collected in addition to suspended sediment samples. Bedload sediment samples will be collected at different stages according to a modified version of USGS protocol (Edwards and Glysson 1999). Samples will be collected using a Helley-Smith handheld sampler with a 15cm orifice. Samples will be dried, sieved and weighed in order to determine a rate of transport as well as a particle size distribution.

vii. POST-CONSTRUCTION MONIITORING

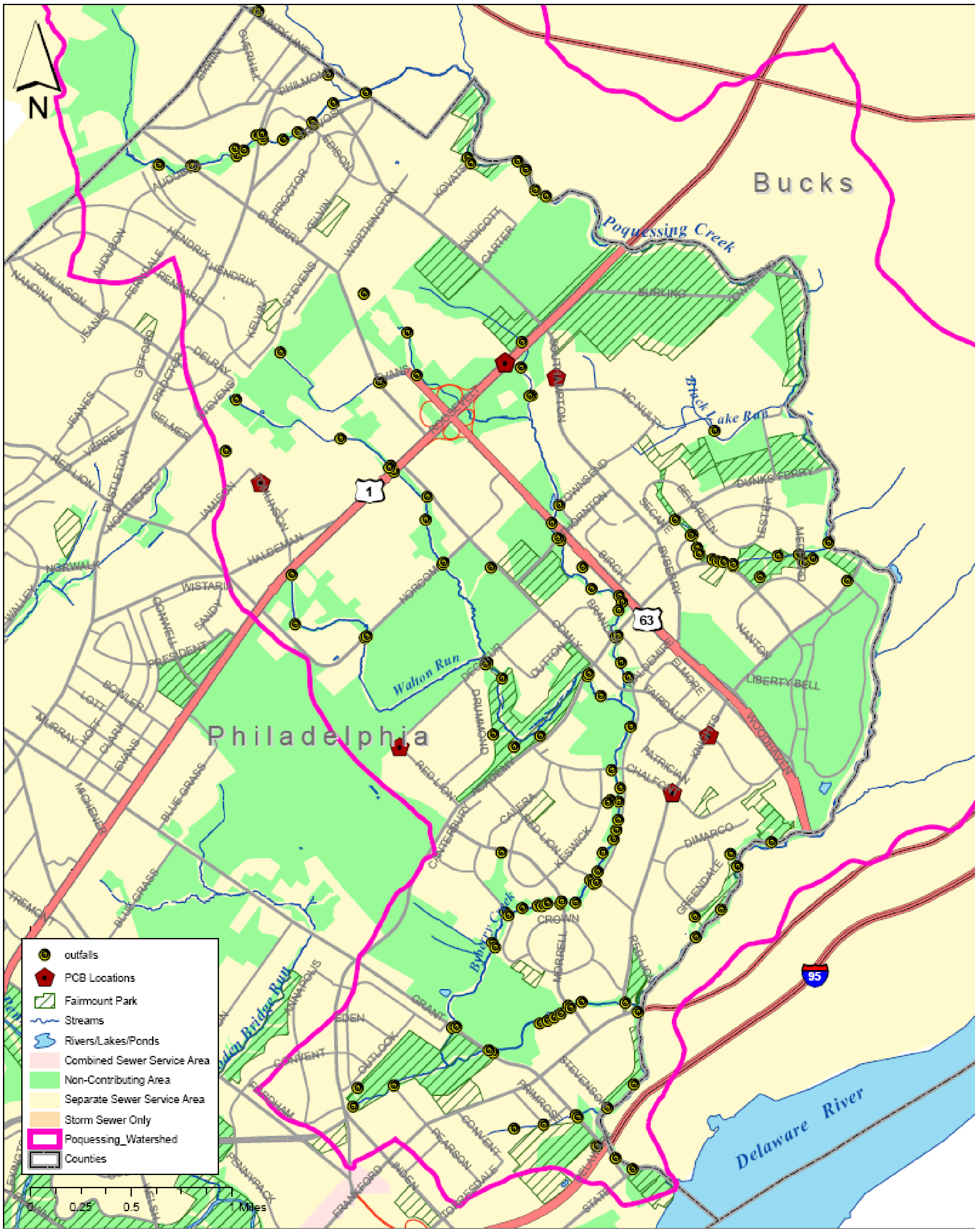
The final objective of the TMDL monitoring program is to measure (i.e., quantify) the efficacy of Best Management Practices (BMPs) and their benefit in terms of sediment reduction in the Wissahickon drainage. In 2005, PWD conducted extensive wet-weather monitoring on three tributaries where various stormwater BMPs have been proposed or are currently under construction.

APPENDIX B – FIGURES FOR PCB PMP IN THE CITY'S MS4 SERVICE AREA

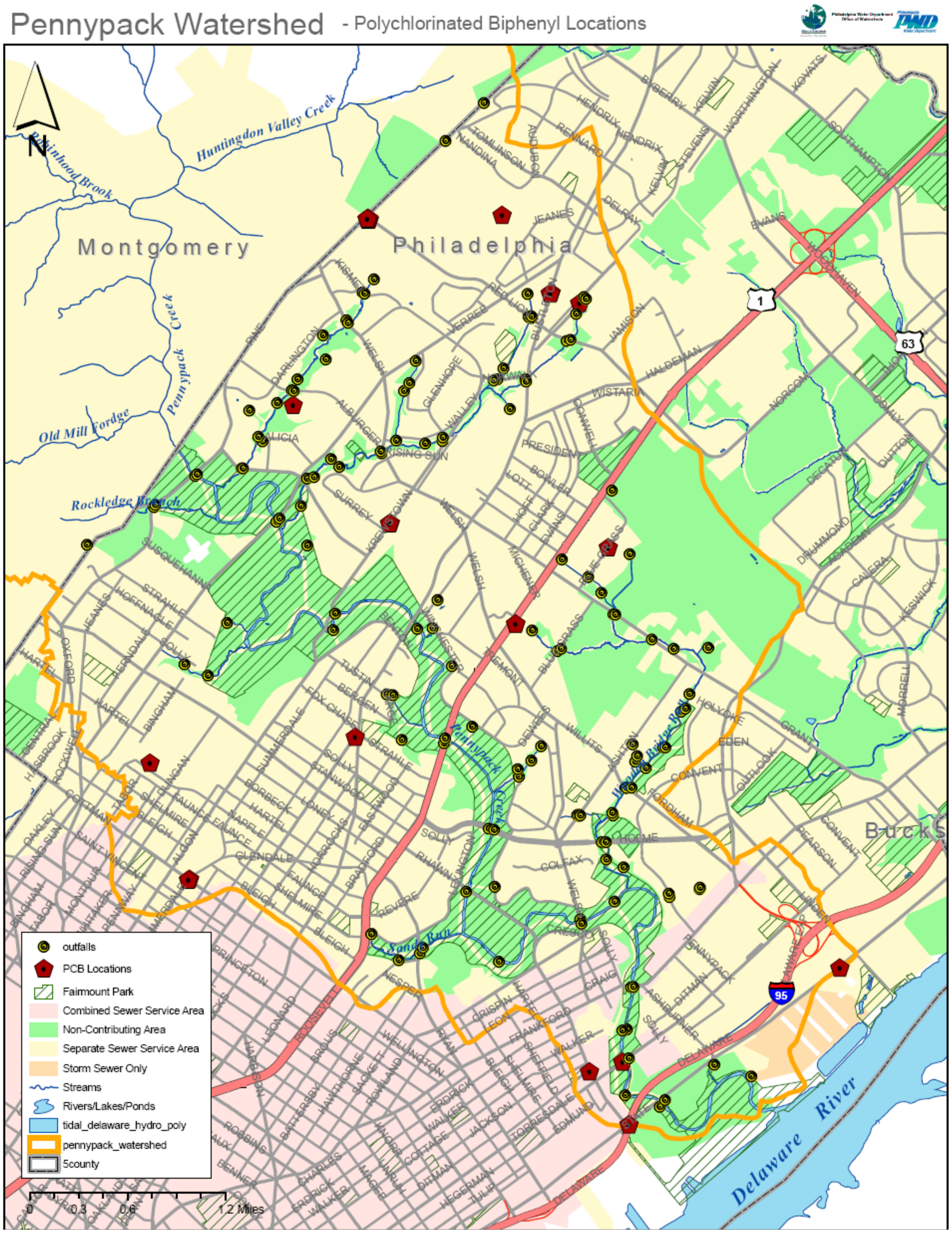
UNIQUE_ID	LIST	WSHED	OUTFALL	SHEET	Address	ZIP	PO_NAME	STATE
NE-H-3	Health Dept.	POQ	Q-107-02	111	Knights Rd. Shopping Center	19154	Philadelphia	PA
NE-053	MS4	POQ	Q-110-17	111	KNIGHTS & CHALFONT	19154	Philadelphia	PA
NE-055	MS4	POQ	Byberry Creek	118	14000 ROOSEVELT BLVD	19116	Philadelphia	PA
NE-056	MS4	POQ	Byberry Creek	118		19116	Philadelphia	PA
NE-057	MS4	POQ	Byberry Creek	118		19116	Philadelphia	PA
NE-058	MS4	POQ	Byberry Creek	118		19116	Philadelphia	PA
NE-080	MS4	POQ	Q-110-05	110	3001 RED LION RD	19154	Philadelphia	PA
NE-084	MS4	POQ	Q-109-07	113	1771 TOMLINSON	19116	Philadelphia	PA
NE-108	MS4	POQ	Q-118-03	118	2900 SOUTHHAMPTON	19154	Philadelphia	PA
NE-003	MS4	PPK	P-090-02	090	7300 Glendale Avenue	19111	Philadelphia	PA
NE-004	MS4	PPK	P-090-02	090		19111	Philadelphia	PA
NE-011	MS4	PPK	P-104-08	104	9381 Krewstown Road	19115	Philadelphia	PA
NE-012	MS4	PPK	P-104-08	104		19115	Philadelphia	PA
NE-013	MS4	PPK	P-113-01	113	10159 Bustleton Avenue	19116	Philadelphia	PA
NE-014	MS4	PPK	P-113-01	113		19116	Philadelphia	PA
NE-046	MS4	PPK	P-105-01	105	9173 ROOSEVELT BLVD	19114	Philadelphia	PA
NE-047	MS4	PPK	P-105-01	105		19114	Philadelphia	PA
NE-049	MS4	PPK	Pennypack Creek	083	8215 TORRESDALE	19136	Philadelphia	PA
NE-054	MS4	PPK	P-108-07	108	SHARON & ALICIA	19115	Philadelphia	PA
NE-062	MS4	PPK	P-091-06	099	8365 CASTOR AVE	19152	Philadelphia	PA
NE-068	MS4	PPK	P-112-03	112	1 RED LION RD	19116	Philadelphia	PA
NE-069	MS4	PPK	P-112-03	112		19116	Philadelphia	PA
NE-092	MS4	PPK	P-112-03	112		19116	Philadelphia	PA
NE-093	MS4	PPK	P-112-03	112		19116	Philadelphia	PA
NE-094	MS4	PPK	P-112-03	112		19116	Philadelphia	PA
NE-095	MS4	PPK	P-112-03	112		19116	Philadelphia	PA
NE-096	MS4	PPK	P-112-03	112		19116	Philadelphia	PA
NE-097	MS4	PPK	P-112-03	112		19116	Philadelphia	PA
NE-098	MS4	PPK	P-112-03	112		19116	Philadelphia	PA
NE-099	MS4	PPK	P-112-03	112		19116	Philadelphia	PA
NE-100	MS4	PPK	P-112-03	112		19116	Philadelphia	PA
NE-101	MS4	PPK	P-112-03	112		19116	Philadelphia	PA
NE-102	MS4	PPK	P-112-03	112		19116	Philadelphia	PA
NE-103	MS4	PPK	P-112-03	112		19116	Philadelphia	PA
NE-120	MS4	PPK	P-112-03	112		19116	Philadelphia	PA
NE-124	MS4	PPK	P-112-03	112		19116	Philadelphia	PA
NE-125	MS4	PPK	P-112-03	112		19116	Philadelphia	PA
NE-126	MS4	PPK	P-112-03	112		19116	Philadelphia	PA
NE-127	MS4	PPK	P-112-03	112		19116	Philadelphia	PA
NE-128	MS4	PPK	P-112-03	112		19116	Philadelphia	PA
NE-129	MS4	PPK	P-112-03	112		19116	Philadelphia	PA
NE-130	MS4	PPK	P-112-03	112		19116	Philadelphia	PA
NE-131	MS4	PPK	P-112-03	112		19116	Philadelphia	PA
NE-132	MS4	PPK	P-112-03	112		19116	Philadelphia	PA
NE-133	MS4	PPK	P-112-03	112		19116	Philadelphia	PA
NE-147	MS4	PPK	P-112-03	112		19116	Philadelphia	PA
NE-110	MS4	PPK	P05	083	8001 STATE RD.	19136	Philadelphia	PA
NE-114	MS4	PPK	P-113-03	113	10175 NORTHEAST AVE	19116	Philadelphia	PA
NE-165	MS4	PPK	P-090-02	099	7738 Tabor Road	19111	Philadelphia	PA
SW-066	MS4	PPK	P-105-12	105	9820 BLUE GRASS RD	19114	Philadelphia	PA
NE-PaDEP-11	PADEP	PPK	P-113-07	113	10060-72 SANDMEYER LN	19116	Philadelphia	PA
NE-PaDEP-25	PADEP	PPK	P-112-03	112	1 RED LION RD	19116	Philadelphia	PA
SW-H-4	Health Dept.	WIS	W-060-01	059	Dupont Street above Henry Ave.	19128	Philadelphia	PA
NE-137	MS4	WIS	W-086-01	086	7735 Germantown Avenue	19118	Philadelphia	PA
NE-156	MS4	WIS	W-086-01	086		19118	Philadelphia	PA
NE-157	MS4	WIS	W-086-01	086	7736 Germantown Avenue	19118	Philadelphia	PA
NE-158	MS4	WIS	W-086-01	086	7737 Germantown Avenue	19118	Philadelphia	PA
NE-159	MS4	WIS	W-086-01	086	7738 Germantown Avenue	19118	Philadelphia	PA
NE-160	MS4	WIS	W-086-01	086	7739 Germantown Avenue	19118	Philadelphia	PA
NE-161	MS4	WIS	W-086-01	086	7740 Germantown Avenue	19118	Philadelphia	PA
NE-163	MS4	WIS	W-086-06	096	1100 Ivy Hill Road	19150	Philadelphia	PA
SE-009	MS4	WIS	W-060-04	060	6101 W MORRIS ST	19144	Philadelphia	PA
SW-156	MS4	WIS	W-067-01	066	7515 Ridge Avenue	19128	Philadelphia	PA

Appendix B, Table 1 - List of known PCB locations within the MS4 Service Area

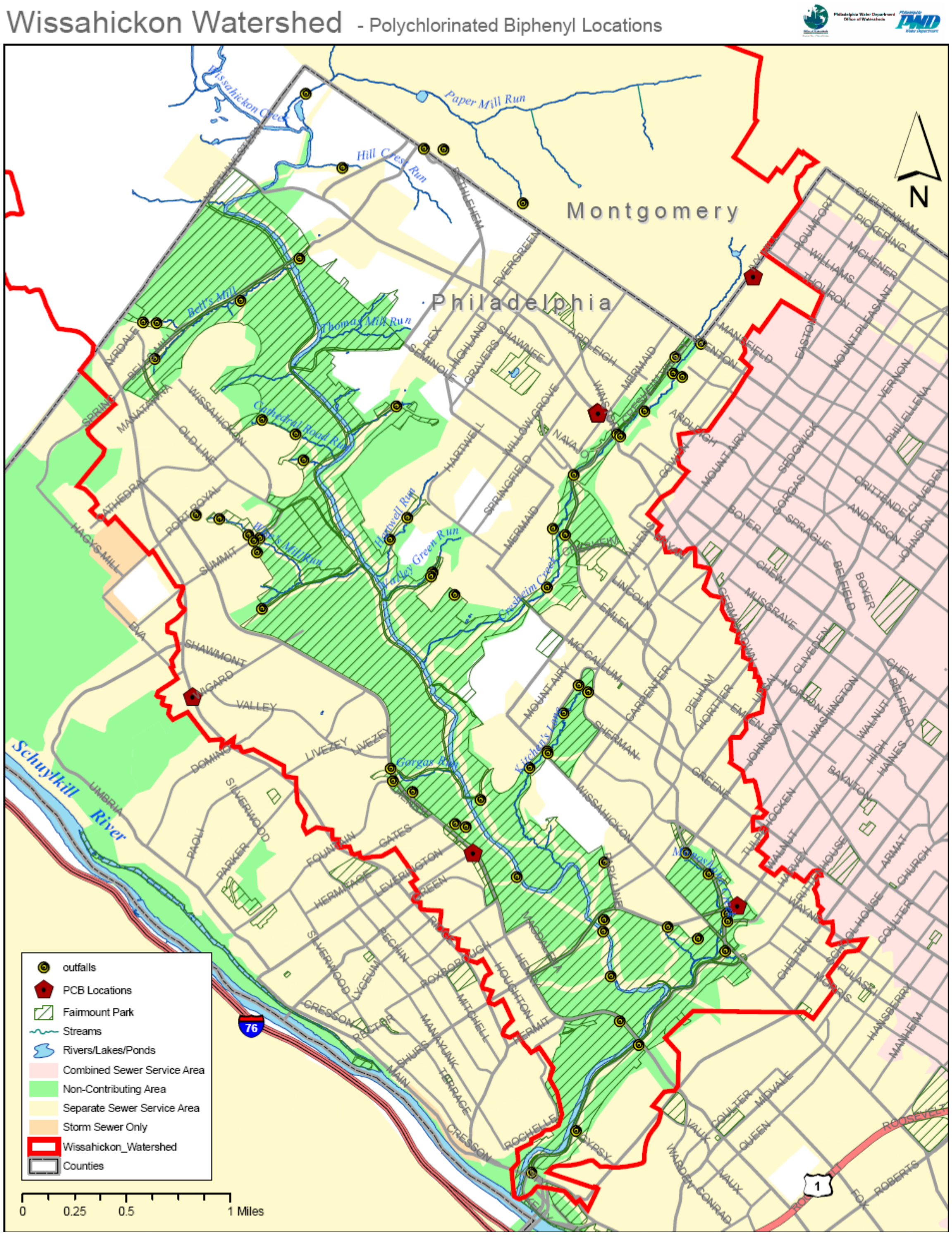
Poquessing Watershed - Polychlorinated Biphenyl Locations



Appendix B, Figure 1 - Known PCB locations in the Poquessing Watershed



Appendix B, Figure 2 - Known PCB locations in the Pennypack Watershed



Appendix B, Figure 3 - Known PCB locations in the Wissahickon Watershed

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Author: pwd
Keywords:
Comments:
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Change Number: 2
Last Saved On: 9/25/2006 3:58 PM
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Last Printed On: 9/29/2006 12:43 PM
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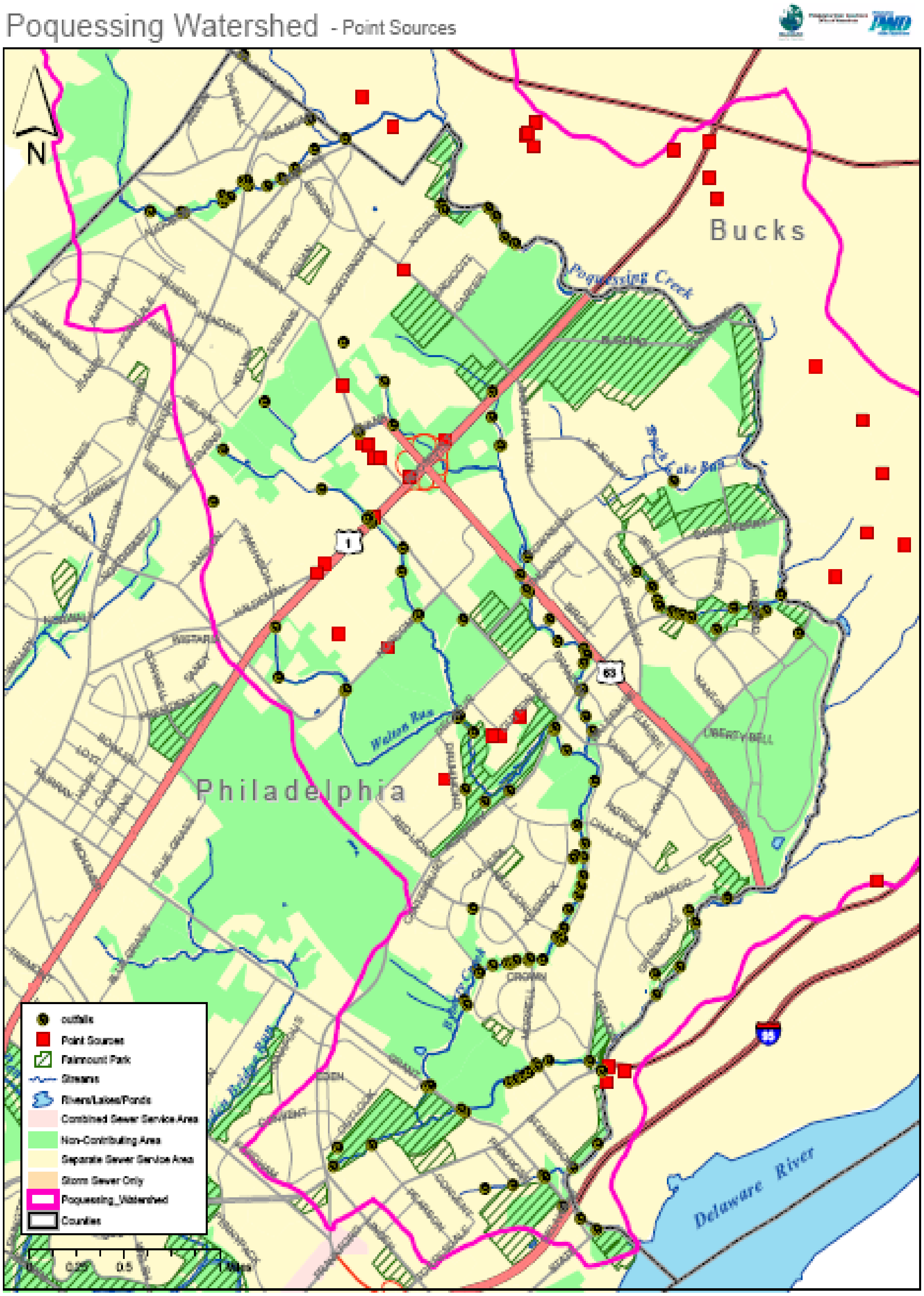
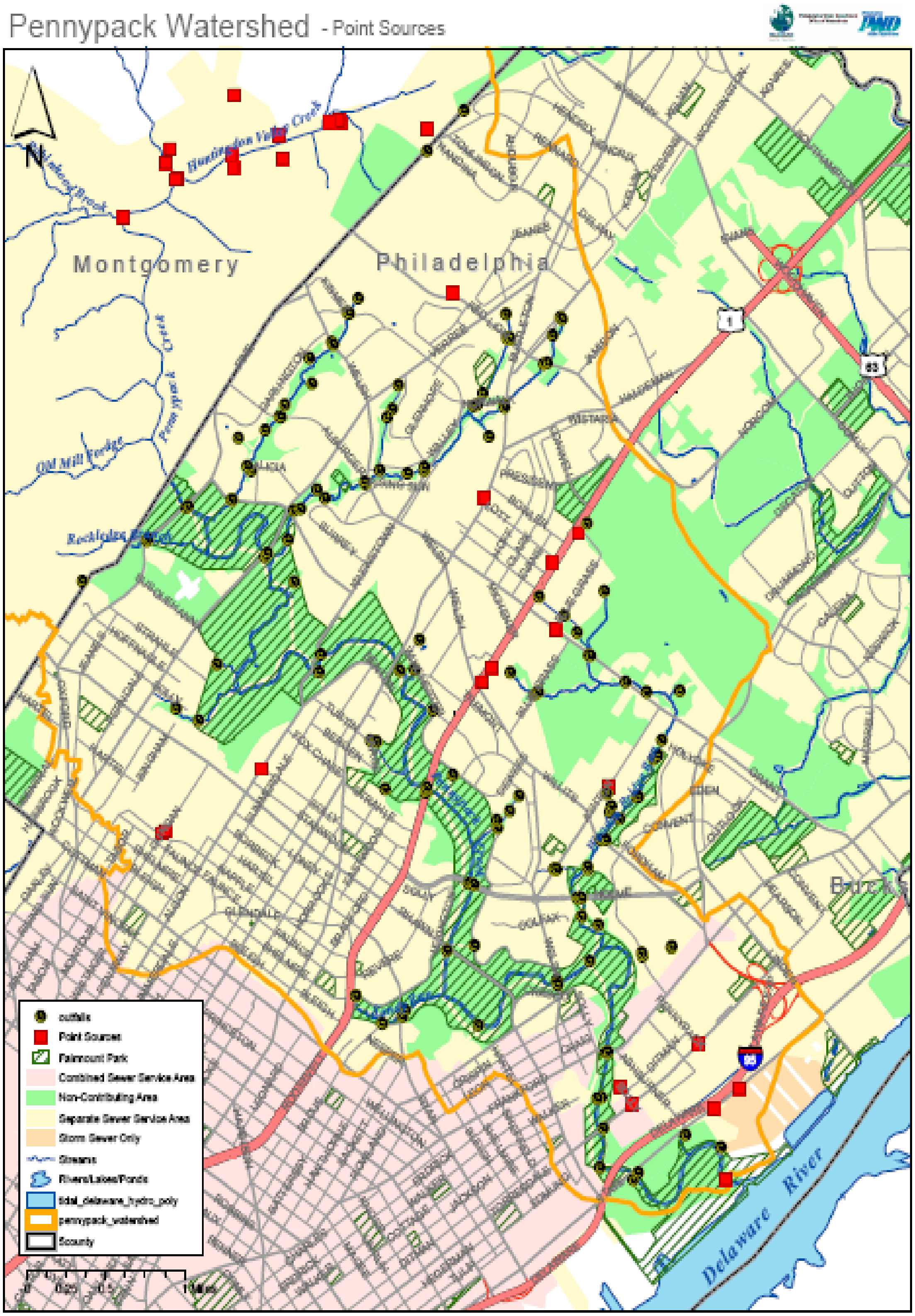
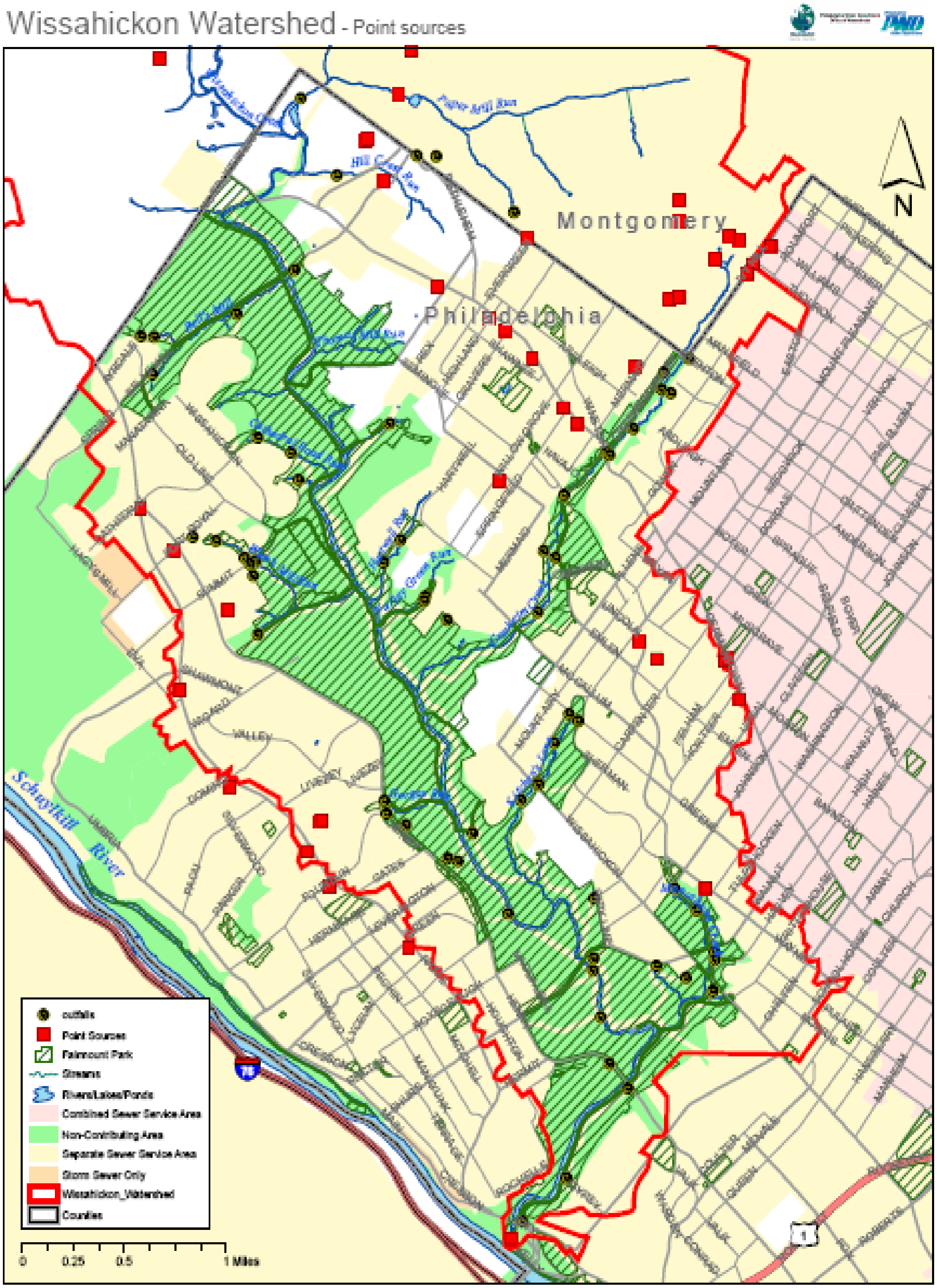
APPENDIX C – LAND USE AND RESOURCE MAPPING



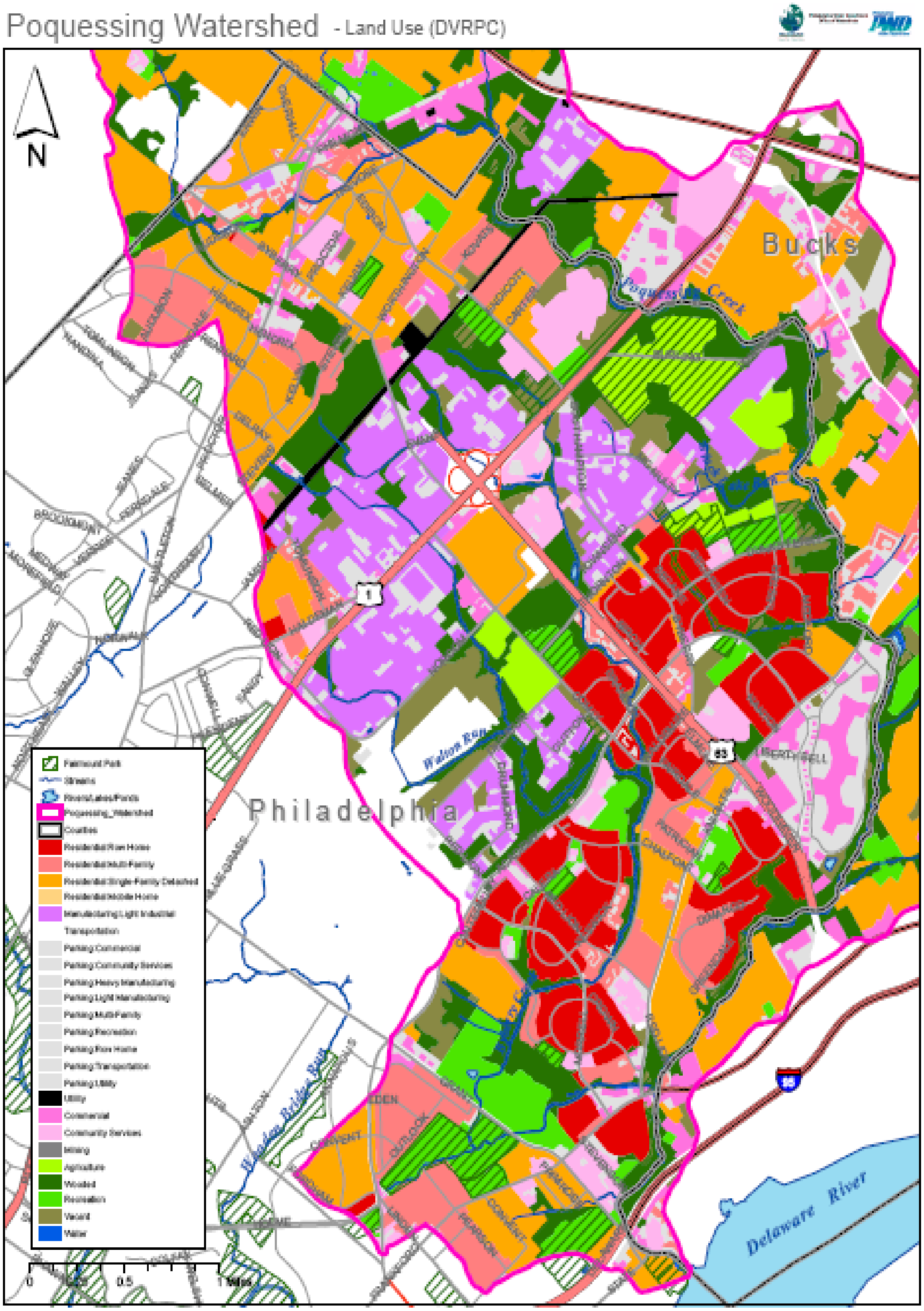
Appendix C, Figure 1 - Poquessing Watershed Point Sources & Outfall Locations



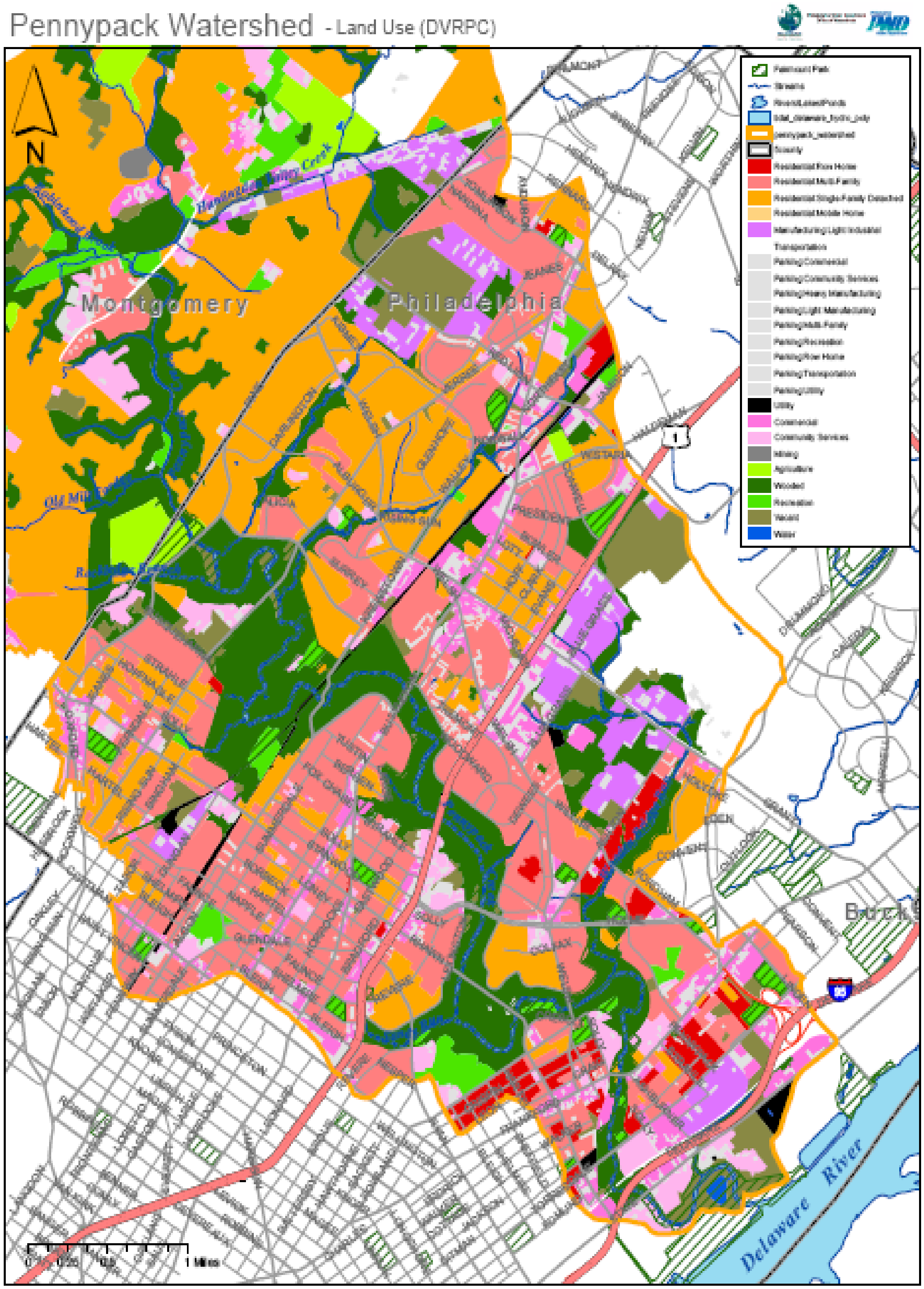
Appendix C, Figure 2 - Pennypack Watershed Point Sources & Outfall Locations



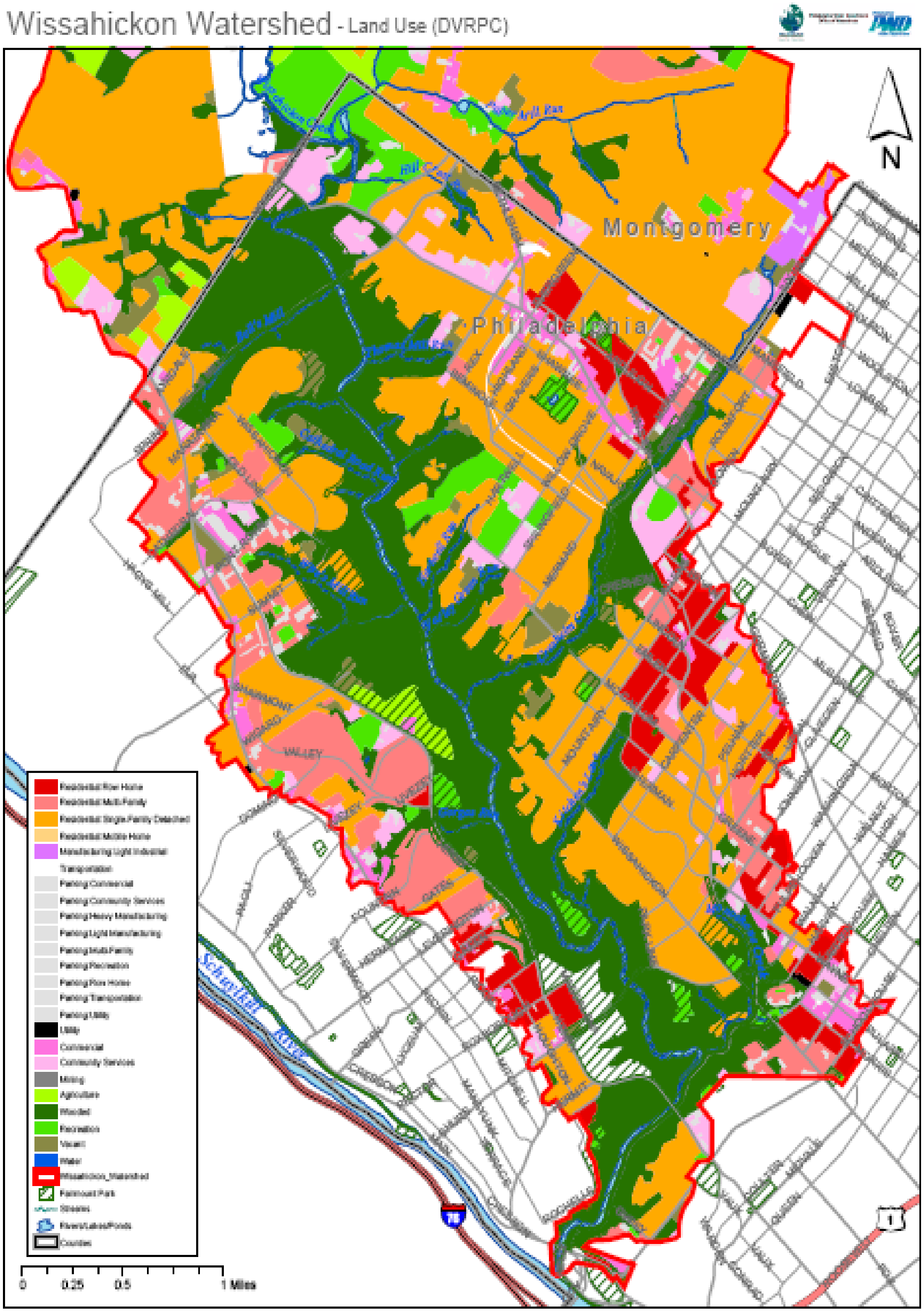
Appendix C, Figure 3 - Wissahickon Watershed Point Source & Outfall Locations



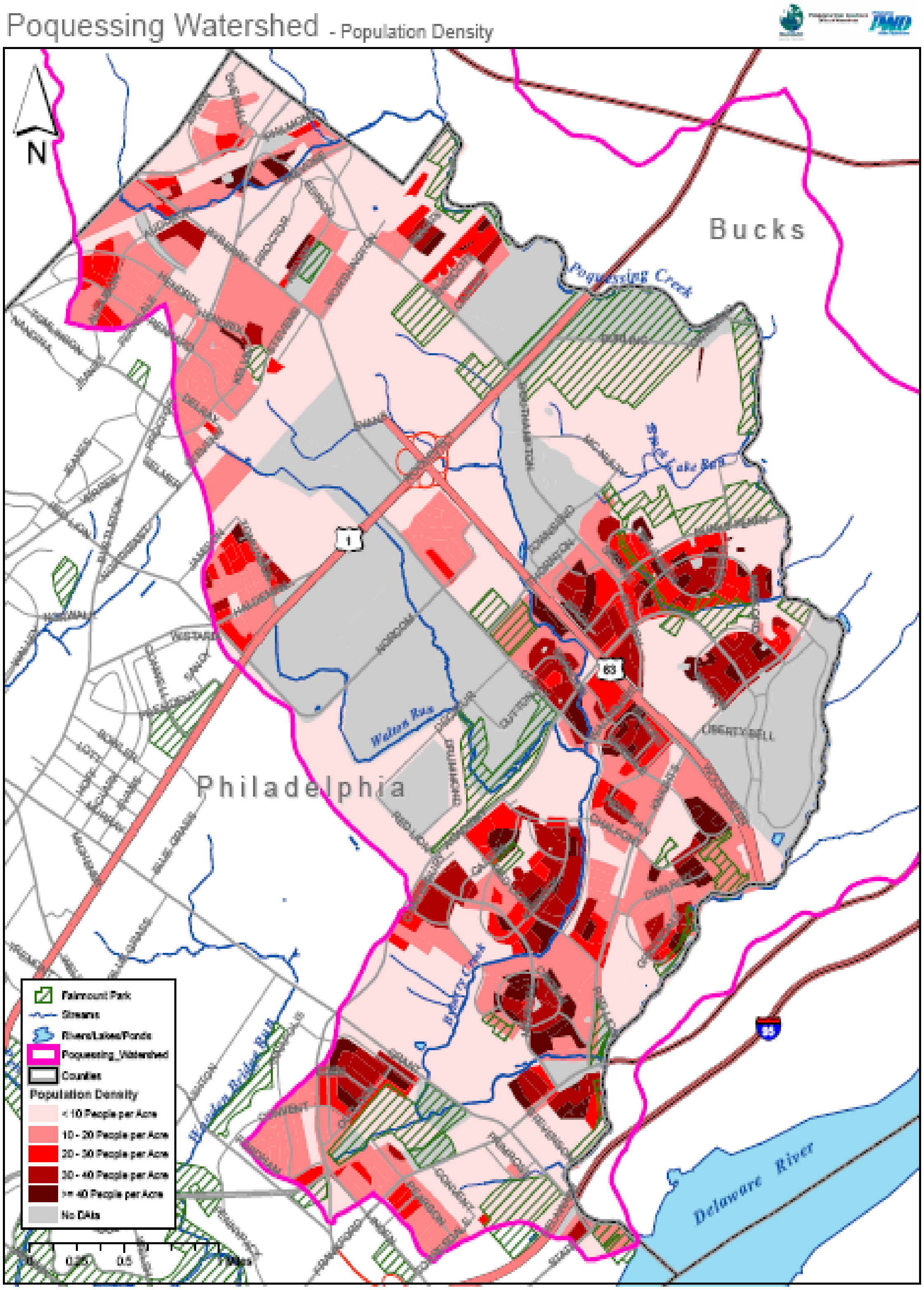
Appendix C, Figure 4 - Poquessing Watershed DVRPC Land Use Mapping



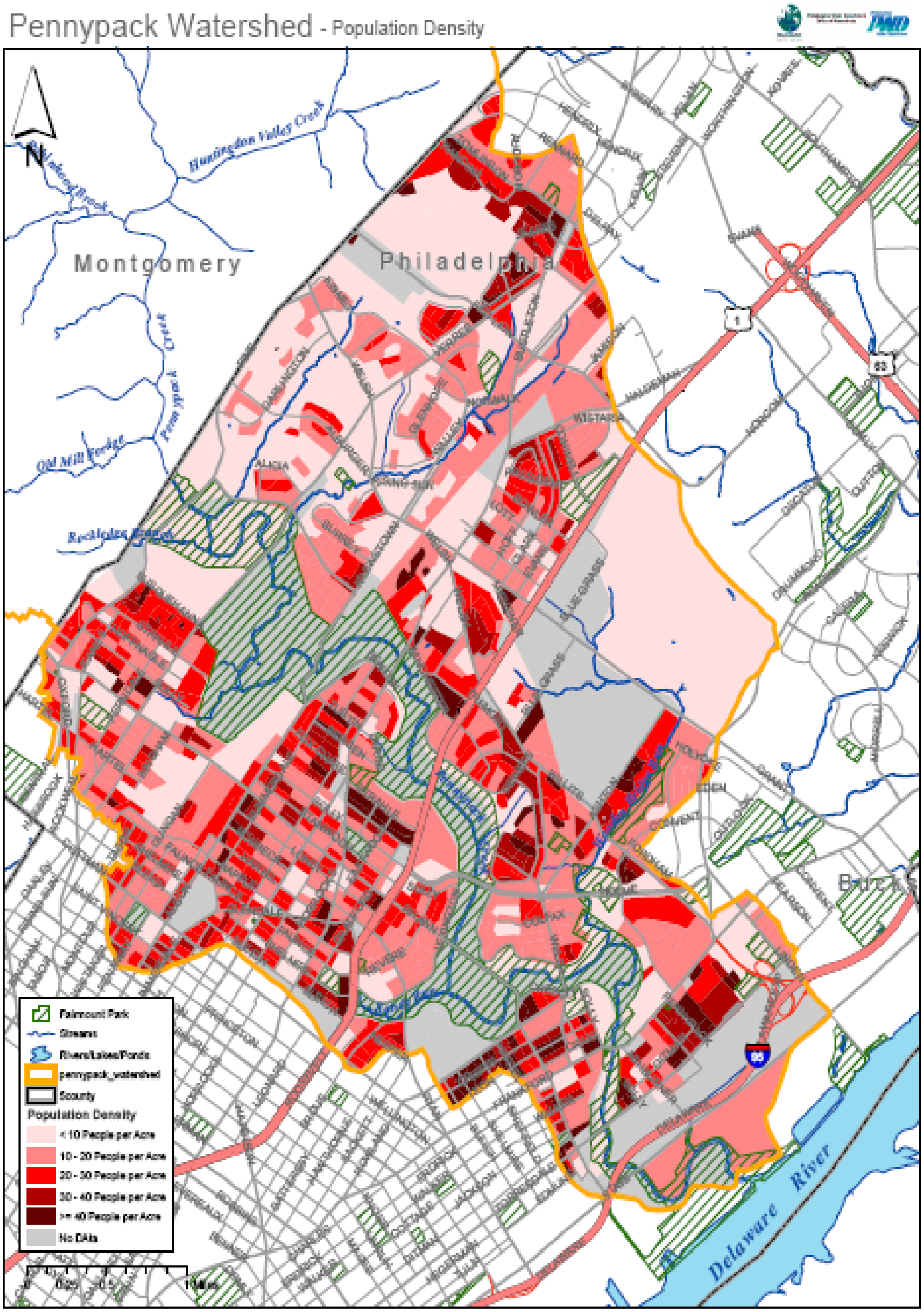
Appendix C, Figure 5 - Pennypack Watershed DVRPC Land Use Mapping



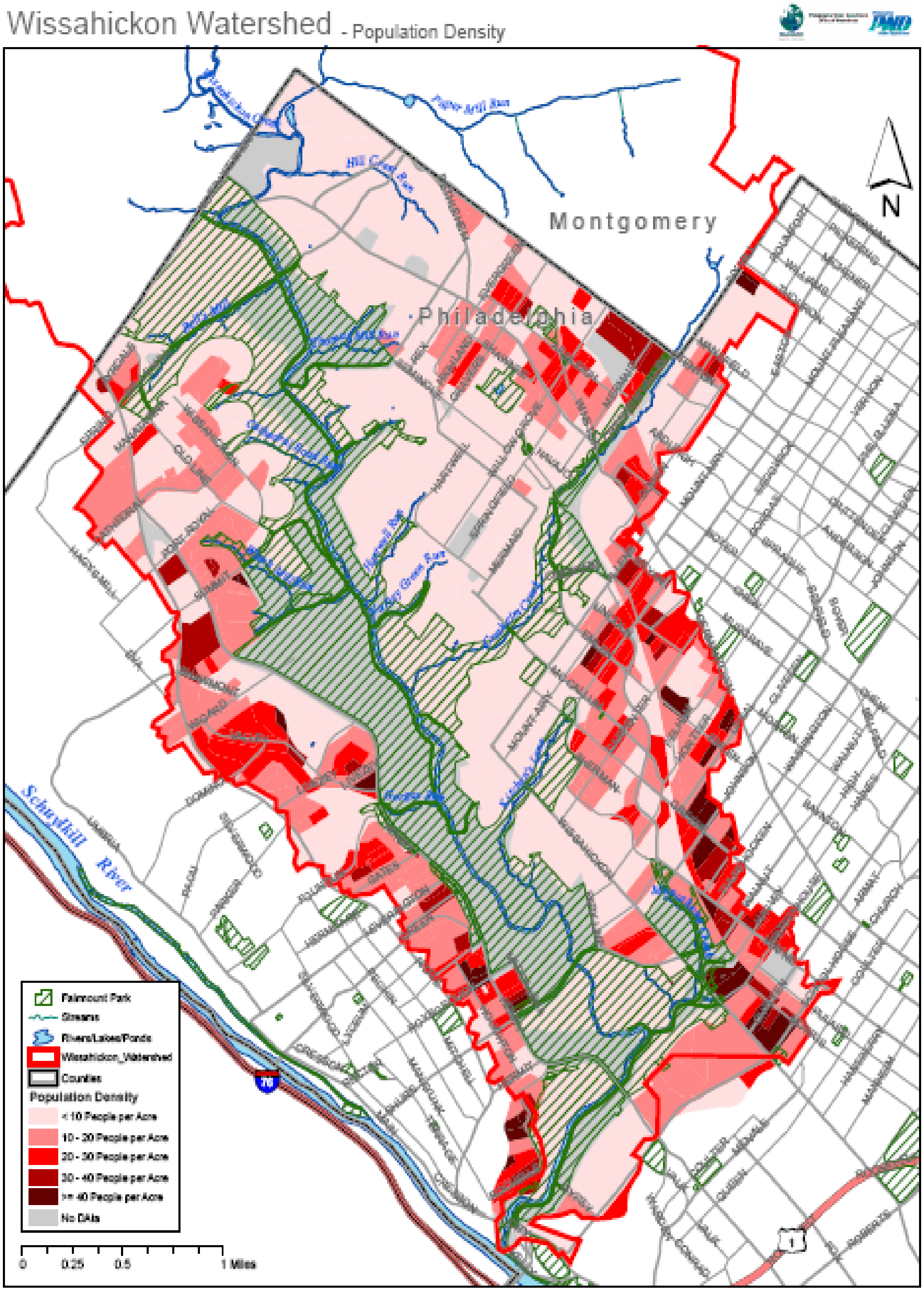
Appendix C, Figure 6 - Wissahickon Watershed DVRPC Land Use Mapping



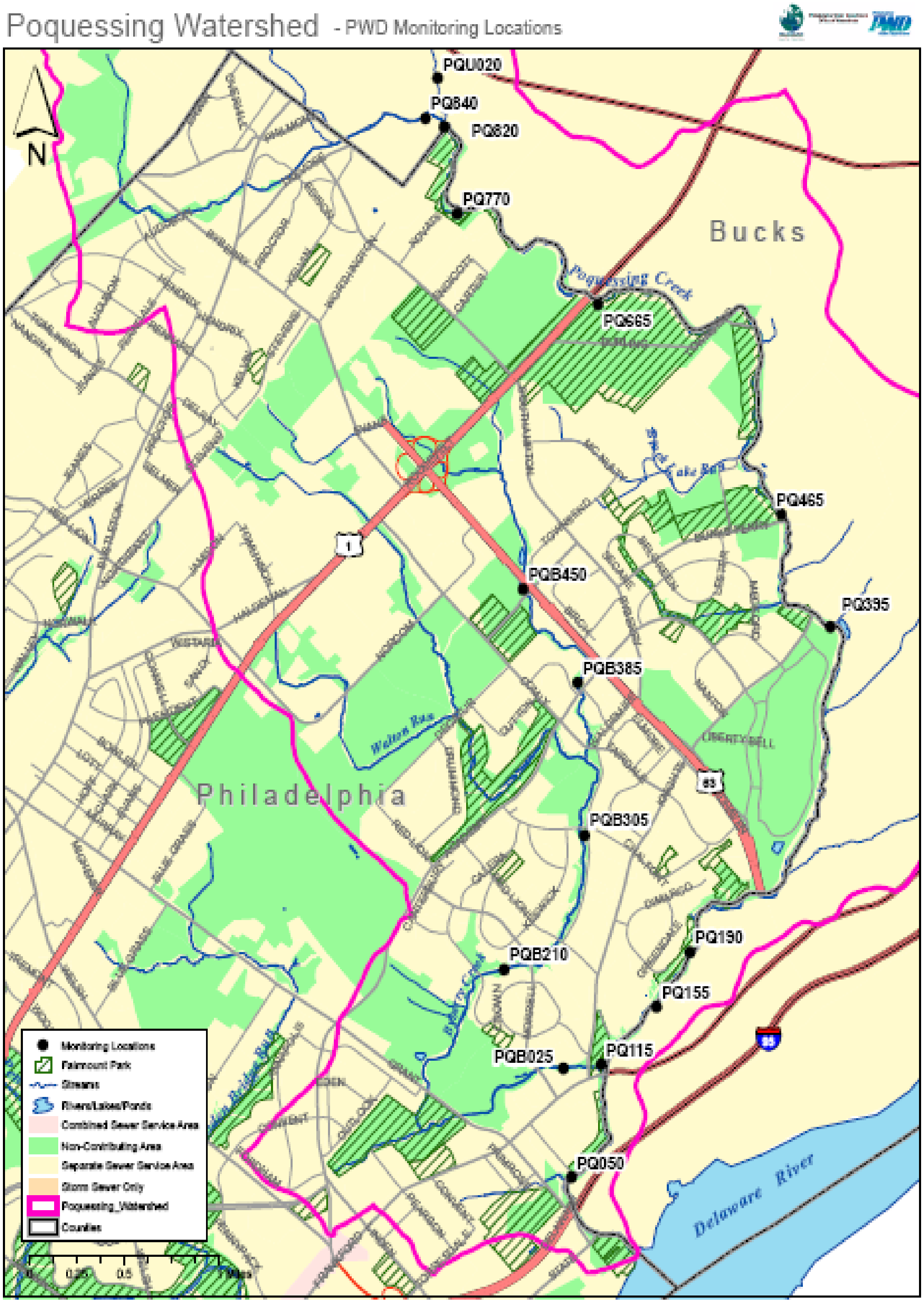
Appendix C, Figure 7 - Poquessing Watershed Population Density



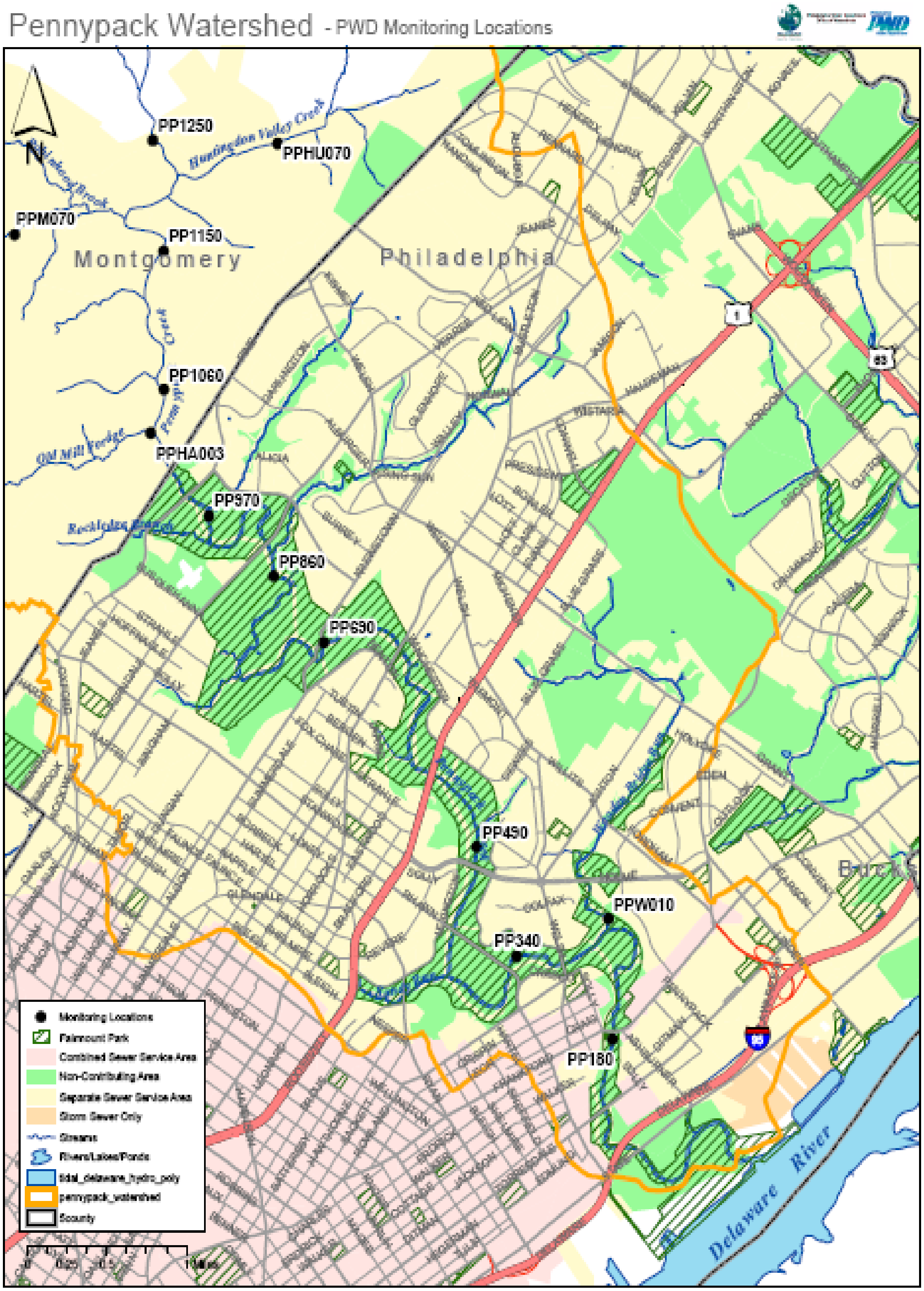
Appendix C, Figure 8 - Pennypack Watershed Population Density



Appendix C, Figure 9 - Wissahickon Watershed Population Density



Appendix C, Figure 10 - Poquessing Watershed PWD Monitoring Locations



Appendix C, Figure 11 - Pennypack Watershed PWD Monitoring Locations

Appendix C, Figure 12 - Wissahickon Watershed PWD Monitoring Locations

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Change Number: 2
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Total Editing Time: 6 Minutes
Last Printed On: 9/29/2006 12:47 PM
As of Last Complete Printing
Number of Pages: 13
Number of Words: 204 (approx.)
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APPENDIX D - COMPREHENSIVE WATERSHED MONITORING PROGRAM: 2005-2010 STRATEGY

INTRODUCTION

Under Section 2 of the City's stormwater National Pollutant Discharge Elimination System (NPDES) permit, the City of Philadelphia recognizes the potential impacts of discharges from stormwater, CSO and other discharges and conditions that affect drinking water and other designated uses of our waterways.

Comprehensive assessment of our waterways is integral to planning for the long-term health and sustainability of our water systems. The Philadelphia Water Department (PWD) considers such assessments as essential to raising awareness in Southeastern Pennsylvania as to the impact that land development activities are having on waterbody health. By measuring all factors that contribute to supporting fishable, swimmable, and drinkable water uses, appropriate management strategies can be developed for each watershed land area that Philadelphia shares.

Specifically, biological monitoring is a useful means of detecting impacts to the aquatic ecosystems necessary for sustainable fisheries and other designated uses. Biological communities respond to wide variety of chemical, physical and biological factors in the environment and can reveal natural and anthropogenic stressors. In this respect, resident biota in a water body act as natural monitors of environmental quality and can reveal the effects of episodic and cumulative pollution and habitat alteration.

Bioassessments, however, must be integrated with appropriate chemical and physical measures, land use characterizations, and pollutant source information necessary to establish linkages between stressors and environmental quality. These linkages can then be used to create decision-making frameworks for selecting restoration techniques that are appropriately balanced between in-stream restoration, land-based management practices, and new water and sewer infrastructure

From 1999 to 2005, the Office of Watersheds has implemented a comprehensive watershed assessment strategy, integrating biological, chemical and physical assessments to provide both quantitative and qualitative information regarding the aquatic integrity of the Philadelphia regional watersheds. This information is being used to plan improvements to the watersheds in the Southeast Region of Pennsylvania.

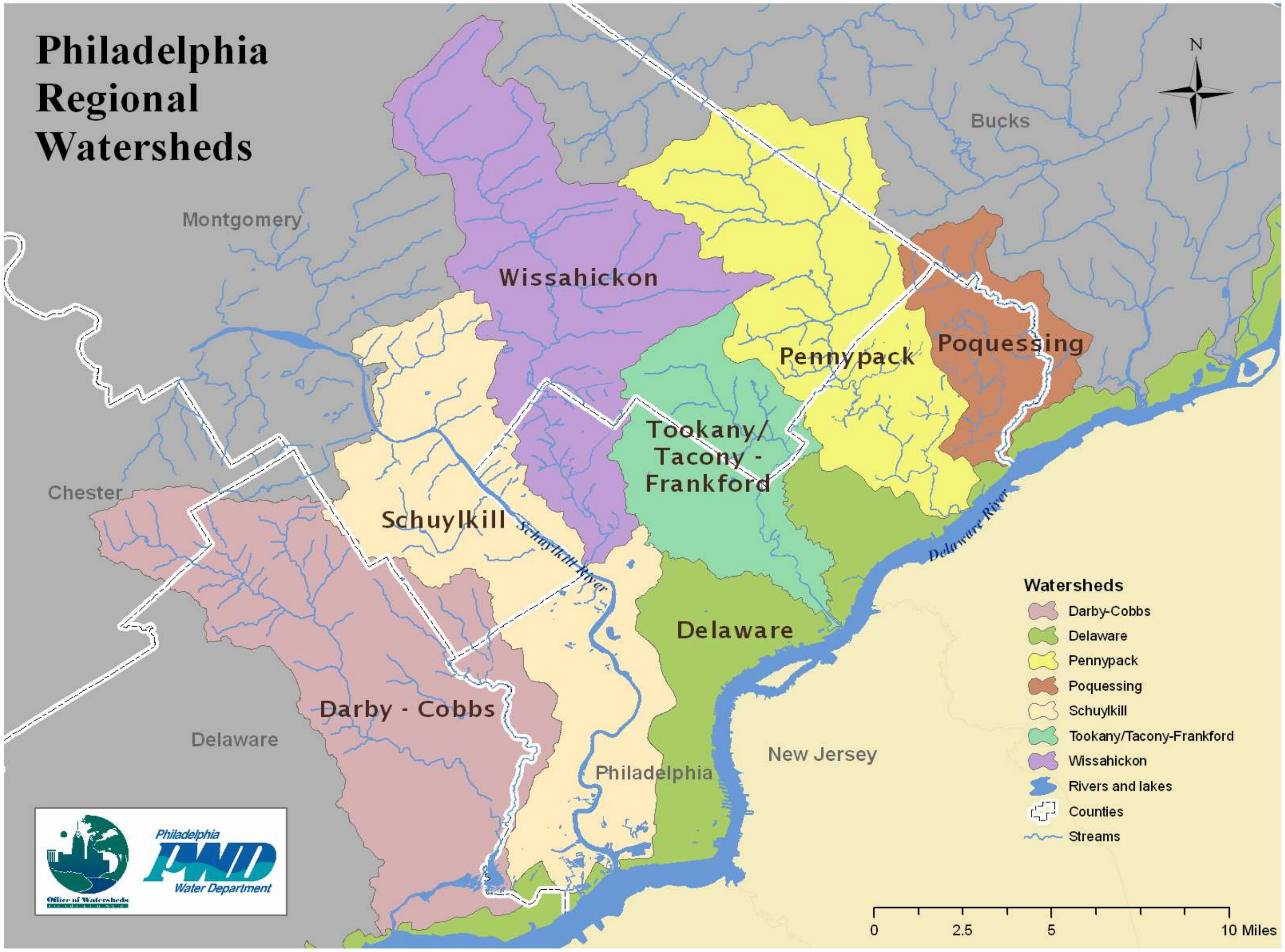
A. BACKGROUND

The Philadelphia Water Department has carried out extensive sampling and monitoring programs to characterize conditions in the seven watersheds (Appendix D, Figure 1), both within the county boundaries and outside counties/municipalities. The program is designed to document the condition of aquatic resources and to provide information for the planning process needed to meet regulatory requirements imposed by EPA and PA DEP. The program includes hydrologic, water quality, biological, habitat, and fluvial geomorphological aspects. PWD is well suited to carry out the program because it merges the goals of the city's stormwater, combined sewer overflow, and sourcewater protection programs into a single unit dedicated to watershed-wide characterization and planning.

Under the provisions of the Clean Water Act, the National Pollutant Discharge Elimination System (NPDES) requires permits for point sources that discharge to waters of the United States. In the six watersheds entering Philadelphia, stormwater outfalls and wet weather sewer overflow points discharging to surface waters are classified as point sources and are regulated by NPDES.

Regulation of stormwater outfalls under the NPDES program requires operators of medium and large municipal stormwater systems or MS4s to obtain a permit for discharges and to develop a stormwater management plan to minimize pollution loads in runoff over the long term. Partially in administration of this program, PA DEP assigns designated uses to water bodies in the state and performs ongoing assessments of the condition of the water bodies to determine whether the uses are met and to document any improvement or degradation. These assessments are performed primarily with biological indicators based on the EPA's Rapid Bioassessment Protocols (RBPs) and physical habitat assessments.

PWD's Office of Watersheds is responsible for characterization and analysis of existing conditions in local watersheds to provide a basis for long-term watershed planning and management. The extensive sampling and monitoring program described in this section is designed to provide the data needed for the long-term planning process.



Appendix D, Figure 1 - Philadelphia regional watersheds.

B. Water Quality Monitoring

Discrete Water Chemistry Assessment

During an assessment cycle, four water quality samples are manually collected during winter, spring and summer at designated locations in each watershed (n=12 sampling events at each location). Parameters are chosen because state water quality criteria apply to them or because they are known or suspected to be important in urban watersheds. The parameters sampled during each sampling event are listed in Appendix D, Table 1. The sampling and analysis program meets AMSA *et al.* (2002) recommendations for the minimum criteria that should form the basis for impairment listings:

- Data collected during the previous five years may be considered to represent current conditions.
- At least ten temporally independent samples should be collected and analyzed for a given parameter.
- A two-year minimum data set is recommended to account for inter-year variation, and the sample set should be distributed over a minimum of two seasons to account for inter-seasonal variation.
- Samples collected fewer than four days apart at the same river location should be considered one sample event.
- Samples collected within 200 meters [about 0.1 miles] of each other will be considered the same station or location." This convention was followed except where two sampling sites were chosen to represent conditions upstream and downstream of a modification such as a dam.

Appendix D, Table 1 - Chemical analytes collected during chemical monitoring programs

Parameter	Units	Discrete	Wet Weather	Continuous
Temperature	deg C	X	X	X
pH	pHU	X	X	X
Specific Conductance	uMHO/cm @ 25C	X	X	X
Alkalinity	mg/L	X	X	
Turbidity	NTU	X	X	X
TSS	mg/L	X	X	
TDS	mg/L	X	X	
DO	mg/L	X	X	X
BOD5	mg/L	X	X	
BOD30	mg/L	X	X	
CBOD5	mg/L	X	X	
Ammonia	mg/L as N	X	X	
TKN	mg/L	X	X	
Nitrite	mg/L	X	X	
Nitrate	mg/L	X	X	
Total Phosphorus	mg/L	X	X	
Phosphate	mg/L	X	X	
Aluminum	mg/L	X	X	
Calcium	mg/L	X	X	
Cadmium	mg/L	X	X	
Chromium	mg/L	X	X	
Copper	mg/L	X	X	
Fluoride	mg/L	X	X	
Iron	mg/L	X	X	
Dissolved Iron	mg/L	X	X	
Magnesium	mg/L	X	X	
Manganese	mg/L	X	X	
Lead	mg/L	X	X	
Zinc	mg/L	X	X	
Total Chlorophyll	Ug/L	X	X	
Chlorophyll A	ug/L	X	X	
Fecal Coliform	#/100 mls	X	X	
E. coli	#/100 mls	X	X	
Osmotic Pressure	mOsm	X		
Phenolics	mg/L	X	X	
Geosmin/MIB	µg/L	X		

Continuous Water Quality Assessment

In addition to discrete chemical sampling, PWD incorporates automated equipment at strategic locations within each watershed as part of the comprehensive monitoring strategy. During continuous sampling, data for selected parameters are collected at 15-minute increments by a submerged instrument (YSI Sonde 6600, 6600 EDS and 600 XLM) over approximately two weeks. Retrieved Sondes are then replaced with QA/QC Sonde replacements in order to produce seamless data for spatial and temporal analyses. Parameters measured include stage, dissolved oxygen, temperature, pH, conductivity and turbidity. Comprehensive Sonde deployments have occurred in the Darby-Cobbs and Tookany/Tacony-Frankford watersheds with plans for completed deployments in the Wissahickon, Pennypack and Poquessing-Byberry watersheds as outlined in Appendix D, Table 2.

Wet Weather Chemical Monitoring

During runoff producing events, automated samplers (Isco, Inc. models 6712, 6700) are strategically placed in locations throughout the watershed and are used to collect samples during the rain event. The automated sampler system obviated the need for scientists to manually collect samples, thereby greatly increasing sampling efficiency. Automated samplers are programmed to commence sampling with a small (0.1ft.) increase in stage. Once sampling is initiated, a computer-controlled peristaltic pump and distribution system collected grab samples at 30 min. to 1 hr. intervals. The data allow characterization of water quality responses to stormwater runoff and wet weather sewer overflows. Chemical analytes processed during wet weather events are displayed in Appendix D, Table 1.

C. Biological Monitoring

The Philadelphia Water Department continues to integrate biological assessments into the monitoring program as a means of identifying potential physical impairments or chemical stressors. In addition, biological indices produced from the various monitoring strategies serve as a baseline for future restoration projects. The biological monitoring protocols employed by PWD are in accordance with methods developed by the United States Environmental Protection Agency and the Pennsylvania Department of Environmental Protection. These procedures are as follows:

- Rapid Bioassessment Protocol III (Benthic Sampling)
- Rapid Bioassessment Protocol V (Fish Sampling)
- Periphyton Assessment (Algae Monitoring)

D. Physical Monitoring

Habitat Assessments

Habitat assessments are conducted at each monitoring site based on the Environmental Protection Agency's *Rapid Bioassessment Protocols for Use in Wadeable Streams and Rivers* (Barbour *et al*., 1999). Reference conditions are used to normalize the assessment to the "best attainable" situation. Habitat parameters are separated into three principal categories: (1) primary, (2) secondary, and (3) tertiary parameters:

- Primary parameters are those that characterize the stream "microscale" habitat and have greatest direct influence on the structure of indigenous communities.
- Secondary parameters measure "macroscale" habitat such as channel morphology characteristics.
- Tertiary parameters evaluate riparian and bank structure and comprise three categories: (1) bank vegetative protection, (2) grazing or other disruptive pressure, and (3) riparian vegetative zone width.

Habitat Suitability Index (HSI) Modeling

In addition to habitat assessments, Habitat Suitability Index (HSI) models, developed by the U.S. Fish and Wildlife Service (USFWS), have been incorporated into the monitoring program. Based on empirical data and supported by years of research and comprehensive review of scientific literature, these models present numerical relationships between various habitat parameters and biological resources, particularly gamefish species and species of special environmental concern. To date, HSI indices have been created for the Darby-Cobbs and Tookany/Tacony-Frankford Creeks.

Fluvial Geomorphologic (FGM) Analysis

To date, FGM analysis has been conducted on the Cobbs Creek, Tookany/Tacony-Frankford Creek and its tributaries, with plans to complete assessments on the Wissahickon, Pennypack and Poquessing-Byberry Creeks. Analysis was conducted in order to characterize channel morphology, disturbance, stability, and habitat parameters as well as to provide a template for hydrologic and hydraulic modeling and serve as a baseline for assessing channel bank and bed changes. Data provided from the FGM analyses will also serve to develop reach rankings within each watershed in order to prioritize restoration strategies. For a detailed description of the FGM standard operating procedures, refer to http://www.phillyriverinfo.org/.

E. Summary of Monitoring Locations

Biological, physical and chemical monitoring locations are based on 3 criteria: 1) appropriate habitat heterogeneity; 2) access availability; and 3) proximity to PADEP

305b monitoring sites. In general, the number of monitoring sites is proportional to the size of the drainage and the watershed's link magnitude (i.e., number of 1st order streams).

A river mile-based naming convention has been created for sampling and monitoring sites in the regional watersheds. The naming convention includes two to four letters and three or more numbers which denote the watershed, stream, and distance from the mouth of the stream. For example, site DCC-110 is located as follows:

- "DC" stands for the Darby-Cobbs watershed.
- "C" stands for Cobbs Creek.
- "110" places the site 1.10 miles upstream of the mouth of Cobbs Creek, where it flows into Darby Creek.

Appendix D, Table 2 explains the current number of assessment sites in each watershed relative to the various monitoring programs. In the Addendum, Figures Appendix D, Figure 3 - Appendix D, Figure 12 display the location and type of monitoring procedure that has been conducted at each assessment site.

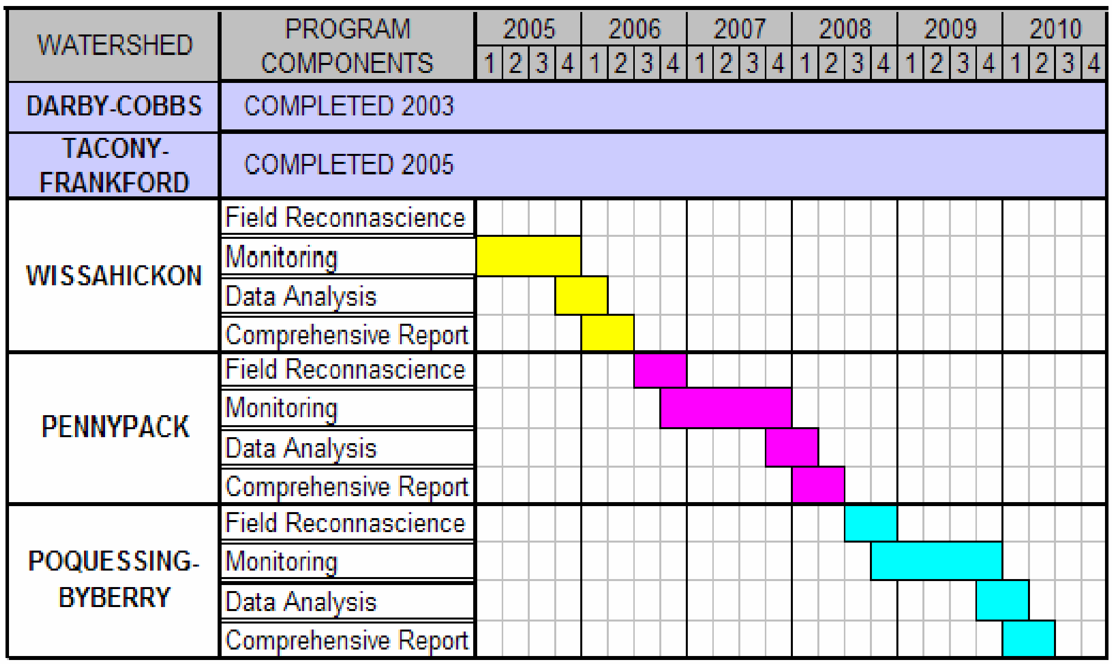
Appendix D, Table 2 - Number of monitoring locations in each watershed relative to the monitoring program.

Watershed	Monitoring Program								
	Biological			Chemical			Physical		
	RBP III	*RBP V*	*Algae*	*Discrete*	*Continuous*	*Wet Weather*	*Habitat*	*HSI Index*	*FGM*
Darby-Cobbs	17	9	NC	9	5	5	17	9	95
Tacony-Frankford	12	7	4	9	8	6	12	7	102
Wissahickon	32	10	5	10	6	8	32	10	230
Pennypack	20	11	NC	13	NC	NC	20	11	130
Poquessing	13	7	NC	7	NC	NC	13	NC	NC
Tidal Schuylkill	N/A	4	NC	4	2	2	NC	NC	NC

N/A: NOT APPLICABLE
N/C: NOT COMPLETED

F. MONITORING TIME LINE STRATEGY

Prior to the creation of a comprehensive monitoring strategy, baseline assessments were conducted in all of the Philadelphia regional watersheds (Appendix D, Figure 2) to ascertain the degree, location and type of impairments occurring within each system. Typically, baseline assessments, encompassing benthic, fish, habitat and discrete water quality monitoring, were routinely completed on a watershed within one year. With the addition of continuous and wet-weather water quality monitoring, periphyton assessments, and specialized physical assessment programs (e.g., FGM assessments), comprehensive characterization reports are now accomplished on a two-year timeline. Figure 12 depicts the proposed watershed monitoring strategy for 2005-2010.



Appendix D, Figure 2 - Proposed watershed monitoring time line 2005-2010

G. Goals and Measures of Success

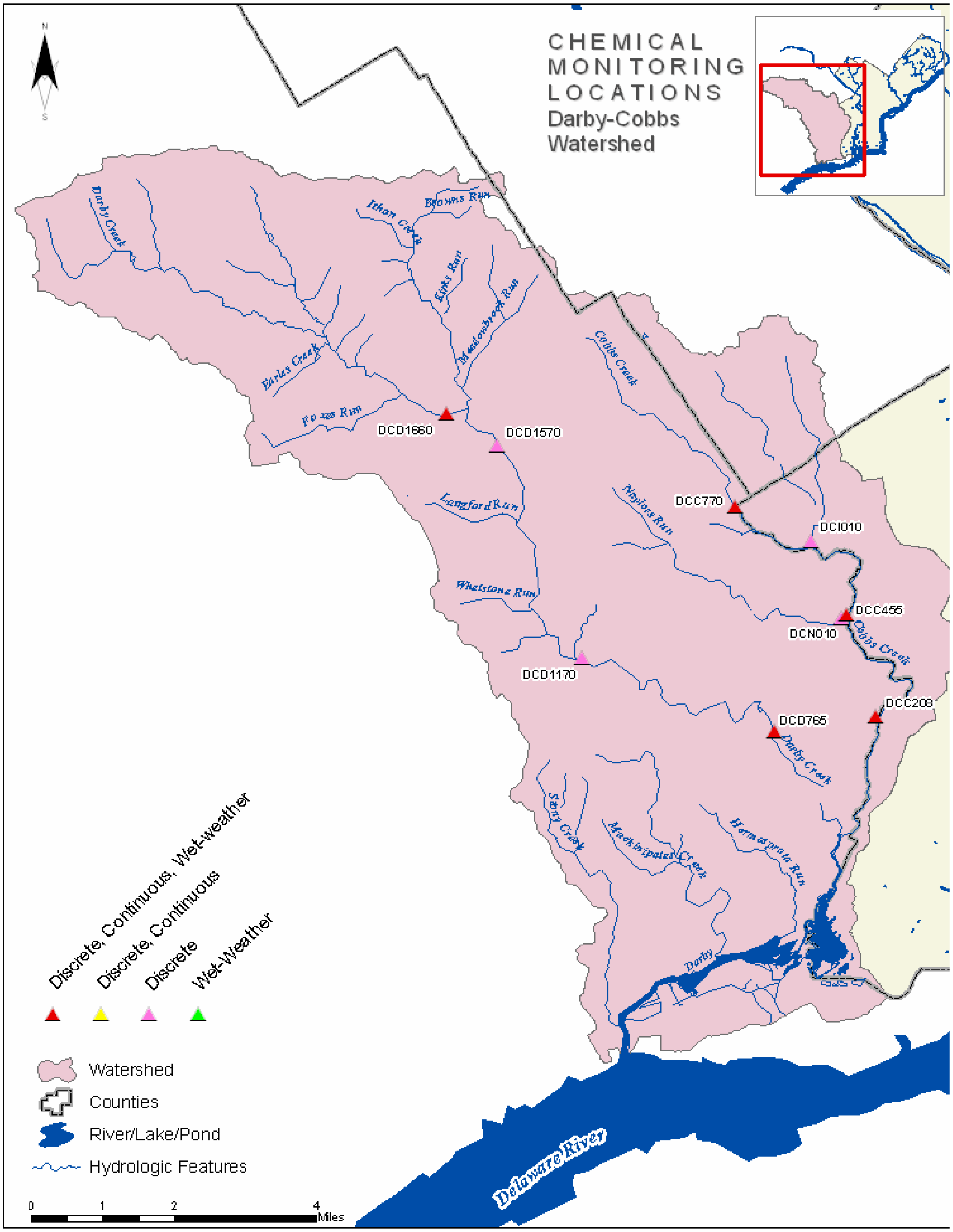
The proposed watershed monitoring strategy is an integrated approach which will improve the evaluations of nonpoint source pollution controls and the combined effectiveness of current point and nonpoint source controls. Similarly, biological attributes can be used to measure site-specific ecosystem responses to remediation or mitigations directed at reducing nonpoint source pollution impacts. By comparing biological indicators, habitat and chemical features before and after the implementation of pollution control systems (e.g. best management practices, structural devices, etc.), scientists can measure the effectiveness of a program.

Through the monitoring programs described in this permit cycle, PWD will be able to measure the relative success of remediation and restoration programs occurring within the Philadelphia regional watersheds. As a major stakeholder in the watersheds, PWD will also be able to provide insight and direction for smaller communities within the watersheds and parties involved in the watershed approach.

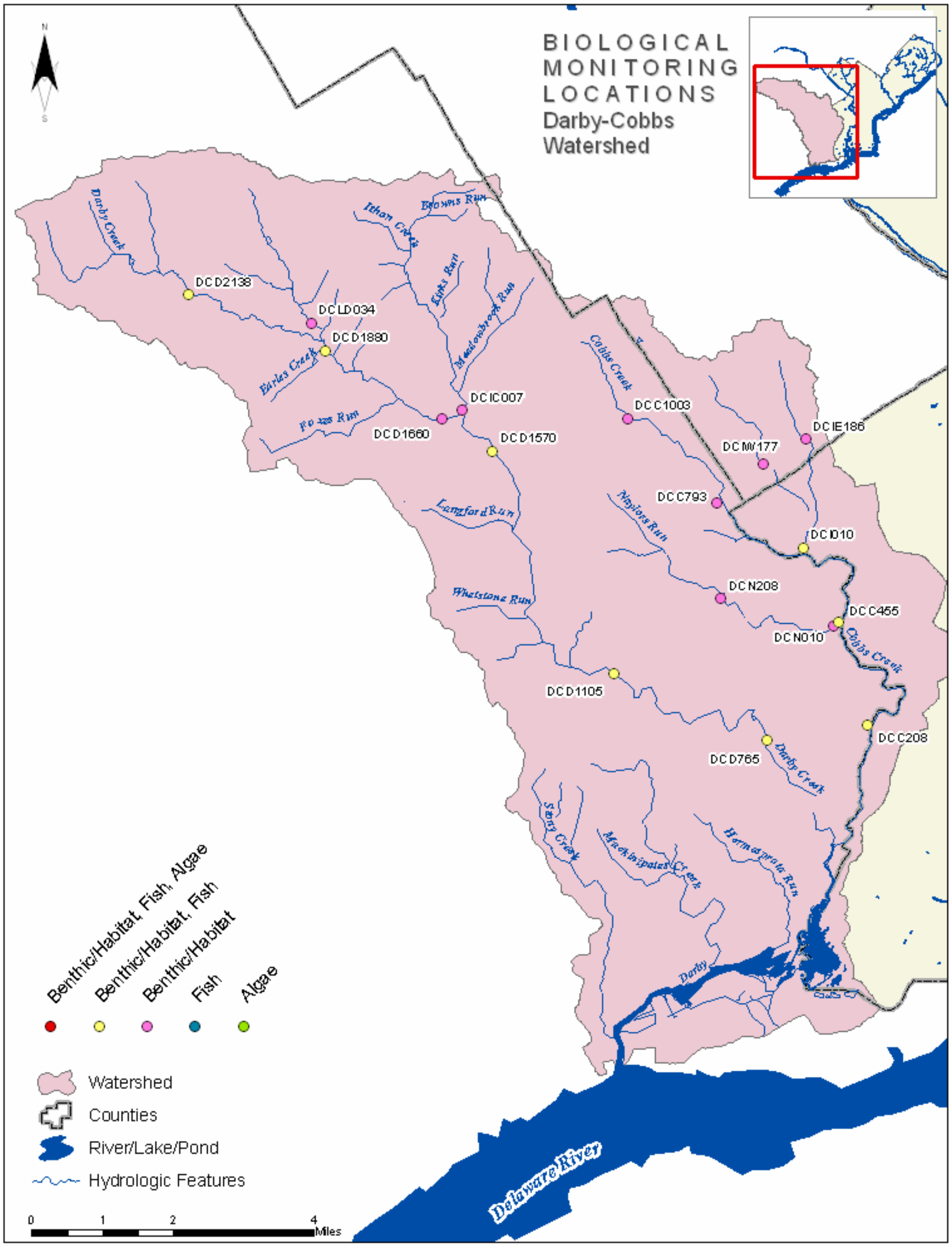
H. Reporting

Based on the monitoring time line strategy, the Philadelphia Water Department has completed all required preliminary and comprehensive assessments in the Wissahickon Creek Watershed during this permit year. In addition, a comprehensive report detailing the biological, chemical and physical attributes of the Wissahickon Creek Watershed is currently under review and is discussed in greater detail within this Annual Report. Reporting timelines for the Pennypack and Poquessing-Byberry watersheds are displayed in Appendix D, Figure 2.

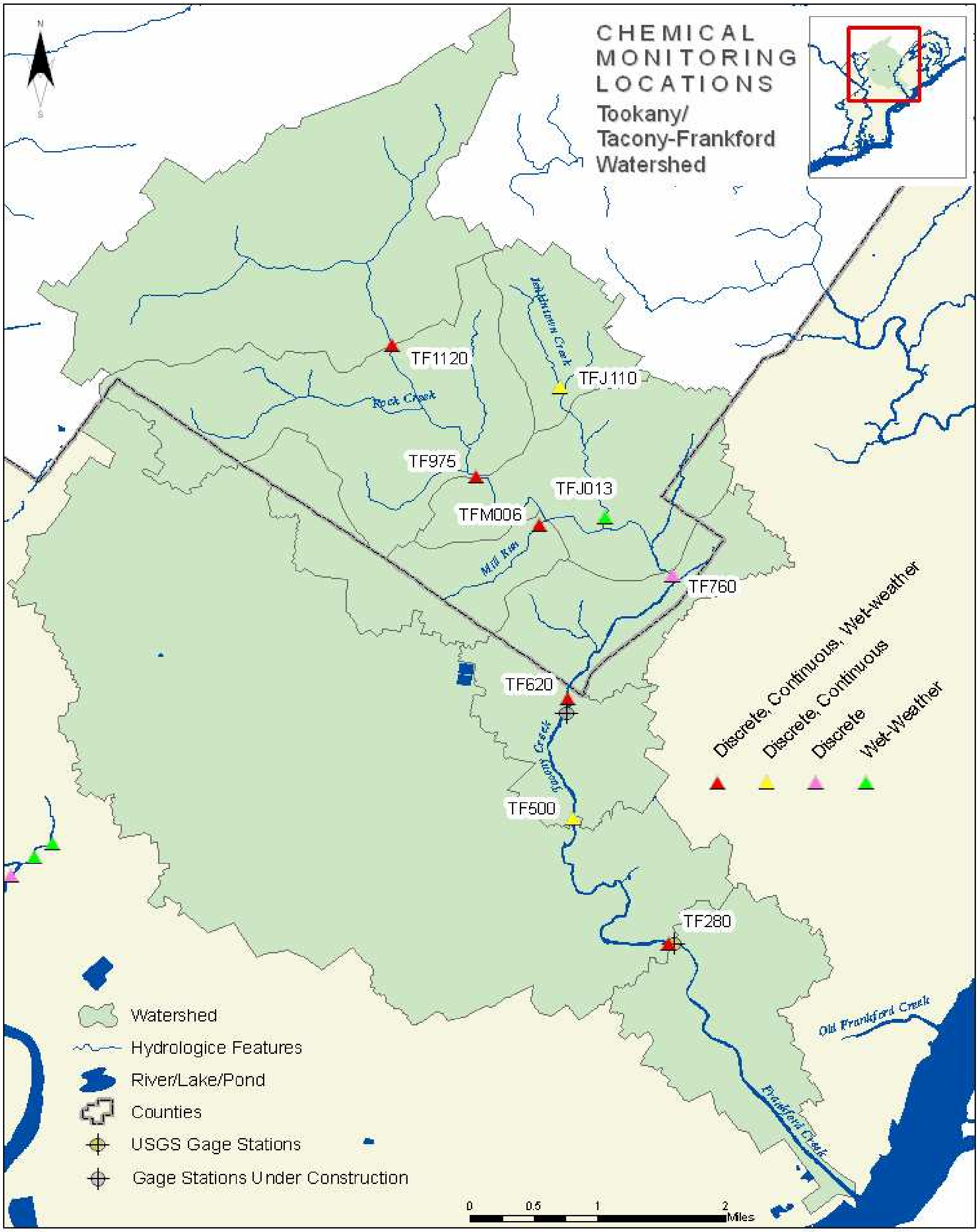
ADDENDUM- SUMMARY OF MONITORING LOCATIONS IN PHILADELPHIA WATERSHEDS



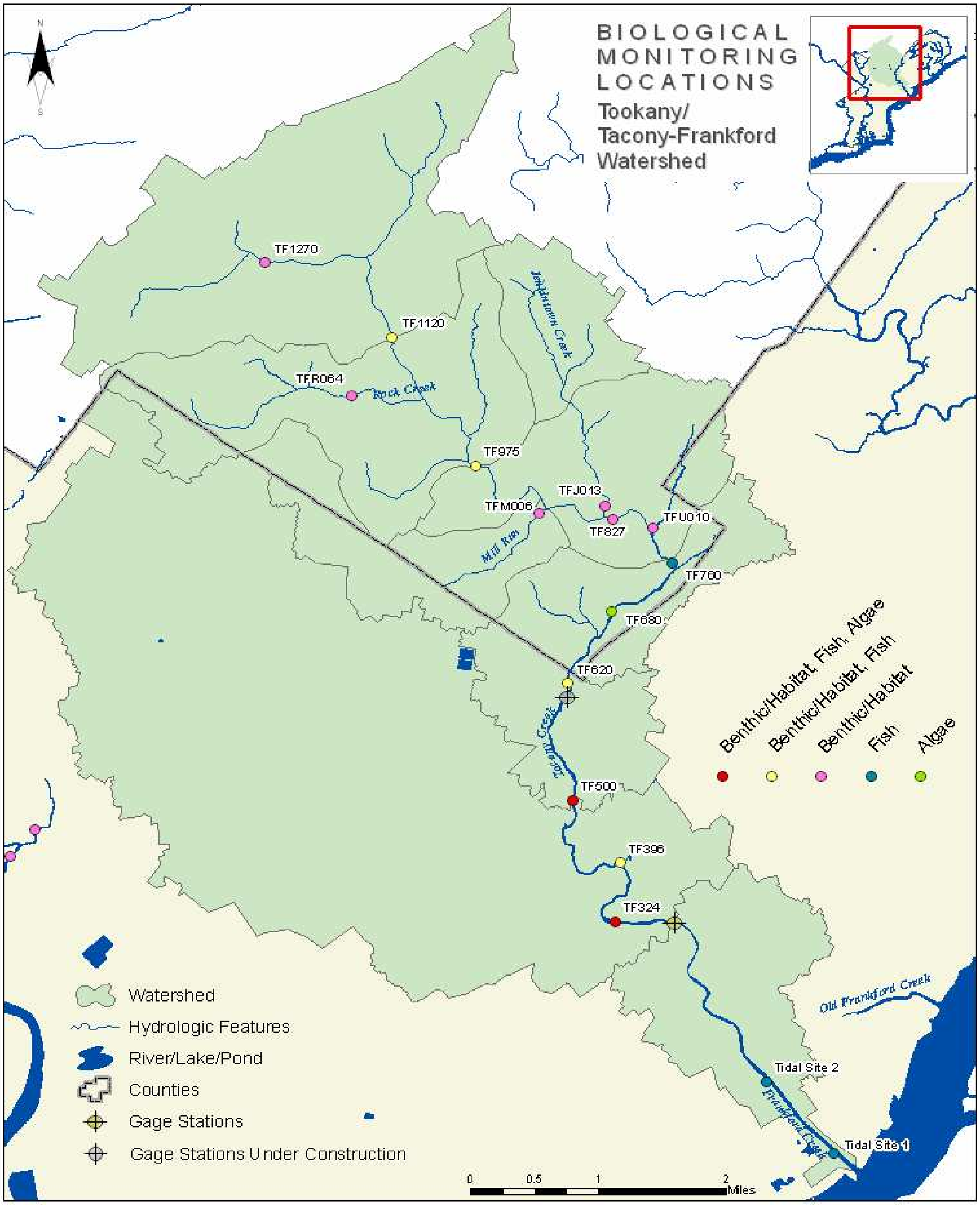
Appendix D, Figure 3 - Chemical monitoring locations in Darby-Cobbs Watershed.



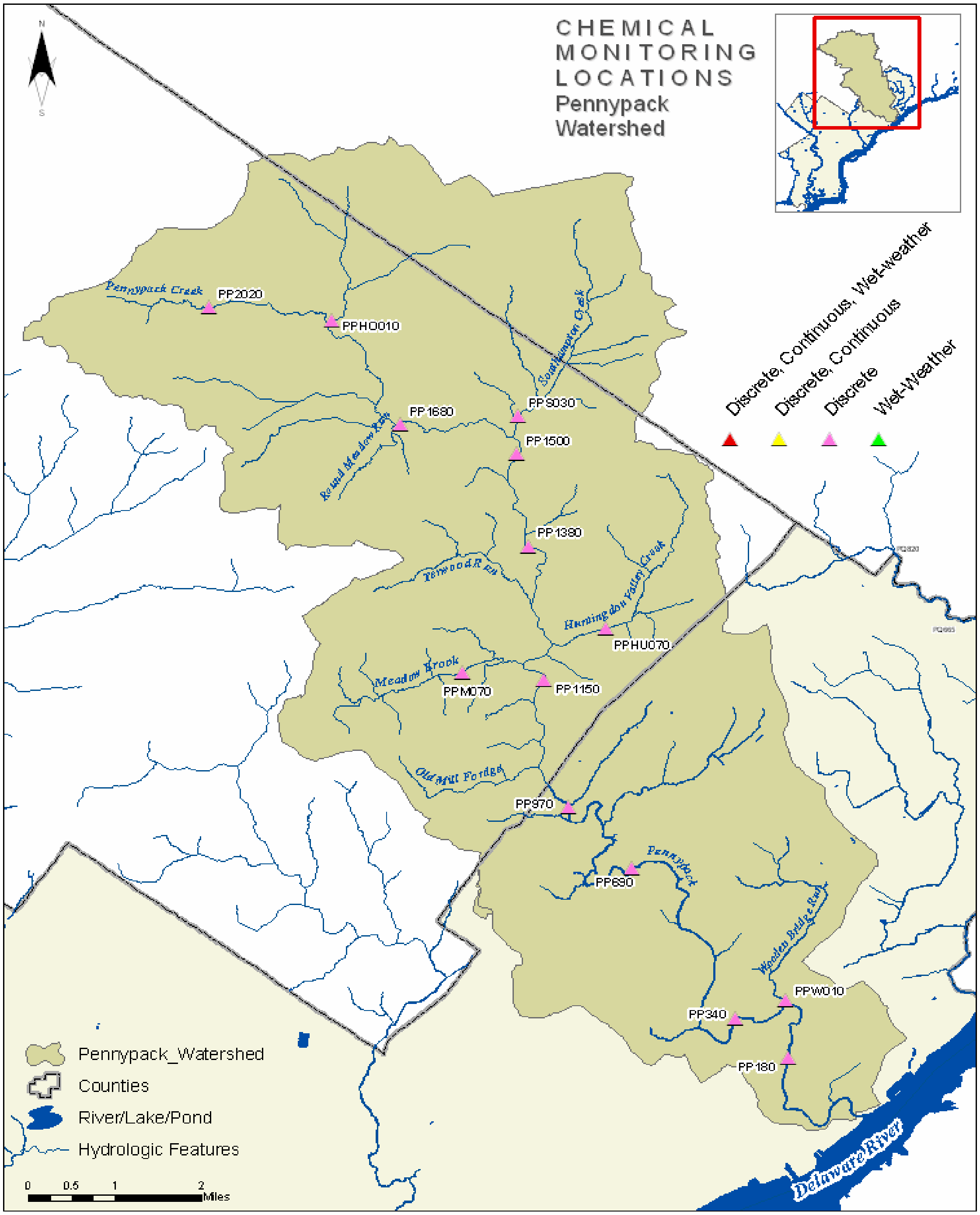
Appendix D, Figure 4 - Biological and physical assessment locations in Darby-Cobbs Watershed



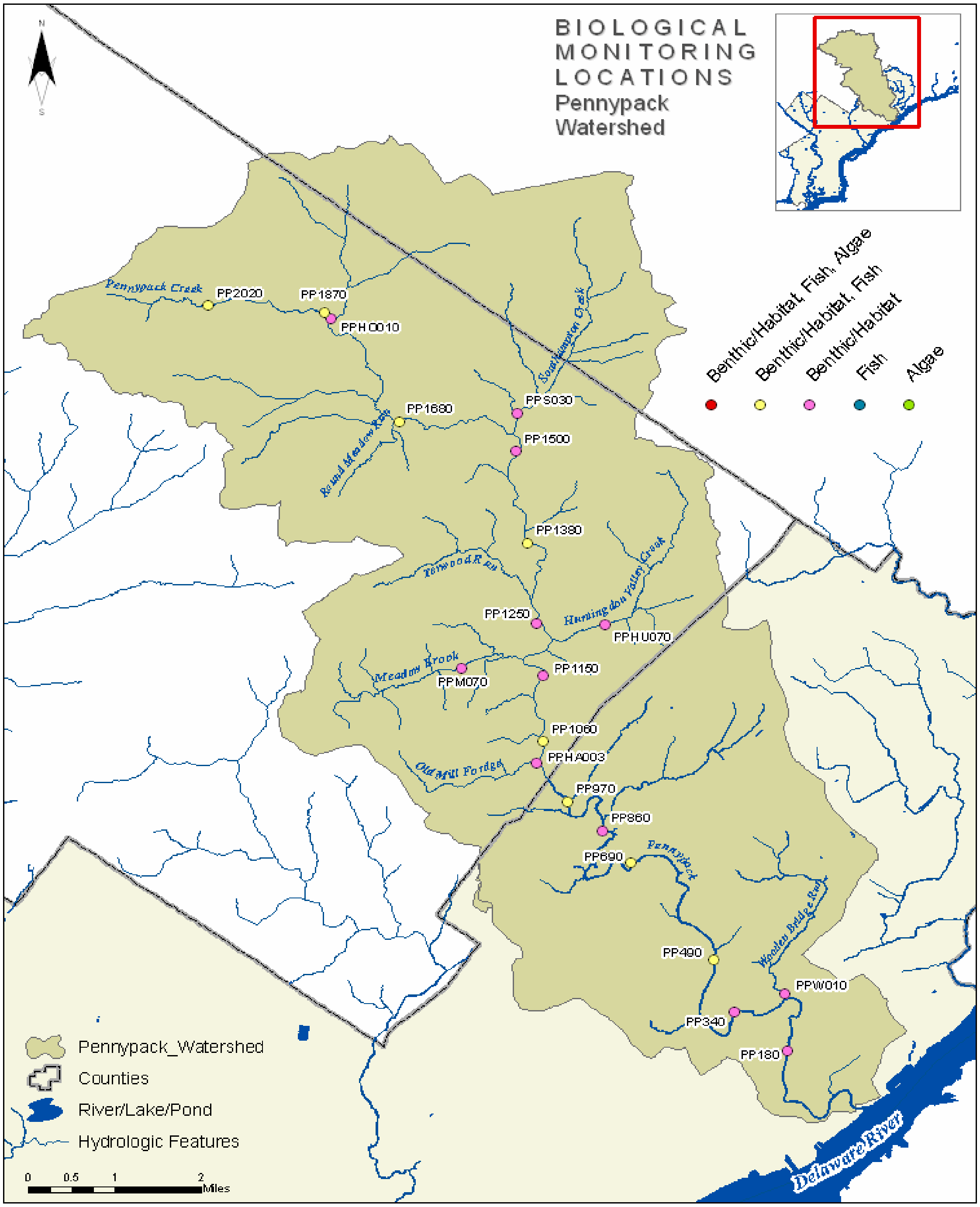
Appendix D, Figure 5 - Chemical monitoring locations in Tacony-Frankford Watershed.



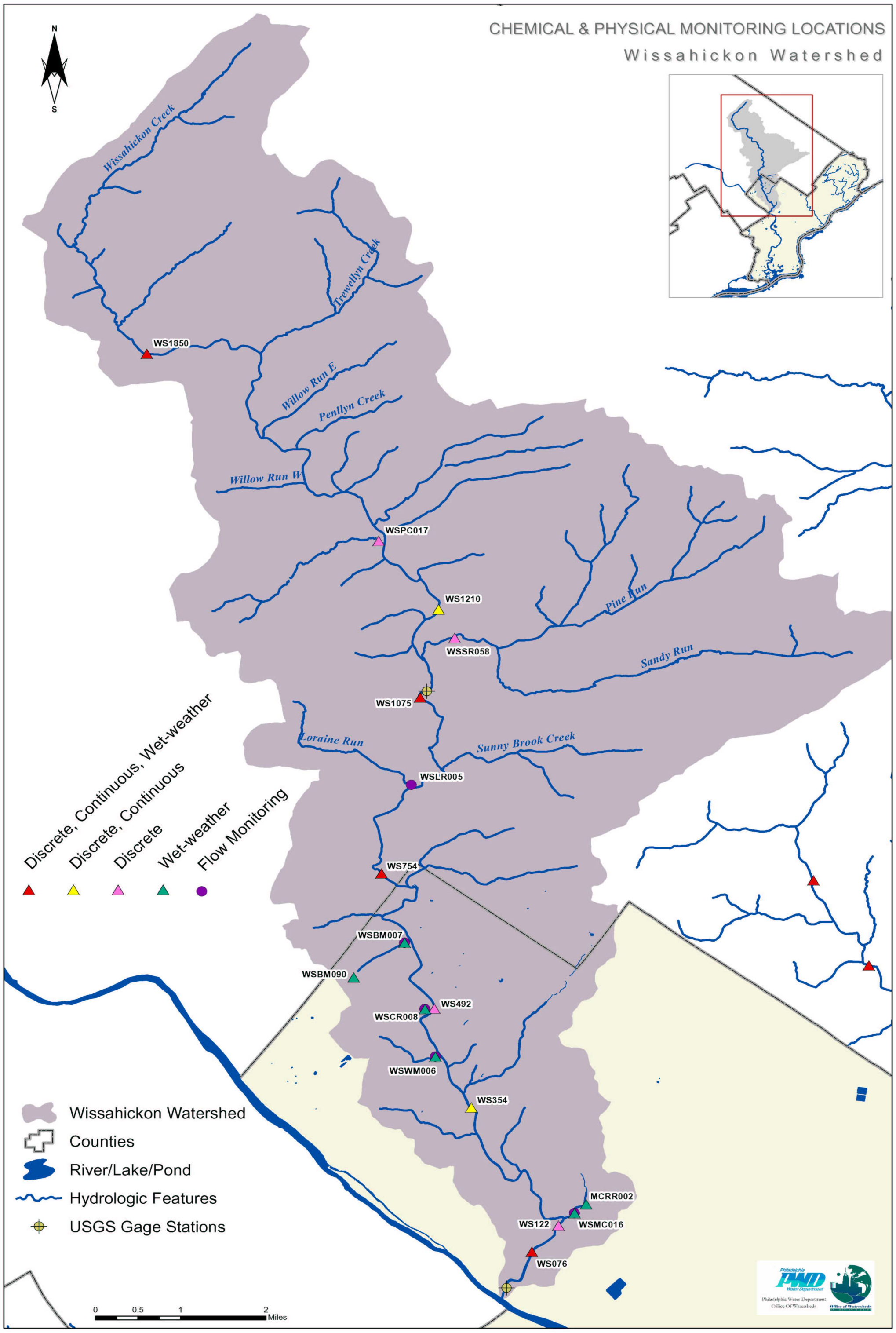
Appendix D, Figure 6 - Biological and physical assessment locations in Tacony-Frankford Watershed.



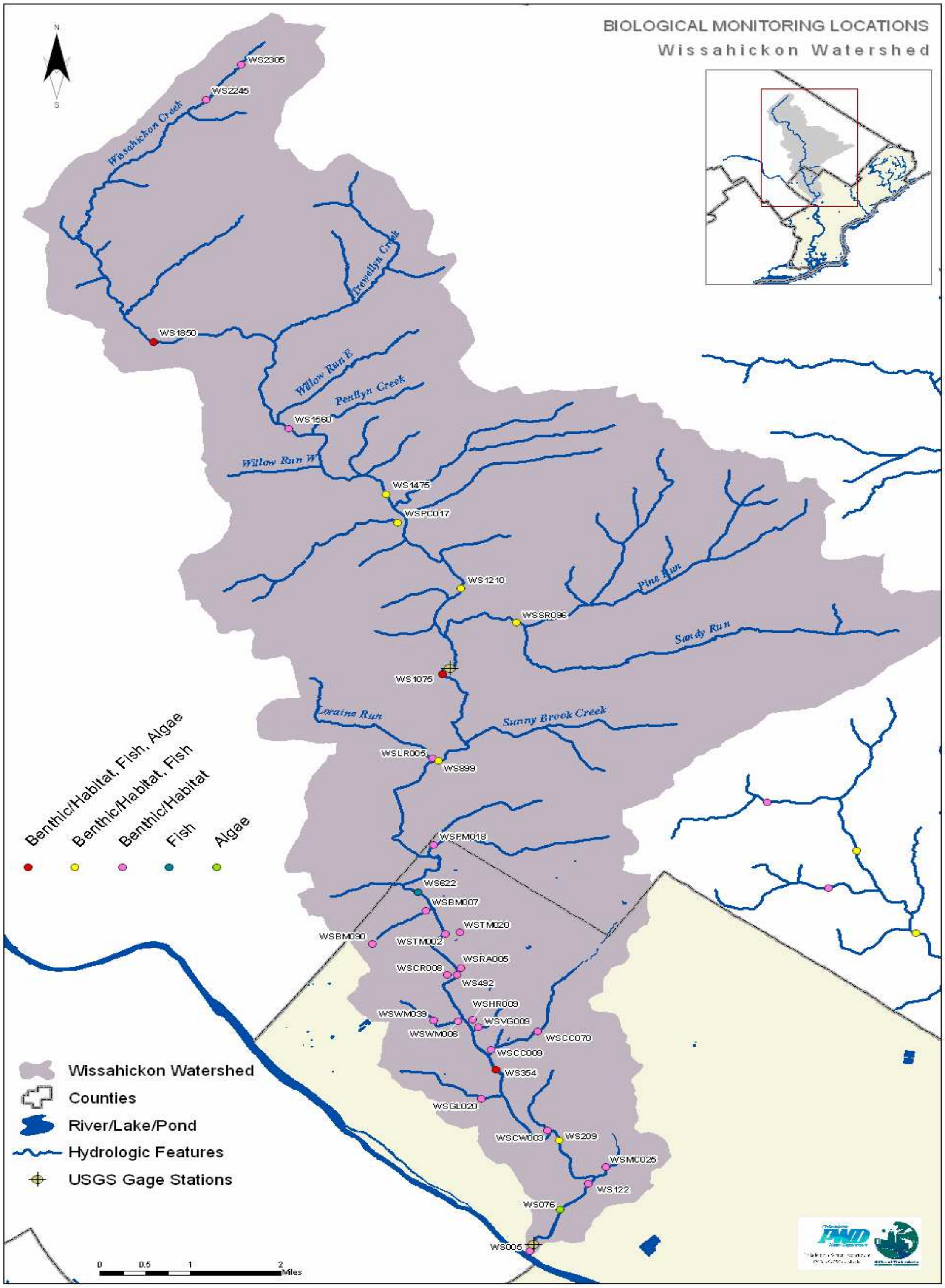
Appendix D, Figure 7 - Chemical monitoring locations in Pennypack Watershed



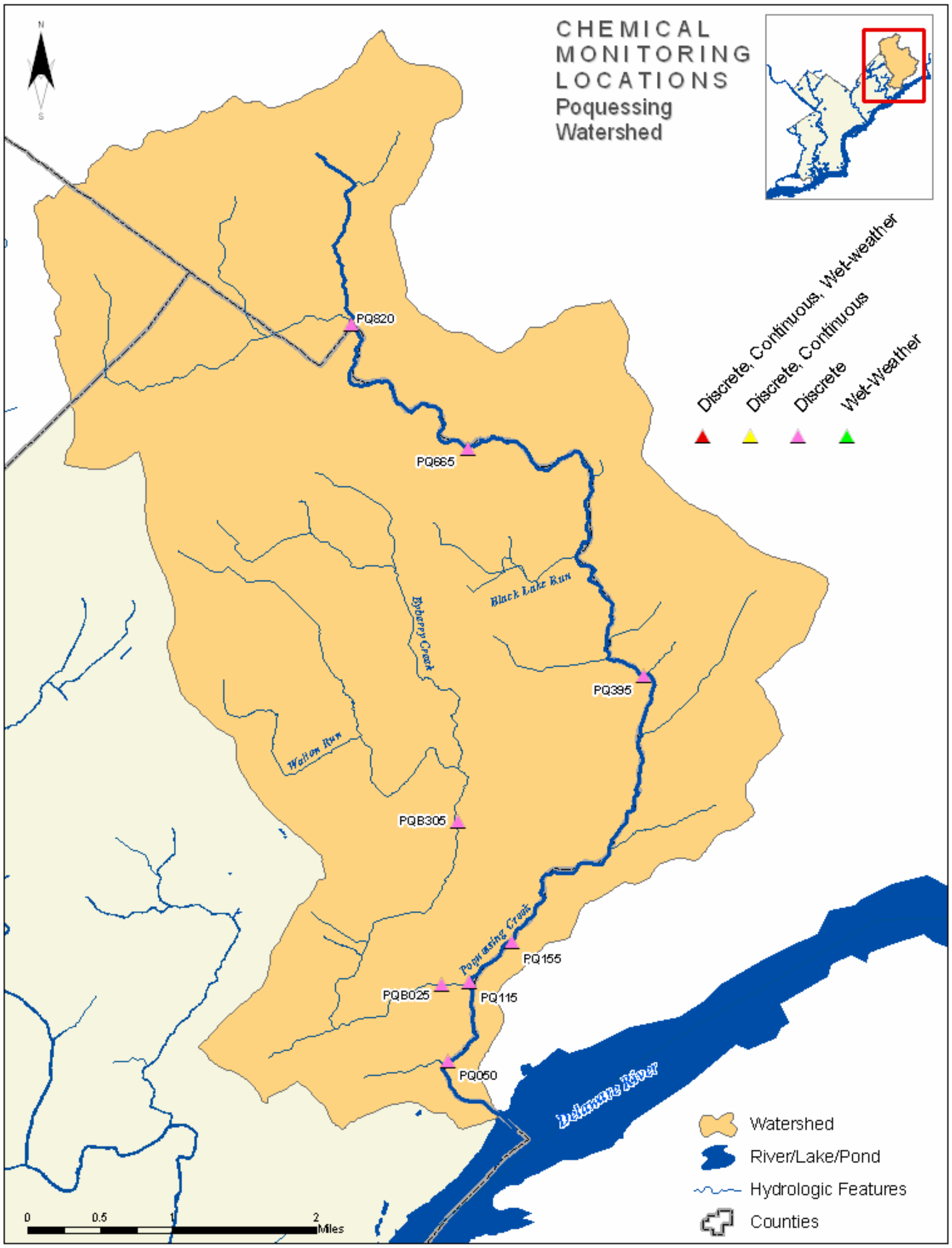
Appendix D, Figure 8 - Biological and physical assessment sites in Pennypack Watershed



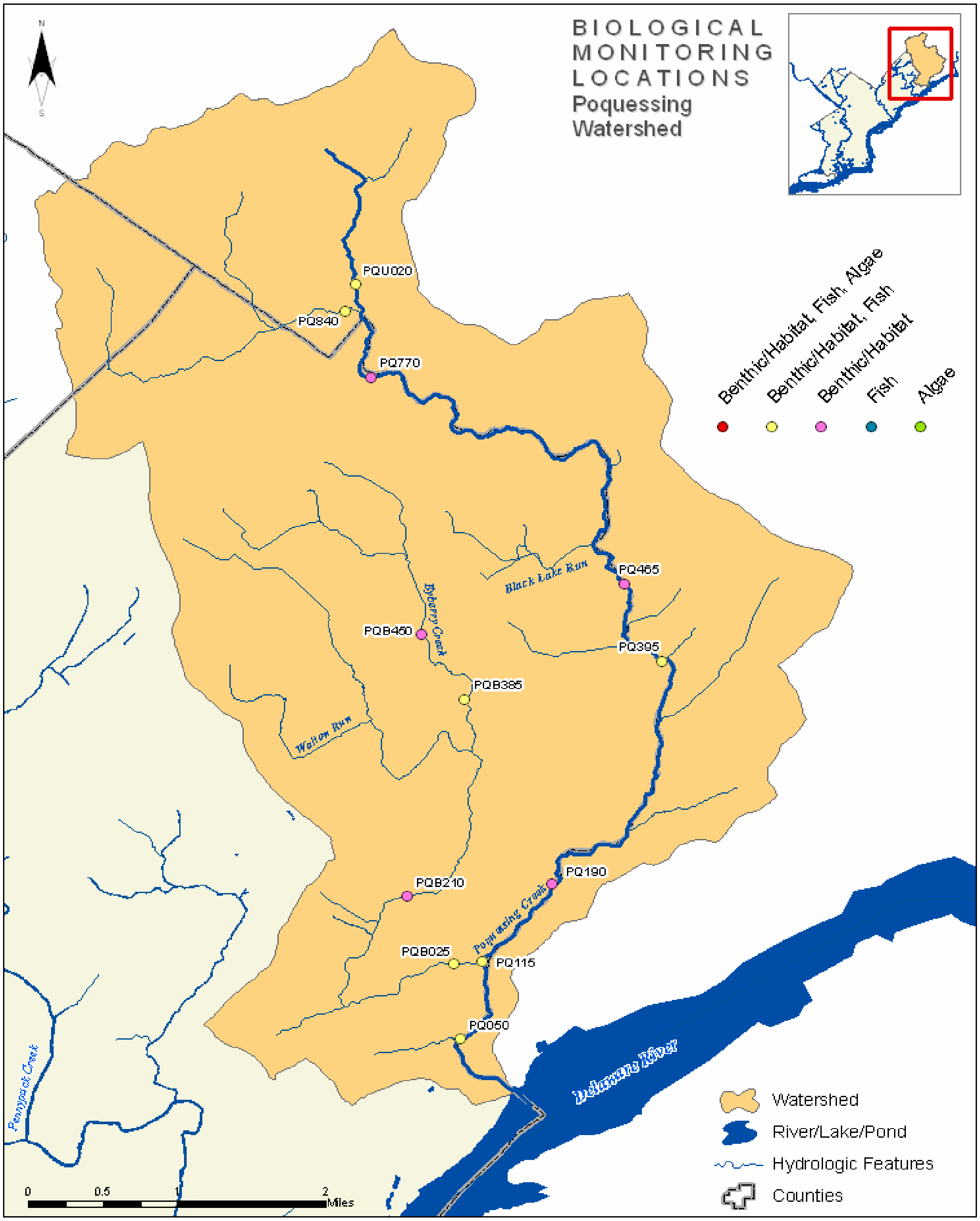
Appendix D, Figure 9 - Chemical monitoring locations in Wissahickon Watershed.



Appendix D, Figure 10 - Biological and physical assessment sites in Wissahickon Watershed

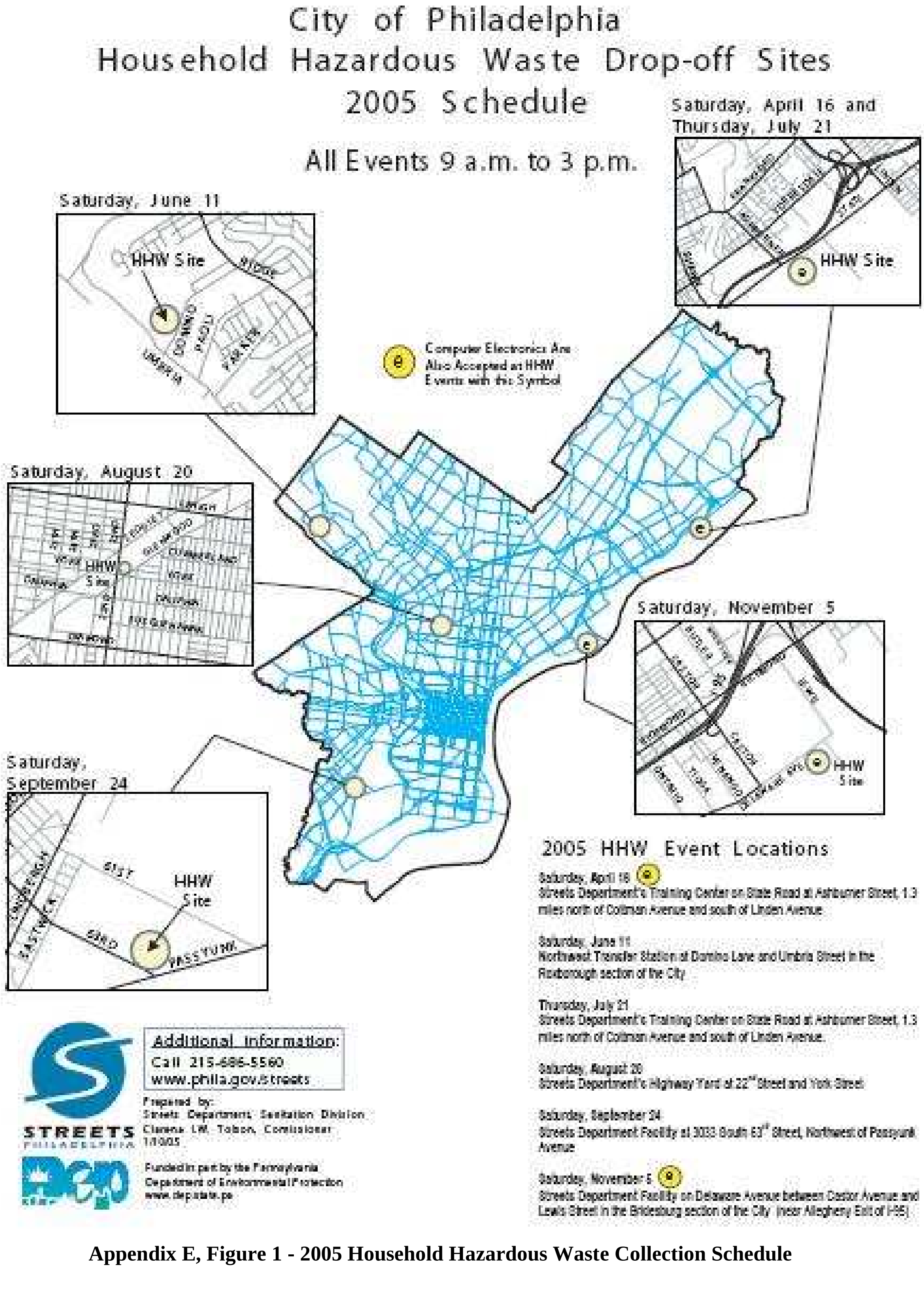


Appendix D, Figure 11 - Chemical monitoring locations in Poquessing-Byberry Watershed

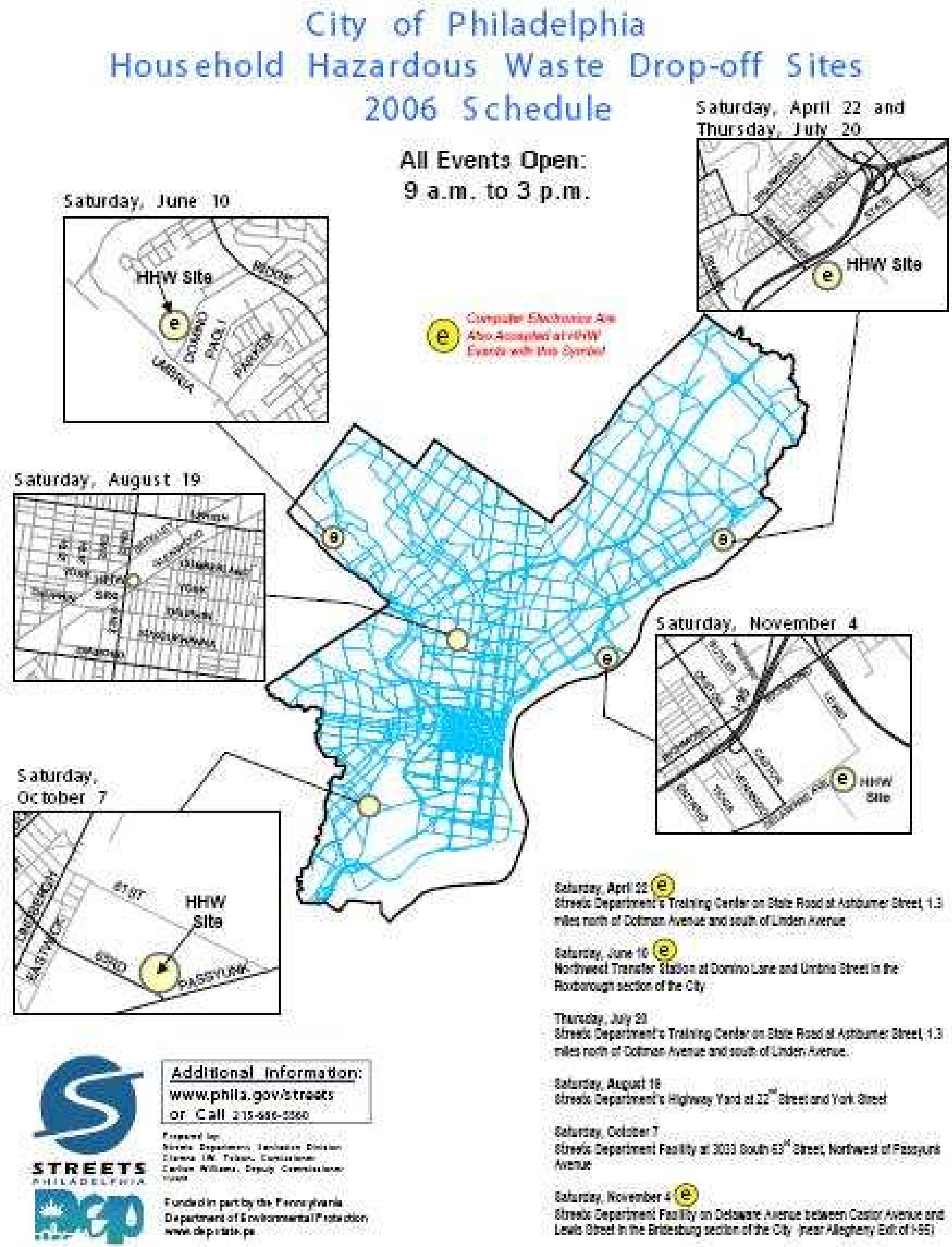


Appendix D, Figure 12 - Biological and physical assessment sites in Poquessing-Byberry Watershed

APPENDIX E – HOUSEHOLD HAZARDOUS WASTE BROCHURES, MAILINGS, ETC.



Appendix E, Figure 1 - 2005 Household Hazardous Waste Collection Schedule



Appendix E, Figure 2 - 2006 Household Hazardous Waste Collection Schedule

City of Philadelphia
Streets Department, Sanitation Division

Typical Materials Accepted at HHW Events

Paint and Paint Related Materials
- Solvent-based paints and stains
- Paint thinner
- Varnish
- Paint stripper and paint brush cleaners

(Note: Latex Paint is not Hazardous)

Lawn and Garden Products
- Pesticides (fungicides, herbicides, insecticides, rodenticides)
- Chemical fertilizers
- Grill type propane cylinders (up to 20 lbs)
- Swimming pool chemicals

Kitchen and Bathroom Products
- Cleaning solvents
- Fire Extinguishers
- Bathroom and tile cleaner
- Toilet bowl cleaner
- Oven cleaners
- Drain cleaners

Automotive Products
- Used motor oil
- Antifreeze
- Lead-acid batteries
- Auto body repair products
- Brake fluid
- Degreasers

Flammable Materials
- Kerosene
- Old gasoline

Other Materials
- PCBs
- Dioxin forming compounds
- Mercury
- Asbestos (non-friable type only**)
- Artists' paints
- Photographic chemicals
- Lead products, including solder, fishing weights, and similar items

Household Batteries
- Rechargeable computer and cell phone batteries
- Button cell batteries used for hearing aids, watches, and calculators

(Note: household batteries size D, C, AA, AAA and 9 volt are not considered hazardous)

Other Household Products
- Moth balls
- Stain and spot removers

e *Computer Electronics Are Also Accepted Only at Selected HHW Events including: April 22, June 10 and November 4*

Note: For disposal of used motor oil call the PADEP Hotline 800-346-4242 to get the location of the nearest used oil collection site or access the PADEP Web Site at: http://www.dep.state.pa.us/dep/deputate/airwaste/wm/Oil/oil.htm

*** For additional information concerning asbestos, contact the City's Health Department at 215-685-7576 or go to www.phila.gov/health (click air management then click asbestos control)*

STREETS PHILADELPHIA

Prepared by:
Streets Department, Sanitation Division

Clarena I. W. Tolson, Commissioner
Carlton Williams, Deputy Commissioner

revised 12-05

Additional Information:
(215) 686-5560
www.phila.gov/streets
www.dep.state.pa.us

Appendix E, Figure 3 - Collection Event Materials List

For dates of drop-off events

and other information about Philadelphia's
Household Hazardous Waste Program:
www.phila.gov/streets
215-686-5560

You can also participate in HHW drop-off events in neighboring counties

Call to learn what household hazardous
waste items they will accept for disposal.

BUCKS COUNTY 215-345-3400
CHESTER COUNTY 610-344-5937
DELAWARE COUNTY 610-892-9627
MONTGOMERY COUNTY 610-278-3618

Protect your family and others

Check your product labels—
because hazardous waste has one or
more of these characteristics:

Toxic: Causes health problems to humans and wildlife—such as: pesticides, antifreeze.
Flammable: Ignites or catches fire easily—such as: gasoline, paint thinner.
Corrosive: Eats away at other materials—such as: strong acids, drain cleaner.
Reactive: Reacts violently with water, other chemicals, air or is shock sensitive—such as: chlorine bleach, pool cleaner.

Remember, latex and other water-based paints are not hazardous waste!

John F. Street
Mayor

STREETS
Clarena I. W. Tolson
Commissioner

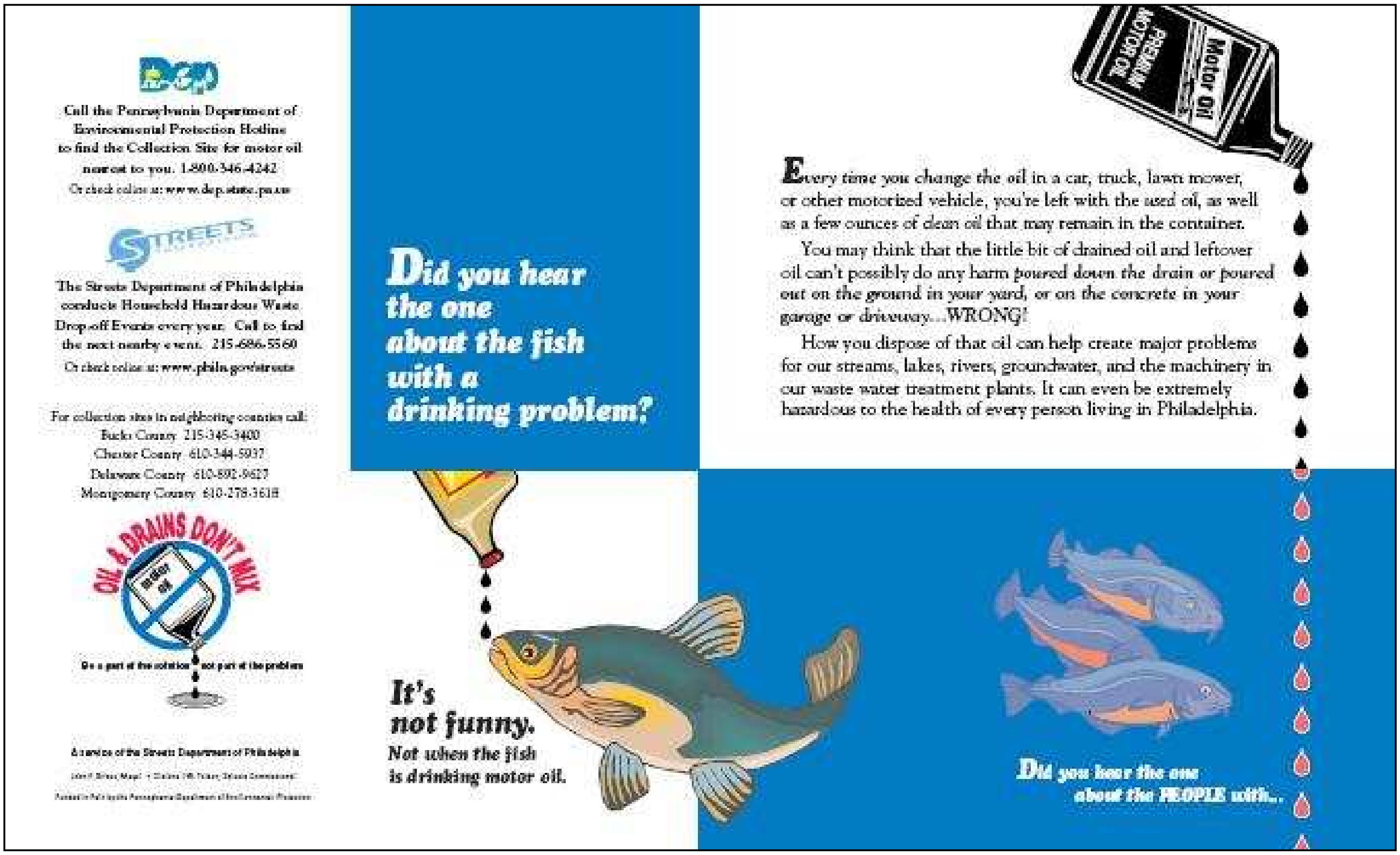
Paid for by a grant from the PA Dept. of Environmental Protection
dep
www.dep.state.pa.us

Printed on Recycled Paper

"Did you see who latex paint is going out with these days?"

Appendix E, Figure 4 - HHW Educational Materials Pamphlet 1

Appendix E, Figure 5 - HHW Educational Materials Pamphlet 2



Appendix E, Figure 6 - HHW Educational Pamphlet

APPENDIX F – MONOSHONE CREEK PROJECT IMPLEMENTATION AND WATER QUALITY ASSESSMENT 1999-2006

EXECUTIVE SUMMARY

The purpose of this report is to both evaluate the impact of completed defective lateral abatements and sewer relining activities in reducing fecal coliform contributions to the Monoshone Creek, and to estimate the additional fecal coliform reductions anticipated from the Saylor Grove Stormwater Wetland BMP, in order to more fully understand the relative value of each approach and to inform future efforts aimed at addressing the problem of fecal coliform concentrations in the Monoshone.

In this report, dry weather fecal coliform data collected at the 7 Monoshone outfalls are analyzed to determine the reductions achieved through defective lateral abatement and sewer relining activities. Since 82 of the 90 abatements performed in the Monoshone were conducted in the sewershed of outfall W-068-04/05, water quality data collected at this outfall is utilized for determining the overall benefit of defective lateral abatements and sewer relining in reducing fecal coliform contributions. After the reductions achieved by these activities are determined for outfall W-068-04/05, the impact of these reductions on fecal coliform concentrations in Monoshone Creek is analyzed. The anticipated dry weather fecal coliform reduction from the Saylor Grove stormwater wetland is then determined and compared with the reductions achieved though the abatements and sewer relining. Wet weather fecal coliform reductions are also estimated for the stormwater wetland and the analysis is then broadened to estimate also the impact of the wetland on total suspended solids concentrations and loadings entering the Monoshone. From this analysis, the following observations were made:

- The 82 defective lateral abatements conducted between 1999 and 2003 in the sewershed of outfall W-068-04/05 have resulted in an 87% or 7/8 log reduction in average fecal coliform *concentrations* and an 88% or 1 log reduction in average fecal coliform *loadings*, a reduction equivalent to 68 billion fewer fecal coliform units each day or 235,532 #/day per $1 of project costs
- The sewer relining completed 2004 in the sewershed of outfall W-068-04/05 resulted in a 50% or 1/3 log further reduction in fecal coliform *concentrations*, and a 44% or ¼ log further reduction in fecal coliform *loadings*, a reduction equivalent to 4.1 billion fecal coliform units/day or 5,663 #/day per $1 of project costs
- A 93% or 1 1/6 reduction in both fecal coliform *concentrations* and *loadings*, equivalent to the removal of an average of 128,000 #/100mL, 72 billion #/day, and 241,200 #/day per $1 of project costs has been achieved as a result of defective lateral abatements and sewer relining
- While fecal coliform concentrations in the headwaters of the Monoshone exceed DEP standards as a result of outfall W-068-04/05, dilution and die-off result in downstream concentrations *consistently* lower than the 2,000 #/100mL non-swimming season standard and concentrations *occasionally* lower than the 200 #/100mL swimming season standard (May-Sept)
- The Saylor Grove stormwater wetland is anticipated to result in a dry weather fecal coliform reduction of 4,081 #/100mL, 1.33 billion #/day, and 2,300 #/day

per $1 spent, values which are much lower than the dry weather reductions achieved through defective lateral abatements or the sewer relining

- Wet weather fecal coliform loading reductions anticipated from the Saylor Grove Wetland BMP, however, exceed the combined dry weather reductions achieved by defective lateral abatements and sewer relining
- Wet weather fecal coliform reductions anticipated from the Saylor Grove wetland are equivalent to 366,213 #/day per $1 spent, about 1.5 times the dry weather reduction value of the defective lateral abatements and sewer relining
- The Saylor Grove wetland is also expected to reduce total suspended solids loadings by about 4.3 tons/yr and reduce the impact of peak flows from outfall W-060-10 to the Monoshone, thereby reducing stream bank erosion and associated suspended solids loadings downstream

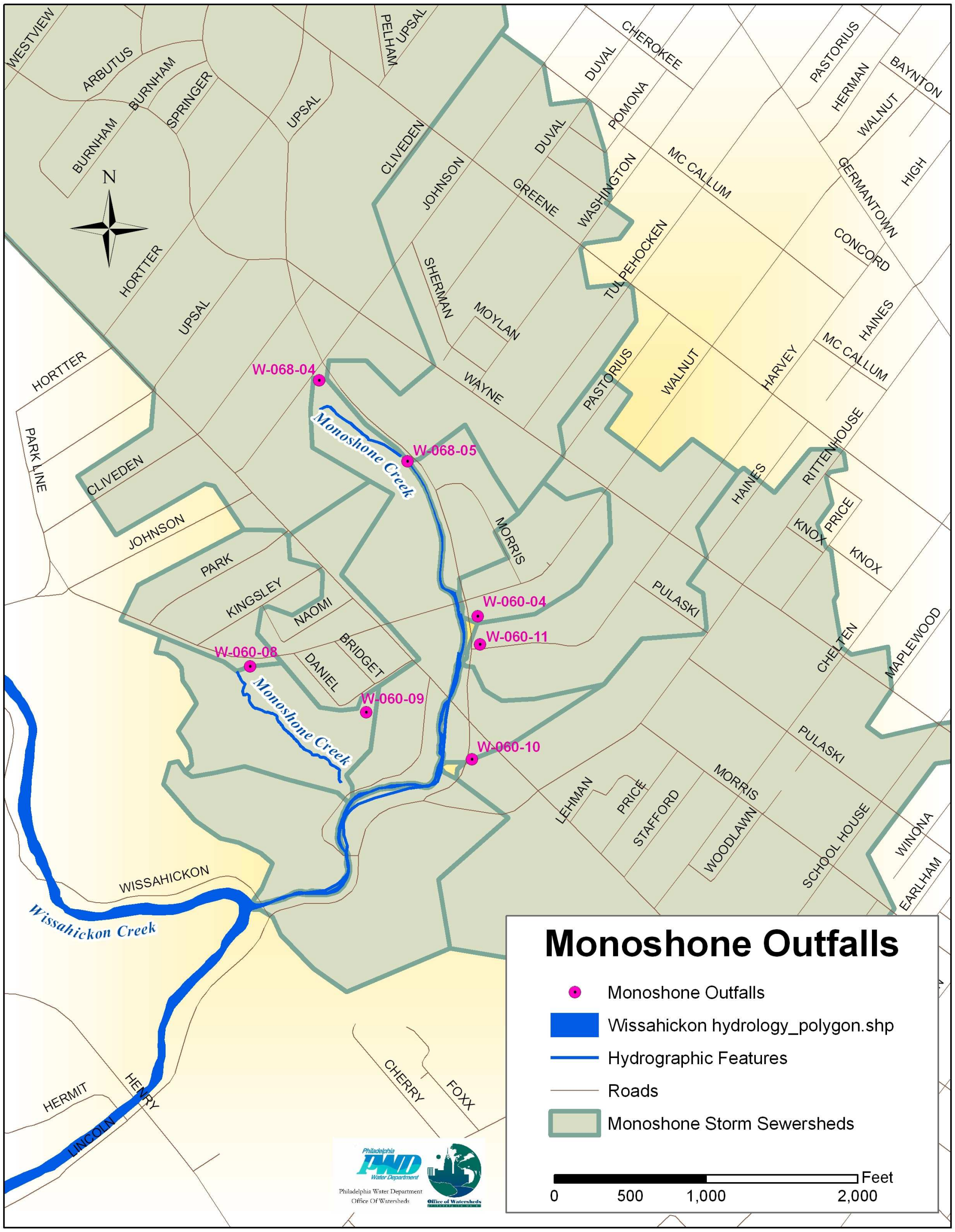
The Defective Lateral Abatement Program (DLAP) has been very successful in reducing dry weather fecal coliform contributions to the Monoshone through defective lateral abatement and sewer relining activities. The implementation of the Saylor Grove wetland is expected to further address the fecal coliform contributions to the Monoshone by treating both dry weather and wet weather contributions from the sewershed of the downstream outfall W-060-10. The analysis conducted in this report shows how both approaches are valuable for addressing the problem of fecal coliform. Furthermore, it is evident that strategic monitoring is required to more accurately determine water quality trends in the Monoshone and to better evaluate the performance of the Saylor Grove wetland. Outfall W-068-04/05 continues to be a significant source of fecal coliform to the Monoshone and innovative treatment solutions may be required to further reduce this impact.

INTRODUCTION

The Saylor Grove Stormwater Treatment Wetland is a 1 acre constructed wetland designed to treat a portion of the stormwater from an underground storm sewer that discharges to the Monoshone Creek. A 48" brick storm sewer collects runoff from a 156-acre drainage area and passes under Saylor Grove Park before discharging through an outfall to the Monoshone Creek. Prior to project implementation, Saylor Grove Park was heavily eroded as a result of stormwater passing through the site from the underground storm sewer, overland flow, and the continuous base flow emerging onto the site from an underground stream. The Saylor Grove wetland project is designed to divert the first flush of each storm through a constructed wetland where the polluted runoff will be treated and then released to the storm sewer that discharges to the Monoshone Creek. Base flow entering the park from Radium Spring supplies the wetland with the continuous flow necessary for sustaining the wetland vegetation.

Seven stormwater outfalls discharge to the Monoshone Creek, identified as W-060-04, W-060-08, W-060-09, W-060-10, W-060-11, W-068-04, and W-068-05 (Appendix F, Figure 1). Runoff passing through the 48" storm sewer underneath Saylor Grove Park discharges to the Monshone through outfall W-060-10. The Industrial Waste Unit (IWU) of PWD has conducted routine monitoring of each of the seven outfalls since 1997 to assess the fecal coliform and fluoride concentrations present in each outfall and to determine the flow rate of the outfall discharge at the time of sampling.

Since 1999, PWD's Defective Lateral Abatement Program (DLAP) has worked to identify the presence of defective laterals in the sewersheds of the Monoshone outfalls and to correct improper connections. A defective lateral, or cross connection, is a commercial or residential sanitary sewer line that is improperly connected to the city's storm sewer infrastructure, resulting in dry weather flow from stormwater outfalls and associated fecal contamination in the receiving streams. Defective laterals are identified through dye testing and then abated by properly connecting the commercial or residential sanitary line to the sanitary sewer, thereby reducing bacterial contamination in the receiving stream.



Appendix F, Figure 1 - Monoshone Creek & Outfalls

One of the primary objectives of the Saylor Grove wetland is to reduce fecal coliform loadings entering the Monoshone from outfall W-060-10. The fecal coliform samples routinely collected from the 7 Monoshone outfalls by IWU provide an indication of the fecal coliform reductions so far achieved through the Defective Lateral Abatement Program. This data will also help determine the relative fecal coliform contributions from outfall W-060-10 in the context of the other Monoshone outfalls and can be utilized to anticipate fecal coliform reductions that will be achieved by the Saylor Grove wetland.

All outfall samples collected by IWU were collected during dry weather conditions. In this report, a sample is considered to be collected during dry weather if the sample was collected more than 12 hours after a rain event of 0.05 inches or greater. Since the evaluation of the benefits of defective lateral abatements and sewer relining in reducing fecal coliform entering the Monoshone will be based exclusively on dry weather data, the initial evaluation of the Saylor Grove wetland will also look at dry weather reduction anticipated from this project even though the actual function of the wetland is to treat stormwater flows. After the project is evaluated based on anticipated dry weather fecal coliform reductions, further analysis will estimate fecal coliform reductions anticipated from the wetland during rain events. Finally, total suspended solids reductions from the Saylor Grove wetland will be estimated since this parameter is also of great importance in stormwater wetland implementation and the evaluation of the anticipated performance of the wetland without consideration of this parameter would provide an incomplete picture of the overall benefit of project implementation.

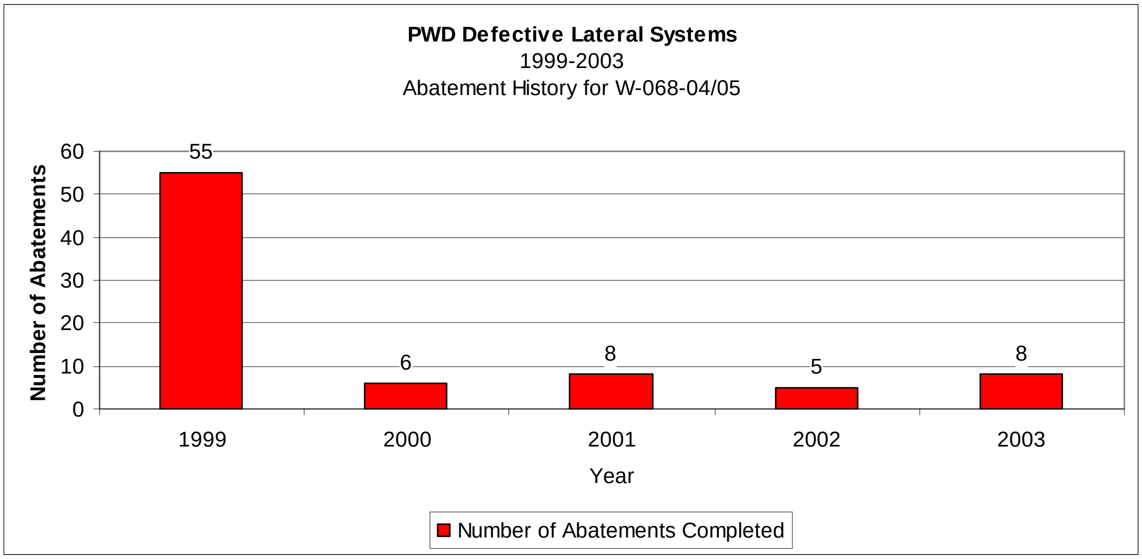
Defective Lateral Abatements in the Monoshone

As of August 2005, 90 defective lateral abatements have been completed within the Monoshone Creek sewersheds. All abatement work completed to date has been conducted within the sewersheds of 4 outfalls, W-060-08, W-060-09, W-060-10, W-068-04, and W-068-05. Since W-68-04 and W-068-05 drain a single sewershed, the DLAP identifies the combined area under the single outfall identification of W-068-05 while IWU continues to sample both outfalls and identifies them separately as W-068-04 and W-068-05. For the purpose of clarity, the combined sewershed is identified consistently in this report as W-068-04/05 and the IWU sampling data for the two separate outfalls are combined accordingly. Appendix F, Table 1 indicates the number of abatements that have been performed in each outfall drainage area to date.

Appendix F, Table 1 - Defective lateral abatements completed in the Monoshone

Outfall	Defective Lateral Abatements
W-060-04	0
W-060-08	1
W-060-09	2
W-060-10	5
W-060-11	0
W-068-04 / W-068-05	82
TOTAL	**90**

Of the 90 defective lateral abatements performed in the Monoshone sewersheds, 82 have been performed in the W-068-04/05 drainage area. Of these 82 abatements, 55 were completed in 1999, with no more than 8 abatements per year being completed in subsequent years (Appendix F, Figure 2). No abatements have been performed in the Monoshone since 2003.

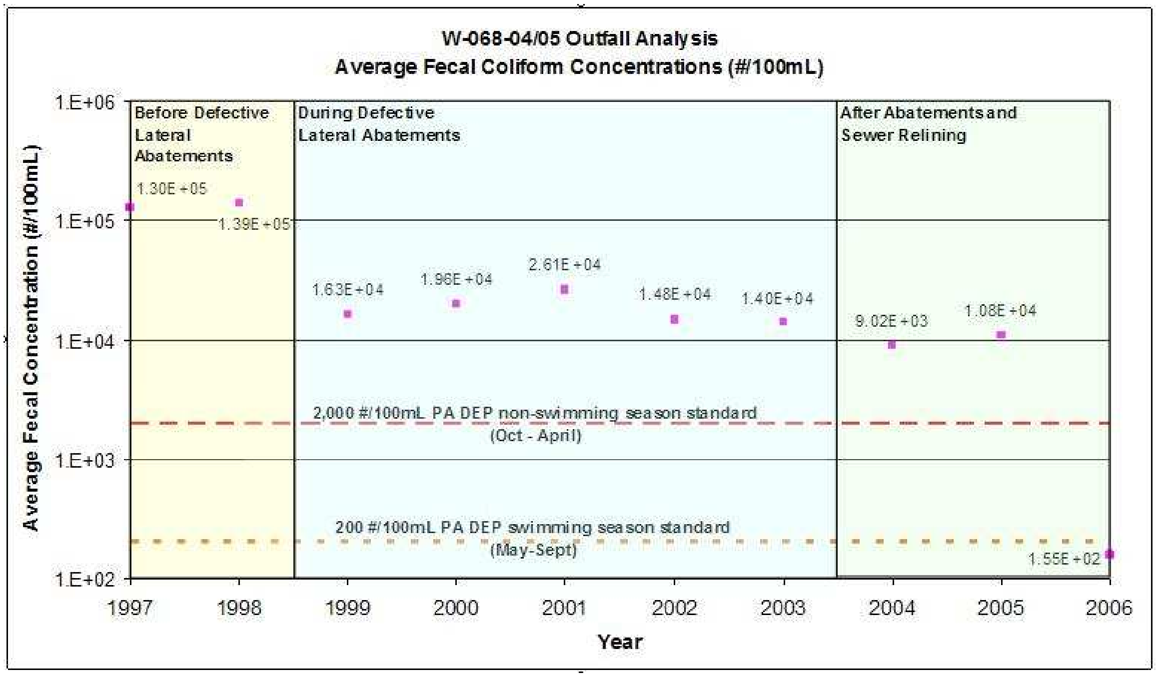


Appendix F, Figure 2 - Abatement History for Outfall W-068-04/05

Since the majority of the defective lateral abatements have been performed in the sewershed of outfall W-068-04/05, the comparison of pre-abatement to post-abatement fecal coliform data from this combined area provides the best indication of the direct benefits achieved in the Monoshone from defective lateral abatements. Prior to 1999, fecal coliform concentrations in W-068-04/05 averaged 137,025 #/100mL. Between 1999 and 2003, during and following the completion of 82 abatements in the same sewershed, concentrations were reduced to an average of 18,481#/100 mL, an 87% or 7/8 log reduction. The most dramatic reduction occurred in 1999, when 55 abatements were performed. The average fecal coliform concentrations observed in the outfall between 1997 and 2003 are depicted in Appendix F, Figure 3 below. Appendix F, Table 2 shows the total number of samples collected at W-068-04/05 per year.

Flow data was collected alongside fecal coliform data between 1997 and 2003, enabling the calculation of fecal coliform loadings from W-068-04/05 during this time period. As a result of defective lateral abatements in this sewershed, average fecal coliform loadings were reduced from 7.74×10^{10} #/day between 1997 and 1998 to 9.34×10^{9} #/day from 1999 to 2003, an 88% or 1 log load reduction equivalent to 68 billion fewer fecal coliform colonies each day. Fecal coliform loadings between 1997 and 2003 are presented in Appendix F, Figure 4.

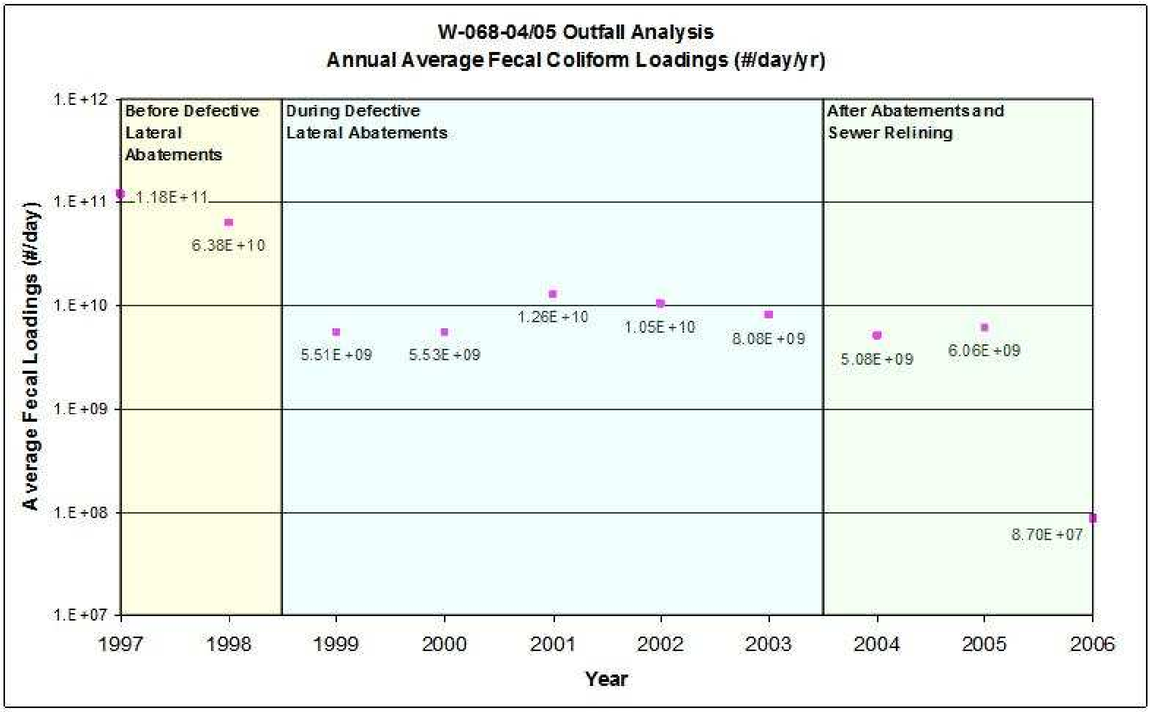
The total cost of the 82 abatements performed in the W-068-05 sewershed was $288,800 with an average cost of $3,565 per abatement. The reduction of approximately 68 billion counts of fecal coliform per day from the 82 abatements performed in the sewershed of outfall W-068-05 is equivalent to the removal of 235,532 counts/day of fecal coliform per $1 spent.



Appendix F, Figure 3 - Average fecal coliform concentrations at W-068-04/05 from 1997-2006

Appendix F, Table 2 - W-068-04/05 samples collected/yr

YEAR	**# samples**
1997	1
1998	3
1999	7
2000	9
2001	9
2002	10
2003	6
2004	34
2005	29
2006	4



Appendix F, Figure 4 - Fecal coliform loadings at W-068-04/05 from 1997-2006

SEWER RELINING IN SEWERSHED OF OUTFALL W-068-05

In the spring of 2004, a project was implemented to address a leak observed in the sanitary sewer under Lincoln Drive in the vicinity of Johnson Street. Inspection of the sewer indicated that a few bricks were missing which resulted in sanitary flow entering the sewershed discharging to the Monoshone through outfall W-068-04/05. The leak was addressed by lining 3,160 feet of the 2'6" brick interceptor sewer under Lincoln Drive from Washington Lane to Arbutus Street. The cost of this project was approximately $729,600 which does not include the $50,000 stream channel restoration conducted at the outfall which was completed under the project scope but not directly related to the relining.

The 2004 and 2005 fecal coliform data collected by IWU reflects a further reduction in fecal coliform at outfall W-068-04/05 as a result of the sewer relining as can be seen from Appendix F, Figure 3 and Appendix F, Figure 4 above. From 1999 to 2003, during which the defective lateral abatements were completed in the sewershed, the average fecal coliform concentration at the outfall was 18,481 #/100mL. From 2004 to 2005, following the sewer relining, average concentrations were reduced to about 9,256 #/100mL, a 50% reduction.

While flow data was not collected during 2004 and 2005 following sewer relining, fecal coliform loadings have been calculated using average flows from 1999-2003. Based on this flow data, this sewer relining resulted in a 44% reduction in daily fecal loadings, the equivalent of removing 4.1 billion fecal coliform colonies per day or 5,663 colonies/day per $1 spent. Since flows were actually reduced following the relining, actual post-project loadings, and therefore overall reductions, are greater than what is reflected in this analysis.

As a result of both defective lateral abatements and sewer relining in the sewershed of W-068-04/05, both fecal concentrations and loadings have been reduced by about 93%. Average fecal coliform concentrations have been reduced by almost 128,000 #/100mL and fecal loadings by over 72 billion #/day, for a total removal of about 241,200 #/day of fecal coliform per $1 spent. Average concentrations and loadings for W-068-04/05 from 1997-2005 are provided in Appendix F, Figure 3 and Appendix F, Figure 4 above and reductions achieved are summarized in Appendix F, Table 3 and Appendix F, Table 4 below.

Appendix F, Table 3 - Fecal coliform concentrations and loadings in W-068-04/05 before and after defective lateral abatements and sewer relining

	Avg Fecal Concentrations (#/100mL)	**Avg Fecal Loadings (#/day)**
Before 1999 (prior to abatements)	137,025	7.74E+10
1999-2003 (following abatements)	18,481	9.34E+09
2004-2006 (following sewer relining)	9,256	5.21E+09

Appendix F, Table 4 - Fecal coliform concentration and loading reductions achieved through defective lateral abatement and sewer relining in outfall W-068-04/05

	Concentration Reductions (#/100mL)		**Loading Reductions (#/day)**	
	%	log	%	log
Defective Lateral Abatements (1999-2003)	87%	7/8	88%	1
Sewer Relining (2004)	50%	1/3	44%	1/4
Total	93%	1 1/6	93%	1 1/6

IMPACTS OF DLAP AND SEWER RELINING ON MONOSHONE CREEK WATER QUALITY

In addition to the outfall sampling conducted by IWU, BLS conducts routine sampling at two in-stream locations on the Monoshone Creek, MONO250 and MONO840. MONO250 is located at Rittenhouse Town just downstream of the W-060-10 outfall and MONO840 is located at Lincoln Drive and Morris Street just downstream of the W-068-04/05 outfall on the Monoshone Creek. Sampling began at MONO250 in April 1999 and samples were collected monthly though 2001 after which quarterly samples have been collected up to the present time. Sampling began at MONO840 in July 2001 and has continued quarterly to the present time with the exception of 6 additional samples collected consecutively on a single day in August 2002. Of the 41 samples collected at MONO250, 23 were collected during dry weather conditions and 18 during wet weather conditions. Of the 19 samples collected at MONO840, 16 were collected during dry weather conditions and only 3 during wet weather. For samples collected in the Monoshone, wet weather samples are considered to be those collected within 36 hrs of a rain event of 0.05 inches or greater. All samples were analyzed for fecal coliform as well as several additional parameters. Appendix F, Table 5 summarizes the number of samples collected during wet and dry conditions from MONO250 and MONO840 between 1999 and 2005.

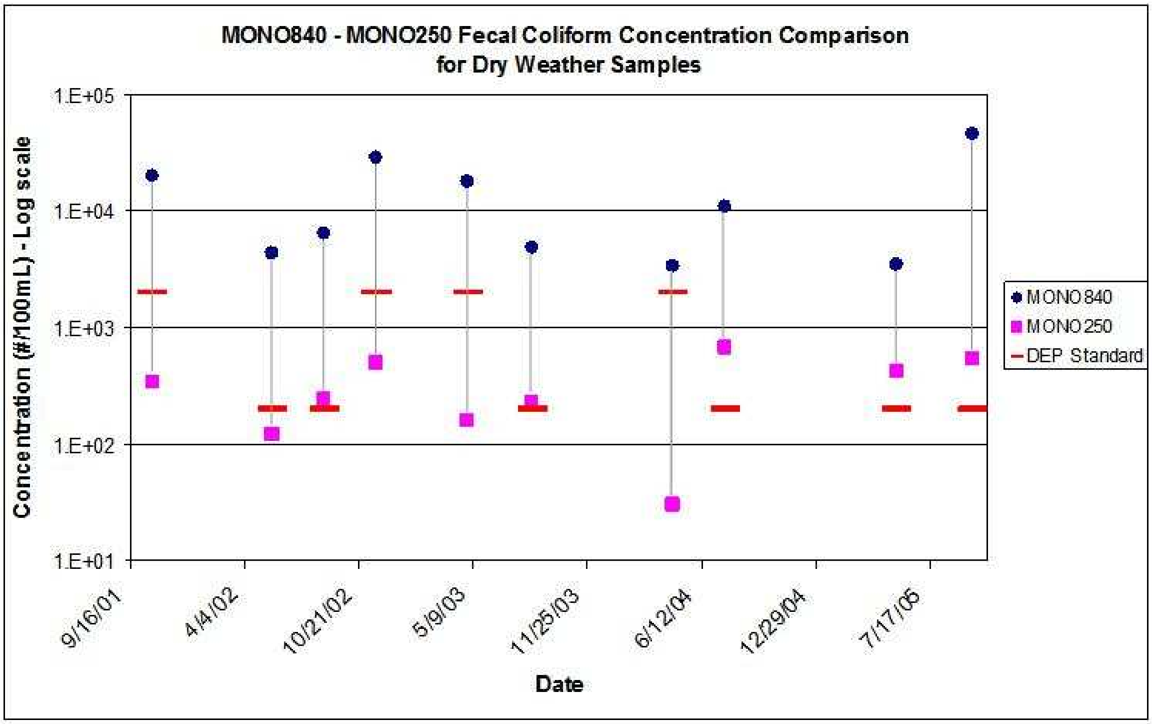
Appendix F, Table 5 - MONO250 and MONO840 samples collected 1999-2005

	MONO250		**MONO840**	
Year	# Dry	# Wet	# Dry	# Wet
1999	5	4	0	0
2000	5	8	0	0
2001	4	4	1	1
2002	3	0	9	0
2003	2	1	2	1
2004	2	1	2	1
2005	2	0	2	0
Total	23	18	16	3

For a variety of reasons the in-stream data collected from the Monoshone does not help in determining the impact of defective lateral abatements or sewer relining on fecal coliform in the Monoshone. The reasons are as follows: 1) neither MONO250 nor MONO840 were sampled prior to 1999 when the majority of the defective lateral abatements were completed; 2) Monoshone sampling is conducted too infrequently to make strong determinations regarding the presence of a downward trend in fecal coliform concentrations; 3) outfall sampling is not conducted in conjunction with Monoshone sampling and therefore the in-stream data cannot be evaluated in the context of the outfall data; and 4) while the fecal coliform concentration data by itself does not show a significant downward trend over the period of time of sampling, without corresponding flow data for the Monoshone it is impossible to determine whether actual fecal coliform counts are decreasing in the Monoshone as a result of these efforts.

While the data collected from MONO840 and MONO250 is not helpful for determining the impact of defective lateral abatements and sewer relining on fecal coliform in the Monoshone, the comparison of data collected from the two Monoshone locations during dry weather do provide some understanding of how the impacts of W-068-04/05 persist downstream. Appendix F, Figure 5 and Appendix F, Table 6 compare dry weather samples from MONO250 and MONO840 and Appendix F, Figure 5 provides the applicable DEP standard for fecal coliform concentrations for each sampling date in the context of recreational human contact. During the swimming season (May 1 – Sept 30), the fecal coliform standard is 200 #/100mL and at other times of the year the standard is 2,000 #/100mL. While these standards are based on the geometric mean of 5 consecutive samples collected on different days during a 30 day period, showing the standard in relationship to single values can be helpful in providing a context for evaluating data which otherwise isn't collected according to the protocols required for a strict application of the standard.

From 2001 to 2005, the time period during which samples were collected for both MONO840 and MONO250, a consistent reduction in fecal coliform concentrations are observed between the two locations on the Monoshone. While concentrations do not follow an identifiable trend at each location between years, from upstream to downstream a consistent reduction between 88 and 99% can be observed, the equivalent of a 1 to 2 log removal with downstream migration. Also, while all 10 MONO840 samples exceed the DEP limit for fecal coliform concentrations in the Monoshone, 4 of the 10 samples collected at MONO250 were below the 200 #/100mL DEP standard for the swimming season and all 10 samples at MONO250 fell below the non-swimming season standard of 2,000 #/100mL. This indicates that while outfall W-068-04/05 continues to significantly impact the headwaters of the Monoshone Creek, fecal coliform concentrations are often reduced to within an acceptable range prior to entering the Wissahickon Creek. This reduction is most likely associated with die-off from sunlight exposure or dilution from downstream outfalls.



Appendix F, Figure 5 - MONO840 - MONO250 Fecal Coliform Concentration Comparison

Appendix F, Table 6 - Dry weather MONO840 and MONO250 fecal coliform concentrations compared (#/100 mL)

Sample Date	MONO840	MONO250	%Reduction	Log reduction	DEP Standard (#/100mL)
10/25/2001	20,000	340	98%	1.77	2,000
5/23/2002	4,400	120	97%	1.56	200
8/22/2002	6,500	240	96%	1.43	200
11/21/2002	29,000	500	98%	1.76	2,000
4/30/2003	18,000	160	99%	2.05	2,000
8/20/2003	4,900	230	95%	1.33	200
4/22/2004	3,400	30	99%	2.05	2,000
7/21/2004	11,000	670	94%	1.22	200
5/18/2005	3,500	420	88%	0.92	200
9/29/2005	46,000	540	99%	1.93	200

FECAL COLIFORM CONTRIBUTIONS FROM MONOSHONE OUTFALLS

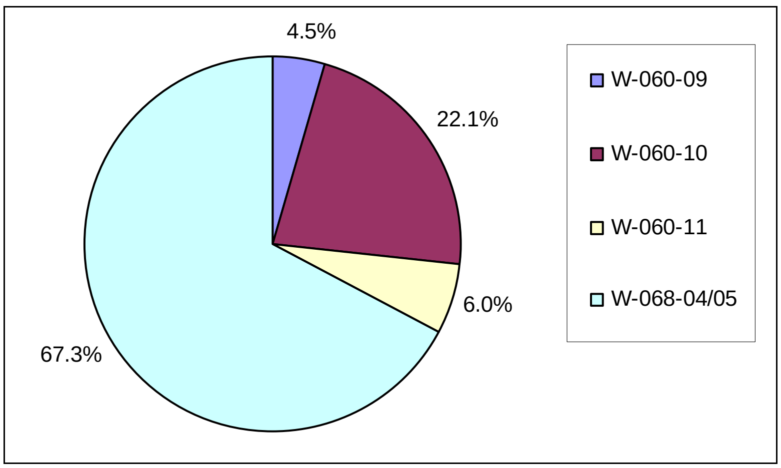
The Saylor Grove Stormwater Wetland is designed to capture and treat the base flow that passes through the site from natural springs, dry weather flow that enters the site from the storm sewer that eventually discharges to outfall W-060-10, and a percentage of the stormwater from the same storm sewer during rain events. A comparison of dry weather fecal coliform contributions from the 7 Monoshone outfalls provides an indication of the significance of implementing a stormwater wetland to treat the W-060-10 discharge as well as the relative significance of this discharge in relation to W-068-04/05 where the majority of the defective lateral abatement and sewer relining activities have been performed to date. Comparing the outfall contributions using data since 2003 provides the best indication of relative contributions of each outfall following the completion of the defective lateral abatements.

Of the 7 Monoshone outfalls illustrated in Appendix F, Figure 1, W-068-04 and W-068-05 drain a single sewershed and are therefore considered as a single outfall (W-068-04/05) and 2 other outfalls have not been sampled since 1999. Consequently, only 4 outfalls are compared in the present analysis.

Appendix F, Table 7 summarizes the loading contributions from each of these outfalls. Appendix F, Figure 6 shows that 67% of the total fecal coliform outfall loading comes from W-068-04/05 and 22% comes from outfall W-060-10. This illustration provides justification for the high priority accorded to W-068-04/05 as well as the present attention being given to W-060-10 through the implementation of the Saylor Grove Stormwater Wetland BMP.

Appendix F, Table 7 - Dry weather fecal coliform loading contributions from Monoshone outfalls since 2003

Outfall	Avg Flow (gal/yr)	Avg fecal conc (#/100mL)	Avg Fecal Loading (#/yr)	# samples
W-060-04	NA	NA	NA	0
W-060-08	NA	NA	NA	0
W-060-09	534,426	7,657	1.55E+11	7
W-060-10	2,940,060	6,794	7.56E+11	12
W-060-11	2,052,168	2,665	2.07E+11	11
W-068-04/05	5,543,669	10,989	2.31E+12	73



Appendix F, Figure 6 - Dry Weather Average Annual Fecal Contributions (#/yr) from Monoshone Outfalls, 2003-2006

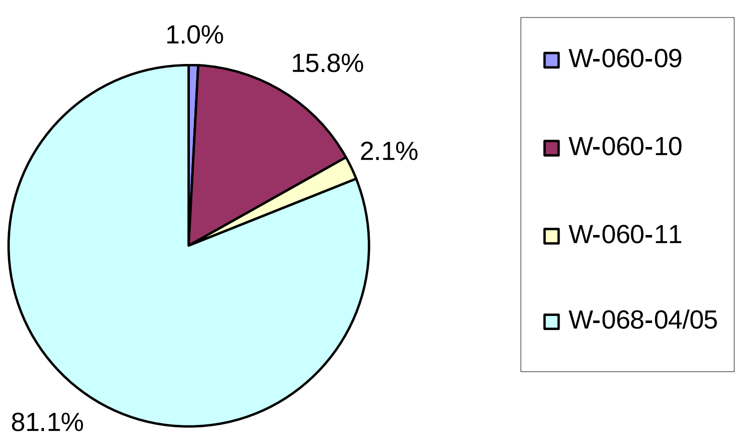
While all outfall samples were collected during dry weather conditions, an estimate of the wet weather contributions of these same 4 outfalls can be made utilizing model predictions for outfall flow, based on drainage area and annual rainfall data (Appendix F, Table 8), and an estimated fecal coliform concentration based on the actual maximum concentrations observed at each outfall during dry conditions (Appendix F, Table 9). Since the Saylor Grove wetland is designed for the treatment of stormwater flows, this assessment allows for the determination of whether estimated wet weather loadings from W-060-10 are significant in relation to the other Monoshone outfalls. Appendix F, Figure 7 illustrates that during rain events W-068-04/05 contributes an even greater percentage of the total outfall loading contribution than during dry weather conditions due to the high fecal concentrations originating from this outfall as well as the tremendous size of its drainage area which is over 3 times greater than the sum of the additional 5 Monoshone outfalls. After W-06/8-04/05, outfall W-060-10 continues to be the next most significant source of fecal coliform loadings to the Monoshone during wet weather, contributing 16% of the total outfall loading.

Appendix F, Table 8 - Estimated outfall discharges modeled using drainage area, precipitation, infiltration, and evapotranspiration

Basin #	Area (ac)	Annual (MG/Y)	Annual (in/Y)
W-068-04/05	717.97	305.2	15.7
W-060-11	38.31	16.2	15.6
W-060-10	138.68	75.2	20.0
W-060-09	17.63	5.3	11.1
W-060-04	9.4	3.5	13.8
W-060-08	17.42	7.5	15.9

Appendix F, Table 9 - Wet weather fecal coliform loading contributions from Monoshone outfalls since 2003

Outfall	Avg WET Flows (gal/yr)	Max fecal conc (#/100mL)	Fecal Loading (#/yr)	# samples
W-060-04	0	NA	NA	0
W-060-08	0	NA	NA	0
W-060-09	5,300,000	40,000	8.03E+12	7
W-060-10	75,200,000	46,000	1.31E+14	12
W-060-11	16,200,000	28,000	1.72E+13	11
W-068-04/05	305,200,000	58,000	6.70E+14	73

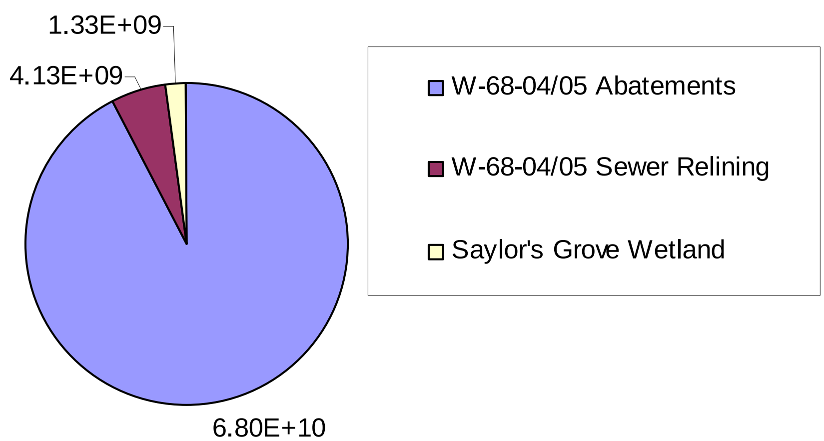


Appendix F, Figure 7 - Wet Weather Average Annual Fecal Contributions (#/yr) from Monoshone Outfalls, 2003-2006

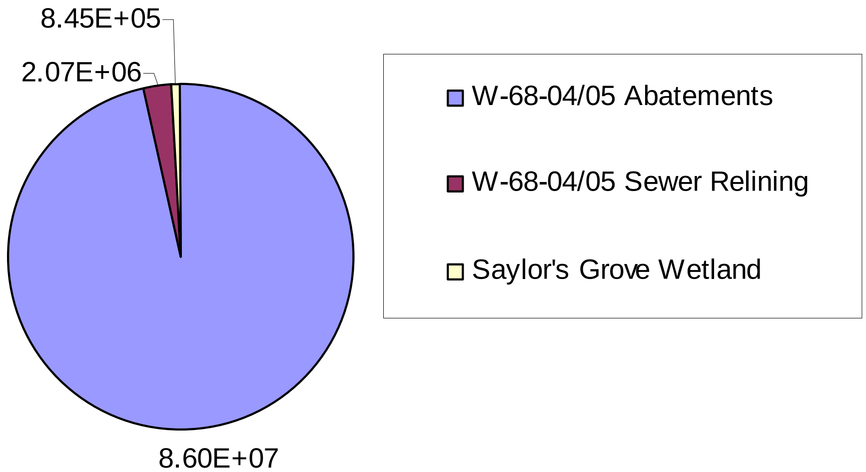
DRY WEATHER FECAL COLIFORM REDUCTIONS FROM SAYLOR GROVE WETLAND

The Saylor Grove Stormwater Wetland is designed to collect and treat 100% of the dry weather flow conveyed through the site and approximately 60% of annual stormwater runoff. The wetland is designed to treat 75% of runoff from a 1" rainfall and 60% of the runoff from a 2" rainfall event. In the W-060-10 sewershed, only 2 events per year would exceed a 2" rainfall event.[1]

The average fecal coliform contribution from W-060-10, based on data collected from 1998 to 2006, is about 4,535 #/100mL or 1.48 billion #/day during dry weather events. Research conducted by Rita Nokes et. Al on water quality improvements associated with wetland treatment has shown that a constructed wetland can reduce fecal coliform concentrations by 99.5% +/- 3% (Nokes et. Al., 2003). From a conservative estimate of 90% fecal coliform removal for the Saylor Grove wetland, dry weather removal is anticipated at 4,081 #/100mL or 1.33 billion #/day. With total project cost of about $575,000, dry weather fecal coliform will be reduced by about 2,300 #/day per $1 spent. Appendix F, Figure 8 and Appendix F, Figure 9 illustrate dry weather fecal coliform loading reductions in outfall W-060-10 anticipated from the Saylor Grove wetland in comparison to the reductions achieved through defective lateral abatements and sewer relining in outfall W-068-04/05. The same data is also presented in Appendix F, Table 10 below.



Appendix F, Figure 8 - Daily dry weather fecal coliform removals from defective lateral abatements, sewer relining, and Saylor Grove Wetland (#/day)



Appendix F, Figure 9 - Annual dry weather fecal coliform removals per project dollar from defective lateral abatements, sewer relining, and Saylor Grove Wetland (#/yr Removed per $1 spent)

Appendix F, Table 10 - Summary of project costs and associated loading reductions

	Costs	Load removal (#/day)	Removal/day/$	Removal/yr/$
W-68-04/05 Abatements	$288,800*	68,021,714,536	235,532	85,969,272
W-68-04/05 Sewer Relining	$729,600	4,131,423,512	5,663	2,066,844
Saylor's Grove Wetland	$575,000	1,330,930,733	2,315	844,852

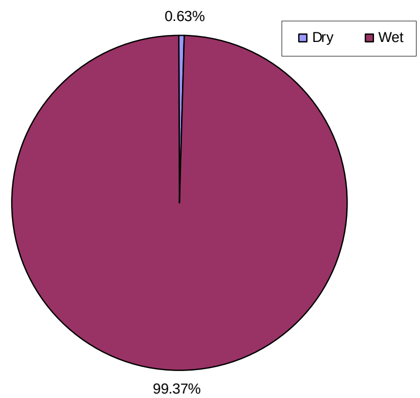
*Abatement costs do not include the cost of dye testing or other activities involved in identifying defective laterals

WET WEATHER FECAL COLIFORM REDUCTIONS FROM SAYLOR GROVE WETLAND

Annual stormwater runoff through W-060-10 is approximately 75.2 MGY (Appendix F, Table 8), and with 60% of the annual runoff passing through the wetland, approximately 45.1 MGY will be treated annually by the wetland.

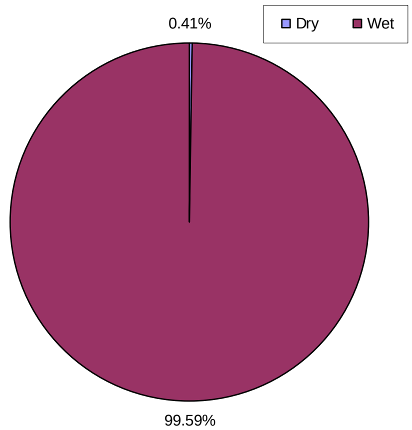
During a 1” rainfall event on 5/20/2005 and a 2” rainfall event on 7/8/2005, ISCO samples were collected from outfall W-060-10 to observe the relationship of fecal coliform concentrations in the outfall to the rise and fall of the hydrograph. The 1” rainfall event showed a peak concentration of 110,000 #/100mL and an event mean concentration of about 20,000 #/100mL. The 2” rainfall had a peak greater than the 200,000 #/100mL and an event mean concentration of about 90,000 #/100mL. The average of all the fecal coliform samples collected during both events was about 50,000 #/100mL. Based on this average wet weather concentration and the 45.1 MGY of stormwater treated annually by the wetland, $2.34x10^{11}$ #/day of fecal coliform enters the wetland during storm events. Using the treatment efficiency of 90%, approximately 45,000 #/100mL or 211 billion #/day will be removed during wet weather events. The wet weather fecal coliform reduction is equivalent to about 366,213 #/day per $1 spent, approximately 1.5 times the removal value of the combined dry weather removal achieved by defective lateral abatement and sewer relining activities in sewershed W-068-04/05.

Appendix F, Figure 10 illustrates the relative wet and dry weather annual fecal coliform loadings that enter the Saylor Grove wetland from the sewershed that eventually discharges through outfall W-060-10. While the dry weather fecal coliform removal anticipated from the wetland is not nearly as significant as what has been achieved through the 82 defective lateral abatements conducted in sewershed W-068-04/05, the real significance of the Saylor Grove wetland is to be found in its performance in the wet weather conditions for which it has been designed.



Appendix F, Figure 10 - Wet vs. dry annual fecal loading contributions to Saylor Grove Wetland

Appendix F, Figure 11 compares the total annual fecal loading from all Monoshone outfalls during dry weather conditions to the annual loading during wet weather conditions. Both Appendix F, Figure 10 and Appendix F, Figure 11 illustrate that while dry weather fecal coliform contributions from outfalls are significant, they are very small in relationship to wet weather fecal coliform contributions. While defective lateral abatement activities address the very real problem of dry weather fecal coliform contributions, Appendix F, Figure 10 and Appendix F, Figure 11 reveal the importance of also addressing wet weather contributions specifically, through implementation of projects such as the Saylor Grove Stormwater Wetland BMP.



Appendix F, Figure 11 - Wet vs. dry total fecal coliform loadings from outfalls on Monoshone, 2003-2006

TOTAL SUSPENDED SOLIDS

While the majority of this report has focused on fecal coliform with the purpose of comparing anticipated reductions from the Saylor Grove wetland to the reductions achieved through defective lateral abatements and sewer relining in outfall W-068-04/05, the full value of the wetland cannot be appreciated without realizing its benefit for other water quality parameters. In the Monoshone and Wissahickon creeks, suspended solid loads, the erosion which increases suspended solids in the watershed, and the peak flows that cause erosion, poses a significant problem. The Saylor Grove wetland is designed to reduce peak flows from the storm sewer connected to outfall W-060-10 and will significantly reduce concentrations of suspended solids (TSS) entering the wetland as well.

While TSS samples are not routinely collected from W-060-10 by IWU during dry weather conditions, TSS was collected during the two rain events previously discussed, on 5/20/2005 and 7/8/2005. During these events, average TSS concentrations were 25.8 mg/L. Taking an estimated treatment efficiency of 80% based on the Nokes et. Al observation of over 83.9% reduction of TSS in constructed wetlands, the Saylor Grove wetland can be expected to remove about 23 mg/L of TSS during storm events, approximately 4.3 tons/yr.

CONCLUSION

The first portion of this report summarized the fecal coliform reductions achieved by the defective lateral abatements and sewer relining in the sewershed of outfall W-068-04/05 in the Monoshone Creek. Since the samples that formed the basis of this analysis were all collected during dry weather conditions, the Saylor Grove wetland fecal coliform reductions were estimated for dry weather conditions for the sake of comparing the anticipated benefits of this project with the previous work completed in the Monoshone. The results of this comparison showed a much more significant reduction in dry weather fecal coliform loadings from defective lateral abatements than from either sewer relining or the anticipated reductions from the stormwater wetland. When the costs of each project were considered, defective lateral abatements achieved 12 times the annual loading removal than the relining and the wetland combined at about half the cost of both the stormwater wetland and the relining. Since the relining was done in the same sewershed as the majority of the defective lateral abatements it was possible to observe the extent to which the relining further reduced fecal coliform loadings, which was certainly noticeable.

While the Saylor Grove estimates for fecal coliform reductions during dry weather are minimal when compared to those achieved by the defective lateral abatements and sewer relining, it is recognized that the purpose of the wetland is to treat stormwater and not dry weather flows and the benefit of such a project is not solely limited to fecal coliform reduction but also addresses water quality parameters such as total suspended solids and reduces downstream erosion resulting from peak flows in the storm sewer. As the Monoshone outfall with the second-highest drainage area, W-060-10 which is treated by the Saylor Grove stormwater wetland is expected to have the second highest wet weather fecal coliform loading after W-068-04/05. Wet weather fecal coliform loading reductions were calculated and exceeded the dry weather reductions achieved by both defective lateral abatements and sewer relining in outfall W-068-04/05. Dry weather fecal coliform loadings entering the wetland were calculated to be almost negligible in comparison to the wet weather loadings. Wet weather TSS reductions for the wetland were also calculated and shown to be significant.

While outfall W-068-04/05 continues to be a major source of fecal coliform for the Monoshone Creek, concentrations are significantly reduced as a result of die-off from sunlight exposure and dilution from downstream outfalls. Consequently, while fecal coliform from this outfall continues to significantly impact the headwaters of the Monoshone, the affect is not likely to be seen in the Wissahickon Creek downstream.

RECOMMENDATIONS AND FUTURE STEPS

While significant progress has been made in reducing fecal coliform contributions to the Monoshone Creek from outfall W-068-04/05 through defective lateral abatements and sewer relining, this outfall continued to discharge concentrations well above the DEP standards of 200 and 2,000 #/100mL. The tremendous size of the sewershed which discharges to this outfall makes further defective lateral identification and abatement very challenging. It is recommended, however, that the results of the above analysis be utilized by DLAP in future prioritization of areas where additional dye testing and abatements are needed.

In addition to future defective lateral abatement activities in the sewershed of outfall W-068-04/05, DLAP is working with the Office of Watersheds (OOW) to pilot the applicability of anti-microbial filtration technology in reducing fecal coliform in stormwater outfalls. OOW has purchased filtration fabric that is surface bonded with an antimicrobial agent which reduces fecal coliform through surface contact. OOW and DLAP are working together to deploy this technology and OOW will be collecting water quality data to evaluate product performance. If this product performs successfully, additional quantities should be purchased and a schedule should be implemented to ensure continues deployment and optimal performance. If the product does not prove effective, other end of pipe technologies should be researched and piloted.

For future characterization of Monoshone Creek water quality it is recommended that more frequent sampling of the Monoshone be conducted, that samples also be conducted just upstream and downstream of the confluence of the Monoshone with the Wissahickon to determine its impact of the Monoshone on the Wissahickon, and to coordinate the in-stream sampling conducted by BLS with the outfall sampling conducted by IWU. More frequent sampling would allow a better determination of water quality trends and the coordination of in-stream with outfall sampling would enable a more thorough evaluation of the direct impacts of the various outfalls on the water quality of the Monoshone Creek.

To determine the actual performance of the Saylor Grove Stormwater Wetland BMP, it is recommended that wet weather monitoring be conducted both at the influent and effluent to the wetland using ISCO automatic samplers. This should being sometime around spring 2007 after the vegetation has had time to grow in the infrastructure issues identified after construction have been resolved. Results from this monitoring will enable the determination of the value of constructing stormwater wetlands for similar applications in other parts of the city.

REFERENCES

1. TRC Omni Environmental Corporation. "Draft Hydrological Study; Saylor Grove Stormwater Wetland". January 2003, p.6
2. Nokes, R.L.; Gerba, C.P.; Karpiscak, M.M. Microbial Water Quality Improvement by Small Scale On-Site Subsurface Wetland Treatment. Journal of Environmental Science and Health. 2003. Vol. A38, No. 9. pp. 1849-1855.
3. Phone conversation with Bill Lucas, TRC Omni Environmental Corporation. May 19, 2006.

APPENDIX G –
CITY OF PHILADELPHIA
STORM WATER MANAGEMENT REGULATIONS

600.0 STORMWATER MANAGEMENT

The Water Department, as authorized by Section 14-1603.1 of the Philadelphia Code, requires the following specifications for stormwater detention and retention systems as of January 1, 2006.

600.1 Definitions

For the purposes of these Regulations, the following words and phrases shall mean and be interpreted pursuant to the below definitions. Whenever any of these words appear in these Regulations in the singular or plural form, the opposite shall also hold as applicable.

(a) Buffer: The area of land immediately adjacent to any surface water body measured perpendicular to and horizontally from the top-of-bank on both sides of a stream that must remain or be restored to native plants, trees, and shrubs.

(b) Design Professional: A licensed professional engineer registered in the Commonwealth of Pennsylvania.

(c) Design Storm: The magnitude and temporal distribution of precipitation from a storm event defined by probability of occurrence (e.g., five-year storm) and duration (e.g., 24-hours), used in the design and evaluation of stormwater management systems.

(d) Developer: Any landowner, agent of such landowner, or tenant with the permission of such landowner, who makes or causes to be made a subdivision of land or land development project prior to issuance of the Certificate of Occupancy.

(e) Development: Any human-induced change to improved or unimproved real estate, whether public or private, including but not limited to land development, construction, installation, or expansion of a building or other structure, land division, street construction, and site alteration such as embankments, dredging, grubbing, grading, paving, parking or storage facilities, excavation, filling, stockpiling, or clearing. As used in these Regulations, development encompasses both new development and redevelopment. It includes the entire development site, even when the project is performed in stages.

(f) Development Site: The specific tract of land where any Earth Disturbance activities are planned, conducted, or maintained.

(g) Diffused Drainage Discharge: Drainage discharge not confined to a single point location or channel, such as sheet flow or shallow concentrated flow.

(h) Directly Connected Impervious Area (DCIA): An impervious or impermeable surface, which is directly connected to the drainage system as defined in the Manual.

(i) Earth Disturbance: Any human activity which moves or changes the surface of land, including, but not limited to, clearing and grubbing, grading, excavation, embankments, land development, agricultural plowing or tilling, timber harvesting activities, road maintenance activities, mineral extraction, and the moving, depositing, stockpiling, or storing of soil, rock or earth materials.

(j) Erosion and Sediment Control Plan: A plan for a project site that identifies stormwater detention and retention structures that will minimize accelerated erosion and sedimentation during the construction phase.

(k) Groundwater Recharge: The replenishment of existing natural underground water supplies without degrading groundwater quality.

(l) Management District: Sub-area delineations that determine peak rate attenuation requirements, as defined in the Manual. Sites located in more than one management district shall conform to the requirements of the district into which the site discharges.

(m) Manual: The most recent version of the Philadelphia Stormwater Management Guidance Manual.

(n) New Development: Any development project that does not meet the definition of redevelopment as defined in these Regulations or any development project at a site where structures or impervious surfaces were removed before January 1, 1970.

(o) Post Construction Stormwater Management Plan (PCSMP): A complete stormwater management plan as described in these regulations and in the Manual.

(p) Predevelopment Condition: For new development, the predevelopment condition shall be the existing condition of the site, and for redevelopment, predevelopment shall be defined according to the procedures found in the Manual.

(q) Redevelopment: Any development on a site that requires demolition or removal of existing structures or impervious surfaces and replacement with new impervious surfaces. This includes replacement of impervious surfaces that have been removed on or after January 1, 1970, with new impervious surfaces. Maintenance activities such as top-layer grinding and re-paving are not considered redevelopment. Interior remodeling projects are also not considered redevelopment.

(r) Stormwater Management Practice (SMP): Any man-made structure that is designed or constructed to convey, store, or otherwise control stormwater runoff quality, rate, or quantity. Typical SMPs include, but are not limited to, detention and retention basins, swales, storm sewers, pipes, and infiltration structures.

(s) Stormwater Pretreatment: Techniques employed to remove pollutants before they enter the SMP, limited to techniques defined and listed as pretreatment in the Manual.

600.2 Regulated Activities

(a) Regulated activities under these Regulations include any development, including new development and redevelopment, that results in an area of earth disturbance greater than or equal to 15,000 square feet. The area of Earth Disturbance during the construction phase determines requirements for both the erosion and sediment controls and the post-construction stormwater management.

(b) The applicability of these Regulations is summarized in the Table of Applicable Stormwater Regulations in Philadelphia.

(c) These Regulations shall apply to the entire development site even if development on that site is to take place in phases.

(d) Existing SMPs may be used on sites where development occurs as long as they meet all of the requirements of these Regulations.

600.3 Exemptions

(a) General Exemptions

The following cases are exempt from the specified requirements of these Regulations.

(1) Development, including new development and redevelopment, that results in an area of Earth Disturbance less than fifteen thousand (15,000) square feet is exempt from all requirements of these Regulations;

(2) Redevelopment that results in an area of Earth Disturbance greater than or equal to fifteen thousand (15,000) square feet, but less than one (1) acre, is exempt from the requirements of Section 600.5(b), Channel Protection Requirement.

(3) Redevelopment that results in an area of Earth Disturbance greater than or equal to one (1) acre and reduces the predevelopment DCIA on the site by at least twenty percent (20%) is exempt from the Channel Protection and Flood Control Requirements of this Regulation.

(b) Exemption Responsibilities

An exemption shall not relieve the Developer from implementing such measures as are necessary to protect public health and safety.

(c) Emergency Exemption

Emergency maintenance work performed for the protection of public health and safety is exempt from the requirements of these Regulations. A written description of the scope and extent of any emergency work performed shall be submitted to the Water Department within two (2) calendar days of the commencement of the activity. If the Water Department finds that the work is not an emergency then the work shall cease immediately and the requirements of these Regulations shall be addressed as applicable.

(d) Special Circumstances

If conditions exist that prevent the reasonable implementation of water quality and /or quantity control practices on site, upon written request by the owner, the Philadelphia Water Department may at its sole discretion accept off-site stormwater management practices, retrofitting, stream restorations, or other practices that provide water quality and /or quantity control equal or greater than onsite practices for the volume which the owner has demonstrated to be infeasible to manage and treat on site.

Table of Applicable Stormwater Regulations in Philadelphia

		Earth Disturbance Associated with Development		
		0-15,000 sq. ft.	15,000 sq. ft.-1 acre	> 1 acre
Section 600.5(a) Water Quality Requirement	New Development	N/A**	Yes	Yes
	Redevelopment	N/A**	Yes	Yes
Section 600.5(b) Channel Protection Requirement	New Development	N/A**	Yes	Yes
	Redevelopment	N/A**	Exempt	Yes (Alternate Criteria)
Section 600.5(c) Flood Control Requirement	New Development	N/A**	Yes	Yes
	Redevelopment	N/A**	Yes (Alternate Criteria)	Yes (Alternate Criteria)
Section 600.6 Nonstructural Project Design Requirement	New Development	N/A**	Yes	Yes
	Redevelopment	N/A**	Yes	Yes
Section 600.8 Post-Construction Stormwater Management Plan Requirement	New Development	N/A**	Yes	Yes
	Redevelopment	N/A**	Yes	Yes

Yes (Alternate Criteria) – requirements of section may be waived depending on post-development site conditions (See Sections 600.3(a)(3), 600.5(b) and 600.5(c) for further details).

N/A - Not Applicable, development project is not subject to requirements of indicated Regulations section. Voluntary controls are encouraged.

Exempt – Development project is not subject to requirements of indicated Regulations section.

**– If the proposed development results in stormwater discharge that exceeds stormwater system capacity, causes a combined sewer overflow, or degrades receiving waters, the design specifications presented in these Regulations may be applied to proposed development activities as warranted to protect public health, safety, or property.

600.4 Erosion and Sediment Control during Earth Disturbance

(a) All Earth Disturbance must comply with the Erosion and Sediment Control requirements of the Pennsylvania Department of Environmental Protection (PADEP) as specified in 25 Pa. Code § 102.4(b).

(b) No Earth Disturbance greater than or equal to fifteen thousand (15,000) square feet and less than 1 acre shall commence until the Water Department approves an Erosion and Sediment Control Plan conforming to the regulations of the PADEP.

600.5 Post-Construction Stormwater Management Criteria

(a) Water Quality Requirement: The Water Quality Requirement is designed to recharge the groundwater table and to provide water quality treatment for stormwater runoff.

(1) The following formula shall be used to determine the water quality volume, (WQv), in cubic feet of storage for the development site.

$$WQ_v = \left(\frac{P}{12}\right) * (I) \qquad \text{Eqn: 600.1}$$

Where:

WQv = Water Quality Volume (cubic feet)

P = 1.0 inch

I = DCIA within the limits of earth disturbance (square feet)

(2) Groundwater Recharge Requirement: In order to preserve or restore a more natural water balance on new development and redevelopment sites, the water quality volume shall be infiltrated on site. A list of acceptable practices for infiltration is provided in the Manual.

(A) The infiltration volume shall be equal to one (1.0) inch of rainfall over all DCIA within the limits of Earth Disturbance.

(B) The Design Professional is required to follow the Hotspot Investigation, Subsurface Stability, and Suitability of Infiltration procedures in the Manual to determine whether the proposed infiltration on the Development Site is appropriate.

(C) If soil investigation reports demonstrate that the soil is unsuitable for infiltration, the Design Professional shall be responsible for providing written documentation to the Water Department showing that the required volume cannot physically be infiltrated within the required time period.

(3) Water Quality Treatment Requirement.

(A) Where it has been demonstrated, in accordance with section 600.5(a)(2) of these Regulations, that a portion or all of the water quality volume cannot be infiltrated on site, the water quality volume which cannot be infiltrated on site must be treated for water quality.

(B) Water quality treatment is attained differently in separate sewer areas than in combined sewer areas. Separate sewer areas achieve water quality treatment through approved stormwater management practices. Combined sewer areas achieve water quality treatment by detaining and releasing stormwater at a specified maximum rate as stated in the Manual.

(b) Channel Protection Requirement: The Channel Protection Requirement is designed to minimize accelerated channel erosion resulting from stormwater runoff from Development Sites.

(1) To meet the Channel Protection Requirement, SMPs shall retain or detain the runoff from all DCIA within the limits of Earth Disturbance from a one-year, 24-hour Natural Resources Conservation Service (NRCS) Type II design storm in the proposed site condition such that the runoff takes a minimum of 24 hours and a maximum of 72 hours to drain from the facility.

(2) Redevelopment sites with less than one (1) acre of Earth Disturbance or redevelopment sites that demonstrate a twenty percent (20%) reduction in DCIA from predevelopment conditions as described in the Manual are exempt from this requirement.

(3) The infiltration and water quality volumes may be incorporated into the channel protection portion of the design provided the design meets all requirements concurrently.

(4) Design criteria and a list of SMPs for channel protection are included in the Manual.

(c) Flood Control Requirement

(1) To prevent flooding caused by extreme events, the City of Philadelphia is divided into Management Districts that require different levels of stormwater attenuation depending on their location. Design Professionals shall determine the appropriate Management District for the development site using the maps provided in the Manual.

(A) The Table of Peak Runoff Rates for Management Districts lists the attenuation requirements for each Management District.

(B) Sites located in more than one Management District shall conform to the requirements of the district where the discharge point is located.

(2) Redevelopment sites that can demonstrate a twenty percent (20%) reduction in DCIA from predevelopment conditions as described in the Manual are exempt from this requirement.

(3) Predevelopment Conditions for Redevelopment are specified in the Manual.

Table of Peak Runoff Rates for Management Districts

District	Column A NRCS Type II 24-hour Design Storm applied to Proposed Condition	Column B NRCS Type II 24 –hour Design Sto applied to Predevelopment Conditio
A	2 – year	1 - year
A	5 – year	5 - year
A	10 – year	10 - year
A	25 – year	25 - year
A	100-year	100-year
B-1	2 – year	1- year
B-1	10 – year	5 - year
B-1	25 – year	10 - year
B-1	50- year	25- year
B-1	100-year	100-year
B-2	2 – year	1- year
B-2	5 – year	2 - year
B-2	25 – year	5 - year
B-2	50- year	10- year
B-2	100 – year	100 - year
C*	Conditional Direct Discharge District	

SMPs shall be designed such that peak rates from Column B are less than or equal to Peak R from Column A.

* In District C, development sites that can discharge directly to the Delaware River main channel or Tidal Schuylkill River major tributary without use of City infrastructure may do s without control of proposed conditions peak rate of runoff. When adequate capacity in the downstream system does not exist and will not be provided through improvements, the propo conditions peak rate of runoff must be controlled to the Predevelopment Conditions peak rate required in District A provisions for the specified Design Storms.

The Predevelopment Condition for new development is the existing condition. For redevelopment purposes, the Predevelopment Condition is determined according to the procedures found in the Manual.

600.6 Nonstructural Project Design and Sequencing to Minimize Stormwater Impacts

(a) A Developer is required to find practicable alternatives to the surface discharge of stormwater, the creation of impervious surfaces, and the degradation of Waters of the Commonwealth.

(b) All development shall include the following steps in sequence to comply with water quality requirements of §14.1603.1 of the Philadelphia Code. The goal of the sequence is to minimize the increases in stormwater runoff and impacts to water quality resulting from the proposed regulated activity.

(1) Prepare an Existing Resource and Site Analysis (ERSA) map and worksheet, showing environmentally sensitive areas including, but not limited to: steep slopes, ponds, lakes, streams, suspected wetlands, hydric soils, vernal pools, land development, any existing recharge areas, and any other requirements of the worksheet available in the Manual;

(2) establish a Buffer by preserving or restoring native plants, trees, and shrubs to the area of land immediately adjacent to any surface water body.

(A) The Buffer shall be a minimum of ten (10) feet on both sides of the stream, measured perpendicular to and horizontally from the top-of-bank.

(B) In the Wissahickon Watershed, there shall be no new impervious ground cover constructed or erected within 200 feet of the bank of a surface water body or within 50 feet of the centerline of a swale.

(3) prepare a draft project layout avoiding the sensitive areas identified in ERSA;

(4) evaluate nonstructural stormwater management alternatives as described in the Manual;

(5) minimize Earth Disturbance during the construction phase;

(6) use site design techniques described in the Manual to minimize the impervious surfaces within the limits of Earth Disturbance;

(7) use techniques in the Manual to minimize DCIA within the limits of Earth Disturbance;

(8) design appropriate detention and retention structures according to the Manual;

(A) meet Water Quality Requirement and provide for Stormwater Pretreatment prior to infiltration or water quality treatment in accordance with the Manual

(B) meet Channel Protection Requirement in accordance with Section 600.5(b) of these Regulations;

(C) meet Flood Control Requirement for the appropriate Management District in accordance with Section 600.5(c) of these Regulations; and

(9) adjust the site design as needed to meet all requirements of the Regulations concurrently.

600.7 Requirements for the Design of SMPs

(a) General Requirements

(1) In order to provide for the protection of public health and safety and to more effectively manage stormwater in Philadelphia, all SMPs shall meet the requirements of these Regulations.

(2) The existing points of concentrated drainage that discharge onto adjacent land shall not be altered in any manner that could cause property damage without written permission of the owner of the adjacent land.

(3) The design of all SMPs shall incorporate sound engineering principles and practices as detailed in the Manual. The Water Department reserves the right to disapprove any design that would result in the creation or continuation of a stormwater problem area.

(4) All stormwater runoff in excess of any volume infiltrated on site must be routed through a dedicated stormwater pipe and conveyed up to the approved connection or point of discharge.

(5) When the Development Site is located within a combined sewer area and adjacent to a receiving water body, stormwater shall be discharged directly to receiving waters after requirements of these Regulations and any applicable state or federal requirements are met.

(6) Areas of existing diffused drainage discharge shall be subject to any applicable discharge criteria in the general direction of existing discharge, whether proposed to be concentrated or maintained as diffused drainage areas, except as otherwise provided by these Regulations. If diffused drainage discharge is proposed to be concentrated and discharged onto adjacent land, the Developer must document that adequate downstream conveyance facilities exist to safely transport the concentrated discharge, or otherwise prove that no erosion, sedimentation, flooding or other impacts will result from the concentrated discharge.

(7) All SMPs shall incorporate maximum ponding and/or draw down requirements consistent with the Manual.

(8) Calculation Methodology: Acceptable calculation methods for the design of SMPs are provided in the Manual.

600.8. PCSMP Requirements

(a) General Requirements

For any activities regulated by these Regulations and the Philadelphia Code Section §14.1603.1:

(1) No zoning permit may be applied for until the Water Department has approved a conceptual site plan.

(2) No Earth Disturbance may commence or Zoning Permit be issued until the Water Department has approved a PCSMP.

(b) Preliminary Approval

In order to obtain preliminary approval from the Water Department, the owner must complete the ERSA worksheet and map and Site Plan Review Meeting with the City as described in the Manual.

(c) PCSMP Approval

(1) The PCSMP shall include a general description of the project, project sequence, calculations, maps and plans as described in Section 600.6(b) of these Regulations. A list of required contents of the PCSMP is located in the Manual.

(2) For any activities that require one or more state or federal permits, proof of application for said permit(s) or approvals shall be part of the plan.

(3) All PCSMP materials shall be submitted to the Water Department in a format that is clear, concise, legible, neat, and well organized; otherwise, the PCSMP shall not be accepted for review and shall be returned to the Developer for revision.

600.9 Permit Requirements by Other Government Entities

(a) Other government entities may require permits for certain regulated Earth Disturbance activities.

(b) Requirements for these permits must be met prior to commencement of Earth Disturbance.

600.10 Inspections

(a) The Water Department or its designee may inspect any phase of the installation of the SMPs.

(b) During any stage of the work, if the Water Department or its designee determines that the SMPs are not being installed in accordance with the approved PCSMP, the Water Department shall issue a “Stop Work Order” until a revised PCSMP is submitted and approved and the deficiencies are corrected.

(c) As-built drawings for all SMPs must be submitted to the Water Department prior to final inspection.

(d) A final inspection of all SMPs shall be conducted by the Water Department or its designee to confirm compliance with the approved PCSMP prior to the issuance of any Certificate of Occupancy.

600.11 Responsibilities for Operations and Maintenance of SMPs

(a) No regulated Earth Disturbance activities shall commence until the Water Department has approved a PCSMP and SMP Operations and Maintenance Plan (O & M Plan), prepared in accordance with the requirements set forth in the Manual, which describes how the post-construction SMPs will be properly operated and maintained.

(b) The O & M Plan must include a signed agreement between the owner and the City to maintain the SMPs in accordance with the O & M Plan.

(c) There shall be no alteration or removal of any SMP required by an approved PCSMP and O & M Plan, and the owner must not allow the property to remain in a condition which does not conform to an approved PCSMP and O & M Plan.

(d) The Water Department reserves the right to accept or reject the operations and maintenance responsibility for any or all of the stormwater controls and SMPs.

600.12 Stormwater Management Easements

(a) Stormwater management easements or right-of-ways are required for all areas used for off-site SMPs or stormwater conveyance, unless a waiver is granted by the Water Department.

(b) Stormwater management easements shall be provided by the owner if necessary for access for inspections and maintenance, or for the preservation of stormwater runoff conveyance, infiltration, detention areas and/or other stormwater controls and SMPs, by persons other than the property owner.

(c) The stormwater management easement and its purpose shall be specified when recorded in accordance with section 600.13 of these Regulations.

600.13 Recording of O& M Plans

(a) The owner of any land upon which SMPs will be placed, constructed or implemented as described in the PCSMP and Operation and Maintenance Plan (O & M Plan), shall record the following documents with the Philadelphia Department of Records, within fifteen (15) calendar days of approval of the PCSMP by the Water Department:

(1) The O & M Plan, or a summary thereof, and

(2) Operations and Maintenance Agreements as included as part of the PCSMP submitted under Section 600.8 and Easements under Section 600.12 of these Regulations.

(b) The Water Department may suspend or revoke any approvals granted for the project site upon discovery of the failure of the owner to comply with these Regulations.

600.14. Prohibited Discharges

(a) No person shall allow, or cause to allow, stormwater discharges into the City's separate storm sewer system which are not composed entirely of stormwater.

(b) In the event that the Water Department determines that any discharge to a storm sewer is not composed entirely of stormwater, the Water Department will notify the responsible person to immediately cease the discharge.

(c) Nothing in this Section shall affect a discharger's responsibilities under state law.

600.15 Prohibited Connections

(a) The following connections are prohibited, except as provided in Section 600.14(a)(1) of these Regulations.

(1) Any drain or conveyance, whether on the surface or subsurface, which allows any non-stormwater discharge including sewage, groundwater, process wastewater, and wash water, to enter the separate storm sewer system.

(2) Any connections to the storm drain system from indoor drains and sinks.

(3) Any drain or conveyance connected from a commercial or industrial land use to the separate storm sewer system that has not been documented in plans, maps, or equivalent records, and approved by the City.

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Bernard Brunwasser
Water Commissioner

Approved as to Form,
Romulo L. Diaz, Jr., City Solicitor

Per:____________________________
Keith J. Jones
Deputy City Solicitor

APPENDIX H – CITY OF PHILADELPHIA – MS4 OUTFALLS

Appendix H, Table 1 - MS4 Outfall Summary

Watershed	Stormwater Outfalls	Subshed/Tributary/Discharge Body	Sewershed Area (acres)	X - Coordinate	Y - Coordinate
Cobbs	A-004-01	Cobbs Creek	2.76	2668521.18086	215803.65877
Cobbs	C-032-01	Indian Creek	6.05	2667114.50719	243017.07214
Cobbs	C-032-02	Indian Creek - West Branch	6.04	2666374.51481	243956.60289
Del_north	D-074-01	Delaware River North	21.03	2731914.31473	262550.63627
Del_north	D-092-05	Delaware River North	211.23	2740847.08658	270295.64228
Del_north	D-093-01	Delaware River North	142.77	2742637.05185	271630.42107
Del_south	D-017-01	Delaware River South	3.34	2702364.21359	219475.33090
Del_south	D-026-01	Delaware River South	3.07	2699716.81191	231727.94895
Del_south	D-026-02	Delaware River South	0.22	2699721.43830	231572.78033
Del_south	D-026-03	Delaware River South	2.63	2699716.57533	231517.09417
Del_south	D-026-04	Delaware River South	4.20	2699744.22198	231024.03275
Del_south	D-026-05	Delaware River South	4.97	2699881.81757	232436.31780
Del_south	D-031-01	Delaware River South	3.96	2700551.59812	235540.32685
Del_south	D-031-02	Delaware River South	6.23	2700218.92882	234075.00318
Del_south	D-031-03	Delaware River South	0.91	2700701.65527	236552.24614
Del_south	D-036-01	Delaware River South	1.72	2700811.75508	238727.93344
Del_south	D-036-02	Delaware River South	1.67	2700882.91763	238899.99288
Del_south	D-036-03	Delaware River South	2.75	2701038.18558	239050.69278
Del_south	D-037-01	Delaware River South	2.72	2704549.03853	242276.53557
Frankford	D-056-09	Frankford Inlet	5.23	2719368.40103	255877.58452
Pennypack	P-082-01	Pennypack Creek	18.61	2732383.68022	269151.50343
Pennypack	P-083-01	Pennypack Creek	5.97	2733439.77613	266643.17226
Pennypack	P-083-02	Pennypack Creek	16.49	2733601.12329	266863.20097
Pennypack	P-083-03	Pennypack Creek	462.09	2735199.92844	268007.34920
Pennypack	P-083-04	Pennypack Creek	140.99	2736388.03302	267625.96411
Pennypack	P-090-01	Sandy Run	7.37	2724118.42219	272227.56496
Pennypack	P-090-02	Sandy Run	1548.66	2724130.22748	272232.56482
Pennypack	P-091-01	Sandy Run	53.75	2725007.39260	271383.41571
Pennypack	P-091-02	Sandy Run	35.29	2725688.47643	271602.75825
Pennypack	P-091-03	Sandy Run	17.11	2725780.72072	271783.40793
Pennypack	P-091-04	Pennypack Creek	39.31	2727185.87376	273604.47773
Pennypack	P-091-05	NLREEP-trib 10	25.87	2728106.98896	273762.10246
Pennypack	P-091-06	Pennypack Creek	228.06	2727917.14900	275646.97019
Pennypack	P-091-07	Pennypack Creek	81.83	2728082.25168	275605.32113
Pennypack	P-091-08	Pennypack Creek	57.63	2728244.43995	271332.45625
Pennypack	P-091-09	Pennypack Creek	60.65	2730869.11752	272716.86587
Pennypack	P-091-10	Pennypack Creek	66.29	2730909.70789	272568.60939
Pennypack	P-091-11	Pennypack Creek	22.72	2731970.80982	273277.95327
Pennypack	P-091-12	Wooden Bridge Run	19.88	2731704.81779	274649.65665
Pennypack	P-091-13	Wooden Bridge Run	7.98	2732264.34762	274394.03181
Pennypack	P-092-01	Crispin Run	4.63	2733753.95537	273429.94226
Pennypack	P-092-02	Crispin Run	8.69	2733727.95202	273544.51961
Pennypack	P-092-03	Crispin Run	5.27	2734720.67876	273687.24446
Pennypack	P-092-04	Crispin Run	6.47	2734736.20161	273733.29774
Pennypack	P-099-01	Sedden's Creek	85.80	2718832.36929	280589.92410
Pennypack	P-099-02	Sedden's Creek	171.95	2718079.41359	280965.13485
Pennypack	P-099-03	NLREEP-trib 13 (Tustin Run)	137.39	2724612.56891	279993.15528
Pennypack	P-099-04	NLREEP-trib 13 (Tustin Run)	25.45	2724807.51123	279964.56545
Pennypack	P-099-05	NLREEP-trib 12 (Tustin Run)	24.47	2725106.96630	278512.97472
Pennypack	P-100-01	Pennypack Creek	26.91	2726718.28740	280894.76010
Pennypack	P-100-02	Pennypack Creek	27.29	2726467.93120	278409.07577
Pennypack	P-100-03	Pennypack Creek	38.64	2726499.56136	278566.35191
Pennypack	P-100-04	NLREEP-trib 11	49.35	2727379.43487	278937.40193
Pennypack	P-100-05	Axe Factory	19.68	2728886.97135	277320.07217
Pennypack	P-100-06	Axe Factory	7.47	2728849.96236	277567.45395

Watershed	Stormwater Outfalls	Subshed/Tributary/Discharge Body	Sewershed Area (acres)	X - Coordinate	Y - Coordinate
Pennypack	P-100-07	Axe Factory	11.62	2729282.38309	277843.01460
Pennypack	P-100-08	Axe Factory	117.90	2729599.98736	278309.98665
Pennypack	P-100-09	Wooden Bridge Run	2.53	2730767.70529	276079.71731
Pennypack	P-100-10	Wooden Bridge Run	5.68	2730834.12616	276061.62727
Pennypack	P-100-11	Wooden Bridge Run	45.54	2730829.73292	276091.95026
Pennypack	P-100-12	Wooden Bridge Run	0.40	2730868.07912	276071.95442
Pennypack	P-100-13	Wooden Bridge Run	13.14	2731557.55216	275205.70486
Pennypack	P-100-14	Wooden Bridge Run	58.16	2731695.32729	275205.65956
Pennypack	P-100-15	Wooden Bridge Run	10.08	2731922.33061	276074.18621
Pennypack	P-100-16	Wooden Bridge Run	56.81	2731904.36895	276154.71596
Pennypack	P-100-17	Wooden Bridge Run	25.35	2732326.20415	276965.62000
Pennypack	P-100-18	Wooden Bridge Run	0.30	2732522.88253	276966.27877
Pennypack	P-100-19	Wooden Bridge Run	9.05	2732368.50463	276955.99563
Pennypack	P-100-20	Wooden Bridge Run	15.45	2732648.74287	277810.64645
Pennypack	P-100-21	Wooden Bridge Run	20.67	2732980.99551	277603.40876
Pennypack	P-100-22	Wooden Bridge Run	6.37	2732708.80014	277994.26605
Pennypack	P-100-23	Wooden Bridge Run	13.00	2732565.80743	278365.26105
Pennypack	P-100-24	Wooden Bridge Run	15.68	2733549.28113	278269.94605
Pennypack	P-100-25	Wooden Bridge Run	9.79	2733615.57225	278268.41202
Pennypack	P-101-01	Wooden Bridge Run	9.49	2734133.68073	279429.80202
Pennypack	P-101-02	Wooden Bridge Run	55.29	2734267.62012	279522.56092
Pennypack	P-103-01	Rockledge Brook	45.13	2717097.00117	286048.51905
Pennypack	P-103-02	Rockledge Brook	6.63	2717131.47966	286122.11749
Pennypack	P-103-03	Rockledge Brook	32.12	2714925.51858	284832.31922
Pennypack	P-104-01	Pennypack Creek	7.75	2718421.96382	287059.96937
Pennypack	P-104-02	Pennypack Creek	22.13	2718482.67172	287106.55848
Pennypack	P-104-03	Pennypack Creek	26.70	2721048.42688	285570.99653
Pennypack	P-104-04	Pennypack Creek	8.61	2721146.45530	285684.88737
Pennypack	P-104-05	Pauls Run	29.77	2721845.33643	286079.56888
Pennypack	P-104-06	Pennypack Creek	57.97	2722048.38165	284810.48564
Pennypack	P-104-07	Slater's Run	137.71	2719453.36530	282295.84142
Pennypack	P-104-08	Pennypack Creek	48.34	2722953.75398	282606.23690
Pennypack	P-104-09	Pennypack Creek	55.02	2722882.36206	282064.36471
Pennypack	P-104-10	Pennypack Creek	36.82	2725597.60715	282101.50202
Pennypack	P-105-01	Wooden Bridge Run	244.20	2729309.17911	282056.66506
Pennypack	P-105-02	Three Springs	92.84	2726094.35784	282134.56628
Pennypack	P-105-03	Wooden Bridge Run	83.37	2730271.61334	284359.62451
Pennypack	P-105-04	Wooden Bridge Run	8.50	2730245.80733	281463.02692
Pennypack	P-105-05	Wooden Bridge Run	8.46	2730130.23207	281389.04669
Pennypack	P-105-06	Three Springs	200.88	2726253.31580	283040.54727
Pennypack	P-105-07	Wooden Bridge Run	21.73	2733886.06478	281455.66188
Pennypack	P-105-08	Wooden Bridge Run	10.10	2733180.67308	281762.15636
Pennypack	P-105-09	Wooden Bridge Run	1.29	2732004.94783	282567.40584
Pennypack	P-105-10	Wooden Bridge Run	4.24	2731940.59400	282580.29479
Pennypack	P-105-11	Wooden Bridge Run	18.00	2731550.28696	283274.37427
Pennypack	P-105-12	Wooden Bridge Run	42.47	2731124.59923	283787.53512
Pennypack	P-105-13	Wooden Bridge Run	15.31	2732462.16329	284523.24492
Pennypack	P-106-01	Wooden Bridge Run	40.09	2735004.26630	281498.61590
Pennypack	P-106-02	Wooden Bridge Run	19.45	2734400.13583	280003.04835
Pennypack	P-108-01	Darlington Run	18.34	2719932.30771	287299.69097
Pennypack	P-108-02	Darlington Run	6.89	2719970.90245	287298.31161
Pennypack	P-108-03	Darlington Run	35.63	2720596.91810	288172.10761
Pennypack	P-108-04	Darlington Run	11.87	2720471.31081	288321.21770
Pennypack	P-108-05	Darlington Run	18.41	2721079.56504	289419.09280
Pennypack	P-108-06	Darlington Run	13.93	2721548.06483	289825.23438

Watershed	Stormwater Outfalls	Subshed/Tributary/Discharge Body	Sewershed Area (acres)	X - Coordinate	Y - Coordinate
Pennypack	P-108-07	Darlington Run	46.20	2721610.08810	289811.41278
Pennypack	P-108-08	Darlington Run	35.10	2720174.23035	289170.92049
Pennypack	P-108-09	Darlington Run	40.39	2721734.56669	290181.56885
Pennypack	P-108-10	Darlington Run	20.99	2722643.76300	290834.07846
Pennypack	P-108-11	Darlington Run	77.17	2722558.97856	291608.44475
Pennypack	P-108-12	Pauls Run	32.10	2722031.58709	286975.49674
Pennypack	P-108-13	Pauls Run	40.17	2722270.28575	287017.80109
Pennypack	P-108-14	Pauls Run	72.20	2722821.00774	287606.71120
Pennypack	P-108-15	Pauls Run	24.65	2723084.95439	287344.06520
Pennypack	P-108-16	Pauls Run	76.91	2724440.23077	287791.31623
Pennypack	P-108-17	Pauls Run	32.19	2724417.21386	287842.69440
Pennypack	P-108-18	Pauls Run	8.62	2724915.53158	288195.28042
Pennypack	P-108-19	Pauls Run	11.38	2725851.84100	288102.26998
Pennypack	P-108-20	Pauls Run	47.40	2726418.88596	288183.17594
Pennypack	P-108-21	Pauls Run	74.77	2726428.88769	288295.90441
Pennypack	P-108-22	Pauls Run	2.10	2725178.34311	289811.81572
Pennypack	P-108-23	Pauls Run	15.76	2725342.49210	290060.00632
Pennypack	P-108-24	Pauls Run	97.70	2725548.70699	290783.80106
Pennypack	P-109-01	Pauls Run	123.74	2728391.82045	290534.26154
Pennypack	P-109-02	Pauls Run	11.32	2729089.37295	290179.12630
Pennypack	P-109-03	Pauls Run	6.34	2729120.63908	290115.65587
Pennypack	P-109-04	Pauls Run	62.05	2728591.49117	289225.39249
Pennypack	P-109-05	Pauls Run	39.34	2728066.85906	290144.17494
Pennypack	P-109-13	Wooden Bridge Run	213.84	2731886.02419	286585.61992
Pennypack	P-109-x	Pauls Run	5.06	2728195.95841	290177.47331
Pennypack	P-112-01	Darlington Run	26.03	2723316.81480	292093.33771
Pennypack	P-112-02	Darlington Run	29.89	2723365.86113	292003.35061
Pennypack	P-112-03	Darlington Run	235.68	2724206.09997	293421.01138
Pennypack	P-112-04	Darlington Run	40.33	2723841.36120	292988.77120
Pennypack	P-112-05	Darlington Run	12.48	2723895.11359	292952.41027
Pennypack	P-113-01	Pauls Run	55.29	2730434.36162	291422.92201
Pennypack	P-113-02	Pauls Run	1.55	2730550.10331	291466.39913
Pennypack	P-113-03	Pauls Run	16.37	2730737.59735	292299.34126
Pennypack	P-113-04	Pauls Run	282.09	2730986.66614	292845.35083
Pennypack	P-113-05	Pauls Run	0.65	2729286.15605	292171.20095
Pennypack	P-113-06	Pauls Run	41.76	2731047.28007	292783.38937
Pennypack	P-113-07	Pauls Run	64.70	2729204.91824	292209.14400
Pennypack	P-113-08	Pauls Run	156.48	2729160.38260	292950.73720
Pennypack	P-113-12	Pauls Run	1.98	2729268.01271	292231.01064
Pennypack	P-113-13	Pauls Run	0.52	2729303.97121	292212.22287
Pennypack	P-116-01	Huntington Valley Creek	37.72	2727760.44724	299126.52693
Pennypack	P-116-02	Huntington Valley Creek	68.92	2726513.51036	297901.59234
Poquessing	Q-101-03	Byberry Creek	177.50	2735915.17469	276144.40043
Poquessing	Q-101-04	Byberry Creek	46.37	2736976.81962	276697.70846
Poquessing	Q-101-05	Byberry Creek	88.49	2738502.15614	278206.16945
Poquessing	Q-101-06	Byberry Creek	2.39	2738616.81657	278227.29273
Poquessing	Q-101-07	Byberry Creek	36.64	2739577.10610	277546.29305
Poquessing	Q-101-08	Byberry Creek	8.50	2739467.70958	277624.20652
Poquessing	Q-101-09	Poquessing Creek	221.69	2740126.00054	275564.83408
Poquessing	Q-101-10	Poquessing Creek	20.84	2740902.19037	275672.17148
Poquessing	Q-101-11	Poquessing Creek	25.10	2741747.77474	275929.03823
Poquessing	Q-101-12	Poquessing Creek	0.44	2741796.20114	275868.66846
Poquessing	Q-101-13	Byberry Creek	7.78	2740803.81331	278326.42147
Poquessing	Q-101-14	Byberry Creek	5.90	2741005.85942	278393.32904
Poquessing	Q-101-15	Byberry Creek	4.68	2741175.98412	278471.03618

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Poquessing	Q-101-16	Byberry Creek	5.60	2741353.73189	278578.27710
Poquessing	Q-101-17	Byberry Creek	29.34	2741543.80154	278785.54490
Poquessing	Q-101-18	Byberry Creek	6.27	2741604.16879	278732.20353
Poquessing	Q-101-19	Byberry Creek	15.41	2741901.45308	278879.09837
Poquessing	Q-101-20	Byberry Creek	51.36	2736032.63606	276638.41362
Poquessing	Q-102-01	Poquessing Creek	17.95	2743372.44784	278613.13920
Poquessing	Q-102-02	Poquessing Creek	36.28	2743260.42167	276724.59024
Poquessing	Q-102-03	Poquessing Creek	28.88	2742564.73188	276103.50818
Poquessing	Q-102-04	Poquessing Creek	8.90	2742781.97369	274799.91123
Poquessing	Q-102-05	Poquessing Creek	5.81	2743231.25606	274515.60133
Poquessing	Q-102-x	Poquessing Creek	7.92	2742292.35232	275115.88308
Poquessing	Q-106-03	Byberry Creek	69.63	2739550.79823	280438.76262
Poquessing	Q-106-04	Byberry Creek	29.99	2739636.48442	280312.84801
Poquessing	Q-106-05	Byberry Creek	24.45	2739894.48288	281225.72076
Poquessing	Q-106-06	Byberry Creek	9.94	2739977.44697	281146.05085
Poquessing	Q-106-07	Byberry Creek	5.09	2740345.92579	281343.83199
Poquessing	Q-106-08	Byberry Creek	15.93	2740750.95679	281399.36318
Poquessing	Q-106-09	Byberry Creek	10.15	2740853.15135	281389.67914
Poquessing	Q-106-10	Byberry Creek	2.66	2740992.53108	281463.53666
Poquessing	Q-106-11	Byberry Creek	5.03	2741339.72690	281447.02782
Poquessing	Q-106-12	Byberry Creek	23.68	2741731.16187	281480.19088
Poquessing	Q-106-13	Byberry Creek	20.95	2742124.60265	282069.92623
Poquessing	Q-106-14	Byberry Creek	7.79	2742270.13133	282014.52330
Poquessing	Q-106-15	Byberry Creek	23.34	2742215.59251	281974.77386
Poquessing	Q-106-16	Byberry Creek	10.69	2742318.86639	282297.95221
Poquessing	Q-106-17	Byberry Creek	8.95	2742451.98512	282783.39646
Poquessing	Q-106-18	Byberry Creek	19.22	2742731.70801	283137.70609
Poquessing	Q-106-19	Byberry Creek	4.26	2742798.67395	283385.76387
Poquessing	Q-106-20	Byberry Creek	3.38	2742856.33210	283646.24072
Poquessing	Q-106-21	Byberry Creek	82.80	2739795.45056	282790.27079
Poquessing	Q-106-22	Byberry Creek	17.50	2741374.05109	281517.15519
Poquessing	Q-107-01	Poquessing Creek	19.39	2746870.29341	283062.24019
Poquessing	Q-107-02	Poquessing Creek	208.23	2745791.45127	282749.18624
Poquessing	Q-107-03	Poquessing Creek	6.81	2745968.33081	282427.33444
Poquessing	Q-107-04	Poquessing Creek	8.41	2745545.25074	281299.44702
Poquessing	Q-107-05	Poquessing Creek	27.48	2744852.48806	281114.64756
Poquessing	Q-107-06	Poquessing Creek	44.33	2744890.14089	280578.51498
Poquessing	Q-107-07	Byberry Creek	45.95	2743039.13998	278859.16783
Poquessing	Q-109-06	Waltons Run	64.27	2734403.43220	288763.13546
Poquessing	Q-109-07	Waltons Run	237.31	2734306.58919	290053.09371
Poquessing	Q-110-01	Waltons Run	33.61	2736229.27424	288410.14618
Poquessing	Q-110-02	Waltons Run	34.85	2739434.08252	287766.45845
Poquessing	Q-110-03	Waltons Run	51.21	2739377.66025	287721.53901
Poquessing	Q-110-04	Waltons Run	21.65	2739811.67033	287341.81420
Poquessing	Q-110-05	Waltons Run	113.00	2739580.77221	285884.23399
Poquessing	Q-110-06	Waltons Run	51.70	2740125.90366	285559.42620
Poquessing	Q-110-07	Waltons Run	14.36	2740808.29752	285838.30426
Poquessing	Q-110-08	Waltons Run	10.76	2742053.75713	287403.93543
Poquessing	Q-110-09	Waltons Run	32.86	2742081.28821	287469.95509
Poquessing	Q-110-10	Waltons Run	8.76	2742392.71574	286884.17503
Poquessing	Q-110-11	Byberry Creek	77.26	2743116.46343	287373.01468
Poquessing	Q-110-12	Byberry Creek	8.30	2742927.01152	287759.09407
Poquessing	Q-110-13	Byberry Creek	20.04	2742785.09186	288422.01666
Poquessing	Q-110-14	Byberry Creek	45.17	2742843.93318	288461.16339
Poquessing	Q-110-15	Byberry Creek	81.72	2743180.65146	286087.03506

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Poquessing	Q-110-16	Byberry Creek	27.45	2742678.23879	284949.32035
Poquessing	Q-110-17	Byberry Creek	63.20	2742899.64368	284480.93191
Poquessing	Q-110-18	Byberry Creek	15.21	2742865.31392	284125.64501
Poquessing	Q-110-19	Byberry Creek	5.93	2742648.33245	284166.65758
Poquessing	Q-110-20	Byberry Creek	48.53	2742577.33409	284092.66798
Poquessing	Q-110-21	Waltons Run	77.27	2736268.25460	288456.02635
Poquessing	Q-113-09	Waltons Run	137.19	2732853.44383	294643.90995
Poquessing	Q-113-10	Waltons Run	19.03	2732582.54792	293293.79079
Poquessing	Q-113-11	Waltons Run	17.94	2735594.09961	293627.39598
Poquessing	Q-114-01	Wilsons Run	23.65	2736641.72379	295085.00855
Poquessing	Q-114-02	Waltons Run	100.41	2736984.03069	292751.94527
Poquessing	Q-114-03	Waltons Run	39.56	2737855.57234	292099.92372
Poquessing	Q-114-04	Waltons Run	33.18	2737816.53210	291501.84139
Poquessing	Q-114-05	Waltons Run	18.91	2738255.24888	290332.29020
Poquessing	Q-114-06	Waltons Run	62.13	2739521.57189	290252.76087
Poquessing	Q-114-07	Byberry Creek	53.63	2741113.49121	291405.68693
Poquessing	Q-114-08	Byberry Creek	24.36	2741345.15964	290961.92112
Poquessing	Q-114-09	Byberry Creek	16.94	2741268.14401	291018.19844
Poquessing	Q-114-10	Byberry Creek	31.22	2741923.65802	290263.95405
Poquessing	Q-114-11	Byberry Creek	25.82	2742156.58794	289690.89764
Poquessing	Q-114-12	Byberry Creek	50.83	2742872.03216	289508.18536
Poquessing	Q-114-13	Byberry Creek	7.96	2742959.68354	289342.69437
Poquessing	Q-114-14	Byberry Creek	4.90	2742868.72138	289128.30431
Poquessing	Q-114-15	Waltons Run	33.50	2736901.38459	292910.37534
Poquessing	Q-114-16	Waltons Run	23.89	2736861.10294	292856.88287
Poquessing	Q-114-17	Waltons Run	7.95	2738280.70495	290384.40514
Poquessing	Q-114-18	Byberry Creek	51.65	2741305.74074	291885.86027
Poquessing	Q-115-01	Black Lake Run	96.48	2744336.35405	291499.04127
Poquessing	Q-115-02	Black Lake Run	15.25	2744806.91108	291101.43200
Poquessing	Q-115-03	Black Lake Run	5.58	2744918.69409	290772.78198
Poquessing	Q-115-04	Black Lake Run	14.89	2744966.57052	290609.87388
Poquessing	Q-115-05	Black Lake Run	7.44	2745325.44242	290461.03857
Poquessing	Q-115-06	Black Lake Run	9.62	2745450.37509	290416.51598
Poquessing	Q-115-07	Black Lake Run	6.86	2745608.31051	290394.02271
Poquessing	Q-115-08	Black Lake Run	19.48	2745846.65003	290289.24686
Poquessing	Q-115-09	Black Lake Run	57.74	2747030.37482	290556.85578
Poquessing	Q-115-10	Black Lake Run	17.17	2747586.64095	290564.26928
Poquessing	Q-115-11	Poquessing Creek	15.64	2748350.45140	290905.01553
Poquessing	Q-115-12	Black Lake Run	114.41	2746560.41336	290008.23251
Poquessing	Q-115-13	Black Lake Run	6.33	2745857.96902	290327.76829
Poquessing	Q-115-14	Black Lake Run	15.29	2747587.20362	290597.51039
Poquessing	Q-115-15	Black Lake Run	0.46	2744757.31166	291089.23141
Poquessing	Q-115-16	Black Lake Run	4.29	2747732.50998	290386.92884
Poquessing	Q-115-17	Black Lake Run	11.88	2747948.91980	290479.53860
Poquessing	Q-115-18	Poquessing Creek	7.74	2748844.13817	289907.28137
Poquessing	Q-117-01	Poquessing Creek	4.88	2730831.35943	300790.32373
Poquessing	Q-117-02	Poquessing Creek	231.36	2731777.81161	300748.14824
Poquessing	Q-117-03	Poquessing Creek	36.91	2731682.90028	300762.95162
Poquessing	Q-117-04	Wilsons Run	133.23	2734016.81335	295875.67381
Poquessing	Q-117-05	Wilsons Run	118.44	2736195.94340	297417.39177
Poquessing	Q-118-01	Byberry Creek	42.96	2740330.29295	296141.37528
Poquessing	Q-118-02	Byberry Creek	33.34	2740309.62999	295484.99263
Poquessing	Q-118-03	Byberry Creek	43.49	2740587.48652	294751.24250
Poquessing	Q-118-04	Byberry Creek	6.62	2740540.54507	294742.29082
Poquessing	Q-118-05	Wilsons Run	14.84	2736592.96640	295093.07936

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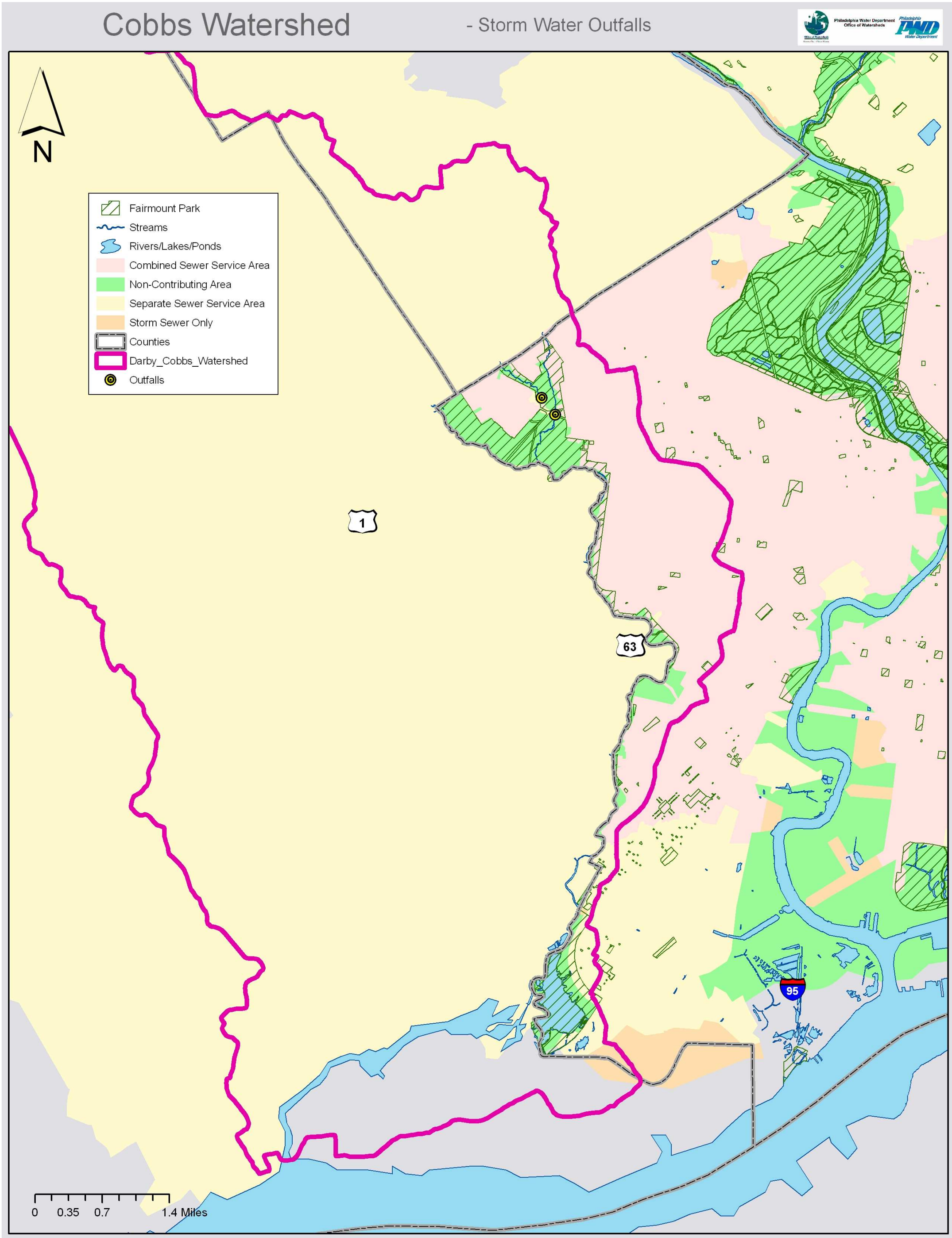
Poquessing	Q-118-06	Wilsons Run	29.11	2737584.19351	295279.19454
Poquessing	Q-118-07	Wilsons Run	28.66	2737340.57959	296394.89925
Poquessing	Q-119-01	UNT	280.74	2745370.00490	293828.16619
Poquessing	Q-120-01	Poquessing Creek	8.17	2732866.45662	301015.95282
Poquessing	Q-120-02	Poquessing Creek	87.55	2733406.48699	301524.76338
Poquessing	Q-120-03	Poquessing Creek	62.58	2733560.77768	301460.25506
Poquessing	Q-120-04	Poquessing Creek	4.28	2733525.57503	301588.93211
Poquessing	Q-120-05	Poquessing Creek	24.11	2733437.07652	304813.52750
Poquessing	Q-120-06	Poquessing Creek	3.62	2734090.30920	301443.34036
Poquessing	Q-120-07	Poquessing Creek	5.40	2734469.99099	301637.54638
Poquessing	Q-120-08	Poquessing Creek	110.08	2734871.52815	301841.46747
Poquessing	Q-120-09	Poquessing Creek	5.91	2734848.90915	301893.34142
Poquessing	Q-120-10	Poquessing Creek	56.08	2735395.30245	302396.41888
Poquessing	Q-120-11	Poquessing Creek	80.26	2735294.37910	303111.45626
Poquessing	Q-120-w	Poquessing Creek	1.82	0.00000	0.00000
Poquessing	Q-120-x	Poquessing Creek	8.14	2734529.63756	301611.48909
Poquessing	Q-120-y	Poquessing Creek	2.89	2732826.57086	301201.24323
Poquessing	Q-120-z	Poquessing Creek	13.10	2736247.66445	302668.21258
Poquessing	Q-121-01	Poquessing Creek	43.92	2738910.22356	300973.81004
Poquessing	Q-121-02	Poquessing Creek	92.55	2738989.87228	300827.15578
Poquessing	Q-121-03	Poquessing Creek	5.69	2740217.55994	300881.66104
Poquessing	Q-121-04	Poquessing Creek	5.16	2740434.44098	300649.58933
Poquessing	Q-121-05	Poquessing Creek	48.52	2740683.91022	300121.98739
Poquessing	Q-121-06	Poquessing Creek	36.65	2740962.82632	299962.83419
SCH_FMT	S-046-01	Schuylkill - Non-Tidal	53.21	2680257.84218	256517.89074
SCH_FMT	S-046-02	Ford Road Run	48.73	2682280.00134	254371.75123
SCH_FMT	S-046-03	Ford Road Run	8.72	2682572.46508	254665.21915
SCH_FMT	S-046-04	Schuylkill - Non-Tidal	124.53	2685359.47688	253033.79342
SCH_FMT	S-046-05	Neil Drive Run	17.77	2681416.25751	255732.01766
SCH_FMT	S-046-06	Schuylkill - Non-Tidal	1071.43	2684965.02885	255685.95295
SCH_FMT	S-046-07	Neil Drive Run	20.82	2680704.57308	255410.68545
SCH_FMT	S-046-08	Neil Drive Run	63.00	2680267.34711	254350.50775
SCH_FMT	S-046-09	Ford Road Run	45.14	2680879.41897	252642.78576
SCH_FMT	S-052-03	Schuylkill - Non-Tidal	44.05	2683402.76857	256521.83993
SCH_FMT	S-052-04	Schuylkill - Non-Tidal	394.83	2684231.60882	256182.05376
SCH_ROX	S-051-01	Schuylkill - Non-Tidal	17.41	2678460.28528	259956.05710
SCH_ROX	S-051-02	Schuylkill - Non-Tidal	5.00	2677926.38090	260498.82699
SCH_ROX	S-051-03	Schuylkill - Non-Tidal	105.27	2676122.71965	261963.70238
SCH_ROX	S-051-04	Schuylkill - Non-Tidal	0.48	2675586.82799	262043.95252
SCH_ROX	S-051-05	Schuylkill - Non-Tidal	24.37	2675347.38188	262288.49779
SCH_ROX	S-051-06	Manayunk Canal	0.80	2676328.42647	261743.71497
SCH_ROX	S-051-07	Schuylkill - Non-Tidal	3.23	2679030.85549	259103.49698
SCH_ROX	S-051-08	Schuylkill - Non-Tidal	223.71	2677675.04625	260700.27324
SCH_ROX	S-052-05	Schuylkill - Non-Tidal	90.76	2679758.89959	258706.04094
SCH_ROX	S-058-01	Manayunk Canal	130.35	2670978.32193	266722.17064
SCH_ROX	S-059-01	Manayunk Canal	202.53	2672406.76162	265168.72493
SCH_ROX	S-059-02	Manayunk Canal	80.30	2673139.56687	264403.09330
SCH_ROX	S-059-03	Manayunk Canal	14.00	2673343.73574	264149.74841
SCH_ROX	S-059-04	Manayunk Canal	176.58	2673979.61235	263510.47041
SCH_ROX	S-059-05	Manayunk Canal	0.35	2673992.32467	263492.45845
SCH_ROX	S-059-06	Manayunk Canal	0.93	2674173.46137	263320.29755
SCH_ROX	S-059-07	Manayunk Canal	1.31	2674657.62354	262844.20135
SCH_ROX	S-059-08	Manayunk Canal	0.77	2674710.23149	262808.41897
SCH_ROX	S-059-09	Manayunk Canal	18.83	2674892.47191	262708.79859
SCH_ROX	S-059-10	Manayunk Canal	0.60	2675042.66432	262624.65353

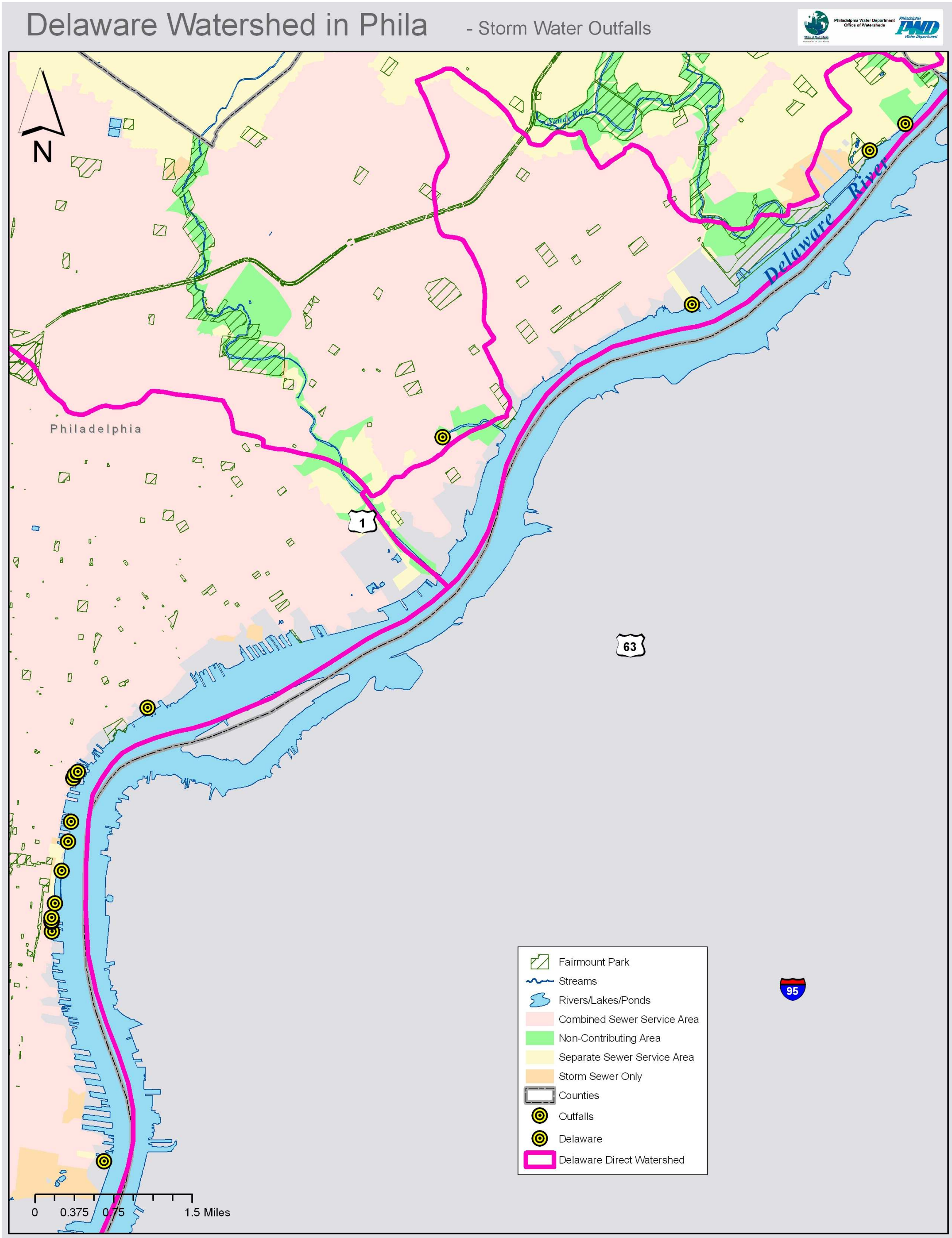
Watershed	Stormwater Outfalls	Subshed/Tributary/Discharge Body	Sewershed Area (acres)	X - Coordinate	Y - Coordinate
SCH_ROX	S-059-11	Manayunk Canal	0.55	2675197.45027	262519.38262
SCH_ROX	S-066-01	Shawmont Run	4.23	2668289.49531	269046.45039
SCH_ROX	S-075-03	Manor Creek	13.99	2669130.37538	276109.93136
SCH_ROX	S-075-04	Schuylkill Center West Trib	8.45	2669401.11090	274949.27170
SCH_tidal	M-002-01	Mingo Creek	81.71	2673183.15040	209173.74671
SCH_tidal	M-002-02	Mingo Creek	202.37	2673080.77983	209053.38584
SCH_tidal	M-002-03	Mingo Creek	42.63	2678189.59022	208560.26972
SCH_tidal	M-002-04	Mingo Creek	112.80	2673421.43856	209253.55543
SCH_tidal	M-005-01	Mingo Creek	80.40	2677560.95803	211153.31122
SCH_tidal	M-005-02	Mingo Creek	139.03	2676675.31159	214414.84017
SCH_tidal	M-005-03	Mingo Creek	1267.71	2675845.59026	214675.12493
SCH_tidal	M-005-04	Mingo Creek	422.98	2675799.59951	214561.19459
SCH_tidal	S-010-01	Schuylkill - Tidal	36.93	2690090.74605	218569.59721
SCH_tidal	S-010-02	Schuylkill - Tidal	64.74	2689827.94591	218927.12620
SCH_tidal	S-011-01	Schuylkill - Tidal	70.37	2691571.98759	215032.75480
SCH_tidal	S-014-01	Schuylkill - Tidal	137.43	2680299.17968	224506.91160
SCH_tidal	S-019-01	Schuylkill - Tidal	13.17	2679879.25869	225962.69581
SCH_tidal	S-024-01	Schuylkill - Tidal	88.66	2684096.35086	232705.61469
SCH_tidal	S-030-01	Schuylkill - Tidal	1.54	2688744.69884	238560.22410
SCH_tidal	S-030-02	Schuylkill - Tidal	8.35	2688822.23961	237642.30358
Tacony	T-050-01	Tacony Creek	32.08	2717771.08615	250023.70144
Tacony	T-050-02	Tacony Creek	7.41	2716733.24292	251309.09280
Tacony	T-055-01	Tacony Creek	4.56	2712633.24384	257140.87259
Tacony	T-056-01	Tacony Creek	10.34	2714340.77770	254871.98672
Tacony	T-056-03	Tacony Creek	19.56	2714594.04614	253624.27764
Tacony	T-056-04	Tacony Creek	43.01	2714710.05837	253779.44598
Tacony	T-056-05	Tacony Creek	51.17	2715200.96020	253019.35624
Tacony	T-056-06	Tacony Creek	4.35	2715767.24793	252466.71813
Tacony	T-056-07	Tacony Creek	11.76	2716407.19478	251720.62823
Tacony	T-056-08	Tacony Creek	17.55	2716191.00238	251830.00315
Tacony	T-063-01	Tacony Creek	1.01	2707412.90616	262485.46380
Tacony	T-063-02	Tacony Creek	11.65	2708631.64358	260677.36318
Tacony	T-063-03	Tacony Creek	6.21	2711484.59734	259800.82675
Tacony	T-063-04	Tacony Creek	6.52	2712193.38777	259407.29994
Tacony	T-063-05	Tacony Creek	9.44	2712455.75770	258833.53507
Tacony	T-063-06	Tacony Creek	4.06	2712179.55146	258199.56361
Tacony	T-071-01	Tacony Creek	1.80	2707387.22464	265236.19668
Tacony	T-079-01	Tacony Creek	188.52	2706837.20037	269847.30592
Tacony	T-079-02	Tacony Creek	21.94	2706782.85129	269394.94806
Tacony	T-080-01	Tookany Creek	47.84	2709229.08085	272806.37315
Tacony	T-080-02	Tookany Creek	38.11	2708242.69132	271848.11452
Tacony	T-080-03	Tookany Creek	10.94	2707757.52714	270961.66826
Tacony	T-088-01	Mill Creek	454.73	2702081.42509	274780.80600
Tacony	T-089-01	Tookany Creek	34.21	2710398.76976	273421.56940
Tacony	T-089-02	Tookany Creek	21.10	2711597.64444	274560.71405
Tacony	T-089-03	Central Ave Trib	39.67	2712208.31010	275329.39560
Tacony	T-089-04	Central Ave Trib	207.87	2712941.68024	276434.13083
Tacony	T-096-01	Tookany Creek	26.00	2689696.67782	283377.54053
Tacony	T-097-01	Tookany Creek	46.78	2691440.19605	282180.28511
Tacony	T-097-02	Tookany Creek	16.66	2691816.92540	281897.56261
Tacony	T-098-01	Burholme Run	41.26	2711813.15213	280253.74102
Tacony	T-098-02	Burholme Run	2.94	2711850.14314	280010.54908
Tacony	T-098-03	Burholme Run	45.97	2712493.16134	279691.00245
Wissahickon	W-052-01	Wissahickon Creek	12.40	2682125.45124	259622.97653
Wissahickon	W-052-02	Wissahickon Creek	15.38	2680993.46702	258558.45478

Watershed	Stormwater Outfalls	Subshed/Tributary/Discharge Body	Sewershed Area (acres)	X - Coordinate	Y - Coordinate
Wissahickon	W-060-01	Wissahickon Creek	105.60	2680614.00121	266107.22612
Wissahickon	W-060-02	Wissahickon Creek	25.49	2682833.27250	265012.13951
Wissahickon	W-060-03	Wissahickon Creek	63.35	2682815.80622	264712.19883
Wissahickon	W-060-04	Monoshone Creek	12.59	2685964.39525	265165.58465
Wissahickon	W-060-05	Wissahickon Creek	96.76	2683008.81251	263567.88850
Wissahickon	W-060-06	Wissahickon Creek	2.58	2683242.95086	262422.85407
Wissahickon	W-060-07	Wissahickon Creek	18.66	2683721.96135	261823.95636
Wissahickon	W-060-08	Monoshone Creek	16.31	2684463.54804	264833.71194
Wissahickon	W-060-09	Monoshone Creek	17.02	2685230.11169	264530.70394
Wissahickon	W-060-10	Monoshone Creek	156.16	2685926.69795	264218.44904
Wissahickon	W-060-11	Monoshone Creek	37.53	2685981.96236	264978.36572
Wissahickon	W-067-01	Gorgas Run	392.59	2677406.28496	268882.08608
Wissahickon	W-067-02	Gorgas Run	39.56	2677456.77229	268558.93339
Wissahickon	W-067-03	Gorgas Run	31.29	2677957.59925	268285.52458
Wissahickon	W-067-04	Wissahickon Creek	22.74	2679046.64051	267468.82858
Wissahickon	W-067-05	Wissahickon Creek	9.87	2679316.27287	267385.52576
Wissahickon	W-067-06	Wissahickon Creek	41.54	2679693.66814	268084.29388
Wissahickon	W-068-01	Carpenter's Woods	12.34	2682188.90448	271003.55223
Wissahickon	W-068-02	Carpenter's Woods	10.68	2682431.31146	270829.88111
Wissahickon	W-068-03	Carpenter's Woods	4.07	2680943.22675	268894.89972
Wissahickon	W-068-04	Monoshone Creek	629.62	2684919.48923	266723.78498
Wissahickon	W-068-05	Monoshone Creek	78.25	2685502.19155	266187.55425
Wissahickon	W-068-06	Carpenter's Woods	15.33	2681804.87465	270291.22138
Wissahickon	W-068-07	Wissahickon Creek	23.88	2682848.39158	266488.40580
Wissahickon	W-068-08E	Carpenter's Woods	25.90	2681389.88347	269322.80114
Wissahickon	W-068-08W	Carpenter's Woods	31.18	2681399.77413	269276.69707
Wissahickon	W-075-01	Wises Mill Run	137.22	2672440.09497	275353.03232
Wissahickon	W-075-02	Wises Mill Run	9.88	2673037.14043	275253.17603
Wissahickon	W-076-01	Cathedral Road Run	90.91	2674120.45446	277787.46762
Wissahickon	W-076-02	Cathedral Road Run	38.27	2674980.33206	277416.58341
Wissahickon	W-076-03	Cathedral Road Run	9.21	2675180.00748	276752.13142
Wissahickon	W-076-04	Wises Mill Run	9.02	2673772.46875	274843.09316
Wissahickon	W-076-05	Wises Mill Run	3.48	2673909.79969	274690.55858
Wissahickon	W-076-06	Wises Mill Run	9.62	2673993.98713	274396.77563
Wissahickon	W-076-07	Hartwell Run	40.90	2677387.57381	274728.56779
Wissahickon	W-076-08	Cresheim Creek	7.00	2679022.87466	273309.17354
Wissahickon	W-076-09	Valley Green Run	52.62	2678470.74275	273889.70436
Wissahickon	W-076-10	Valley Green Run	46.90	2678426.76526	273779.70908
Wissahickon	W-076-11	Cresheim Creek	13.67	2681381.85759	273501.79104
Wissahickon	W-076-12	Cresheim Creek	46.79	2681537.04817	275008.85385
Wissahickon	W-076-13	Wises Mill Run	91.99	2674125.87702	272956.70746
Wissahickon	W-076-14	Hartwell Run	68.95	2674066.85459	274764.31502
Wissahickon	W-076-X	Wises Mill Run	9.47		
Wissahickon	W-077-01	Cresheim Creek	45.88	2681841.71549	274841.37098
Wissahickon	W-077-02	Cresheim Creek	238.46	2682066.93393	276380.57360
Wissahickon	W-084-01	Bells Mill Run	62.75	2673579.69779	280818.62476
Wissahickon	W-084-02	Bells Mill Run	105.04	2671389.37255	279341.58291
Wissahickon	W-084-03	Bells Mill Run	4.94	2671439.53194	280252.94529
Wissahickon	W-084-04	Bells Mill Run	10.50	2671091.77501	280272.88832
Wissahickon	W-085-01	Wissahickon Creek	81.74	2675070.52788	281903.83251
Wissahickon	W-085-02	Wissahickon Creek	54.93	2677546.55592	278131.94293
Wissahickon	W-086-01	Cresheim Creek	275.84	2683174.91496	277421.04456
Wissahickon	W-086-02	Cresheim Creek	76.65	2683244.76428	277360.00643
Wissahickon	W-086-03	Cresheim Creek	35.83	2683863.36060	278000.98960
Wissahickon	W-086-04	Cresheim Creek	31.62	2684595.92850	278964.78030

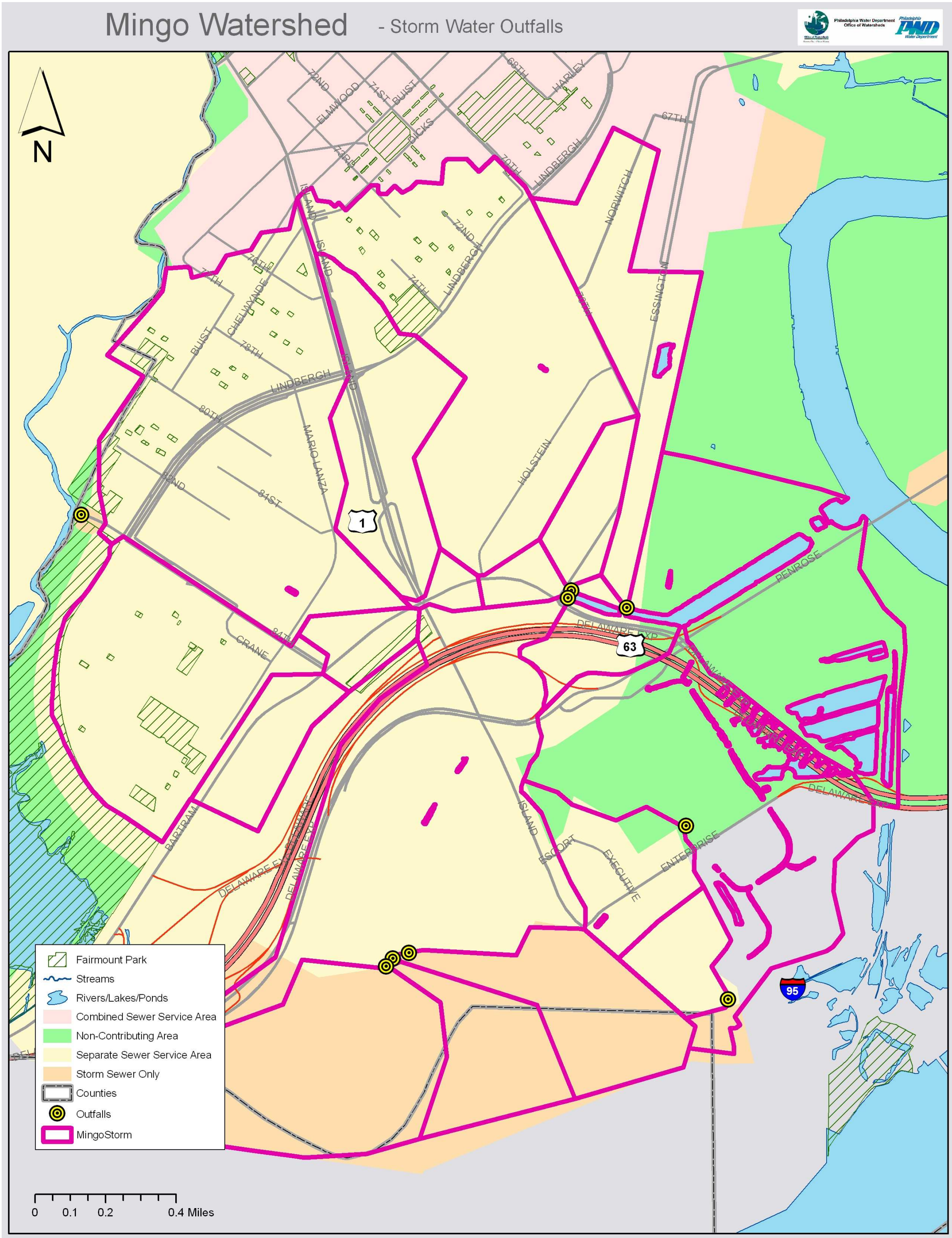
Watershed	Stormwater Outfalls	Subshed/Tributary/Discharge Body	Sewershed Area (acres)	X - Coordinate	Y - Coordinate
Wissahickon	W-086-05	Cresheim Creek	48.58	2684827.57436	278876.71916
Wissahickon	W-086-06	Cresheim Creek	86.18	2685304.21801	279722.02944
Wissahickon	W-086-07	Cresheim Creek	24.33	2684651.92677	279394.06498
Wissahickon	W-095-01	Hillcrest Run	97.19	2676140.93568	284216.20415
Wissahickon	W-095-02	Paper Mill Run		2675318.42006	286082.40661
Wissahickon	W-095-03	Paper Mill Run	51.84	2678249.20878	284708.06662
Wissahickon	W-095-04	Paper Mill Run	13.32	2678750.96071	284684.08320
Wissahickon	W-095-05	Paper Mill Run	25.94	2680764.80999	283312.46282



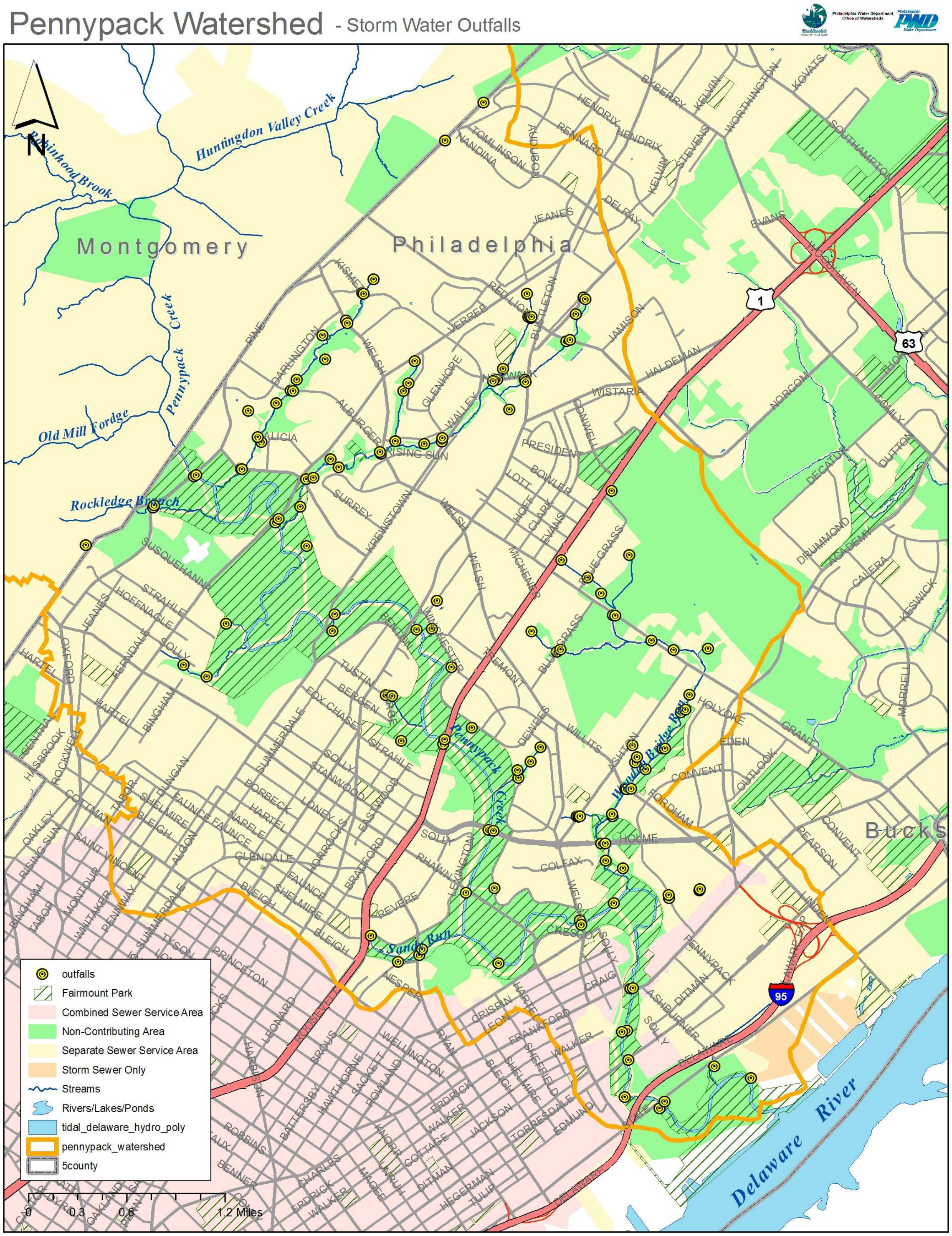
Appendix H, Figure 1 - MS4 Outfalls in the Cobbs Creek Watershed



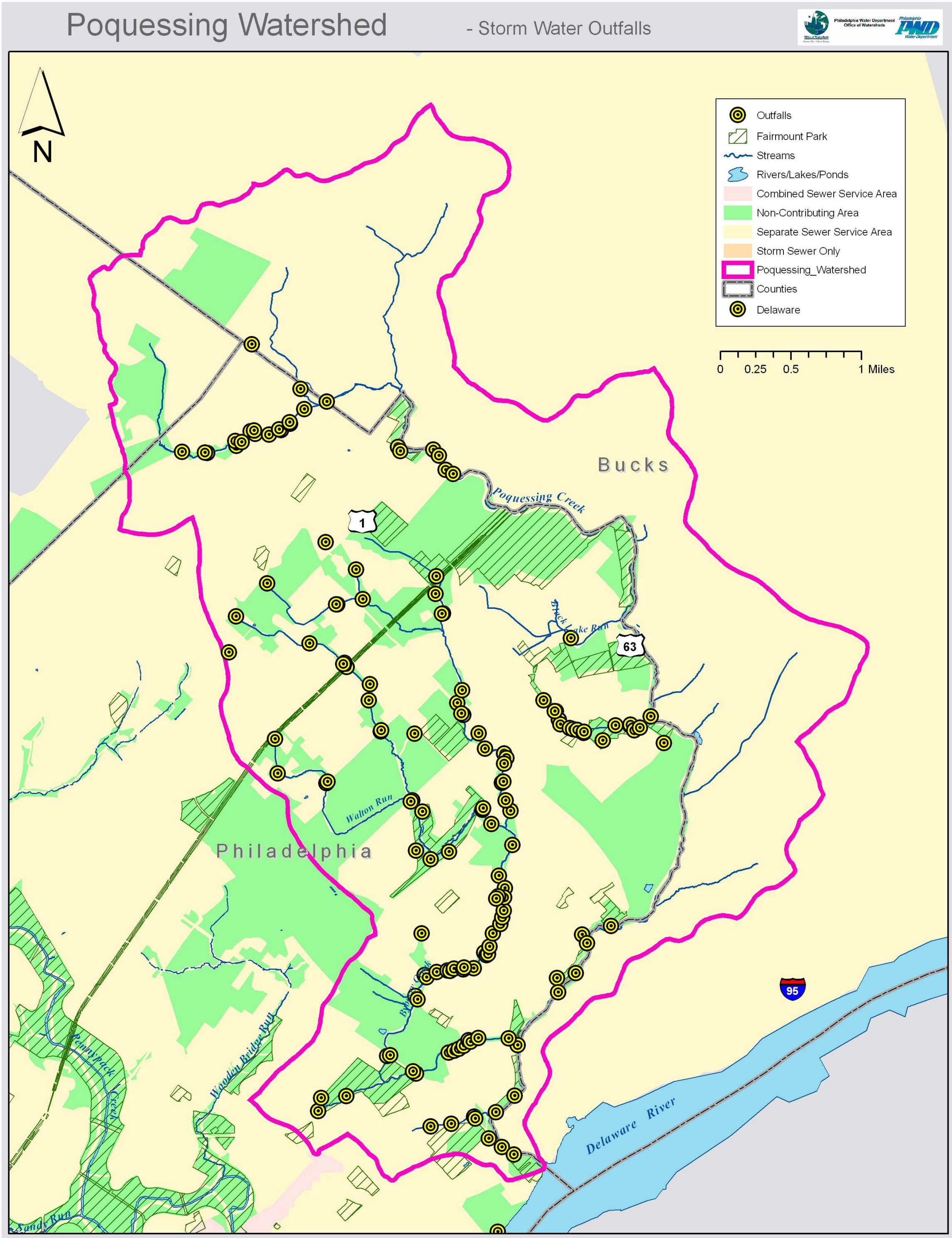
Appendix H, Figure 2 - MS4 Outfalls in the Delaware River Watershed



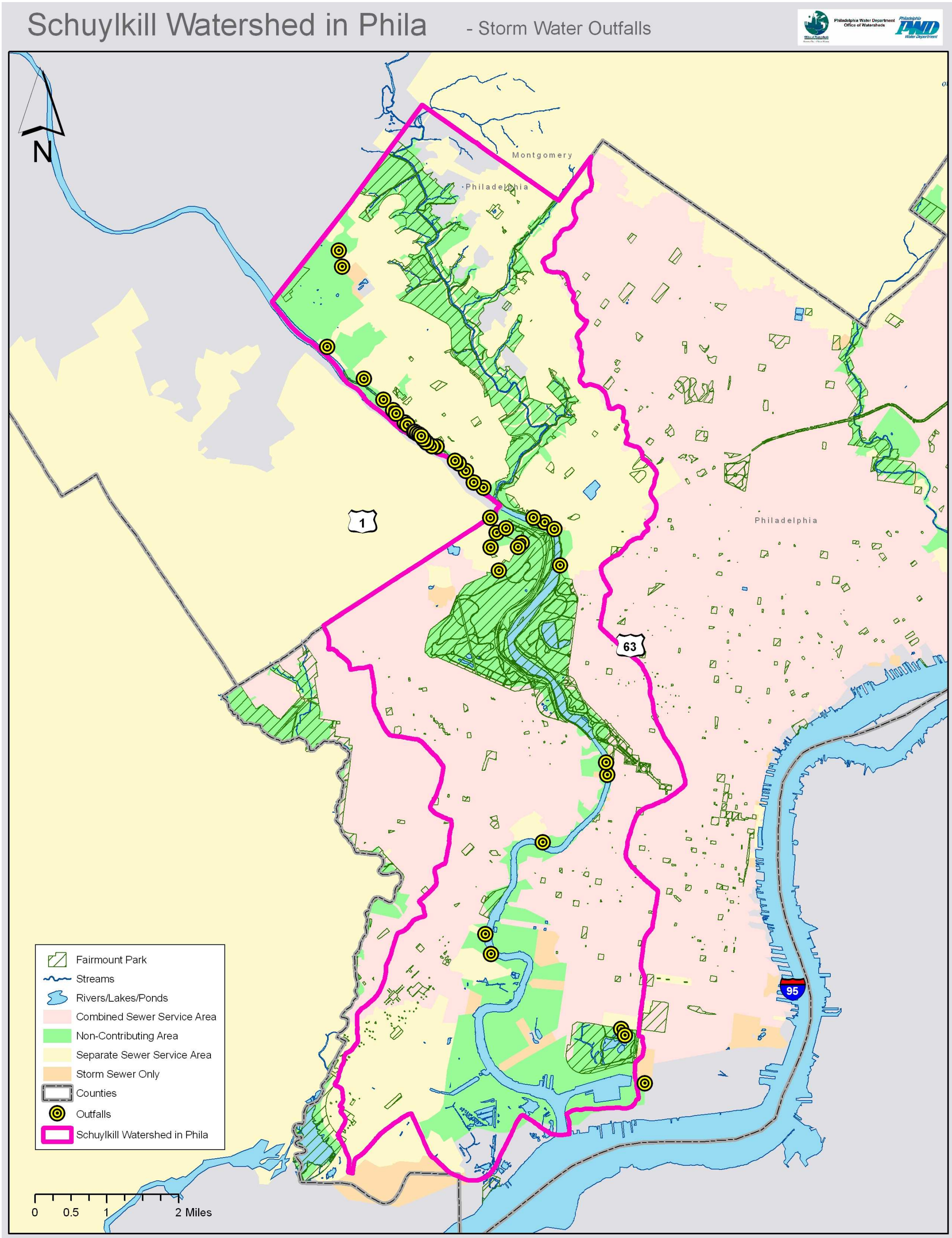
Appendix H, Figure 3 - MS4 Outfalls in the Mingo Creek Watershed



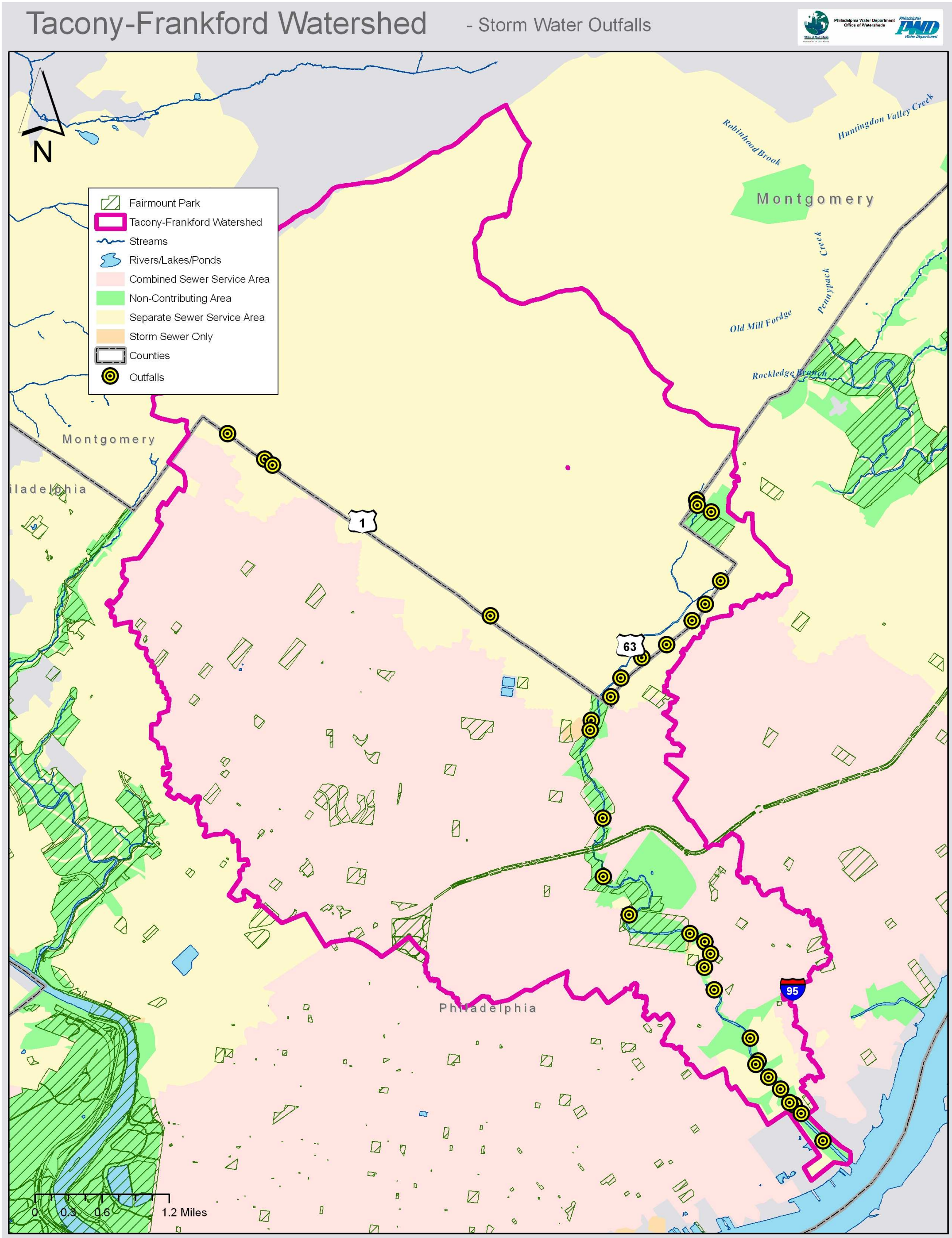
Appendix H, Figure 4 - MS4 Outfalls in the Pennypack Creek Watershed



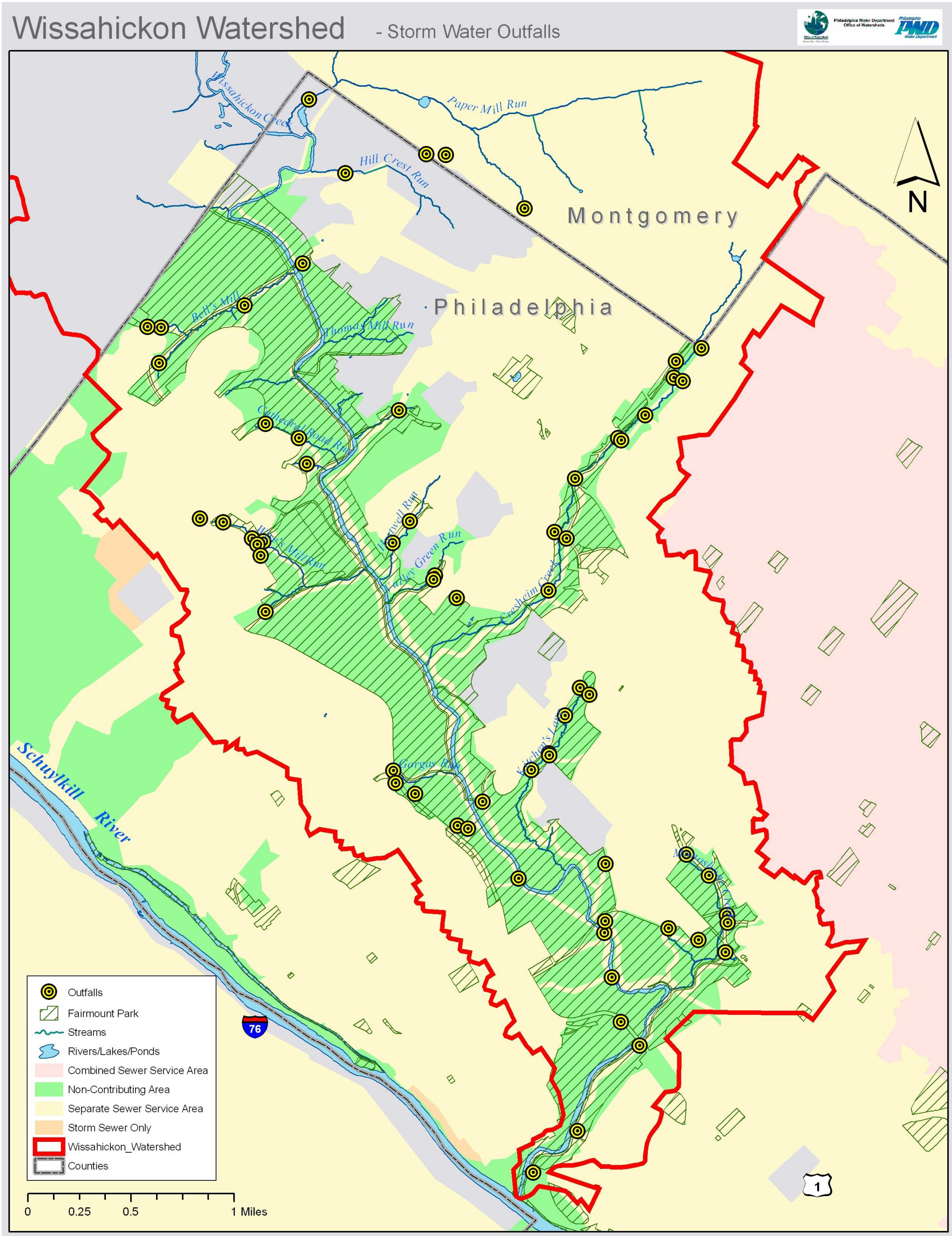
Appendix H, Figure 5 - MS4 Outfalls in the Poquessing Creek Watershed



Appendix H, Figure 6 - MS4 Outfalls in the Schuylkill River Watershed



Appendix H, Figure 7 - MS4 Outfalls in the Tacony-Frankford Watershed



Appendix H, Figure 8 - MS4 Outfalls in the Wissahickon Creek Watershed