Moving from Assessment to Protection…

The Delaware River Watershed Source Water Protection Plan

Prepared by:

Philadelphia Water Department (PWSID #1510001)

Baxter Water Treatment Plant Surface Water Intake

Philadelphia, Pennsylvania

June 2007

Delaware River Watershed Source Water Protection Plan
(PWD Baxter Intake – PWSID# 1510001)

The Delaware River Watershed Source Water Protection Plan is on file and available for public review at the following location:

Pennsylvania Department of Environmental Protection **Southeast Regional Office** **2 East Main Street** **Norristown, PA 19401**

Any questions regarding the information contained within the protection plan should be directed to:

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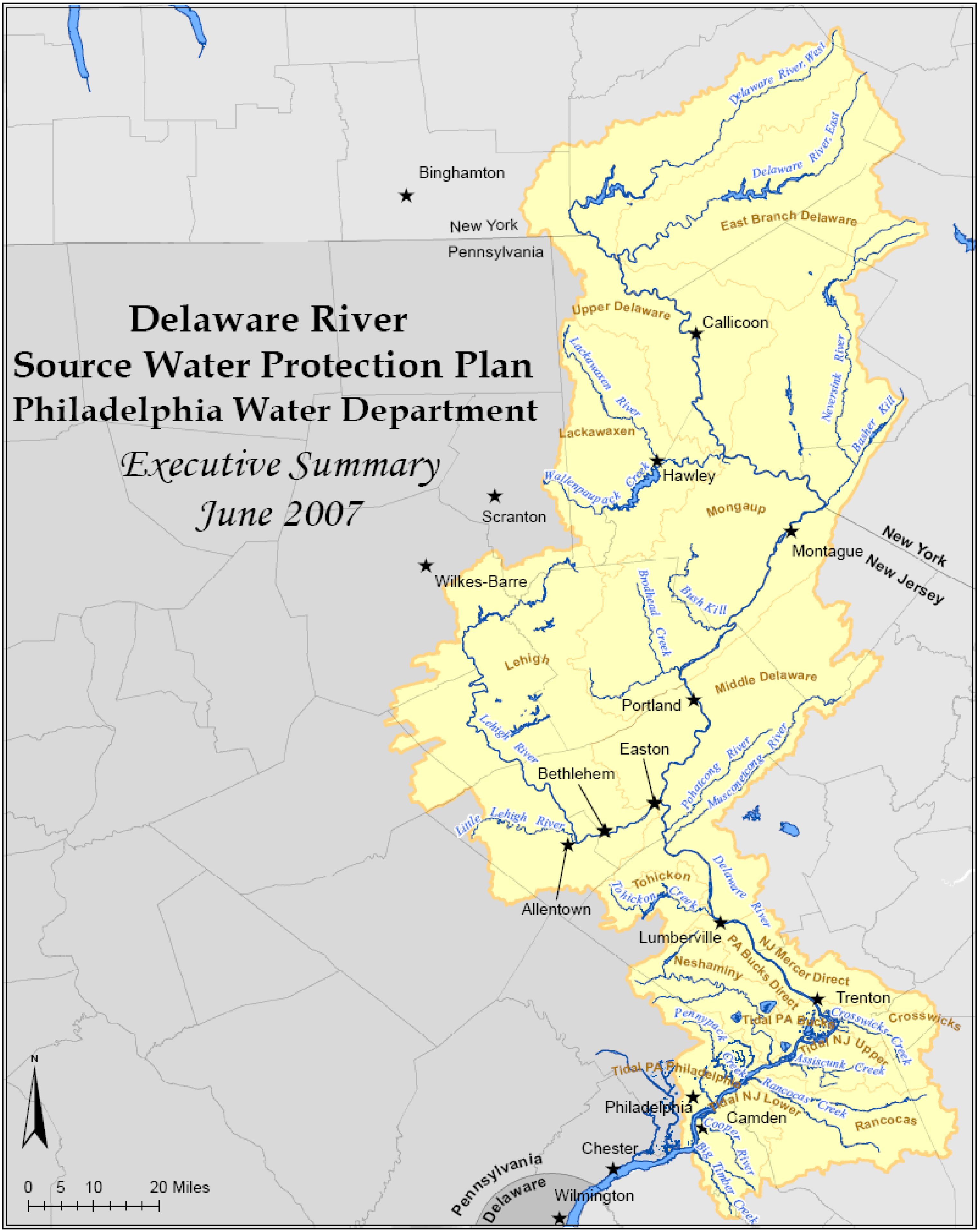
Delaware River
Source Water Protection Plan
Philadelphia Water Department

Executive Summary

June 2007



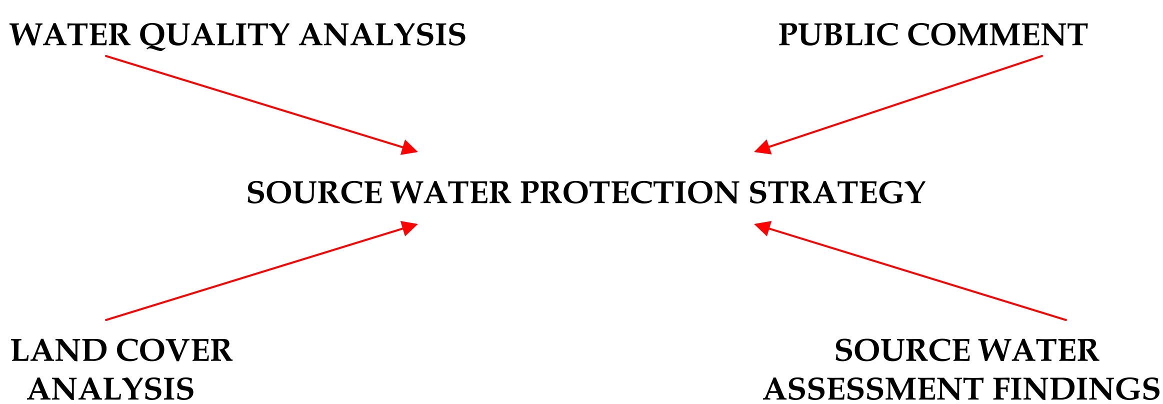
Purpose

The purpose of the Delaware River Protection Plan is to design a source water protection strategy to counter current and future water supply concerns of the Philadelphia Water Department and drinking water utilities that share the Delaware River as a resource.

The Baxter Water Treatment Plant, one of three drinking water facilities in Philadelphia, is supplied by the Delaware River. The Delaware River watershed extends 8,000 square miles through Pennsylvania, New Jersey, and New York. The Delaware River Source Water Protection Plan uses critical water quality, land cover, and population analyses as well as point and non-point source pollution modeling to characterize the water supply. The source water quality and quantity characterization, incorporated with the results from the 2002 Source Water Assessment, provide the technical foundation for a Delaware River source water protection strategy.

The Baxter Water Treatment Plant provides over 190 million gallons of safe and high quality drinking water per day to the citizens of Philadelphia and surrounding communities. The plant uses dual media filtration and chlorine disinfection technologies to provide high quality drinking water year round. The Baxter Water Treatment Plant has an exceptional performance record and has never violated Safe Drinking Water Act regulations. The Baxter Water Treatment Plant owes its exceptional record to the hard work of dedicated Philadelphia Water Department staff and the quality source water supplied from the Delaware River.

The Philadelphia Water Department uses source water assessment and protection planning to maintain the integrity of the Delaware River as a drinking water supply.



Delaware River Water Quality

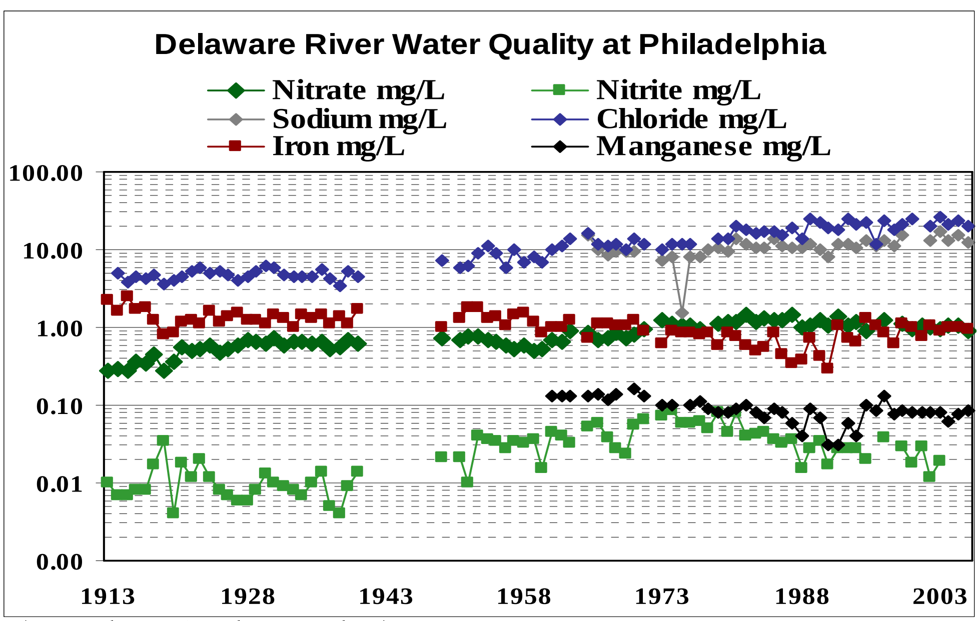
The Delaware River is an excellent drinking water supply. The Delaware River was once plagued by pollution from sewage and heavy industry, but now again provides a welcoming environment to native fish and wildlife species not seen in decades. However, this does not mean our work is finished, as newer challenges to source water quality need to be addressed. The graph at the bottom of the page depicts the long term trends of water quality parameters measured at the Baxter Water Treatment Plant in Philadelphia. The features in the graph and the major water quality categories that are of interest to the Baxter Water Treatment Plant are described below.

Metals
The metals iron and manganese are water supply concerns because they give drinking water odors, colors, and tastes as well as slowing filters and treatment processes. These metals have decreased from high concentrations early in the twentieth century and are no longer a major concern.

Nutrients
Nitrate and nitrite are water supply concerns because they are not removed during the drinking water treatment process and can cause health conditions in small children and babies. These nutrients were once increasing in the Delaware River, but now the concentrations are stable and beginning to slowly decline.

Salts
Sodium and chloride are water supply concerns because they are not removed in the drinking water treatment process and can pose a health threat to customers on low sodium diets. Both sodium and chloride have been steadily increasing in the Delaware River over time.

Pathogens
Cryptosporidium, absent from the graph below, is the primary pathogen water supply concern because it is very difficult to remove and can cause intestinal discomfort. This pathogen is fortunately present at very low concentrations in the water supply at Philadelphia, but requires constant vigilance.



(Jaworski 1996 and Baxter data)

Water Contaminant Sources

The Baxter Water Treatment Plant is located in the tidal zone of the Delaware River and can therefore be affected by contaminants moving north to south with the river flow and south to north with the tidal waters. The contaminants within the waters that reach the intake come from four potential sources: natural, point, non-point, and accidental.

Natural Sources
The most significant natural contaminant of the Delaware River is salt water. A distinct boundary, or salt line, is formed where the salt water from the Delaware Bay meets the fresh water from the Delaware River in the tidal zone. If the salt line were to reach the Baxter location, the plant would have to stop operation until the salt line retreated south of the intake. There are detailed Delaware River Basin Commission resolutions dictating minimum flow requirements and reservoir releases to keep the salt line south of the Baxter intake during drought conditions. There is a need to model the behavior of the salt line under climate change and higher sea level conditions. The minimum flow requirements will likely need to be adjusted to changing hydrologic conditions.

Point Sources
Point sources can introduce both industrial and municipal waste to water ways. Municipal point sources discharging effluent from wastewater treatment plants are a source of water quality contaminants in the form of pathogens. Wastewater treatment plants are responsible for the water quality improvement experienced by the Delaware River in the past 50 years. However, concerns remain about pathogens contained in the effluent, mainly *Cryptosporidium.* Year round disinfection of wastewater effluent is the desired means to reduce the threat to source water from *Cryptosporidium.*

Non-Point Sources
Non-point source pollution, stormwater runoff from urban and suburban areas, is a source of metals, nutrients, suspended solids, and chemicals such as pesticides, herbicides, fertilizers, gasoline, and motor oil. Stormwater is likely to increase in volume as the watershed becomes more populated and developed. The water quality threat from stormwater creates a need for low impact development, sustainable design, and stormwater best management practices.

Accidental Sources
Accidental sources of contamination are spills or leaks from cars, trains, shipping vessels, underground pipeline bursts, and industrial accidents. The most recent example is the oil spill from the Athos I shipping vessel in 2004. One protection against these activities is the Delaware Valley Early Warning System, which provides advance notice of accidental contamination events. The advance notice from the Early Warning System allows utilities to execute emergency response protocols and prepare the treatment plants for changes in source water quality.

Key Water Quality Findings

Sodium, Chloride, and Conductivity
Sodium, chloride, and conductivity levels across the Delaware River watershed were found to be increasing since 1975. Sodium and chloride are not removed during the drinking water treatment process. Sodium, chloride, and conductivity were examined at four locations on the main stem Delaware River ranging north to south from Montague, NJ to Trenton, NJ. The chloride concentrations are increasing very slowly and do not raise concern. However, sodium is expected to surpass the American Heart Association's recommended drinking water concentration, 20 mg/L, in under 100 years at the Baxter intake location.

Total Organic Carbon (TOC)
Total Organic Carbon (TOC) is at the lowest concentration in the Delaware River in decades. During the middle of the twentieth century, severe pollution on the Delaware River caused TOC concentrations to rise over 4 mg/L. The average concentration from 2006 is 2.43 mg/L. The reduction of TOC in the Delaware River is critical to reducing the formation of undesirable disinfection byproducts (DBPs) at Baxter. DBPs are formed when natural organic matter, accounted for in the TOC measurement, reacts with chlorine. In order to reduce the concentration of DBPs, the precursors that lead to their formation must be reduced in the source water.

Bromide
No trend was identified for bromide. Bromide is naturally occurring in the Delaware River at very low concentrations, < 0.03 mg/L average. Bromide concentrations rise when streamflow falls, and when streamflow rises the bromide concentration declines. Bromide is a source water quality concern due to its role in the formation of brominated disinfection byproducts.

Taste and Odor
The compound that causes taste and odor concerns at the Baxter intake is the algal byproduct methylisoborneol, or MIB. MIB typically increases within the Delaware River at Philadelphia in May and early June. Although Baxter does not frequently experience taste and odor problems from MIB, there is a desire to reduce the presence of this compound in the source water. Additional research is needed to identify the environmental triggers of the algae associated with MIB production.

Cryptosporidium
Two year sampling for the Long Term 2 Enhanced Surface Water Treatment Rule (LT2) compliance identified the average *Cryptosporidium* concentration at the Baxter intake as less than 0.075 oocysts/L. This low concentration places the Baxter intake in "Bin 1" of the LT2 regulation, which is reserved for the highest quality source water that does not require additional treatment processes for pathogen removal. There is potential for *Cryptosporidium* concentrations to rise in the Delaware River. Population growth creates more wastewater and therefore increases the amount of effluent, often not disinfected, that is discharged into the Delaware River.

Activities of Concern

Population Growth and Land Cover Change

The main threat to the water quality and quantity of the Delaware River comes from population growth and subsequent land cover changes. USGS National Land Cover Data identifies that 68% of the land cover within Delaware River watershed is forested. Forested lands can maintain water quality, recharge groundwater, and absorb precipitation thus preventing floods.

In 2000, the population of the watershed was 4.17 million people. Based on the rate of change between the 1990 and 2000 population, a 7.6% increase, an estimated 6 million people will live in the Delaware River watershed by 2040. A minimum estimate of land cover change can be calculated by basing the land consumption rate on the ratio of people to developed acres ratio from the 2001 USGS NLCD and 2000 Census. Assuming this ratio stays constant, the developed area will increase by at least 9%, as shown in the pie charts below.

Regional efforts must begin to preserve as much forested land as possible. The scenarios presented here are minimum estimates of development; real scenarios may be far more consequential. *There is a critical need to understand the relationship between land cover and water quality and quantity, and population growth and development within the Delaware River watershed.*

States	2000 Census Population	1990 Census Population	% Change between 1990 and 2000 Census	State Percentage of Study Area Population
New Jersey	1,412,418	1,273,673	10.9 %	33.8 %
Pennsylvania	2,643,426	2,491,428	6.1 %	63.4 %
New York	117,069	111,693	4.8 %	2.8 %
Total	**4,172,913**	**3,876,794**	**7.6 %**	**100 %**

Source: U.S. Census Bureau, 1990 and 2000

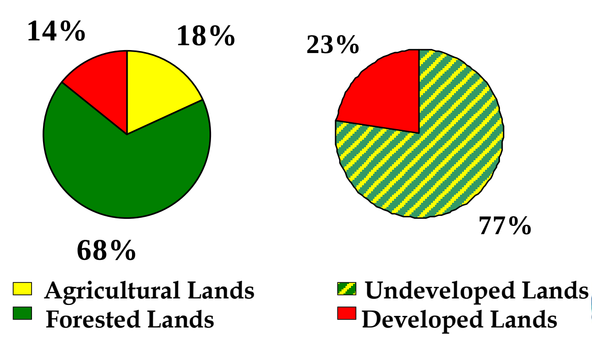
Implications of Land Cover Change

Higher Consumption
Less Groundwater Recharge
Lower Baseflow
Salt Line Encroachment
Increased Flooding
Increased Point Source Pollution
Increased Non-Point Source Pollution
Potential for Increasing Concentrations:
Bromide
Metals
Sodium
Chloride
Cryptosporidium
Alkalinity

Delaware River Watershed Land Cover

2001 Current Conditions

2040 Minimum Development Scenario



Activities of Concern

Climate Change – Sea Level Rise

If sea level were to rise due to climate change, the Baxter Water Treatment Plant intake would be at great risk of contamination by the tidal salt line. Water south of the salt wedge is far too saline for Baxter to use, and any flow of such salty water into the Baxter settling basins would act as a contaminant. The Baxter Water Treatment Plant can only use as its supply the fresh water located north of the salt line. An increase in the sea level of the oceans would be reflected in an increase in the level of the Delaware Bay. The volume that currently moves north and south in the tidal zone would be increased under sea level rise scenarios, therefore moving the salt line farther north than it commonly vacillates and threatening the intake.

Climate Change – Hydrologic Changes

Climate change is expected to alter the hydrology of the Delaware River. The increases in evaporation, loss in soil moisture, increased winter precipitation, more severe rain storms, and season length changes are just some of the factors that could alter hydrology. Streamflow is expected to decrease below summer averages and increase over winter averages. Alterations in streamflow have two major effects on the source water quality of the Delaware River; salt line movement and water quality changes. The anticipated water quality changes due to climate change effects on hydrology are similar to those caused by land cover change. Findings from the most recent report to examine climate change impacts on the U.S. Northeast region are summarized below.

Potential climate change effects on the salt line and streamflow require a re-examination of regional water policy, including minimum flow requirements and reservoir releases.

	High Emissions Scenario	**Low Emissions Scenario**
Winter Warming	Extra 8 to 12 F	Extra 5 to 7.5 F
Summer Warming	Extra 6 to 14 F	Extra 3 to 7 F
Days where temp. > 90 F	Average 60 Days	Average 30 Days
Days where temp. > 100 F	14 to 28	Average 3
Winter Snow Season	Time cut by 50%	Time cut by 25%
Short Term Drought (3 month length)	Once per year	Only slightly higher than today
Spring Arrival	Three weeks early	Two weeks early
Summer Arrival	Three weeks early and three weeks late departure	One week early and one week late departure
Sea Level Rise	8 inches to 3 feet	3 inches to 2 feet

Changes Under Both Scenarios	
10% increase in extreme rainfall events	More dry summer and fall seasons
20% increase in rainfall per five day period	Extended periods of low streamflow
Increased winter precipitation by 20 - 30%	Increased evaporation
Expanded growing season	Reduced soil moisture

Source: Union of Concerned Scientists, Climate Change in the U.S. Northeast, October 2006

Source Water Protection Initiatives

Enhance and Make Permanent the DRBC Special Protection Water Resolution

The Philadelphia Water Department supports permanency of the DRBC Special Protection Waters Resolution (SPW). The Philadelphia Water Department also supports the enhancement of the SPW Resolution to require wastewater treatment plant dischargers within the Delaware River watershed to perform year round disinfection, and to include forest and canopy protection into existing non-point source pollution regulations.

The enhancement and permanence of this resolution will help to prevent *Cryptosporidium* concentrations from increasing at the Baxter intake. *Cryptosporidium* levels are expected to rise when population growth drives wastewater volume increases. Disinfecting wastewater will inactivate this pathogen, reducing the likelihood that Baxter will lose its Bin 1 status.

The addition of forest and canopy protections into DRBC non-point source controls in the SPW Resolution will help mitigate the water quality impacts of land cover change and preserve forested areas. The Philadelphia Water Department will reach out to the DRBC and the Pennsylvania Department of Environmental Protection to advocate for the enhancement and permanence of the SPW Resolution.

Delaware River Salinity Reduction Initiative

Analyses within the plan identify that sodium has been steadily increasing across the Delaware River watershed in the past few decades. Due to the health concerns associated with sodium for some customers, the Philadelphia Water Department would like to halt the rising trend in sodium concentrations. The first step toward this goal is for the Philadelphia Water Department to research specific contributions of sodium from watershed sources such as road salt applications, wastewater treatment plants, sodium hypochlorite disinfection, and water softening chemicals. Before any sources can be targeted for reduction projects the loadings of sodium from sub-watershed sources must be identified in order to prioritize activities.

This initial research on sodium will be performed at the Philadelphia Water Department's treatment systems. Understanding the Philadelphia system will improve knowledge of sodium contributions from other wastewater and drinking water treatment plants. De-icing materials such as road salt have long been known to contribute sodium and chloride to fresh waters. This research initiative will also account for the amount of salts applied to transportation surfaces.

The Philadelphia Water Department will begin efforts to reduce salinity in the Study Area through research and targeted outreach to communicate key findings.

Source Water Protection Initiatives

Forest Protection and Conservation Development Initiative

The Philadelphia Water Department has developed a three step source water protection initiative that aims to preserve forested lands and open space.

Step 1 Support ongoing forest protection initiatives by providing information to counties, municipalities, land trusts, the Smart Growth Alliance, and other environmental conservation groups.

Through providing information about the benefits of source water protection and the means with which to execute it, the Philadelphia Water Department will support ongoing forest protection initiatives within the Delaware River Study Area. The Philadelphia Water Department will support the incorporation of canopy cover and tree protection ordinances into Pennsylvania Act 167, Erosion and Sedimentation construction controls, and county Open Space Plans. The ordinances would aim to prevent developers from clear cutting sites, require developers to save large trees of a specific size, and favor smart development that preserves open space. To assist land preservation efforts by counties, land trusts, and other groups, the Philadelphia Water Department can provide source water protection priority maps that identify the most valuable resources to protect in order to maintain the local drinking water supply.

Step 2 Meet with the Pennsylvania Department of Conservation and Natural Resources (DCNR) about purchasing, or means to conserve, forested lands for source water protection.

The Philadelphia Water Department will initiate a dialogue with DCNR about the role forests play in maintaining source water quality. Given DCNR's role in protecting forests and natural resources, the agency is an important ally in mitigating forest loss in Pennsylvania. Pennsylvania is under intense development pressure and has more forested lands to potentially lose to development than the New Jersey and New York portions of the Study Area. By engaging DCNR, our goal is to ensure that source water protection will be considered in forest conservation and grant activities, thus amplifying efforts to maintain the high source water quality of the Delaware River.

Step 3 Explore funding options for purchasing land or easements in the name of source water protection.

In order to purchase land for source water protection, the Philadelphia Water Department must forge partnerships that align the mutual beneficiaries of land preservation. Drinking water utilities, land trusts, conservation organizations, agricultural cooperatives, individual farm owners, watershed organizations, and flooding prevention groups are just some examples of those who would benefit from purchases of land for conservation.

Source Water Protection Initiatives

Delaware Valley Climate Change Initiative

The Philadelphia Water Department will partner with the Partnership for the Delaware Estuary (PDE) to explore climate change issues relating to the salt line and water quality of the Delaware River. The Philadelphia Water Department has major concerns regarding salt line movement and water quality changes that may occur due to climate change, and therefore must be aware of all research that focuses on this issue in the Delaware River.

One of the main research initiatives the Philadelphia Water Department would like to facilitate is a new model of tidal salt line movement based on current climate change predictions for sea level rise and altered fresh water flow. Movement of the salt line closer to the Baxter intake is a major threat to the Philadelphia Water Department and relies on the preventative releases of water from reservoirs in New York and Pennsylvania during threatening conditions. The Philadelphia Water Department believes that a new model is warranted given that climate change can move the salt line due to sea level rise and through alterations of fresh water flow. Current release amounts and minimum flow levels may not remain effective at salt line control under climate change conditions. The DRBC resolutions governing reservoir releases and minimum flows must be re-examined under climate change conditions, and this cannot be done without a new model of the salt line.

Early Warning System Expansion

In order to further protect the water supply of the Delaware River Study Area, the Philadelphia Water Department will expand the Delaware Valley Early Warning System (EWS). The EWS will be expanded to strengthen its response mechanism in the event of terrorist attacks or catastrophes, the notification system will be expanded to include industrial intakes and dischargers, and stand alone time of travel models will be developed to help utilities prepare emergency response plans.

Regional Disinfection Byproduct Precursor Investigation

The Philadelphia Water Department will research bromide, TOC, DOC, and UV254, which are disinfection byproduct precursors, and ultimately work to reduce their prevalence in the Delaware River Study Area. A literature search must first be performed to identify any climate change and land cover change concentration effects on bromide, DOC, TOC, and UV254. Although the sources of these compounds are known to be natural, a greater understanding of these sources within Delaware River watershed is needed. The Philadelphia Water Department will also work to expand the network of utilities that collect UV254 data. With a vast network of data and knowledge of watershed sources, source water protection projects can be designed to reduce disinfection byproduct precursors.

Source Water Protection

A Cooperative Approach

The Philadelphia Water Department employs source water protection to prevent the water quality degradation and water quantity disruption of the Delaware River water supply. Source water protection is a cooperative approach that enlists the utility, citizens, regulators, environmental organizations, educational institutions, state and local governments. Through the source water protection strategy developed in this plan, the Philadelphia Water Department will draw the attention of regional stakeholders to the Delaware River as a valuable water supply that must be protected and maintained.

The Philadelphia Water Department has four source water protection goals it hopes to achieve:

Goal 1

Ensure the Baxter WTP is adequately protected under regional water policy from climate change effects on the salt line and streamflow.

Goal 2

Prevent the Baxter Water Treatment Plant from losing Bin 1 status under the Long Term 2 Enhanced Surface Water Treatment Rule

Goal 3

Become a regional leader and facilitator of efforts to offset the effects of land cover change on the water quality and quantity of the Delaware River.

Goal 4

Raise the profile of the Delaware River as a drinking water supply that needs to be maintained and protected in the eyes of the public, government, and regulatory communities.

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Section 1

Overview of the Source Water Program and Protection Plan

1.1 Introduction

The Philadelphia Water Department (PWD) has long recognized the importance of water supply protection dating back to the 1880's. Philadelphia is located between two major Eastern United States rivers, the Schuylkill and Delaware, and relies on the rivers for drinking water as well as commerce and recreation. During the late nineteenth century, growth in the industrial sector and population led to the pollution of the Delaware River from multiple sources. The pollution of the Delaware River is noted to have been so bad at one point that it could be smelled from city hall, over a mile away. The river is no longer noted for its smell, but rather highlighted by the return of anadromous species such as the shad and striped bass. The Philadelphia Water Department is committed to long term source water protection even though great strides in water quality have been achieved. Long term source water protection is carried out through the diligence of the Source Water Protection Program and through initiatives like the Delaware River Source Water Assessment and Protection Plan.

The watershed has changed significantly since the industrial revolution. Industrialization and development upstream and within the city required wastewater treatment plants along the Delaware River that serve Philadelphia and many other towns in New Jersey and Pennsylvania to control urban related pollution from wastewater and industrial discharges. Emergence of pathogens such as *Cryptosporidium* and other contaminants that could pass through existing surface water treatment processes, however, have demanded ever more sophisticated levels of technology. Current threats also require a renewed focus on source water protection in order to preserve the high quality of PWD's water supply.

In response to this need, PWD established a source water protection program in 1999 dedicated to protecting and improving its water supply. Between 1999 and 2003, PWD participated in the Pennsylvania Department of Environmental Protection (PA-DEP) source water assessments as the primary contractor for surface water supplies in the Delaware River watershed.[1] PWD held over 25 technical advisory group and public meetings with watershed stakeholders to obtain information on which potential sources were of the greatest importance to them. These assessments resulted in the identification of pollution sources posing the biggest threat to drinking water intakes along the Delaware. PWD then used the results of this assessment to develop this

[1] PWD was the recipient of the 2002 USEPA Region III Source Water Protection Award, the 2003 Exemplary Source Water Protection Award by the American Water Works Association, and the 2003 USEPA Clean Water Partners Award

comprehensive source water protection plan for the Baxter Water Treatment Plant intake and the Delaware River, which further prioritizes threats identified in the assessments and outlines several complementary approaches to reducing these threats.

Due to the large size of the Delaware River watershed, it can be difficult to successfully implement projects that cover such a wide range in scope and effectively address the problems associated with the watershed. In response to this issue, the U.S. Environmental Protection Agency (EPA), Delaware River Basin Commission (DRBC), Pennsylvania Department of Environmental Protection (PA-DEP), and Philadelphia Water Department often coordinate on projects designed to improve water quality. By building upon these existing partnerships, rather than competing for resources and duplicating efforts, greater progress can be made.

This source water protection plan fills several specific roles. It clearly identifies the important actual and potential sources of contamination to the raw water supplying the Philadelphia Water Department's Baxter Water Treatment Plant and outlines targeted protection and cleanup projects based on these sources. Secondly, information from the plan can be utilized to effectively educate the public about its drinking water source and efforts being made to protect and improve it. Thirdly, the plan serves as the first step for long-term sustainable planning for the future of the communities in the watershed. Lastly, it provides a comprehensive framework for implementing a watershed-wide effort to improve source water quality.

1.2 Background on Source Water Assessments

The Delaware River is a source of drinking water for 750,000 people in Northeast Philadelphia and Lower Bucks County. In total the Delaware River supplies drinking water to over 17 million people, or 10 percent of the United States population. The Delaware River extends 330-miles in length from New York to Philadelphia within a 7,500 square mile watershed. The watershed is geographically diverse, flowing from the Catskill Mountains, through rich farmland and low rolling hills in the Piedmont Province, into the highly urbanized Atlantic Coastal Plain.

Industrialization and mining in the 19th and 20th centuries left the Delaware one of the most polluted rivers in the nation. In recent decades the river's water quality has improved and migratory fish are returning, but problems remain. Major contributors to these problems include waste water treatment plant discharges, road salt application, population growth, land cover change, climate change, and potential salt line movement.

Between 1999 and 2003, the Delaware River Source Water Assessments were created with the help of individuals from PWD, the Pennsylvania Department of Environmental Protection, the New Jersey Department of Environmental Protections, the Delaware River Basin Commission, the Philadelphia Suburban Water Company[2], the Pennsylvania American Water Company, Bucks County Water and Sewer Authority, regional

[2] Philadelphia Suburban Water Company was purchased in 2003 by Aqua America, Inc.

environmental and watershed organizations, and interested citizens. Assessments were performed for several area water supplies including the Baxter Water Treatment Plant, New Hope, Middletown, Morrisville, Bristol NJ, Neshaminy, Yardley, and Lower Bucks County Municipal Authority. The assessment process contained several unique aspects, including:

- The development of a comprehensive, point source database for the entire Delaware River watershed. The database is programmed to locate the thousands of potential point sources in relationship to the river and tributary, estimate potential contaminant loading for 10 contaminant categories from each source, estimate potential contaminant concentration at the intake from each of the sources, and estimate travel time to the intake under high water flow conditions from each of the sources.

- The development of one of the largest applications of a stormwater model using the EPA Storm Water Management Model code to estimate non-point source contaminant loading to the Delaware River for nine of the 10 contaminant categories. The Storm Water Management Model is a continuous simulation model.

- The use of sophisticated decision support software to screen the thousands of point sources, and to integrate the point sources and non-point sources into a single evaluation to identify the 100 highest priority sources for the Baxter Water Treatment Plant and other intakes on the Delaware River.

The assessment process outlined above resulted in a comprehensive list of contaminant sources and priority restoration locations. Detailed information on the assessment process can be found in Sections 1.5 and 2.2 of the source water assessment reports available for public review at the PA-DEP regional offices.

1.2.1 Key Findings of the Source Water Assessments

Over 6,000 potential point sources were identified within the almost 8,000 square mile Delaware River Study Area that supplies water to the Baxter Intake. Most of these potential sources do not, and will never, discharge to the Delaware River. All of the highest priority discharge sources are either National Pollution Discharge Elimination System (NPDES) sites or stormwater loadings from specific sub-watersheds.

Of the non-point pollution sources, the developed land areas associated with industrial/commercial land use and residential uses were estimated to contribute the highest per acre loadings of most of the contaminants evaluated including; disinfection by-products, metals, nutrients, petroleum hydrocarbons, salts, and coliforms. The lower Delaware River watershed is where the majority of developed and industrial/commercial land is located. NPDES and non-point source discharges within the Baxter intake Zone A and Zone B were determined to have the highest protection priorities in the watershed.

Overall, the primary source water protection areas include the tidal areas of the Delaware River between Trenton and Philadelphia/Camden. Non-point source protection should be focused in the Pennypack Creek, Poquessing/Byberry Creek, Neshaminy Creek, as well as portions of the Musconetcong, Pohatcong, and Lehigh Rivers. Additional parts of the watershed may need limited attention for contaminant specific issues.

1.2.2 Relating the Baxter Source Water Assessment to the Protection Plan

This protection plan builds on the results of the Baxter Water Treatment Plant Source Water Assessment Sections 1 and 2 (SWA). For example, the SWA established priority sources based on their impact on the Baxter Water Treatment Plant Intake. The protection plan re-examines these same sources and further prioritizes them according to their impact on the watershed as a whole. Also, the source water assessment examined pollution sources based on a set of ten contaminants determined by the Pennsylvania Department of Environmental Protection's (PA-DEP) guidelines for conducting watershed assessments. The water quality section in the protection plan is focused on target parameters identified in the source water assessment and new concerns. These parameters are nitrate, nitrite, bromide, chloride, sodium, iron, manganese, alkalinity, conductivity, *Cryptosporidium*, taste and odor compounds, and compounds of potential concern. The parameters discussed in the water quality section were chosen based on the results of the sourcewater assessment, their relationship to the water treatment process, and their prevalence in the Delaware River watershed.

The SWA Sections 1 and 2 concluded that stream impairments in the Lower Delaware River watershed are primarily caused by stormwater runoff from urban and suburban areas. The Delaware River Runoff Loading Model was developed to estimate contaminant loadings to the river from storm runoff. The model used the physical characteristics of the sub-watersheds, meteorological data, updated land use information, and event mean concentrations for the nine parameters of interest to estimate average daily contaminant loadings within each of the Baxter intake's zones of contribution. The model helped to prioritize areas with the highest pollution contribution.

Results of the watershed-wide prioritizations and detailed findings can be found in Section 4.3.6 of this document. Detailed prioritization methodologies implemented during both the intake-specific and watershed-wide prioritizations, including specific criteria used, can also be found in Section 4.3.6.

1.2.3 Identifying Projects for the Protection Plan

This protection plan outlines specific projects and studies intended to address sources of pollution and to improve the quality of the Philadelphia Water Department's water supply. (Please refer to Section 5 for project information.) These projects are determined in part by the results of the Source Water Assessments, but are also based on additional analyses of population growth and land cover change and up to date water quality data. Three reports that contributed input regarding overall stream health and impairments are the 2006 New Jersey Integrated Water Quality Monitoring and Assessment Report, New York State Water Quality 2004, and 2006 Pennsylvania Integrated Water Quality Monitoring and Assessment Report. These reports identify impaired stream segments in the Delaware River Study Area based on biological and chemical data collected throughout the watershed. Within the Delaware River Study Area, there are 14,057 miles of stream and creeks. Of those stream miles, 28% are designated as impaired by either the New Jersey, New York, or Pennsylvania 305b reports. Impaired streams are examined in more detail in Section 2.6 of this report.

By recommending projects intended to address concerns and priorities from multiple sources, this protection plan promotes a comprehensive approach to maintaining and enhancing the Delaware River as a drinking water source as outlined by the Safe Drinking Water Act Reauthorization of 1996 (SDWA). Additional components of the SDWA include the adoption of a watershed protection program, public involvement in setting water system priorities, and the establishment of drinking water protection programs, all of which are incorporated either through the Philadelphia Water Department's existing Source Water Protection Program, within this protection plan, or through the Philadelphia Water Department's involvement with the regional agencies and civic organizations.

1.2.4 Implementing Projects Outlined in the Protection Plan

The Philadelphia Water Department's approach for successful implementation of its protection plan is based on the prioritization of source water threats and participation in strong regional partnerships who all work towards the goal of protecting the Delaware River. The prioritization of source water threats is essential to identifying the most pressing source water quality concerns of the Baxter Intake. Once the source water quality and threats are evaluated, the Philadelphia Water Department can begin to reach out to the multiple stakeholders of the Delaware River Valley. The source water protection initiatives described in Section 5 of this document provide water quality benefits to the many users of the Delaware River. The source water protection initiatives will not only benefit the Philadelphia Water Department, but will enhance and maintain the water quality of the Delaware River, a resource for the entire Delaware Valley region and the Delaware Estuary. The source water protection initiatives suggested in this plan aim to highlight the importance of the Delaware River as a water supply and unite organizations, agencies, and citizens behind protecting this resource.

1.3 Agencies and Roles in the Delaware River Watershed

Delaware River Basin Commission (DRBC)

The Delaware River Basin Commission (DRBC) was created in 1961 as a regional body with legal enforcement capability to oversee the Delaware River watershed. The DRBC is composed of commissioners and representatives from New Jersey, Pennsylvania, Delaware and New York. The DRBC provides watershed management, water resources stewardship, seeks public involvement in Delaware River issues, and coordinates inter-agency and state projects.

In 2004 the DRBC produced the *Basin Plan,* which incorporates watershed management policies, goals, and implementation strategies. The *Basin Plan* outlined key points of interest that will guide the actions of the DRBC for the next thirty years, including: sustainable use and supply, waterway corridor management, linking land and water resources management, institutional coordination and cooperation, and education and involvement for stewardship.

Partnership for the Delaware Estuary (PDE)

The mission of the Partnership for the Delaware Estuary (PDE) is to lead both collaborative and creative efforts to protect and enhance the Delaware Estuary and its tributaries. In 2004, the Partnership for the Delaware Estuary merged with the Delaware Estuary Program to form a single cohesive organization. The role of the recently merged PDE is to implement goals and objectives set forth by the Comprehensive Conservation and Management Plan (CCMP) approved in 1996.

The Delaware Estuary was listed under the Environmental Protection Agency's National Estuary Program in 1988. A requirement of the National Estuary Program is that each listed area produce and implement a CCMP focused on attaining or maintaining water quality within the estuary.

Pennsylvania Department of Environmental Protection (PA-DEP)

The Pennsylvania Department of Environmental Protection (PA-DEP) is responsible for regulatory, permitting, and enforcement of environmental law and policy within the state of Pennsylvania. The Delaware River watershed boundary is adjacent to both the Southeast and Northeast Regions of the PA-DEP.

With regards to water resources, the PA-DEP plays an active role in protection and restoration on a watershed basis. Activities of the PA-DEP include: water conservation, aquatic life protection, discharge permitting, source and groundwater quality monitoring and enhancement, as well as encouragement and engagement of local watershed organizations.

New Jersey Department of Environmental Protection (NJ-DEP)

The mission of the New Jersey Department of Environmental Protection (NJ-DEP) is to assist New Jersey citizens in preserving, sustaining, protecting, and enhancing the environment to ensure high environmental quality, public health, and economic vitality.

The NJ-DEP concentrates on water resources through the Division of Water Quality, Division of Watershed Management, the Water Supply Administration, and the office of Water Quality Monitoring and Standards.

United States Coast Guard

Across the country the Coast Guard plays a large maritime role in search and rescue mission, port security, boating safety, licensing, navigation, and traffic services. Concerning water resources, the Coast Guard is the executor of two important agencies; the National Pollution Funds Center, and the National Response Center.

The National Pollution Funds Center was created by the Oil Pollution Act and pays for removal and remediation costs incurred by the EPA and Coast Guard during the event of an oil spill. National Pollution Funds Center financing recently paid $50 million towards the Athos I oil spill clean-up on the Delaware River in 2004. The National Response Center is the sole point of federal government contact regarding oil, chemical, biological, and radiological environmental spills and discharges.

Army Corps of Engineers (ACE), Philadelphia District

The Army Corps of Engineers (ACE) Philadelphia District jurisdiction includes the Delaware River Basin and the Atlantic Ocean coast from Manasquan Inlet in New Jersey to the southern boundary of Delaware, over 550 miles of navigable waters. The ACE Philadelphia District also provides services and support to the Dover Air Force Base in Dover, Delaware and Fort Dix New Jersey.

The ACE initiates and performs all dredging and shipping channel maintenance operations. Within the Delaware River Basin, the Coast Guard has been the main advocate of deepening the Delaware Estuary shipping channel from 40 feet to 45 feet. Other water resource functions of the ACE are dam and bridge construction and maintenance, flood protection, disaster response, and geographic information system technical support.

United States Environmental Protection Agency, Region 3 (EPA)

Region 3 of the United States Environmental Protection Agency includes the states of DE, PA, MD, VA, WV, and the District of Columbia. The EPA is the federal regulatory, policy, and enforcement body concerning multiple assets of environmental science and function.

The main function of the EPA with regards to water resources is the administration of the National Estuary Program, Clean Water Act, Safe Drinking Water Act, and includes the Total Maximum Daily Load program and National Pollution Discharge Elimination System. The EPA periodically amends the regulations and standards within those three major policies to include the latest advancements in water quality technology, science, and human health.

Table 1.3-1 Matrix of Agencies and their Roles in the Delaware River Watershed

	DRBC	PA DEP	NJ DEP	DelEP	Coast Guard	Army Corps Eng. Phila.	EPA	PWD
Regulatory + Enforcement	X	X	X		X	X	X	
Water Quality Monitoring	X	X	X				X	X
Watershed Management	X	X	X				X	X
Education + Public Outreach	X	X	X	X			X	X
Channel and Port Security + Maintenance	X	X	X		X	X		
Disaster Response + Remediation	X	X	X	X	X	X	X	X
Point and Non-Point Source Pollution Prevention	X	X	X	X			X	X
Stormwater Management	X	X	X				X	X
Drought Planning	X	X	X				X	X
Supply Allocation + Demand Planning	X	X	X					X
Water Quality Remediation + BMP Implementation	X	X	X	X			X	X
Funding + Technical Support	X	X	X	X	X	X	X	X

Section 2

Watershed Description

2.1 General Delaware River Watershed Information

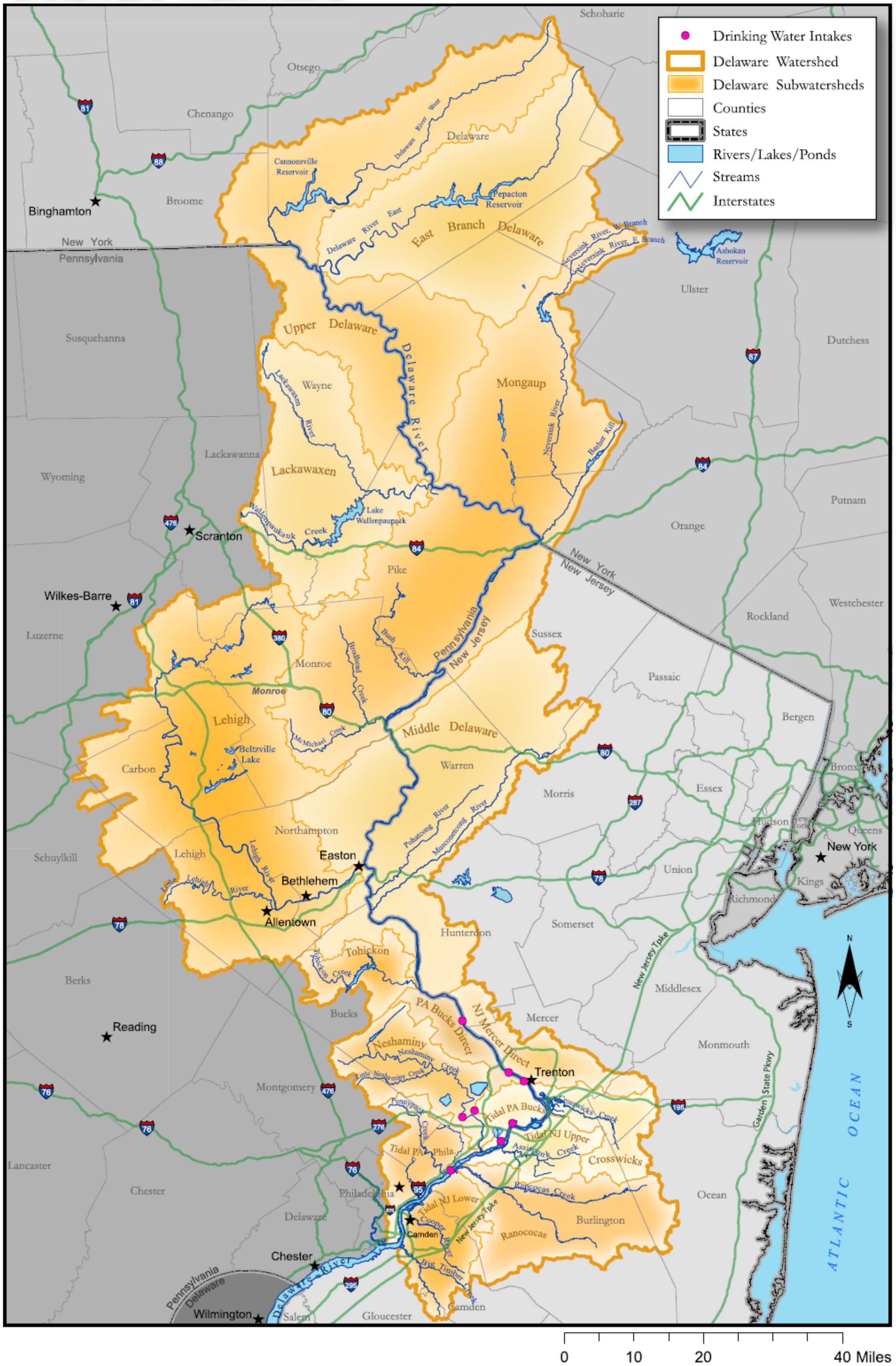
From Point Mountain in the Catskills Range of Hancock (Schoharie County), New York to the mouth of the Delaware Bay in Philadelphia, Pennsylvania, the 330 mile-long Delaware River winds its way through four states on the eastern coast of the United States, encompassing 42 counties and 838 municipalities in the Mid-Atlantic Region of the country. Originating on the western slopes of New York State's Catskill Mountains as two separate branches that meet downstream in Hancock, NY, the river flows southeast for 78 miles through rural regions along the New York-Pennsylvania border to Port Jervis in the Shawangunk (Catskills) Mountains. From there, it heads southwest, along the border between Pennsylvania and New Jersey, through the Appalachian Mountains and 42 miles of the Minisink Valley and the Water Gap in the Kittatinny Mountains (also known as Blue Mountain in PA). Turning southeast again at Easton, PA, where it is met by the Lehigh River (its second largest tributary) with an average annual flow rate of 2,890 cubic feet per second (cfs), the Delaware then flows approximately 80 miles to the tidal waters of Trenton, New Jersey with an average annual flow rate of 11,700 cfs, thus completing about 200 miles of its 330-mile journey. About 30 miles downstream of Trenton, the river passes through the fifth largest metropolitan region in the nation—the heavily industrialized Philadelphia/Camden area—and the mouth of the Schuylkill River, its largest tributary, which flows into the Delaware at an average annual flow rate of about 2,720 cfs. From there, the river flows on past Wilmington, Delaware and through the more rural regions of Cape May, New Jersey on its eastern shore and Cape Henlopen, Delaware on the west, completing its course to the Delaware Bay.

Along its route from the headwaters to the mouth of the bay, the Delaware River drains a total of 13,539 square miles (0.4% of the land mass in the U.S.) in New York, Pennsylvania, New Jersey, and Delaware. Figure 2.1-1 presents a map of the Delaware River Study Area that is the water supply for the Baxter Intake.

The river, its bay, and 216 tributary streams play a significant role in sustaining life and the economy in these areas. Among other things, these bodies of water are used for fishing, transportation, power, cooling, recreation, and other industrial and residential purposes. Most importantly, though, they provide drinking water for about 17 million people, or almost 10% of the country's population.

There are three reaches of the Delaware River: the 197 non-tidal miles from Hancock, NY to Trenton, NJ comprise the first, the next 85 tidal miles from Trenton to Liston Point, DE, which are referred to as the "Delaware Estuary," are the second reach, and the remaining 48 miles of the Delaware Bay that extend into the Atlantic Ocean between Cape May, NJ and Cape Henlopen, DE make up the third reach.

Figure 2.1-1 Delaware River Study Area



As the 33rd largest river in the U.S. in terms of flow, the Delaware may be unimpressive in size, but it is one of the nation's most heavily used rivers as far as the volume of tonnage traveling on it every day. Sixty-seven and a half million tons of cargo moved along the Delaware River in 1980, most of which consisted of petroleum, ore, and sugar (Toffey, 1982). With no dams on its main stem, the Delaware River is also one of the few remaining large free-flowing rivers in the country. As such, it continues to be an important asset to the regions that comprise its watershed. However, it is a resource that has had to be slowly salvaged from a severely deteriorated state over the last 300 years, and it is still in the process of recovering from those three centuries of abuse. The Delaware's return to a relatively sustainable, healthy condition is one of the world's most successful and ongoing river restoration stories, and it is a project that is studied worldwide today as a model of successful interstate water management.

When settlers of the region arrived, the biota of the Delaware River Watershed was much more diverse than it is today. The immigrants found a plethora of life both in the water and on the land. Sadly, many species that once thrived have since been eliminated or only survive in limited numbers today due to pollution or overfishing/overhunting. Currently, forty-five fish species can be found in the Upper Delaware, where the highest quality river water in the basin is located. These species include American shad, brook trout, brown rainbow trout, chain pickerel, large and small mouth bass, and walleyed pike. Trout, salmon, and walleye are stocked in many of the Delaware's tributaries today, and eels and shad can still be found migrating in its waters, mainly due to the lack of dams on the river that would prevent their passage upstream.

On land, habitat loss, which is primarily due to development, put an end to some animal species that roamed in pre-colonial times. The Canada lynx, mountain lion, and passenger pigeon are a few species that no longer inhabit the watershed. However, there still exists a wide variety of fauna in the basin, such as bear, beaver, bobcat, deer, fox, muskrat, rabbit, raccoon, opossum, skunk, squirrel, and woodchuck, among others, as well as over 200 species of permanent and migratory birds, such as bald eagle, bluebird, merganser, osprey, pheasant, turkey, and several species of woodpeckers. The Delaware Estuary, at the lower end of the watershed, is a crucial stop for the second-largest group of migrating birds to North America. As part of the Atlantic Flyway, the estuary provides a respite for food and shelter to these travelers as they journey north.

The Delaware River watershed and the estuary in particular, were quite different in pre-colonial times. They consisted of a diversity of vegetation that covered a combination of land types. The uplands of the watershed, from the headwaters of the Delaware River in the Catskill Mountains (NY) to the Water Gap (between northern NJ and PA), is the area that has been least affected by colonization, and it retains much of its wild, scenic, natural beauty. Among the 1,100 plant species that thrive in this region are: oak, maple, hemlock, beech, walnut, ash, pine, dogwood, cedar, birch, rhododendron, mountain laurel, wild flowers, mosses, and ferns. Farming continues to play a large economic role in this area.

The middle section of the watershed, from the Water Gap to the falls at Trenton, NJ, used to be a contiguous mature forest that comprised the midpoint between a northern plateau of white pine, Eastern hemlock, beech, and maple trees and southern primeval forests of white oak, American chestnut, hickory, and chestnut oak. Only about half of the middle section remains wooded today. The majority of the original forest, having been cleared by settlers for farms and homes, is still trying to recover.

The estuary section near the lower portion of the watershed has undergone extensive change since colonial times, most notably, its ongoing development from an area of diverse and natural wild land into a rapidly industrialized region of man-made factories and ports, in the upper part of the estuary in particular. Yet, the region remains a vital resource for plant, animal, and human life throughout the watershed, especially the bay area.

A few sections of the river that have managed to retain a healthy level of their pristine pre-colonial condition or recover from former damage have been granted special recognition and protection from future abuse as part of the National Wild and Scenic Rivers System. The Upper River has also been classified as "Special Protection Waters," thus entitling it to increased protective regulation in order to preserve the high quality of its water. The story of the rest of the Delaware's main stem, however, is not so impressive, as the whole of the river has yet to attain such an exemplary condition.

2.2 History of the Delaware River Watershed

The Delaware River Watershed has long been a life-source for inhabitants in these regions. It is believed that the earliest settlers in this area, the hunter-gatherer Paleo Native Americans, used the river, the bay, and the surrounding lands for food, transportation, and trade roughly 12,000-13,000 years ago, with little resulting damage to the river's ecosystem. Other tribes later moved into the area, one of whom was the woodland Native American Lenape (Le-náh-pay) who made conservative use of the Delaware River system to serve their needs for hundreds of years starting from about 1,400 years ago until the time that a new wave of settlers arrived from overseas (Webster, 1996). The Lenape called the river "Lenape Wihittuck" ("the river of the Lenape"), and they lived, fished, and farmed along its banks, using it wisely, mainly for food and water for their small farms of beans, corn, pumpkins, squash, and tobacco, among other things. However, natural stewardship began its decline in the 1600s when Europeans arrived on eastern American shores, and brought with them not only a greater number of settlers to the watershed, but also rapid industrialization and exploitation of this important resource. The Europeans called the river the "Delaware" and referred to the Lenape who lived along its banks as "the Delawares" (Bryant and Pennock, 1988).

The Native Americans eventually disappeared due to westward migration relatively soon after European settlement. European settlers subsequently dominated the river, beginning in 1623 with the Dutch, who established a trading post at Fort Nassau near present day Gloucester, New Jersey, and a whaling colony near Lewes, Delaware in 1631. The whaling colony was destroyed by Native Americans in 1632. They were followed by the Swedes, who settled at what is now Wilmington, Delaware in 1638, and then the Finns. Scandinavian Settlers controlled the region until about 1663, when the English took control of the Delaware Estuary. Shortly thereafter, development and urbanization in the region began in earnest, particularly in the Philadelphia area following the city's founding by William Penn in 1682.

By the 1770s, the Delaware Estuary region, from the bay area up to present-day Trenton, had become the locus of industry in America. In addition to tanneries, glass works, shipyards, and brickyards, soon leather, lumber, paper, textile, and coal mills popped up along the river and spewed their waste into its waters. Anthracite coal was abundant in the eastern section of the watershed, especially in Pennsylvania between the Delaware and Susquehanna rivers in Lehigh, Schuylkill, and Wyoming Counties (Rhone, 1902) where the majority of the nation's 7 billion tons of anthracite coal is located. (PA-DEP, **http://www.dep.state.pa.us/dep/deputate/enved/go_with_inspector/coalmine/Anthracite_Coal_Mining.htm)** . Waste from the mines that was dumped or leaked into the rivers caused turbidity and contamination as sulfur from the rocks mixed with oxygen and water, making the water highly acidic. Over 2,400 of the 54,000 miles of streams in Pennsylvania have been polluted by abandoned mine drainage from mining operations since the 1700s. In fact, abandoned mine drainage (AMD) is the single largest source of water pollution in Pennsylvania, a problem the state has been combating since 1913, when Act 375 was passed in order to prohibit the discharge of anthracite coal, culm (fine particles of coal and clay), or refuse into streams.

However, AMD discharges were not the only pollution problem in the watershed. As the Industrial Revolution began to creep into the colonies at the beginning of the nineteenth century, the waterfront developed into a hotspot for manufacturing and shipping. The quick rate at which this development occurred and the pollution that resulted from such rapid residential and commercial growth stressed the river's resources.

The majority of the damage done to the river and shoreline was concentrated within the heavily industrialized estuary region from Wilmington, DE north to the tidal waters at Trenton, NJ, especially near the major cities of Philadelphia and Trenton, which were the largest sources of pollution. The less-populated upper half of the watershed above Trenton, where agriculture was still the predominant economic activity and development proceeded more slowly, was not so severely affected.

As a result of decades of continuous contamination, the health of the river rapidly deteriorated. By the end of the 1800s, the fisheries that had flourished in the early days of colonial settlement were hurting for business on account of over-fishing and the excessively polluted water that contained too little oxygen to support much aquatic life (Webster, 1996). In just over a century's time, the riverfront had changed from a predominantly wild, wooded area supported by a clean, healthy river teeming with life in pre-colonial times, to a farming and recreational area whose river supported the needs of new settlements throughout the 1700s, to a dangerously polluted hub of industrial manufacturing beginning in the early 1800s. In the estuary, contaminated water could not even sustain aquatic life and was no longer safe to drink, swim in, or breathe near due to noxious odors from raw sewage that was dumped into it on a daily basis.

By the 1940s, World War II efforts kicked manufacturing into overdrive once again. While the estuary was an industrial giant with a major world port in the metropolis of Philadelphia, the economic success of the estuarine colonies was dampened due to the heavy environmental cost. The land was stripped and stressed from years of clearing, poor farming practices (colonists did not know about crop rotation to maintain soil fertility), erosion and pollution. The sewage from residential and industrial waste depleted oxygen levels to an extreme that nearly drove fisheries out of business and left the rivers virtually dead. It is estimated that 85% of Philadelphia's untreated residential waste was discharged directly into the estuary in the 1940s (Marrazzo and Panzitta, 1984).

As Christopher Roberts (Delaware River Basin Commission) explained it, "the lower Delaware had become an open sewer, spewing septic gases that tarnished ships' metalwork and sickened sailors (Roberts, 1989)." In this way, colonial waste disposal practices made what had once been a pristine, healthy, flowing life source into a stagnant, lifeless, noxious cesspool often referred to as the "black waters" during that time, a period that is recognized as the Delaware's darkest hour (Toffey, 1982). Recent environmental practices, legislation, and public interest have enabled the Delaware to rebound during the mid-twentieth century. Recreation and native species, such as the shad, have returned to the river as the Delaware moves into the twenty-first century.

2.3 Delaware River Water Supply

Inhabitants of the Delaware River Basin get their water from surface and ground sources, depending on where they live within the watershed. Urban areas make use of the rivers near which they were founded, while suburban and rural regions rely more on groundwater from regional wells. In the Delaware River Basin, 88% percent of the total amount of water withdrawals is taken from surface water supplies, whereas 12% comes from groundwater sources (based on 1991 and 1993 data, DRBC, http://www.state.nj.us/drbc/gwsw93.htm). Surface sources supply 60% of the water that is used consumptively, with the remaining 40% coming from groundwater stores (USGS NAWQA, 1999).

Consumptive water use, as defined by the DRBC is: “that part of water withdrawn which is evaporated, transpired, incorporated into products or crops, consumed by humans or livestock, or otherwise removed from the immediate water environment…not available for other valuable purposes such as public water supply, salinity repulsion in the Delaware estuary, maintenance of streamflow, water quality, fisheries and recreation (http://www.state.nj.us/drbc/consdef.htm) “, as opposed to water that is used non-consumptively, which is returned to the basin's rivers and streams by means of point sources.

The following table is reproduced from the 2005 Delaware River Basin Commission (DRBC) figures for consumptive use in the tidal portion of the Delaware River Study Area. This table can be found online at http://www.state.nj.us/drbc/wateruse/largeusers_05.htm.

Table 2.3-1 2005 Water Withdrawal and Consumptive Use by Large Users on the Tidal Delaware River

					Consumptive Use		
	Surface Water (MGY)	Ground Water (MGY)	Purchased Water (MGY)	Total Water Use (MGY)	(MGY)	As % of Total	Notes
Pennsylvania							
Power							
Exelon - Delaware	1.544			1.544	0.154	10	(1)
Exelon - Eddystone - Units 1-4	320,057			320,057	897	0.3	
FPL Energy MH 50, Marcus Hook	30			30	13	43.3	
FPL Energy MH 750, Marcus Hook	1,427			1,427	1,005	70.4	
Fairless Energy, LLC (Dominion)	736			736	495	67.3	
Industry							
Kimberly-Clark Corporation	2,404			2,404	170	7.1	
Philadelphia Gas Works - Richmond	2,938			2,938	59	2.0	(2)
Rohm & Haas - Bristol	1,752		218	1,970	101	5.1	
Rohm & Haas - Philadelphia	598		57	655	1	0.2	
Sun Refining Co. - Marcus Hook	3,526		1,130	4,656	2,176	46.7	
Tosco/BP Oil/Bayway Refining	33,718			33,718	472	1.4	
USX-US Steel Div - Fairless Works	12,555			12,555	380	3.0	
Wheelabrator- Falls	275			275	275	100.0	
Public Water Supply							
Lower Bucks Co. Joint Municipal Authority	2,870	61		2,931	293	10.0	(2)

					Consumptive Use		
	Surface Water (MGY)	Ground Water (MGY)	Purchased Water (MGY)	Total Water Use (MGY)	(MGY)	As % of Total	Notes
Aqua Pennsylvania - Bristol Division	2,027			2,027	203	10.0	(2)
Philadelphia Water Dept - Torresdale	57,785			57,785	5,779	10.0	(2)
Delaware							
Power							
Conectiv - Edgemoor Units 1-4	68,543		155	68,698	342	0.5	
Conectiv - Edgemoor Unit 5	67,201			67,201	194	0.3	
Conectiv - Hay Road	470			470	470	100.0	
Industry							
CitiSteel	45			45	45	100.0	(2)
E.I. DuPont - Edgemoor	2,650		393	3,043	265	8.7	
Premcor	134,238			134,238	1,268	0.9	
SPI Polyols	699			699	7	1.0	(2)
New Jersey							
Power							
Conectiv - Deepwater Station	32,842	62	1	32,905	156	0.5	
Logan Generating Company	843			843	813	96.4	
PSE&G - Burlington Station	0		15	15	0	0	
PSE&G - Hope Creek Station	19,561			19,561	5,038	25.8	
PSE&G - Mercer Station	233,679		180	233,859	1,304	0.6	
PSE&G - Salem Station	1,067,892			1,067,892	7,559	0.7	
Industry							
Sunoco Eagle Point	2,394			2,394	1,213	50.7	
E.I. DuPont - Chambers Plant	14,388	856		15,244	1,582	10.4	
E.I. DuPont - Repauno Plant	1,407	301		1,708	361	21	
MAFCO Worldwide Corporation	53			53	13	24.5	
National Gypsum Company	91			91	56	61.5	
Valero Refining Corp	2,775			2,775	788	28.4	

					Consumptive Use		
	Surface Water (MGY)	Ground Water (MGY)	Purchased Water (MGY)	Total Water Use (MGY)	(MGY)	As % of Total	Notes
Wheelabrator - Gloucester Co.	5,138			5,138	5.8	0.1	
Public Water Supply							
Burlington City	538			538	53.8	10.0	(2)
New Jersey American Water Co.	7,930			7,930	793	10.0	(2)

Source: DRBC http://www.state.nj.us/drbc/wateruse/largeusers_05.htm
(1) 2005 will be the last year in operation.
(2) Consumptive Use Estimated by DRBC Staff.
MGY = million gallons/year
All figures are provisional and subject to change

According to Table 2.3-1 above, the largest water withdrawals of water from the Delaware River are by regional power utilities. PSE&G Salem, Exelon Eddystone, and PSE&G Mercer are the top three water withdrawals in 2005. Consumptive use varies among the power, industry, and drinking water providers. The majority of water withdrawn for electrical utilities is not consumed and eventually returned to the river. In contrast, some steel and mineral industries, large percentages of water withdrawn are consumed.

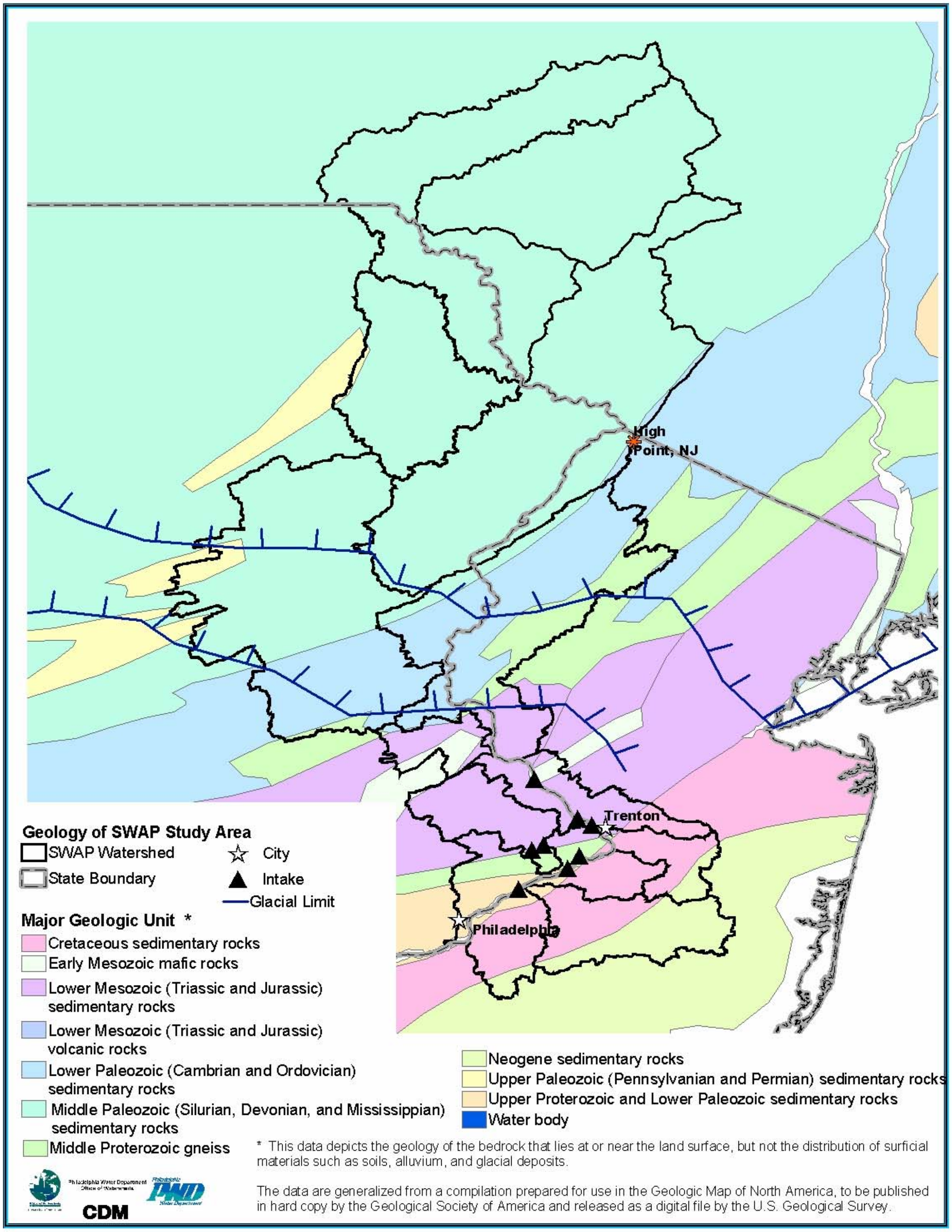
2.4 Geology and Soils

The Baxter Intake is located within the Atlantic Coastal Plane Province, with the Piedmont Province lying to the north. The area surrounding the intake is characterized by several different types of geologic formations. The major rocks and soil formations are briefly described here. For a more detailed discussion of basin geology and soils, please refer to the General Section of the Source Water Assessment Report for the Delaware River Watershed. This report is available at www.phillyriverinfo.org.

Middle Paleozoic Sedimentary Rocks

Silurian strata include the Bloomsburg, High Falls, and Shawangunk Formations. These are sedimentary rocks, and include coarse conglomerate, quartzose sandstone, and shale. Mudrocks are dominant in the Devonian section, however, small amounts of chert and limestone are important constituents in the lower half, and siltstones, sandstones, and conglomerates dominate parts of the upper half. Mississippian rocks are distributed at the surface in the Delaware Basin in the Anthracite region, and consist of the Mauch Chunk Formation (red siltstone and sandstone, and tan to brown sandstone and conglomerate), the Mount Carbon Member (coarse grained sandstone and conglomerate), the Spechty Kopf Formations (cominantly sandstone), and the Beckville Member (finer grained sandstone and conglomerate).

Figure 2.4-1 Geology of Delaware River Study Area



Lower Paleozoic Sedimentary Rock

In the Lehigh Valley region, a resistant Cambrian unit (Hardystone Formation) reaches a maximum of nearly 800 feet thick. It consists of conglomerate and arkose, feldspathic sandstone, siliceous sandstone, and silty shale. Above this unit lies a carbonate sequence of fine to coarse-grained dolomite. The sedimentary rocks of the Ordovician age crop out in southeastern Pennsylvania. They are mainly dolomite-limestone rocks, dominated by thin to thick bedded dolomite and interbedded limestone.

Lower Mesozoic Sedimentary Rocks

In the Jurassic time, about 200 million years ago, the mountains in the area began to erode to low foothills, and the ancestral Delaware River developed. The first deposits of the southward flowing Schuylkill and Delaware Rivers occurred at this time. Some of the formations within the Newark Basin include the Stockton Formation (arkosic sandstone and siltstone), the Lockatong Formation (fossiliferous black shales), and the Brunswick Group (red and gray silty mudstones and shales). These are sedimentary rocks consisting of fluvial and lacustrine deposits that can exceed 20,000 feet in thickness.

Cretaceous Sediments

Cretaceous and Tertiary sediments (unconsolidated) crop out in a narrow zone along the Delaware River in southeastern Pennsylvania. The coastal plain sediments are largely a sequence of sands, clays, and gravels, and form the most extensive aquifers of the Lower Delaware Basin. The sources of sediment deposited are diverse and related directly to the fluvial systems entering the coastal area, including the ancestral Schuylkill and Delaware Rivers. The sediments varied from that which was highly feldspathic and rich in metamorphic minerals to that which was nonfeldspathic and impoverished in heavy minerals. They are subdivided into four units: Potomac Formation (oldest, thick beds of pale-gray to grayish-orange sand interbedded with clay), Bryn Mawr Formation (isolated sand and gravel deposits), Bridgeton Formation (sand interspersed with gravel beds), and Pensauken Formation (youngest, mainly sand).

Soils

The physical properties of the soils in the Delaware River drainage basin are the determining factor in the sediment-transport characteristics of the Delaware River and its tributaries. The soils, in turn, are determined by the geology and weathering processes of the rock material. Many of the soils surrounding the Baxter Intake are classified as urban land, because the soil profile has been reworked during the cut-and-fill operations and construction projects. They generally have the same soil particle size distribution as the original silty loams.

The Delaware River Watershed is comprised of a variety of soils, which determine the landscape of the watershed and the transport properties of the river and its tributaries. Within the major hydrological classifications and groups of soils, there are 58 specific subtypes in the SWAP study area. The Wellsboro, Valley, Hagerstown, Hazelton, Berks, Washington, Wurtsboro, and Willowemoc soil classifications define approximately 50 percent of the watershed soils. More detail about these soil types is provided in the general section of this report. The predominant soils in the vicinity of the Baxter Intake include Chester, Downer, Pocomoke, Hammonton, and Sulfaquen types. Table 2.4-1 indicates that these soils are generally well drained and produce moderate runoff. The Pocomoke and Sulfaquent soils are the two soils that are very poorly drained. However, both of these soil types do not surround the Baxter Intake and are located within New Jersey.

Table 2.4-1 Prevalence of Major Soil Types in the Lower Delaware Study Area

Soil Type	Percentage of Entire Study Area	Slopes %	Permeability	Runoff	Drainage	Found on
Chester	2	0-65	Moderate	Medium	Well drained	Upland divides and upper slopes
Downer	1	0-5	Moderate to moderately rapid	Slow to rapid	Well drained	Hills and ridges
Pocomoke	1	0-2	Moderate	Medium to rapid	Very poorly drained	Level uplands and closed depressions
Hammonton	1	0-5	Moderately rapid	Slow	Well drained	Low hills, flats, and depressions
Sulfaquent	Less than 1	0-2	Moderate	Medium to rapid	Very poorly drained	Tidal flats, adjacent to bays, and tidal streams

Source: United States Department of Agriculture. Natural Resources Conservation Service. Pennsylvania Soil Survey. Official Series Descriptions.

2.5 Climate and Hydrology

The Delaware River Basin experiences the Humid Continental climate pattern. This pattern encompasses relatively normal variations in weather, which are predominantly the result of a series of high and low-pressure systems. Precipitation and cloudy weather are products of the frontal systems that are associated with low pressure. In contrast, the passage of a high-pressure system results in clear skies. In general, annual average variations of temperature and precipitation are primarily due to differences in elevation and exposure to wind direction within the Delaware River Basin (Majumdar, Millar, and Sage, 1988).

Although the Delaware River Basin experiences a continental climate, temperatures often reach extreme conditions. Maximum temperatures range from approximately 94°F in the northern basin to 105°F in the southern basin, whereas minimum temperatures vary from approximately –34°F in the north to -11°F in the south. Therefore, the maximum temperature range across the basin is almost 140°F. With respect to seasonal climate, winter temperatures fluctuate between approximately 23°F in the Upper Basin and 35°F in the Lower Basin. Conversely, summer temperatures normally average between 65°F in the Upper Basin and 77°F in the Lower Basin. Annually, the average temperature varies from about 48°F in the Upper Basin to about 54°F in the Lower Basin (Climate and Man, 1941, Climates of the States – Pennsylvania, Annual in Majumdar, Millar, and Sage, 1988).

Annual average precipitation within the Delaware River Basin is about 45 inches of precipitation per year. The driest month is normally February, with precipitation totals ranging from 2.7 to 3 inches. In contrast, July and August are the months with the most precipitation, measuring from 4.5 to 4.7 inches of precipitation. The precipitation in the cold months results from the passage of fronts in the low-pressure systems of the westerly wind belt. During the warm months, much of the precipitation occurs as convectional storms, which are supplemented by the occasional passage of a front (Climate and Man, 1941 in Majumdar, Millar, and Sage, 1988).

Table 2.5-1 gives a summary of the major tributaries in the Delaware River below Trenton New Jersey, their drainage areas, river mile location, and length. These tributaries are located within the tidal zone, and are therefore affected by water quantity and quality tidal cycles. The Neshaminy River and the Rancocas Creek are the two largest tributaries in this area. Both of these tributaries drain into the Delaware River above the location of the Baxter Intake and would therefore affect the water quality at the intake.

Table 2.5-1 Characteristics of Tributaries in the Lower Delaware River Watershed

Major Tributary	Drainage Area (mi2)	River Mile Location	Length (mi)
Assiscunk Creek	45.9	119	16.31
Big Timber Creek	55.2	96	16.00
Bustleton Creek	2.6	121	2.91
Byberry Creek	18.7	112	10.595
Cooper Creek	40.2	102	15.81
Crafts Creek	13.8	125	11.38
Crosswicks Creek	138.5	129	26.46
Martins Creek (Lower)	11.5	123	5.05
Mill Creek	19.8	119	39.96
Mill Run	37.0	105	14.81
Neshaminy River	232.4	116	51.37
Newton Creek	10.6	97	10.58
Pennsauken Creek	36.1	106	13.06
Pompeston Creek	7.7	109	5.37
Rancocas Creek	347.7	111	33.65
Rockledge Branch	55.1	110	15.57

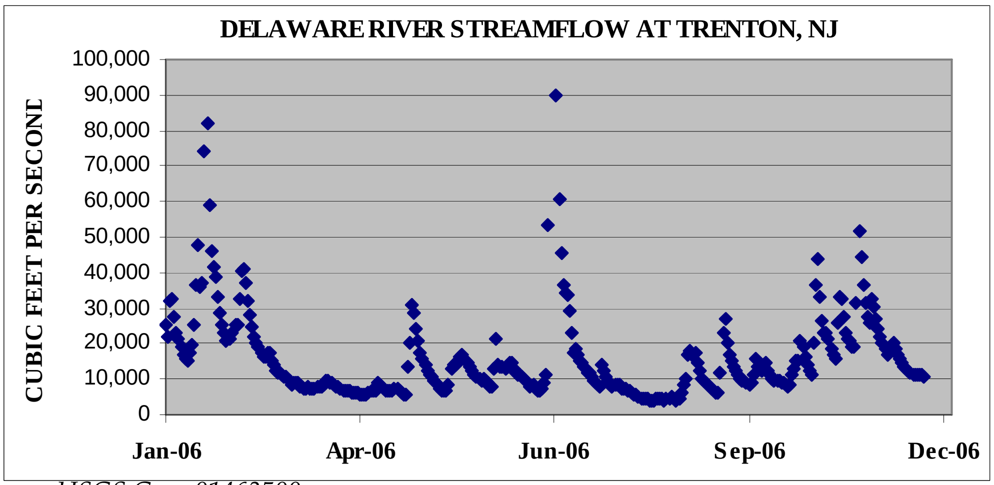
Table 2.5-2 provides some information on the three reservoirs located within the Pennsylvania Tidal Delaware River Zone. Each of the Reservoirs is located within the Neshaminy River Drainage Area.

Table 2.5-2 Reservoirs within the Neshaminy River Watershed

State	Reservoir	Water Body	Drainage Area (mi2)	Surface Area (mi2)
PA	Churchville Reservoir	Ironworks Creek	1.63	0.26
PA	Silver Lake	Mill Creek	1.45	0.09
PA	Core Creek	Core Creek	3.28	0.27

Stream flow within the Delaware Basin fluctuates immensely. The maximum discharge occurs after the periods of heaviest precipitation, often due to the passage of a tropical storm. Seasonal variation in runoff is driven by the melting snow, spring rains, and warm air temperatures and droughts when the evaporation of surface waters is high.

Figure 2.5-1 2006 Delaware River Streamflow at Trenton, NJ



Source: USGS Gage 01463500

The streamflow of the Delaware River during 2006 is presented above in Figure 2.5-1. The measurements were recorded at USGS Gage 01463500 at Trenton, New Jersey. The historical daily average Delaware River streamflow at Trenton, NJ is 12,100 cubic feet per second (CFS). The 2006 daily average is 17,200 CFS. The difference between the current average and the historical average is due to a major storm in 2006 that caused flooding during June where the streamflow peaked at 224,000 CFS.

Flooding can damage property, habitat, and cost millions of dollars. Table 2.5-3 below lists flood events that occurred from 1999 to 2006. The flooding data was obtained from the Delaware River Basin Commission (DRBC) website at http://www.state.nj.us/drbc/Flood_Website/floodinf.htm . Streamflow information was obtained from the USGS Gage 01463400 at Trenton, NJ.

Table 2.5-3 Flooding Events between 1999 and 2006

Time Period		Rainfall Inches	Event	Delaware River Streamflow Peak CFS and Date
Year	Dates			
1999	September 16	6-10	Hurricane Floyd	75,300 on September 17
2001	June 16-17	10	Tropical Storm Allison	14,500 on June 18
2003	September 1-3	5	Strong rains	39,100 on September 5
2003	September 15	8	Strong rains	27,400 on September 17
2003	September 18-19	2-3	Hurricane Isabel	21,000 on September 19
2003	September 23	2-3	Strong rains	51,100 on September 24
2004	July 12-13	4-6	Strong rains	14,200 on July 13
2004	August 1	5	Strong rains	14,500 on August 1
2004	August 12	7	Strong rains	52,900 on August 14
2004	August 17	3-5	Strong rains	22,300 on September 17
2004	September 9-10	1-4	Hurricane Francis	25,400 on September 11
2004	September 17	3-5	Tropical Storm Ivan	181,000 on September 19
2004	September 28	4-8	Tropical Storm Jeanne	61,600 on September 29
2005	March 28-29	2-3	Strong rains	98,800 on March 30
2005	April 2-3	3-5	Strong rains	230,000 on April 4
2006	June 24-28	6-15	Strong rains	224,000 on June 29

Source: DRBC http://www.state.nj.us/drbc/Flood_Website/floodinf.htm

2.6 Stream Impairments

2.6.1 Clean Water Act Section 305b and Section 303d

One of the federal strategies for improving watershed health is to require states to monitor their water resources and develop a remediation strategy for locations that do not meet state water quality standards. This strategy is detailed in Section 305b of the Federal Clean Water Act, which requires each state to publish a Water Quality Assessment Report every two years. The Section 305b report identifies surface water segments that attain their designated use and those that do not.

States assign at least one designated use, such as a cold water fishery, to specific segments of rivers, streams, and lakes. The water quality standards that define each designated use provide criteria to which surface water quality can be compared. Streams, rivers, and lakes that meet their designated use are known as assessed, attaining waters. Those segments that do not meet the water quality criteria of their designated use are known as assessed, impaired waters. Collectively, waters that do not meet their designated use are referred to as the state 303d list of impaired waters. States strive to assess all of the waters within their jurisdiction, but some locations remain un-assessed.

The 303d list of impaired waters is used to generate legally binding water quality improvements called Total Maximum Daily Loads (TMDL). A TMDL is both a water quality standard as well a legal commitment enforced by the U.S. Environmental Protection Agency. The TMDL identifies the maximum level that a particular contaminant can exist in the water body, as well as the timeline that states have to meet such a water quality requirement. TMDLs can be assigned for a range of water quality parameters such as metals, nutrients, and pathogens. The focus of each TMDL relies on the source and cause of impairment identified for each segment in the 303d list within the state 305b report.

Source water protection and the TMDL policy both aim to improve the quality of water resources. Source water protection focuses on the drinking water supply and TMDL policy focuses on general water quality improvement. Although the targets of these two programs are slightly different, the benefits and successes are easily shared. For example, a TMDL that reduces excess nutrients within a stream can possibly prevent the growth of taste and odor causing algae within the Study Area. TMDLs that reduce suspended solids remove the substrate that harmful pathogens and metals bind to and travel downstream. Due to the shared benefits between the TMDL program and source water protection, it is important to identify the mileage and location of 303d listed stream segments within the Delaware River Study Area. The 303d listed segments indicate not only impairments, but where state water quality improvements may eventually take place.

Three reports that comprise the known impairments within the Study Area are: the 2006 305b New Jersey Integrated Water Quality Monitoring and Assessment Report from the New Jersey Department of Environmental Protection (NJ-DEP), the 2006 305b Pennsylvania Integrated Water Quality Monitoring and Assessment Report from the Pennsylvania Department of Environmental Protection (PA-DEP), and the 2004 305b New York State Water Quality 2004 from the New York State Department of Environmental Conservation (NYS-DEC).

2.6.2 Delaware River Study Area 303d Impairments

The Delaware River Study Area includes 14,057 miles of streams and creeks. Three states border the main stem of the Delaware River, and each state assesses those reaches along with the smaller tributaries within the state boundary. Table 2.6.2-1 presents the number of assessed and un-assessed stream miles within each state, as well as the mileage of attaining and impaired streams. The Delaware River main stem is included in each state assessment. This multiple coverage is why the sum of total attaining, impaired, and un-assessed stream miles in Table 2.6.2-1, final column, is more than the 14,057 miles of streams and creeks in the Delaware River Study Area.

Table 2.6.2-1 Delaware River Study Area Assessed and Un-Assessed Stream Miles

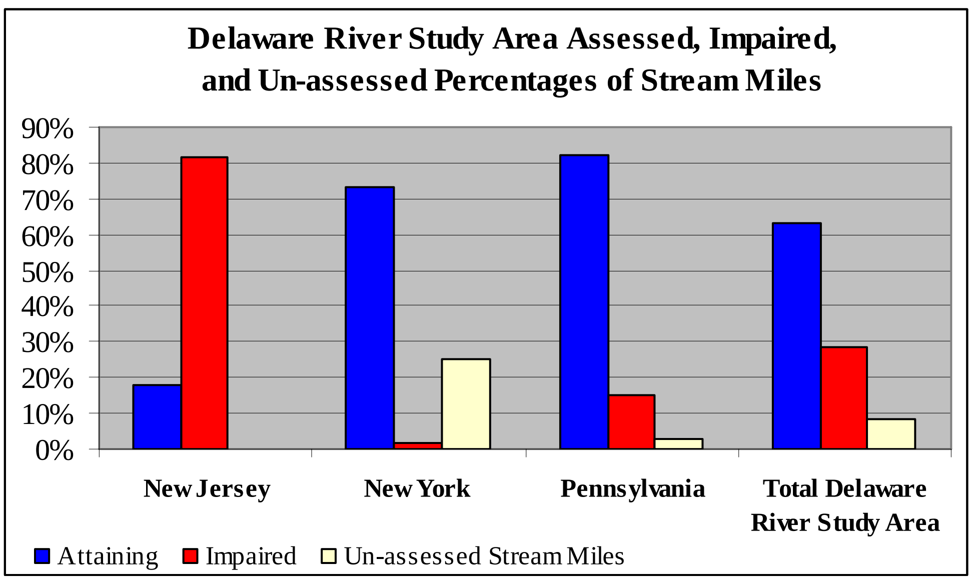
State	Assessed Stream Miles		Un-assessed Stream Miles	Total Stream Miles for Assessment
	Attaining	Impaired		
New Jersey	670.2	3022.5	0	**3692.7**
New York	2972.9	73.6	1015.5	**4062**
Pennsylvania	5388.2	999.4	182.4	**6570**
Total	**9031.3**	**4095.5**	**1197.9**	**14325.7**

**The Delaware River main stem is included within the calculations for each state. This means the shared segments of the Delaware River main stem are assessed twice, once by each state that borders the river.*

Sources: 2006 New Jersey Integrated Water Quality Monitoring and Assessment Report, New York State Water Quality 2004, 2006 Pennsylvania Integrated Water Quality Monitoring and Assessment Report

The majority of stream miles within the Delaware River Study Area are located within Pennsylvania. Pennsylvania also has the largest number of attaining streams. New Jersey has the largest amount of impaired stream miles and New York the least. Using the mileages presented above in Table 2.6.2-1, the following figure depicts the percentages of attaining, impaired, and un-assessed stream miles for each state and the total Delaware River Study Area.

Figure 2.6.2-1 Delaware River Study Area Stream Miles



Sources: 2006 New Jersey Integrated Water Quality Monitoring and Assessment Report, New York State Water Quality 2004, 2006 Pennsylvania Integrated Water Quality Monitoring and Assessment Report

In the Delaware River Study Area, 28.6 percent of the streams are impaired and 63 percent of the streams are attaining their designated use. The largest mileage of impaired streams is found in New Jersey. Over 80 percent of all streams within the New Jersey portion of the Study Area are impaired. In contrast to New Jersey, the New York portion of the Study Area has the smallest amount of impaired streams. Less than two percent of the New York area streams are impaired. The Neversink River and Trout Creek are the two tributaries where the New York state impairments for fish consumption are located. Pennsylvania has the largest percentage of attaining streams within the Study Area. Over 80 percent of Pennsylvania streams within the watershed are attaining their designated use.

There are multiple designated uses the states can assign to stream segments. The four most common designated uses within the Study Area are; aquatic life, fish consumption, potable water supply, and recreation including primary contact (swimming). One stream segment can be assigned multiple designated uses, and therefore contain multiple impairments. Tables 2.6.2-2 and 2.6.2-3 identify the impaired stream miles according to designated use within Pennsylvania and New Jersey.

Table 2.6.2-2 New Jersey Impaired Stream Miles

New Jersey Sub-Watersheds	Impaired Stream Miles according to Designated Use			
	Aquatic Life	Fish Consumption	Potable Water Supply	Recreation
Crosswicks	360.8	213.4	204.1	63.2
Middle Delaware	555.4	0	825.9	124.3
Mongaup	67.8	14.6	106.4	14.6
NJ Mercer Direct	223.8	76.5	269.2	41.2
Rancocas	575.2	187.4	179.6	215.8
Tidal NJ Lower	224.0	207.6	140.6	123.5
Tidal NJ Upper	202.1	102.0	0	26.9
Total	**2209.1**	**801.5**	**1725.8**	**609.4**

**Calculations include the Delaware River main stem from the New York and New Jersey border to the southernmost reaches of the study area.*

Source: 2006 New Jersey Integrated Water Quality Monitoring and Assessment Report

In New Jersey the largest class of stream impairments is waters designated for aquatic life. The second largest class of impairments is waters designated for potable water supply. In the New Jersey portion of the Study Area the smallest mileages of impairments are for designated fish consumption and recreation areas.

Table 2.6.2-3 Pennsylvania Impaired Stream Miles

Pennsylvania Sub-Watersheds	Impaired Stream Miles according to Designated Use			
	Aquatic Life	Fish Consumption	Potable Water Supply	Recreation
Lackawaxen	9.2	0	0	0
Lehigh	141.6	10.3	0	1.3
Middle Delaware	22.3	55.4	0	0
Mongaup	8.0	73.4	0	0
Neshaminy	215.3	72.1	4.5	0
PA Bucks Direct	37.7	26.3	0	0
Tidal PA Bucks	44.1	21.5	0	0
Tidal PA Philadelphia	126.6	17.9	3.1	0
Tohickon	44.7	0	0	0
Upper Delaware	2.1	62.1	0	0
Total	**651.5**	**338.9**	**7.6**	**1.3**

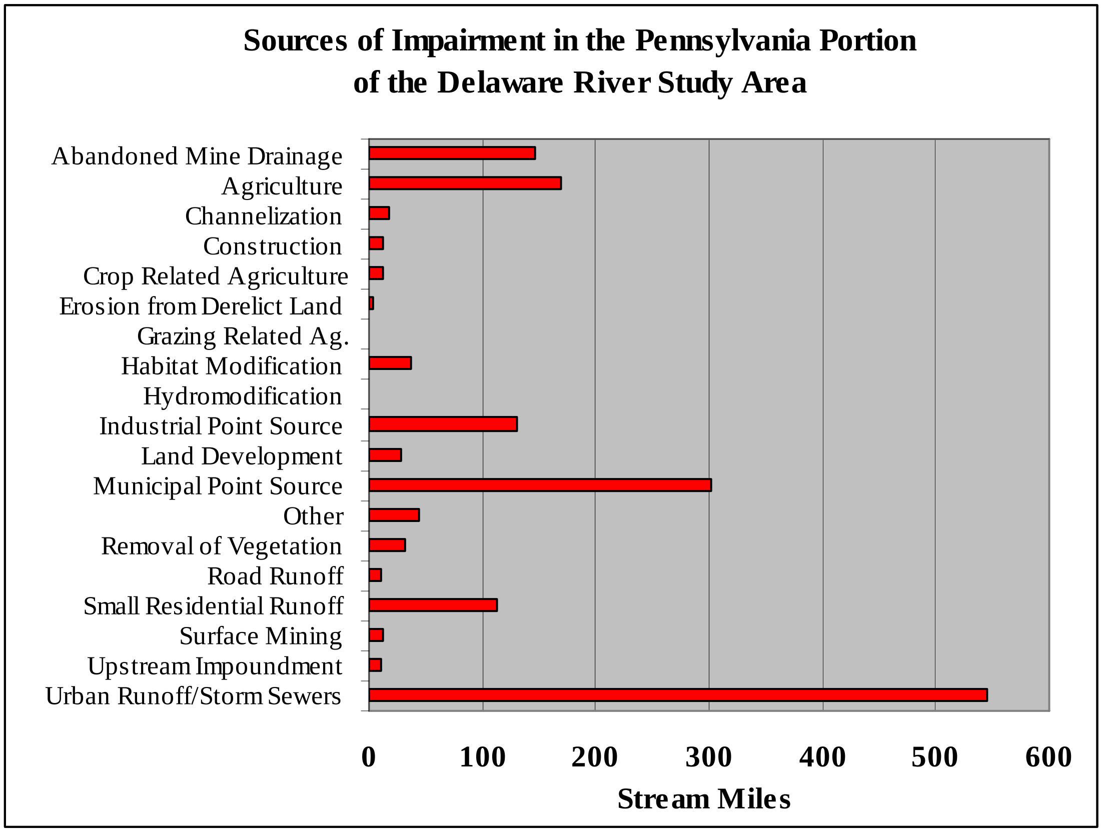
**Calculations include the Delaware River main stem from the New York and Pennsylvania border to the southernmost reaches of the study area.*

Source: 2006 Pennsylvania Integrated Water Quality Monitoring and Assessment Report

In Pennsylvania the largest class of stream impairments is for segments with an aquatic life designated use. The second largest class of impairments is for segments with a fish consumption designated use. In the Pennsylvania portion of the Study Area the smallest mileage of impairments are for designated recreation and potable water supply areas.

The causes of impairment can vary from stream to stream. Data defining the causes of impairment is not readily available and can vary from state to state. The New York and New Jersey data was not readily available, however the Pennsylvania data was. The following figure identifies the causes of impairment within the Pennsylvania portion of the Delaware River Study Area.

Figure 2.6.2-2 Pennsylvania Sources of Impairment



Source: 2006 Pennsylvania Integrated Water Quality Monitoring and Assessment Report

In Pennsylvania, the leading source of impairment is urban runoff/storm sewers. The second leading source of impairment is municipal point sources. These findings indicate that Pennsylvania streams are impacted by point source discharges from urban stormwater outfalls and wastewater treatment plants. Pennsylvania streams within the Study Area are also impaired due to municipal point sources, industrial point sources, agriculture, and abandoned mine drainage.

Section 3

Delineation of Source Water Assessment Zones

3.1 Zone Definition

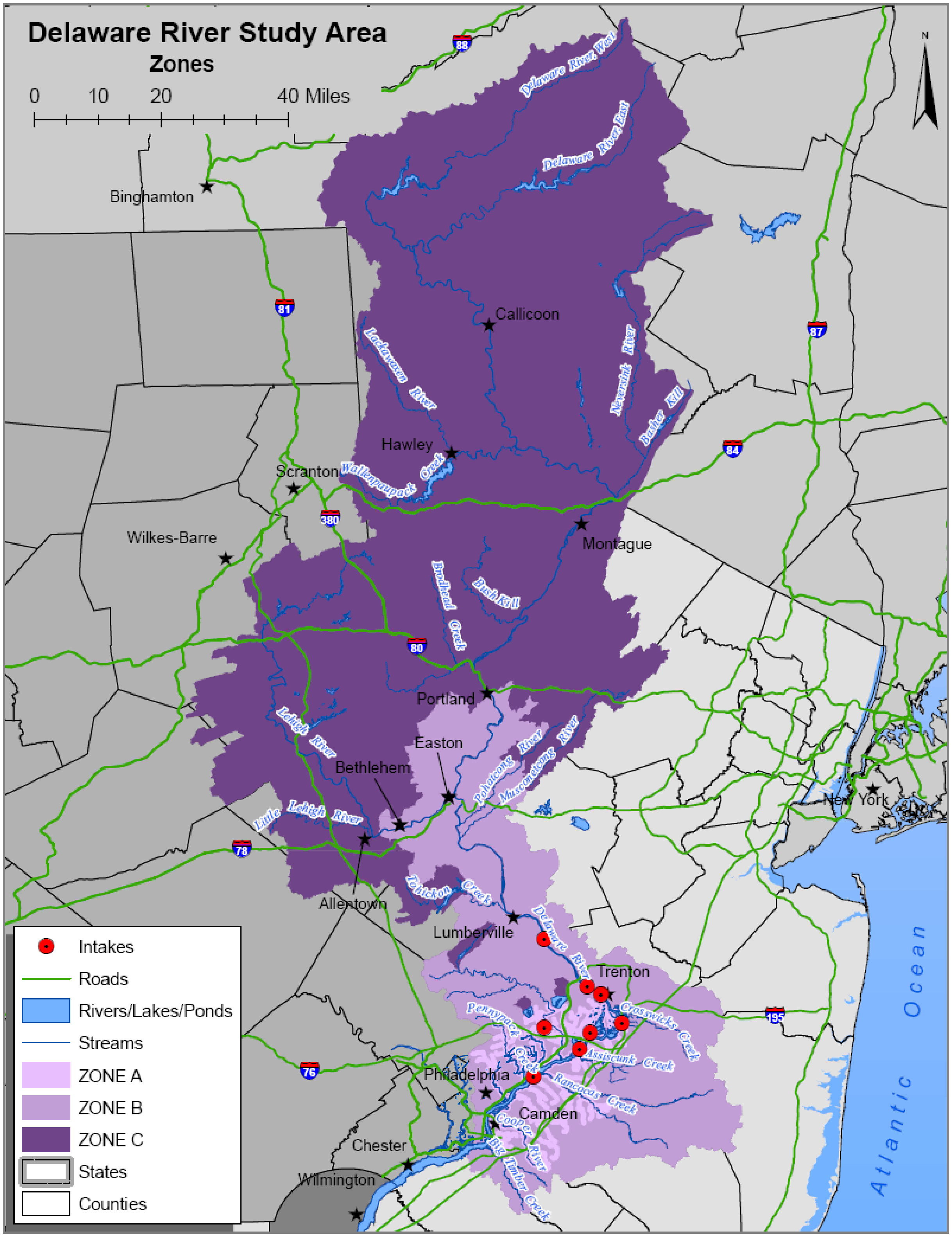
The Baxter Water Supply Intake receives water from a drainage area greater than 8,100 square miles. Identification of all potential contaminant sources within such a large area requires a systematic approach to examine the area in such a way as to prioritize all pertinent sources. This approach, as defined by the Pennsylvania Department of Environmental Protection (PA-DEP) Source Water Assessment Plan, involves a segmentation approach that divides the watershed into zones based on the proximity of a potential contaminant source to a water supply intake. This method assumes that proximity is directly linked to a potential source's impact on a water supply in most cases. Using this logic, the PA-DEP's Source Water Assessment Plan divided the source water assessment area for a given intake into the following three zones and prioritized all contaminant sources accordingly:

Zone A - This is the critical area of highest potential impact on the water supply, as proximity to the water supply's intake results in reduced response times and potential lower dilution and attenuation of a contaminant. Zone A includes any potentially significant source within a five-hour time of travel along the river to the intake; including a 1/4 mile perimeter around the intake reaching downstream and onto both sides of the river/stream. These may include large and small discharges, catastrophic event related sources (broken oil pipelines and chemical storage tanks), large runoff sources, or special contaminant sources.

Zone B - This is the area between the 5-hour and 25-hour time of travel along the river to a given water supply intake, including a two mile-wide area on either side of the river or stream extending upstream to the 25-hour time of travel boundary. Only significant potential sources of contamination are identified for inclusion in the contaminant inventory. This generally represents larger discharges (>one million gallons per day), catastrophic event related sources (broken oil pipelines and chemical storage tanks), large runoff sources, or special contaminant sources.

Zone C - This is the area greater than 25-hour time of travel to a given water supply intake. All major potential sources of contamination are identified for inclusion in the contaminant inventory. This generally represents larger discharges (>one to ten million gallons per day), catastrophic event related sources (broken oil pipelines and chemical storage tanks), large runoff sources, or special contaminant sources.

Figure 3.1-1 Delaware River Source Water Assessment Zones



Similar to the Source Water Assessment Sections 1 and 2, the Delaware River Source Water Protection Plan delineates the watershed into zones within 5 hours, between 5 and 25 hours, and greater than 25 hours travel time from water intakes. The delineation for the Philadelphia Water Department's Baxter Water Supply Intake has been developed with consideration of the fact that this intake is located in the tidal portion of the Delaware River. Water intakes located on free flowing streams or rivers can only be affected by contaminant discharges to locations upstream of the water intake. In tidal rivers and estuaries, tidal current oscillations can transport contaminants in an upstream direction during the flood portion of the tidal cycle. Therefore, this source water assessment zone delineation includes evaluations of portions of the Delaware River Watershed both upstream and downstream of this water intake. Figure 3.1-1 on the preceding page presents the boundaries of all Delaware River Study Area Zones, A-C.

3.2 Non-Tidal Zone Velocity Assumptions

The time of travel and zone delineations are based on high flow, and thus on high velocity conditions. The USGS provided estimates of high flow condition velocities, which were used to delineate Zones A and B for the Baxter Intake. The average velocity assigned to all river segments above Trenton is five and one half feet per second. The same velocity, 5.5 feet per second, was used in all time of travel calculations during the source prioritization.

3.3 Tidal Zone Hydrodynamic Modeling

The delineation of the source water assessment zones for this intake, located in the tidal portion of the Delaware River, requires an understanding of the unique circulation characteristics of tidal rivers and estuaries. The movement and mixing of contaminants introduced to tidal riverine or estuarine environments are controlled by three basic processes: tides, winds and river inflow. The tides generate the oscillatory currents and water surface variations in an estuary. Saltwater from the ocean is transported into an estuary by the tidal oscillations; mixing of saltwater and freshwater is caused by the turbulence generated by the tidal action. Wind can be a source of water column turbulence, with a strong wind tending to increase the vertical mixing in the water column. The speed and direction of estuarine currents, particularly near the surface, can also be affected by the wind.

Freshwater inflow to an estuary creates water density variations, referred to as density gradients. Because freshwater is less dense than seawater; freshwater will float on top of seawater. The estuarine density gradients, in both the horizontal and vertical directions, cause a quasi-steady circulation pattern to develop that is quite different from the oscillatory flow due to the tides. Generally, freshwater flows into an estuary and is transported to the ocean in a layer of water near the surface. Saltwater is transported to the upstream reaches of an estuary in the bottom layers of the water column, in the opposite direction of the fresher flow in the surface layer.

The amount of mixing that occurs between the fresher surface layer and the level of turbulence in the vertical direction determines the saltier bottom layer. More turbulence increases the mixing of the water column. A thoroughly mixed water column where salinity is nearly constant in the vertical produces what is known as an un-stratified condition. Low vertical mixing produces a stratified situation where the surface layer has a significantly lower salinity than the bottom layer, with the differential usually ranging between five parts per thousand (ppt) and 15 ppt. The level of stratification in an estuary can dramatically affect the circulation pattern and hence, the transport and fate of contaminants introduced into the estuary. In general the Delaware Estuary is well mixed in the vertical dimension (HydroQual, 1998).

Source water assessment zone delineations for this water intake, and others located in the tidal portion of the river, were determined through application of the three dimensional, time variable hydrodynamic and water quality models developed for the Delaware River Basin Commission (HydroQual, 1998). The hydrodynamic model is a version of the Estuarine, Coast and Ocean Model developed by Blumberg and Mellor (1980, 1987). It is three-dimensional and time-dependent so that it can reproduce the complex physics present. Evolving water masses, plumes, fronts and eddies are accounted for by prognostic equations for the thermodynamic quantities, temperature and salinity. Free surface elevation is also calculated prognostically so that tides and storm surge events can be simulated.

The spatial domain and the computational grid of the model extend from Trenton at the upstream limit to Liston Point at the downstream limit. The grid includes one lateral segment in the upper 15 miles, from the upstream boundary at Trenton to Burlington. For the next 23 miles, between Burlington and the southern portion of Camden, the grid contains three lateral segments. Downstream of Camden the grid contains five lateral segments.

Two sets of river flows were used in the analysis to provide a conservative assessment of the zones within 5 or 25 hours travel time to the water intakes. The critical flow conditions with respect to maximizing the size of zones within 5 and 25 hour travel times are dependent on whether the contaminant source is upstream or downstream of the water intake. For contaminant sources located upstream of the water intake, high flow conditions represent the critical case because of the higher net downstream advective velocities produced by elevated freshwater inflows. For contaminant sources located downstream of the water intake, low flow conditions represent the critical case because of the reduced downstream net advective velocities.

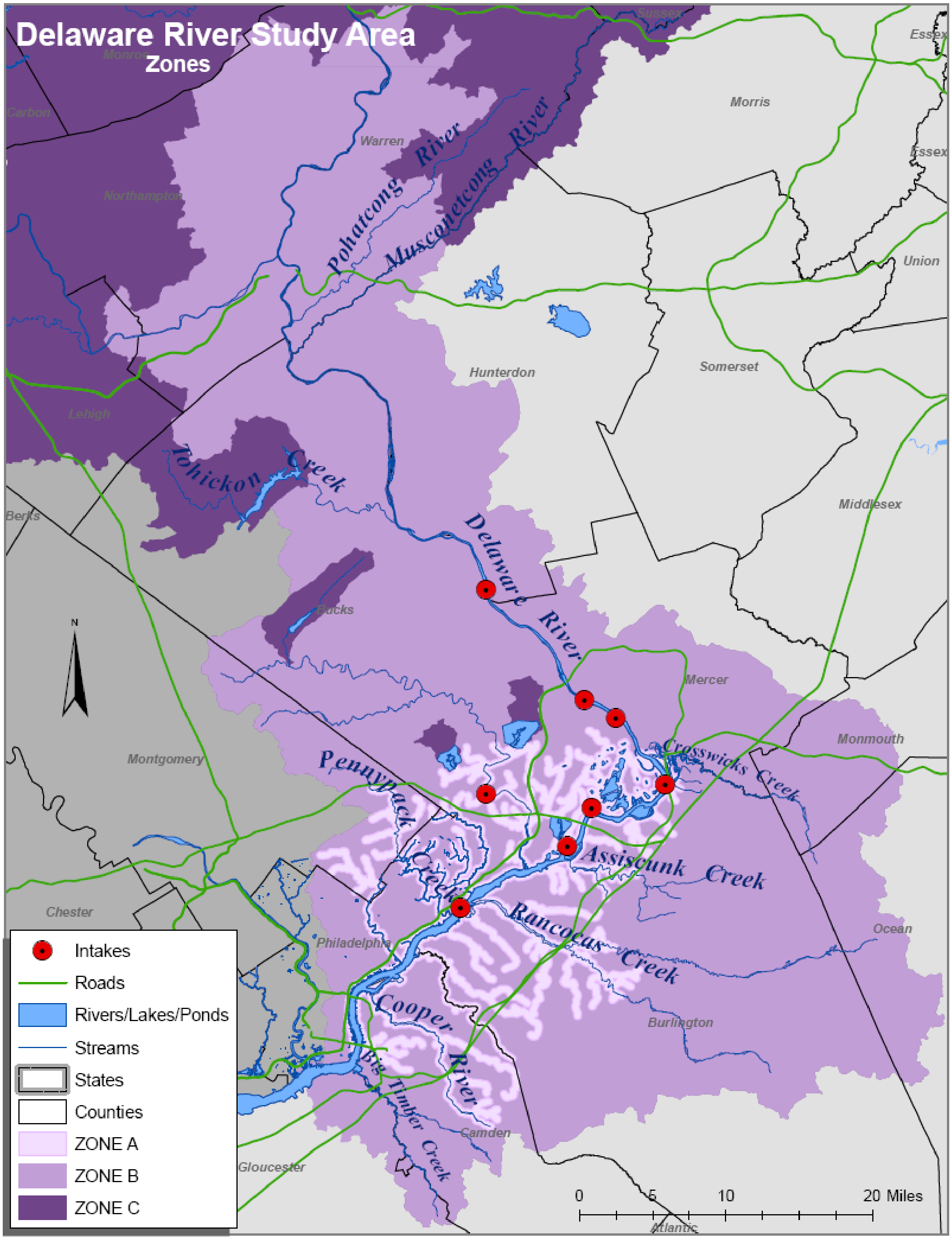
3.4 Zone Delineation

The final zone delineation combined the tidal zone results from the hydrodynamic modeling with the upstream USGS zone delineation based on high flow condition stream velocities. Zones were calculated on the Delaware River as well as along the main tributaries. Figure 3.4-1 displays the different zones delineated for the Baxter water supply intake for the Philadelphia Water Department. As shown in detail, Zone A encompasses an area of 206 square miles and continues upstream of the intake to river mile 131 at Trenton, New Jersey. Zone A consists of the Tacony Creek Watershed, Poquessing Creek Watershed, almost the entire Pennypack Creek Watershed, the entire Cooper River, Pennsauken Creek and large portions of the Rancocas Creek Watershed. Also included is the lower portion of the Neshaminy Creek Watershed, Mill Creek and Assiscunk Creek Watershed.

Zone B encompasses an area of 2,060 square miles and extends upstream to river mile 208 as shown in Figure 3.4-1. For the Baxter Intake, Zone B extends upstream from the intake to approximately 0.25 miles south of Portland, PA. Zone B also includes all the tributaries below the Lehigh River. Zone B includes portions of the Neshaminy and Tohickon Creeks, below the large reservoirs/lakes located in each watershed. Zone C consists of the remainder of the watershed, primarily the headwaters of the Delaware River, and the remainder of the Lehigh River. Also shown in Figure 3.4-1 are the locations of other water supply intakes within the zones delineated for the water supply. As shown, the Zone A or B of the Baxter Intake overlaps with the Zone A or B of numerous other intakes. This overlapping of zones allows for a more detailed assessment of potential sources for the whole watershed area.

All of the zones of delineation were determined and provided by the USGS and approved by PA-DEP for use in the Source Water Assessments. These zones of delineation were modified using the results of the tidal zone hydrodynamic modeling to include downstream areas as well. This modified zone delineation is considered the most accurate description available.

Figure 3.4-1 Delaware River Source Water Assessment Zones for the Baxter Intake



3.5 Lower Delaware Drinking Water Intakes

Over 17 million people use the Delaware River as a drinking water source. The Delaware River provides drinking water to New York City, Philadelphia, and the metropolitan regions of those cities. Within the Lower Delaware River watershed Zones A and B delineations are eight drinking water treatment plants, including Baxter. These facilities are listed in Table 3.5-1 and presented in Figure 2.1-1.

Table 3.5-1 Lower Delaware Drinking Water Intakes

Facility	Operator
Baxter Water Treatment Plant	Philadelphia Water Department
Bristol	Aqua Pennsylvania
Lower Bucks County	Lower Bucks Joint Municipal Authority
Middletown	Bucks County Water and Sewer
Morrisville	Morrisville Borough Authority
Neshaminy	Aqua Pennsylvania
New Hope Waterworks	Bucks County Water and Sewer
Yardley	Pennsylvania American Water

Section 4

Drinking Source Water Quality

4.1 Introduction

The goal of this section is to identify source water parameters of concern and activities of concern by integrating a new water quality analysis with the water quality conclusions from the Baxter Treatment Plant Source Water Assessments (SWA) Section 1: General Delaware River Watershed and Section 2: Delaware River Intake. Section 1 identified universal trends in the Delaware River watershed such as long term water quality, changes in the past decade, stream impairments, and watershed wide dumping, discharge, runoff, and development impacts. Section 2 focused on water quality measured at the Baxter Treatment Plant intake. The Section 2 analysis identified and discussed parameters that are directly targeted in the drinking water treatment process and ultimately related to the quality of finished water.

Delaware River water quality conclusions from the SWA Section 1 Report:

1. Delaware River water quality has significantly improved over the past 20 years.
2. As the impacts of point sources discharging to the Delaware River have been reduced over the years, the importance of non-point sources such as stormwater runoff from developed areas within the watershed has become evident.
3. While conductivity, nitrate, and iron concentrations have slightly increased over the past few decades, concentrations of dissolved oxygen, ammonia, phosphorus, and fecal coliforms have significantly improved, due to reductions in agricultural runoff and improved wastewater treatment.

Delaware River water quality conclusions from the SWA Section 2 Report:

1. Turbidity and other suspended contaminants in the river tend to increase as a function of precipitation, runoff and river flow.
2. Salt levels in the river appear to fluctuate seasonally, perhaps in response to application of road salts during the winter.
3. Over the past decade, 1990-1999, levels of alkalinity, conductivity, sodium, chloride, bromide, iron, manganese, nitrate, and turbidity in the Delaware River have increased at the Baxter Intake. Increased pollution from runoff is the most likely source of these changes.

4. Stream impairments in the lower Delaware River Watershed are primarily caused by stormwater runoff from urban and suburban areas.

The new water quality analysis included in this plan focuses on specific parameters of and activities of concern to drinking source water quality. The parameters and activities of concern are identified from the SWA findings as well as the definition of water quality as it relates specifically to a drinking water supply.

4.1.1 Drinking Source Water Quality vs. General Water Quality

Water quality is defined using multiple criteria, that when combined describe how suitable the water source is for different designated uses. The designated use of a surface water body is defined by corresponding water quality parameters and concentrations, outlined by each state's respective environmental agency. In Pennsylvania, the Department of Environmental Protection defines designated uses and water quality guidelines. All state water quality guidelines must be in accordance with Clean Water Act (CWA) standards. States may implement stricter standards, but can never implement standards more lenient than those of the CWA. Pennsylvania designated statewide water uses are warm water fish habitat, potable water supply, industrial water supply, livestock water supply, wildlife water supply, irrigation, boating, fishing, water contact sports, and aesthetics. Absent from this list is a designated use that defines drinking source water.

The potable water supply designation above is public water for consumption after it has undergone conventional water treatment according to regulations set by the Federal Safe Drinking Water Act (SDWA). Drinking source water is the water body or groundwater aquifer that supplies raw, untreated water to a water treatment plant.

The potable water supply for all states must comply with the SDWA. The SDWA uses Maximum Contaminant Levels (MCLs) to define the limit for contaminants. The MCL is the highest concentration of a specific parameter that a human can tolerate with no negative health effects.

There are no drinking source water standards mandated by the CWA or SDWA The standards only focus on the quality of water after the treatment process and other designated uses of surface water. The absence of drinking source water standards does not mean that quality can not be defined. Quality can be defined through a close examination of each parameter that answers the following questions specific to the Baxter intake:

1. Is this parameter above the MCL before it even enters the treatment plant? If yes, what are the values of this parameter at multiple locations in the Delaware River Study Area?

2. Did the SWA Section 1 identify any long term trends with this parameter in the watershed?

3. What is the presence of this parameter in the water supply attributed to?

4. How does this parameter behave in the treatment process? Is it easy to remove, hard to remove, expensive to remove, impossible to remove?

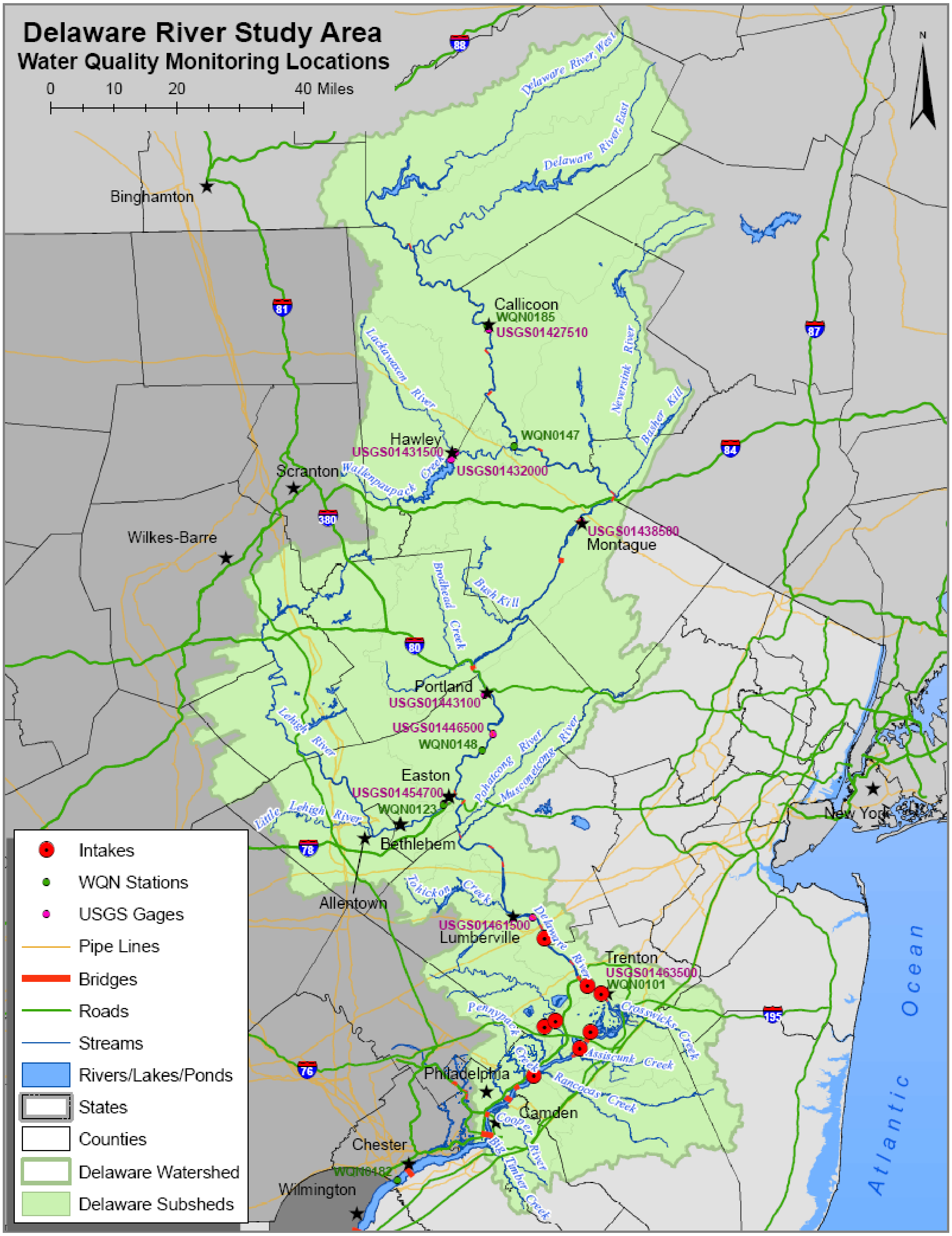
These questions help to define drinking source water quality by emphasizing parameters most important to the treatment process, concentrations of the parameter in the water supply within a defined distance, context of the parameter amid long term trends, and potential sources of the parameter. The questions prioritize water constituents into drinking source water parameters of concern. Once the parameters of concern are identified, activities within the watershed that can alter these parameters must also be acknowledged. The parameters of concern and activities of concern within the Delaware River Study Area are the focus of the following water quality analysis and discussion.

Table 4.1.1-1 Parameters and Activities of Concern

Parameters of Concern		**Activities of Concern**
Alkalinity	Nitrate	Land Cover Change
Bromide	Nitrite	Population Change
Chloride	Sodium	Climate Change
Conductivity	Disinfection Byproduct Precursors	Spills and Contamination Events
Cryptosporidium	Compounds of Potential Concern	Municipal Wastewater Treatment Plant Discharge
Iron	Volatile Organic Compounds	Combined Sewer Overflows and Stormwater Discharge
Manganese	Taste and Odor Compounds	Point and Non-Point Source Pollution

The following page contains a map of all of the water quality monitoring locations used to analyze the source water quality of the Delaware River Study Area. The gage and station numbers, as well as the towns they are adjacent to are presented. The map also contains the locations of oil and gas pipelines that are located within the Delaware River Study Area.

Figure 4.1.1-1 Delaware River Study Area Water Quality Monitoring Locations



4.2 Parameters of Concern

4.2.1 Alkalinity

The SWA Sections 1 and 2 identified alkalinity as a source water quality concern due to a perceived increasing trend. Alkalinity is not regulated by the EPA through an MCL or Secondary MCL. The EPA does suggest that source water should have an alkalinity of at least 20 mg/L to provide minor protection from corrosion and pH variation. This regulation is not enforced; it was presented as a recommendation in the Quality Criteria for Water in 1986.

4.2.1.1 Alkalinity Background

Alkalinity is a measurement of the capacity of water to neutralize acid. Acids such as natural carbonic acid or those contained in artificial point source discharges can have influence over the pH of source water depending on the alkalinity concentration. The ability of alkalinity to neutralize acids is often referred to as the buffer capacity of water. Waters without adequate buffer capacity can be easily influenced by acids, and therefore have a highly variable pH.

In the drinking water treatment process, pH is an extremely important regulator of the effectiveness of coagulation chemicals. If coagulation chemicals are not optimized, treatment costs can rise because more chemicals are needed and the quality of the finished water can decrease because fewer contaminants are removed during the coagulation process.

The Delaware River, as described in the SWA Sections 1 and 2, is a low alkalinity river compared to other major rivers in the Eastern region of the United States. The pH of the Delaware River decreases during rain storms because the alkalinity becomes diluted, reducing the acid buffering capacity. Alkalinity occurs naturally from the dissolution of minerals, and also occurs unnaturally in the drainage from abandoned mining facilities. The Delaware River watershed has multiple abandoned mine locations upstream of the Baxter Water Treatment Plant intake.

4.2.1.2 Alkalinity Analysis

Alkalinity can be measured by the amount of carbonates, bi-carbonates, phosphates, or hydroxides in the water. In this analysis and in the SWA, alkalinity is measured as the concentration of calcium carbonate, $CaCO_3$ mg/L. The following analysis updates the information presented in the SWA to include data thru 2006, and examines the data to determine whether any trends can be detected.

Data used in the following analysis were obtained from the Philadelphia Water Department Bureau of Laboratory Services. Samples were measured at the Baxter Water Treatment Plant intake.

Table 4.2.1.2-1 below includes statistics presented in the SWA Section 2 and statistics for values from 1999 to 2006. The statistics presented are useful to describe the range that alkalinity concentrations can cover over the course of a year, but will not give any indication of trend. The basic statistics are useful to indicate if the parameter is approaching levels of concern. The asterisk in the first row of data indicates the values reproduced from the SWA Section 2.

Table 4.2.1.2-1 Alkalinity Concentrations, mg/L $CaCO_3$

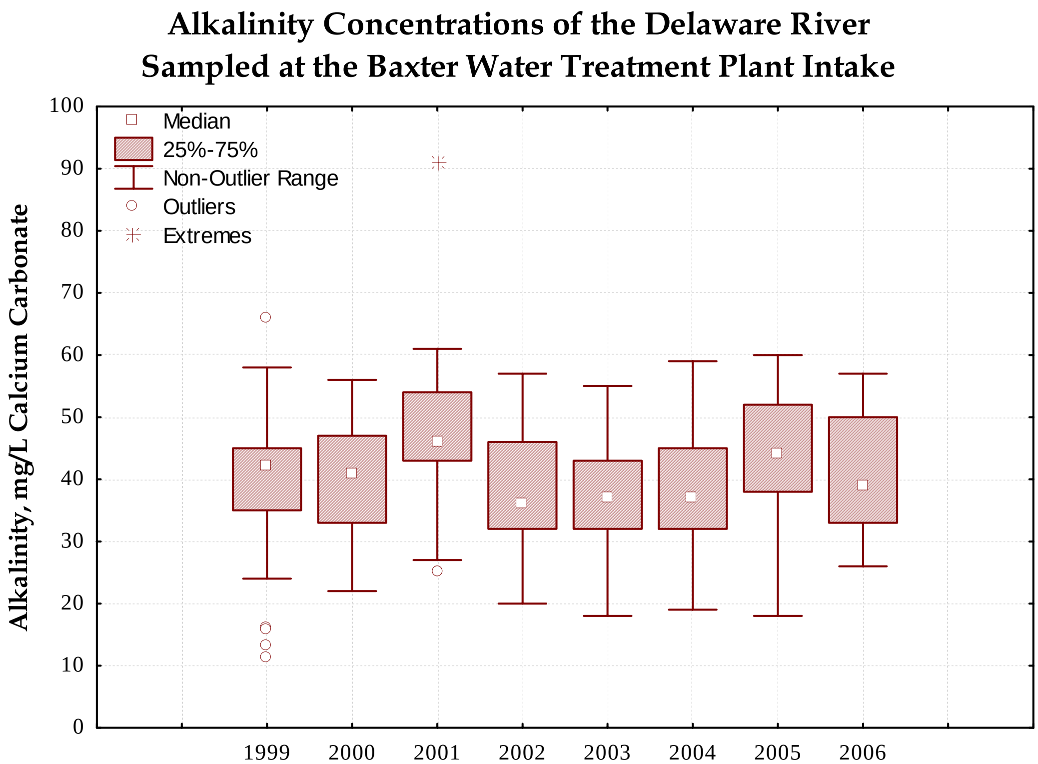
Sampling Date Range		Minimum Value	Maximum Value	Mean	Median	Number of Samples
January 1990 *	**June 1999**	18	86	41	41	504
January 1999	**December 2006**	11.3	91	40.7	41	404
January 1999	**December 1999**	11.3	66	39.4	42	47
January 2000	**December 2000**	22	56	40.7	41	49
January 2001	**December 2001**	25	91	47	46	51
January 2002	**December 2002**	20	57	37.4	36	53
January 2003	**December 2003**	18	55	37.5	37	53
January 2004	**December 2004**	19	59	38.9	37	51
January 2005	**December 2005**	18	60	44.3	44	51
January 2006	**December 2006**	26	57	41	39	49

** Data from SWA Section 2*

The mean and median values in the 1990-1999 and the 1999-2006 groups are almost identical. There has been variation in the mean and median values throughout the years from 1999 to 2006, but that variation is likely due to differences in precipitation within each year. These differences are likely due to the tendency of alkalinity to increase during periods of low river flow and variations in annual climate that lead to droughts or wet years. The high concentrations are common to summer months and periods of drought.

The box plots in Figure 4.2.1.2-1 below demonstrate the variability of alkalinity concentrations across the years from 1999 to 2006. The box plot method also displays median values as reference points.

Figure 4.2.1.2-1 Alkalinity Box Plots



Alkalinity data examined in the above graph do not follow an increasing or decreasing pattern that warrants additional trend analysis. The variation in the ranges of alkalinity concentrations between years and within years is likely due to climate influence on the flow of the Delaware River.

The concentrations vacillate within each year because of weather influences, but do not indicate a general increasing or decreasing trend. Alkalinity will always be a source water concern because it influences the pH of the Delaware River. pH is one of the most important factors to control when treating surface water for potable uses and therefore alkalinity will always be monitored carefully in the Delaware River.

4.2.2 Bromide

The SWA Sections 1 and 2 identified bromide, Br^{-}, as a source water quality concern with the potential to increase in concentration. Bromide is a threat to source water quality because it can react with disinfectants used in the water treatment process to produce suspected carcinogenic contaminants. Bromide is a naturally occurring ion in the Delaware River watershed and is a parameter to monitor closely due to its ability to react with disinfection chemicals. There is no regulation of bromide, but the disinfection byproducts that it causes are regulated under the EPA Stage 1 and 2 Disinfection Byproducts Rule.

4.2.2.1 Bromide Background

The SWA Sections 1 and 2 described the Delaware River Basin as a watershed with high natural bromide. Bromide can be released from minerals within geologic formations and accumulate in groundwater. Similar to other dissolved salts, bromide concentrations increase during periods of low river flow. Bromide has seasonally high concentrations during the warmest months and winter months based on low flows during summer and winter dry periods.

The presence of bromide in the watershed is a threat to source water quality because of multiple disinfection byproducts that can result when bromide and natural organic matter are exposed to chlorine during water treatment. During the disinfection stages at Baxter Water Treatment Plant, chlorine is exposed to surface water during pre-treatment and post treatment. The disinfection byproducts that can be produced are two of the five haloacetic acids and three of the four total trihalomethanes regulated under the EPA Stage 1 and 2 Disinfection Byproduct Rule. The full names of the chlorinated bromide compounds are dibromoacetic acid, bromoacetic acid, bromodichloromethane, dibromochloromethane, and bromoform. Water treatment plants that use ozone for disinfection can produce bromate, which is also a toxic disinfection byproduct.

4.2.2.2 Bromide Analysis

According to the SWA, the bromide concentrations in the Baxter source water area have been increasing in the past decade. Due to the implicated increasing trend and the important interactions between bromide and disinfection chemicals, the abundance of bromide at the Baxter intake is being reassessed.

Data used in the following analysis were obtained from the Philadelphia Water Department Bureau of Laboratory Services. Samples were measured at the Baxter Water Treatment Plant intake.

Table 4.2.2.2-1 below includes statistics presented in the SWA Section 2 and statistics for values from 1999 to 2006. The statistics presented are useful to describe the range that bromide concentrations can cover over the course of a year, but will not give any indication of trend. The asterisk in the first row of data indicates the values reproduced from the SWA Section 2.

Table 4.2.2.2-1 Bromide Concentrations, mg/L

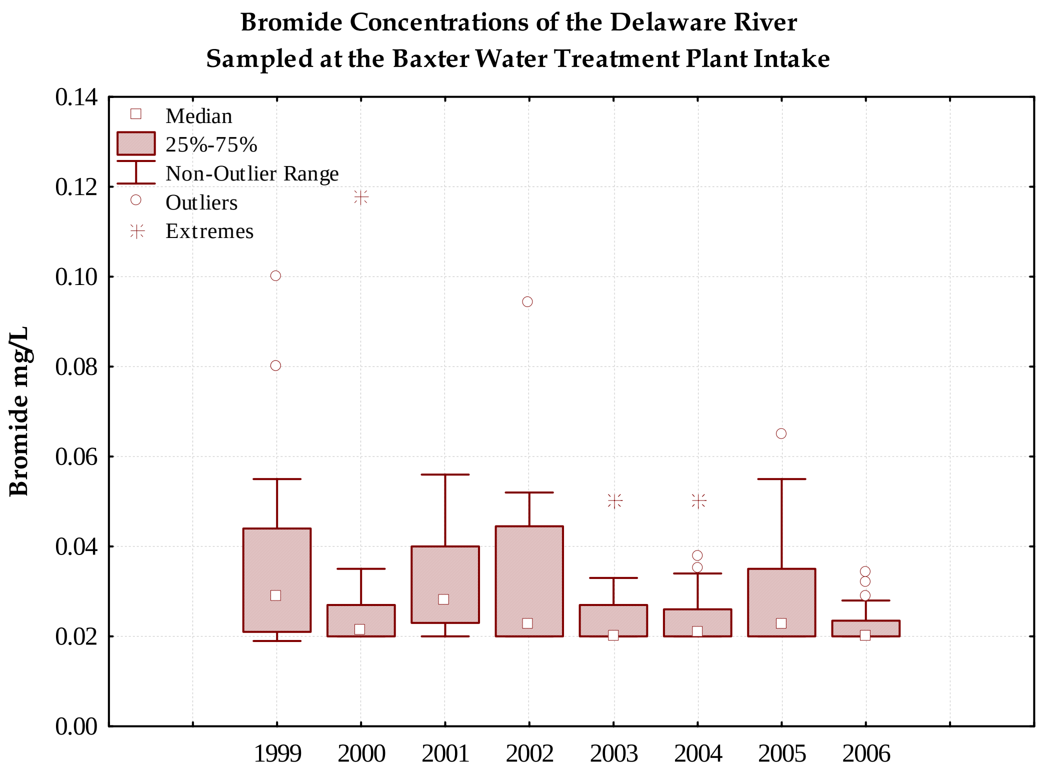
Sampling Date Range		Minimum Value	Maximum Value	Mean	Median	Number of Samples
May 1995 *	**December 1999**	0.015	0.136	0.036	0.032	85
January 1999	**December 2006**	0.019	0.118	0.028	0.023	340
January 1999	**December 1999**	0.019	0.100	0.034	0.029	45
January 2000	**December 2000**	0.020	0.118	0.025	0.022	48
January 2001	**December 2001**	0.020	0.056	0.032	0.028	51
January 2002	**December 2002**	0.020	0.094	0.032	0.023	28
January 2003	**December 2003**	0.020	0.050	0.026	0.020	15
January 2004	**December 2004**	0.020	0.050	0.024	0.021	53
January 2005	**December 2005**	0.020	0.065	0.030	0.023	52
January 2006	**December 2006**	0.020	0.034	0.022	0.020	48

** Data from SWA Section 2*

The mean and median values have both decreased from the 1995-1999 data and 1999-2006 data. In multiple instances, the mean and median values are not similar. The largest disparity is seen in 2002 where the mean is 0.032 mg/L and the median value is 0.023 mg/L. These differences are likely due to the tendency of bromide concentrations to increase during periods of low river flow and variations in annual climate that lead to droughts or wet years.

The box plots in Figure 4.2.2.2-1 below demonstrate the variability of bromide concentrations across the years from 1999 to 2006. The box plot method also displays median values as reference points. The minimum reporting concentration from 2000 to 2006 is 0.020 mg/L, which is why there are no concentrations below that limit.

Figure 4.2.2.2-1 Bromide Box Plots



The bromide concentration data presented is highly variable between years and within each year. Bromide concentrations are dependent on river baseflow and the amount of dilution that occurs from runoff and precipitation. When Delaware River flow is low, the bromide concentrations increase. This pattern is most notable in the late summer months. While there are no detectable increases in bromide concentration, bromide will always be a parameter to watch in the Delaware River watershed due to its ability to react with water treatment disinfection chemicals and produce carcinogenic byproducts.

4.2.3 Chloride and Sodium

Chloride, Cl^-, was identified in the Source Water Assessment (SWA) Section 1 and 2 as an increasing component of Delaware River water. The Environmental Protection Agency has assigned chloride a Secondary MCL of 250 mg/L.

The SWA Sections 1 and 2 also identified sodium as an increasing source water quality concern. The EPA does not regulate sodium through a MCL or Secondary MCL, but suggests that sodium concentrations should be kept to 20 mg/L and below. The American Heart Association also recommends that adults should consume no more than 2,300 milligrams per day. This section updates the chloride and sodium analysis using data from 1999 to 2006, and also examines and compares chloride and sodium concentrations across the Delaware River watershed.

4.2.3.1 Chloride Background

Chloride is present in surface water due to the dissolution of minerals and salts such as sodium chloride and calcium chloride. Surface water interacts with groundwater that contains dissolved chlorides from underlying soils and geologic formations. Chloride exhibits a seasonal concentration pattern with high concentrations in winter and late summer. High chloride concentrations during the winter are due to the application of de-icing materials to transportation surfaces during winter storms. Salts wash off the roadways and enter local creeks, soils, and groundwater, leading to potential negative impacts on aquatic life, aquatic vegetation, and drinking water taste. Concentrations increase during late summer due to lack of rainfall, which reduces the dilution effect that runoff has on groundwater fed baseflow concentrations in non-winter months. Additional sources of chloride are water treatment chemicals, point source discharges, wastewater treatment plant effluent, fertilizer manufacturing plants, and irrigation drainage.

The drinking water treatment process does not remove chloride from source water. It can add chloride in small amounts due to the breakdown of coagulation chemicals. If the chlorides are above the Secondary MCL of 250 mg/L, the drinking water will have a salty taste. Chloride concentrations at the Baxter intake are far below the Secondary MCL, but the increasing trend in concentrations between 1990 and 1999 identified in the SWA Sections 1 and 2 warrants additional analyses.

4.2.3.2 Sodium Background

Sodium is a very conservative parameter, meaning the concentration is only reduced by dilution and not biological uptake or precipitation. The sodium ion is present in source water by both natural and un-natural pathways. Sodium is a common element in minerals such as halite and feldspar. The weathering of geologic formations containing these minerals contributes sodium to the source water. Non-natural sources of sodium include de-icing materials, wastewater treatment plant effluent, and sodium hypochlorite. The wastewater treatment process does not remove sodium or chloride from the waste stream. As the watershed develops the Delaware River will receive ever increasing discharges from wastewater treatment plants. Watershed development also results in increased transportation surfaces and ultimately the total amount of de-icing materials applied in the Delaware River watershed will increase. Sodium hypochlorite is a disinfectant used by wastewater treatment plants and drinking water treatment plants. An additional source of sodium is chemical water softeners used in public and home drinking water treatment systems.

Similar to chloride, sodium is not removed during the drinking water treatment process and can impart a salty taste to the water. The 2005 Consumer Confidence Report from the Baxter Water Treatment Plant listed the sodium concentration at 19 mg/L, or 4 milligrams of sodium per 8 ounce glass of water. The low sodium content of Baxter finished water is important to the cardiac health of the City of Philadelphia, and therefore important to maintain.

4.2.3.3 Chloride and Sodium Analysis

The SWA Sections 1 and 2 found that chloride and sodium concentrations have been increasing at the Baxter intake between 1990 and 1999. The following analyses focuses on recent data from 1999-2006.

Data included in the following analyses was recorded by the Philadelphia Water Department Bureau of Laboratory Services. The dissolved chloride and sodium concentrations were sampled at the intake of the Baxter Water Treatment Plant.

Table 4.2.3.3-1 includes statistics presented in the SWA Section 2 and statistics for values from 1999 to 2006. The statistics presented are useful to describe the range that chloride and sodium concentrations can cover over the course of a year, but will not give any indication of trend. The basic statistics are useful to indicate if the parameters are approaching levels of concern such as the 250 mg/L Secondary MCL for chloride and the 20 mg/L suggested sodium level. The asterisk in the first row of data indicates the values reproduced from the SWA Section 2.

Table 4.2.3.3-1 Chloride Concentrations, mg/L

Sampling Date Range		Minimum Value	Maximum Value	Mean	Median	Number of Samples
January 1990 *	**February 1999**	8	71	23	21	148
April 1999	**November 2006**	0.00	51.3	18.4	18	242
April 1999	**December 1999**	0.025	30	21.4	21	38
January 2000	**April 2000**	18	47	25.4	20	10
January 2001	**December 2001**	NDA	NDA	NDA	NDA	NDA
June 2002	**December 2002**	13.9	26.2	20.6	18.9	7
January 2003	**December 2003**	13.3	51.3	26.6	22.8	13
January 2004	**December 2004**	12.8	30.7	21.2	19.45	12
January 2005	**December 2005**	11	42	24.1	24.3	12
January 2006	**October 2006**	15.9	29.4	20.4	19.3	11

NDA – No Data Available
** Data from SWA Section 2*

Table 4.2.3.3-2 Sodium Concentrations, mg/L

Sampling Date Range		Minimum Value	Maximum Value	Mean	Median	Number of Samples
January 1990 *	**November 1999**	0.02	44	12	12	140
January 1999	**September 2006**	7.18	44.1	14.7	13.7	78
January 1999	**December 1999**	10.6	44.1	15.7	13.8	29
January 2000	**December 2000**	NDA	NDA	NDA	NDA	NDA
January 2001	**December 2001**	NDA	NDA	NDA	NDA	NDA
June 2002	**December 2002**	8.4	17	13.4	12	7
January 2003	**December 2003**	12.5	29.3	16.8	14.1	9
January 2004	**December 2004**	7.78	18.4	12.8	11.8	12
January 2005	**December 2005**	7.18	25.8	15	14.8	12
January 2006	**September 2006**	8.81	17	12.2	11.1	9

NDA – No Data Available
** Data from SWA Section 2*

The chloride concentrations in Table 4.2.3.3-1 do not exceed or come close to the MCL of 250 mg/L. The highest value in the past eight years, 51.3 mg/L in 2003, is far below the MCL.

Sodium concentrations in Table 4.2.3.3-2 are close to the EPA recommended level of 20 mg/L, but the mean and median concentrations from 1999-2006 have not surpassed that level. The maximum values recorded for 1999, 2003, and 2005 all are above the recommended sodium level.

Chloride and sodium are still source water quality concerns even though the mean and median concentrations of both parameters do not exceed their respective EPA MCL and suggested limit. Mentioned earlier, there are multiple sources of chloride and sodium including; road salt, wastewater treatment plant effluent, and sodium hypochlorite.

4.2.3.4 Chloride and Sodium Trend Analysis

The SWA Sections 1 and 2 both observed that chloride and sodium concentrations in the Delaware River watershed appeared to be increasing through time. The next analysis will use a statistical method followed by the USGS and water resource professionals to determine whether or not a statistically significant trend is present from 1975 to 2005. This method, the Seasonal Kendall Test, will also identify the magnitude, or slope, of the trend. The Seasonal Kendall Test (SKT) will be performed on four locations along the Delaware River to identify the geographic extent of any chloride and sodium trends.

4.2.3.4.1 Trend Test Methodology

Dissolved sodium and chloride concentrations and streamflow data at four locations are used in this analysis. The four locations were chosen due to their location on the main stem of the Delaware River and the availability of data. The four locations are presented in Figure 4.1.1-1. They are Trenton, NJ, Lumberville, PA, Portland, PA, and Montague, NJ. The four sites cover the geographic range of the Delaware Source Water Protection Plan Study Area from the headwaters in New York to the edge of the tidal zone at Trenton, NJ. Baxter Water Treatment Plant data was not used in this analysis because the historical records are not as large as those of the USGS. Data was obtained from the USGS at www.usgs.gov. The data type, location, gauge number, and parameter codes are presented below in Tables 4.2.3.4.1-1, 4.2.3.4.1-2, and 4.2.3.4.1-3.

Table 4.2.3.4.1-1 Sodium Data Locations

Sodium, mg/L		
Location	**Gauge #**	**Parameter Code**
Trenton, NJ	1463500	930
Lumberville, PA	1461000	930
Portland, PA	1443000	930
Montague, NJ	1438500	930

Table 4.2.3.4.1-2 Chloride Data Locations

Chloride, mg/L		
Location	**Gauge #**	**Parameter Code**
Trenton, NJ	1463500	940
Lumberville, PA	1461000	940
Portland, PA	1443000	940
Montague, NJ	1438500	940

Table 4.2.3.4.1-3 Streamflow Locations

Streamflow, cubic feet per second		
Location	**Gauge #**	**Parameter Code**
Trenton, NJ	1463500	60
Belvidere, NJ	1446500	60
Montague, NJ	1438500	60

In the analysis, concentration data is aligned with streamflow at matching locations and dates. Due to the lack of a streamflow gauge at Portland and Lumberville, additional calculations were performed. Portland, PA, streamflow data was calculated by multiplying Belvidere, NJ streamflow data by 0.92 because the watershed above Portland is eight percent smaller than the watershed above Belvidere, NJ. Lumberville, PA streamflow data was calculated by multiplying Trenton, NJ streamflow data by 0.97 because the watershed above Lumberville, PA is three percent smaller than the watershed above Trenton, NJ.

The programs used in this analysis are Microsoft Excel, StatSoft Statistica, and the USGS Kendall.exe program. Excel and Statistica were used for the data formatting and preparation. The USGS offers the Kendall.exe program for free on its website at http://pubs.usgs.gov/sir/2005/5275/downloads. A guidance document titled Computer Program for the Kendall Family of Trend Tests is also available on the website as Scientific Investigations Report 2005-5275.

In this application of the SKT, the test is performed on concentration data normalized to streamflow. When streamflow is high, sodium and chloride concentrations are diluted. Under low flow conditions the concentrations increase because they are not diluted. The dynamic between streamflow and concentrations with these particular parameters requires that concentration be adjusted prior to a trend test in order to isolate the trend from the streamflow relationship. The sodium and chloride data normalized to streamflow is equivalent to the residuals of a locally weighted exponential scatterplot smoothing (LOWESS, f=0.5). The Kendall.exe program performs the LOWESS smooth for the user.

The SKT identifies long term trends by initially testing for the presence of trends in seasons. The statistic then combines the seasonal results to evaluate the whole data set. This application of the SKT was performed on four seasons. The season and months are chosen and manually assigned by the user. The seasons used in this analysis are listed below in Table 4.2.3.4.1-4. Duplicate values within seasons are averaged in the program.

Table 4.2.3.4.1-4 Seasons

Season	Months
Winter	December, January, February
Spring	March, April, May
Summer	June, July, August
Fall	September, October, November

In order for a trend to be statistically significant, the adjusted p-value calculated by the program would have to be less than or equal to 0.05. An adjusted p-value less than 0.05 means the likelihood of the trend occurring due to chance is less than 5 percent.

4.2.3.4.2 Trend Test Results

The results of the SKT are presented in Tables 4.2.3.4.2-1 and 4.2.3.4.2-2. Increasing sodium and chloride trends are detected at Trenton, NJ, Lumberville, PA, and Portland, PA. A trend at Montague, NJ was not detected under the stringent p-value criteria chosen, however, a trend would be detected under more liberal criteria.

Table 4.2.3.4.2-1 Sodium SKT Results

Location	p-value	Significant Trend	Trend Direction	Estimated Years to 20 mg/L AHA* Recommendation
Trenton, NJ 1975-2005	0.0000	Yes	Increasing	70-90 Years
Lumberville, PA 1976-2005	0.0000	Yes	Increasing	70-90 Years
Portland, PA 1975-2005	0.0000	Yes	Increasing	115-135 Years
Montague, NJ 1991-2005	0.0009	Yes	Increasing	175-195 Years

**American Heart Association*

Table 4.2.3.4.2-2 Chloride SKT Results

Location	p-value	Significant Trend	Trend Direction	Estimated Years to 250 mg/L MCL
Trenton, NJ 1975-2005	0.0000	Yes	Increasing	790-810 Years
Lumberville, PA 1976-2005	0.0000	Yes	Increasing	770-790 Years
Portland, PA 1975-2005	0.0000	Yes	Increasing	970-990 Years
Montague, NJ 1991-2005	0.0634	No	-	-

The far right column in the sodium and chloride tables is the estimated number of years it will take to reach the chloride MCL and the sodium American Heart Association (AHA) recommendation based on the trend results. Both parameters are not a short term concern. Chloride is estimated to take a very long time to reach the MCL. Sodium will be a concern in less than 100 years given no change in the slope of the trend. With regards to drinking source water quality, sodium and chloride are increasing, but not at an alarming rate.

The lower, middle, and upper Delaware River watershed are all experiencing rising sodium and chloride concentrations since 1975. The trend has been found to be present upstream of the densely populated lower Delaware area that was the focus of study in the SWA Sections. Although these trends are not an imminent drinking water threat, the regional salinization of the Delaware River watershed may pose an unknown threat to aquatic flora and fauna. The Delaware Valley region will have to carefully balance driver safety and water quality concerns when de-icing materials are applied to transportation surfaces.

4.2.4 Conductivity

Conductivity was identified in both SWA Sections 1 and 2 as a source water quality concern due to an increasing trend. Conductivity, or specific conductance, is a measurement of the physical property of the water similar to pH or temperature. The EPA does not regulate conductivity through an MCL or Secondary MCL.

4.2.4.1 Conductivity Background

One of the most commonly used general measurements of water quality is conductivity, or specific conductance. Conductivity is a measurement of the ability of water to conduct electrical current. Conductivity is not a specific ion or element measure. Conductivity is a physical property of water at the time of the sample analysis. Conductivity is used as an indicator because the measurement is influenced by many water quality parameters.

Ions in the surface water increase conductivity. They result from dissolved solids, salts, metals, and soil particles. Sources of these materials are stormwater and urban runoff, abandoned mine drainage, agricultural runoff, and point source discharges. Organic material in the surface water decreases conductivity. Sources of organic material are algal blooms, chemical spills, and particularly oil spills.

Water temperature also heavily influences conductivity. The ability of water to conduct electricity improves under warm temperatures, therefore conductivity rises when the water temperature rises. Conductivity is measured in microsiemens per centimeter, or µS/cm. To compensate for the relationship between conductivity and temperature, the sample is adjusted to 25 Celsius by the measurement device or brought to 25 Celsius in the laboratory before the sample is analyzed.

4.2.4.2 Conductivity Analysis

In the Delaware River watershed, the SWA Sections 1 and 2 both concluded that conductivity has been increasing since 1990. The following analysis updates the information presented in the SWA to include data up to 2006, and examines the data to determine whether any trends can be detected.

Data included in the following table was recorded by the Philadelphia Water Department Bureau of Laboratory Services. Conductivity was measured at the intake of the Baxter Water Treatment Plant.

Table 4.2.4.2-1 below includes statistics presented in the SWA Section 2 and statistics for values from 1999 to 2006. The statistics presented are useful to describe the range of conductivity over the course of a year, but will not give any indication of trend. The first row of data indicates the values reproduced from the SWA Section 2.

Table 4.2.4.2-1 Conductivity, uS/cm

Sampling Date Range		Minimum Value	Maximum Value	Mean	Median	Number of Samples
January 1990 *	December 1999	95	607	204	201	488
January 1999	December 2006	0.02	448	212.5	215	228
January 1999	December 1999	0.02	355	187.3	210	44
January 2000	December 2000	115	406	219.7	219.5	42
January 2001	December 2001	169	448	255.6	262	51
January 2002	December 2002	116	342	198.3	190	32
January 2003	December 2003	109	263	194.9	189.5	12
January 2004	December 2004	32	349	210	208	19
January 2005	December 2005	105	294	213.6	220	11
January 2006	December 2006	128	255	172.5	166	17

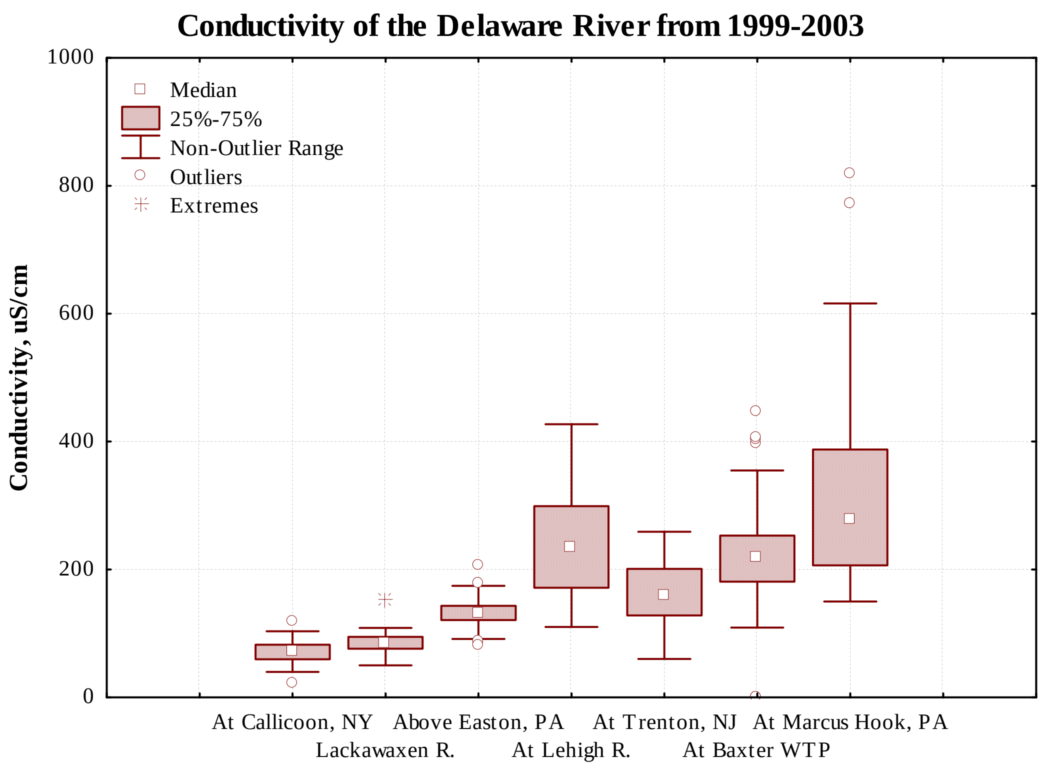
** Data from SWA Section 2*

According to the above statistics, conductivity measurements vary greatly within one year and between years. Conductivity is affected by multiple water quality parameters, and the readings over time reflect those parameters.

Figure 4.2.4.2-1 is a comparison of the conductivity ranges from 1999 to 2003 at two major tributaries and five locations on the Delaware River. This analysis is slightly different than the upstream loading comparisons used to discuss other parameters in this section. The nature of the conductivity measurement does not lend itself to a loading comparison. Conductivity is a measurement of the physical property of water, and like other physical readings such as temperature or pH, conductivity can not be converted into units that will represent mass transport.

Data used in the following analyses were obtained from multiple sources. Conductivity measurements used in the analysis were sampled and processed by the Pennsylvania Department of Environmental Protection Source Water Quality Network. The water quality data was retrieved for sampling locations 182, 101, 123, 148, 147, and 185. The data can be downloaded from the EPA database STORET at http://www.epa.gov/storet/dw_home.html, under Organization 21PA, Project ID WQN. Baxter intake data was recorded by the Philadelphia Water Department Bureau of Laboratory Services.

Figure 4.2.4.2-1 Conductivity Box Plots



The conductivity increases from upstream locations to downstream locations. The conductivity of the Lehigh River is higher than locations upstream, which is likely a reflection of the high iron and manganese concentrations in that watershed.

4.2.4.3 Conductivity Trend Analysis

The previous discussion of chloride and sodium found an increasing trend in both parameters throughout the Delaware River watershed. The SWA Sections 1 and 2 both observed that conductivity in the Delaware River watershed appeared to be increasing through time. The Seasonal Kendall Test conducted on chloride and sodium is performed here on conductivity to identify any trends as well as support the findings of the sodium and chloride analysis.

4.2.4.3.1 Trend Test Methodology

Conductivity and streamflow data at four locations are used in this analysis. The four locations were chosen due to their location on the main stem of the Delaware River and the availability of data. The four locations are presented in Figure 4.1.1-1. They are Trenton, NJ, Lumberville, PA, Portland, PA, and Montague, NJ. The four sites cover the geographic range of the Delaware Source Water Protection Plan Study Area from the headwaters in New York to the edge of the tidal zone at Trenton, NJ. Baxter Water Treatment Plant data was not used in this analysis because the historical records are not as large as those of the USGS. Data was obtained from the USGS at www.usgs.gov. The data type, location, gauge number, and parameter codes are presented below in Tables4.2.4.3.1-1 and 4.2.4.3.1-2.

Table 4.2.4.3.1-1 Conductivity Data Locations

Conductivity, uS/cm		
Location	**Gauge #**	**Parameter Code**
Trenton, NJ	1463500	95
Lumberville, PA	1461000	95
Portland, PA	1443000	95
Montague, NJ	1438500	95

Table 4.2.4.3.1-2 Streamflow Locations

Streamflow, cubic feet per second		
Location	**Gauge #**	**Parameter Code**
Trenton, NJ	1463500	60
Belvidere, NJ	1446500	60
Montague, NJ	1438500	60

In the analysis, conductivity data is aligned with streamflow at matching locations and dates. Due to the lack of a streamflow gauge at Portland and Lumberville, additional calculations were performed. Portland, PA, streamflow data was calculated by multiplying Belvidere, NJ streamflow data by 0.92 because the watershed above Portland is eight percent smaller than the watershed above Belvidere, NJ. Lumberville, PA streamflow data was calculated by multiplying Trenton, NJ streamflow data by 0.97 because the watershed above Lumberville, PA is three percent smaller than the watershed above Trenton, NJ.

The programs used in this analysis are Microsoft Excel, StatSoft Statistica, and the USGS Kendall.exe program. Excel and Statistica were used for the data formatting and preparation. The USGS offers the Kendall.exe program for free on their website at http://pubs.usgs.gov/sir/2005/5275/downloads. A guidance document titled Computer Program for the Kendall Family of Trend Tests is also available on the website as Scientific Investigations Report 2005-5275.

In this application of the SKT, the test is performed on conductivity data normalized to streamflow. When streamflow is high, ions become diluted which reduces conductivity. Under low flow conditions the concentrations of ions increase because they are not diluted, and this increases conductivity. The dynamic between streamflow and conductivity requires that conductivity be normalized to streamflow prior to a trend test in order to isolate the trend from the streamflow relationship. The data normalized to streamflow is equivalent to the residuals of a locally weighted exponential scatterplot smoothing (LOWESS, f=0.5). The Kendall.exe program performs the LOWESS smooth for the user.

The SKT identifies long term trends by initially testing for the presence of trends in seasons. The statistic then combines the seasonal results to evaluate the whole data set. This application of the SKT was performed on four seasons. The season and months are chosen and manually assigned by the user. The seasons used in this analysis are listed below in Table 4.2.4.3.1-3. Duplicate values within seasons are averaged in the program.

Table 4.2.4.3.1-3 Seasons

Season	Months
Winter	December, January, February
Spring	March, April, May
Summer	June, July, August
Fall	September, October, November

In order for a trend to be statistically significant, the adjusted p-value calculated by the program would have to be less than or equal to 0.05. An adjusted p-value less than 0.05 means the likelihood of the trend occurring due to chance is less than 5 percent.

4.2.4.3.2 Trend Test Results

The results of the SKT are presented in Table 4.2.4.3.2-1. Increasing conductivity trends are detected at Trenton, NJ, Lumberville, PA, and Portland, PA. A trend at Montague, NJ was not detected.

Table 4.2.4.3.2-1 Conductivity SKT Results

Location	p-value	Significant Trend	Trend Direction
Trenton, NJ 1975-2005	0.0003	Yes	Increasing
Lumberville, PA 1976-2005	0.0043	Yes	Increasing
Portland, PA 1975-2005	0.0002	Yes	Increasing
Montague, NJ 1991-2005	0.3270	No	-

Conductivity is shown here to be increasing in the lower and middle sections of the Delaware River watershed. This conclusion supports the findings of the chloride and sodium section that identified an increasing trend over time in those parameters and locations. There are no mandatory regulations for conductivity in surface water or drinking water, so this parameter is not directly a source water quality concern. Conductivity is of interest indirectly as an indicator of source water quality because any changes or trends in the measurement will indicate that other parameters in the watershed are also changing.

4.2.5 *Cryptosporidium*

Cryptosporidium is a pathogenic protozoan common in source water and resistant to chlorine disinfection. This pathogen is regulated by the Safe Drinking Water Act under the Long Term 2 Enhanced Surface Water Treatment Rule (LT2). The LT2 was designed to reduce the presence of *Cryptosporidium* and similar emerging pathogens by using source water quality to dictate how much *Cryptosporidium* in the source water needs to be removed. This regulation is the first of its kind to directly implicate source water quality as the reason for very explicit removal standards. With other regulations, all drinking water treatment plants across the nation are held to the same removal standards, regardless of source water quality. This regulation is progressive and requires that drinking water suppliers with high *Cryptosporidium* concentrations in the source water must implement additional treatment and/or source water protection measures to ensure adequate protection against this pathogen.

Cryptosporidium is aggressively managed by the Safe Drinking Water Act LT2 regulation because it has a low infectious dose, can lead to waterborne outbreaks, resists disinfection, and is found in most surface waters. *Cryptosporidium* can enter the surface water through treated wastewater treatment plant effluent, combined sewer overflow events, septic system failures, non-point source pollution from livestock areas, wildlife, or domestic animals. Initially, the LT2 requires two years of source water monitoring; 48 samples in 24 months. The results of the two year monitoring are then averaged, and the averaged result is used to assign the source water into one of four bins. Source waters with higher concentrations of *Cryptosporidium* oocysts are assigned into higher bins where treatment and/or additional source water protection efforts would be required.

Cryptosporidium sampling results submitted to the EPA by the Philadelphia Water Department (PWD) concluded that Delaware River source water for the Baxter Water Treatment Plant falls into Bin 1. To be in Bin 1, the two year average crypto concentration must be less that 0.075 oocysts/L. Bin 1 represents the source water with the lowest *Cryptosporidium* concentrations and does not require any additional treatment or disinfection measures.

Cryptosporidium is a parameter of concern to the Baxter Water Treatment Plant due to over 130 wastewater treatment plants and numerous combined sewer overflows that discharge into the Delaware River source water area. While the results of the LT2 compliance sampling reveal that *Cryptosporidium* is not a current source water quality concern, there is potential for *Cryptosporidium* to increase in the Delaware River without year long disinfection at all wastewater treatment plants. PWD will continue to closely monitor this pathogen due to the number and proximity of wastewater treatment plants and combined sewer overflows in the watershed.

4.2.6 Iron and Manganese

Iron and manganese are abundant metals in the Delaware River watershed. The Baxter Water Treatment Plant Source Water Assessments Section 1 & 2 (SWA) both identify iron and manganese as source water quality concerns. The EPA does not regulate iron or manganese in drinking water by the usual means of mandatory requirements. For these metals the EPA has created a Secondary Maximum Contaminant Level (MCL). The Secondary MCL is not a mandatory requirement, but a suggested level that identifies when taste, odor, and color compounds are below sensory levels. The metals and compounds assigned Secondary MCLs tend to affect the aesthetic quality of drinking water and are not typically associated with the health concerns of contaminants that fall under mandatory MCL guidelines.

The Secondary MCL for total iron is 0.3 mg/L and 0.05 mg/L for total manganese. In the SWA the mean and median total iron concentrations of the Delaware River at the Baxter intake were both above the Secondary MCL before treatment. The total iron and manganese concentrations reported in the SWA are updated and analyzed in this section to identify local and watershed wide trends and sources.

4.2.6.1 Iron and Manganese Background

High concentrations of iron and manganese in source water can affect the aesthetic of treated drinking water as well as treatment costs. Iron can impart a rust color and metallic taste to finished drinking water when concentrations are not reduced below the Secondary MCL of 0.3 mg/L. High iron concentrations can also cause sedimentation of particulates in the treatment plant, iron deposits on faucets, and reddish staining of surfaces such as dishwashers and sinks. Manganese can leave drinking water with a black to brown tint and a bitter metallic taste if the concentration of finished water is not reduced to at least 0.05 mg/L.

Iron and manganese can be removed by standard drinking water treatment processes such as coagulation, flocculation, and filtration. Aeration and granular activated carbon steps also remove iron and manganese. Treatment costs can rise when the metals are present in concentrations that require increased chemical use.

Iron and manganese are typically found in a dissolved state in groundwater, and in un-dissolved compounds in surface water. Dissolved oxygen and salinity in surface water regulate whether the metals are dissolved, in a compound state, or precipitate out of the water column. The iron and manganese compounds are often adsorbed to organic particles or precipitate out of the water column particularly in the lower Delaware River tidal zone. The main source of iron and manganese in groundwater is the weathering of underlying geologic formations under low oxygen conditions. Natural movement of the groundwater introduces dissolved metals to surface water.

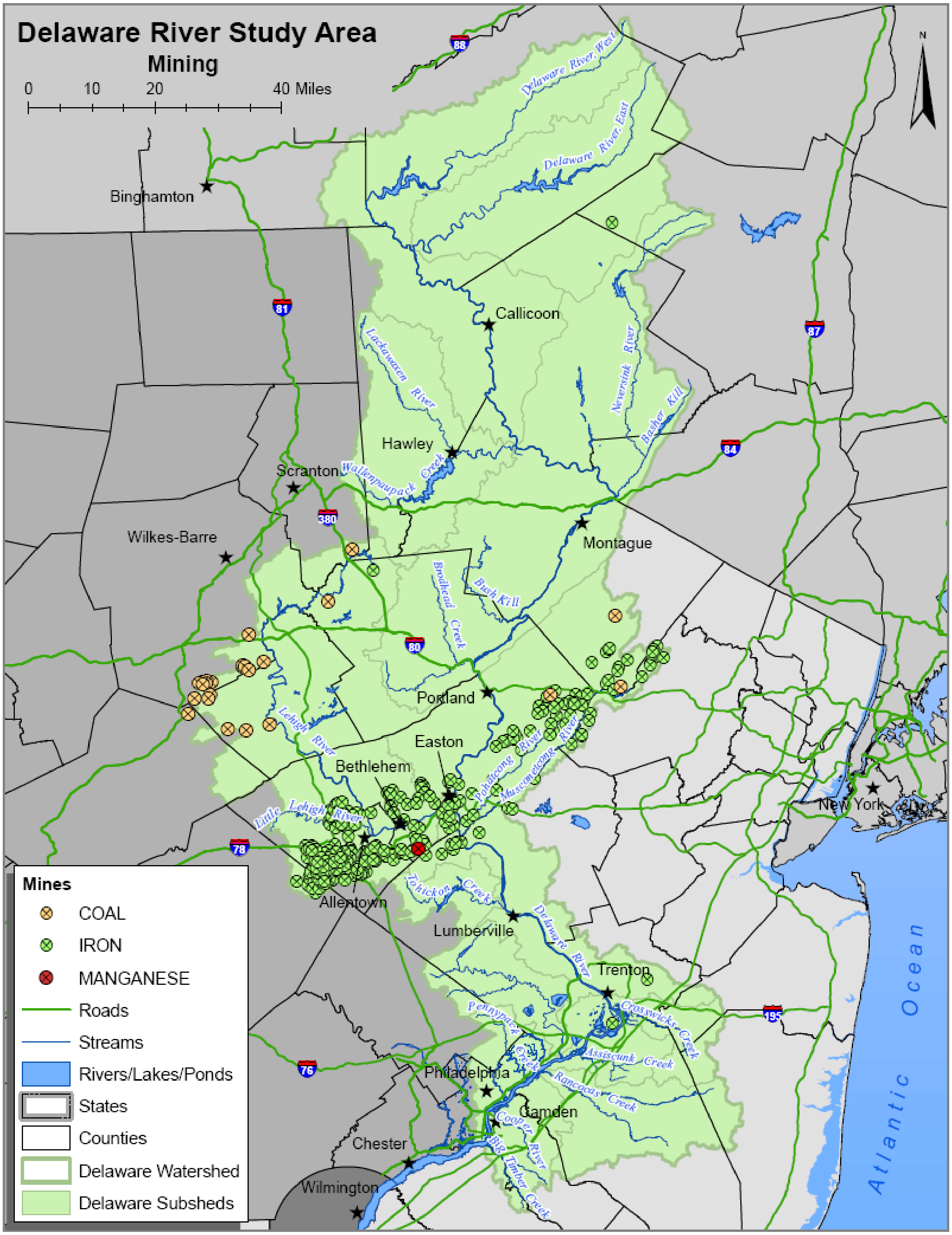
Surface water can also gain metals from drainage escaping abandoned mines, as well as river sediment interactions. Iron and manganese were heavily mined in the twentieth century in the Delaware River watershed. Figure 4.2.6.2-1 identifies the locations of iron, manganese, and coal mines within the Delaware River Study Area. The mining and steel production industry was once an important economic driver for the Delaware Valley region. Unfortunately, one legacy of this once dominant industry is surface water pollution in certain locations from the drainage of abandoned mines.

Due to the industrial history of the Delaware River Basin and the location of the Baxter intake, the source water is high in iron and manganese due to a combination of the sources described. The following analysis of iron and manganese in the Delaware River includes an overview of concentrations recorded at the Baxter intake, a loading comparison from the upper watershed, and a concentration comparison within the tidal zone.

4.2.6.2 Iron and Manganese Analysis

Data used in the following analyses were obtained from multiple sources. Streamflow data were retrieved from http://waterdata.usgs.gov/pa/nwis/rt for USGS stream gage stations 01463500, 01454700, 01446500, 01431500, 01432000, 01427510. Stream gages 01431500 and 01432000 were used together to calculate the streamflow of the mouth of the Lackawaxen River. Iron and manganese concentrations used in the analysis were sampled and processed by the Pennsylvania Department of Environmental Protection Source Water Quality Network. The water quality data was retrieved from sampling locations 182, 101, 123, 148, 147, and 185. The data can be downloaded from the EPA database STORET at http://www.epa.gov/storet/dw_home.html, under Organization 21PA, Project ID WQN. Baxter intake data was recorded by the Philadelphia Water Department Bureau of Laboratory Services.

Figure 4.2.6.2-1 Delaware River Study Area Mining Locations



Tables 4.2.6.2-1 and 4.2.6.2-2 below include statistics presented in the SWA Section 2 and statistics for values from 1999 to 2006. The statistics presented are useful to describe the range that iron and manganese concentrations can cover over the course of a year, but will not give any indication of a trend. The basic statistics are useful to indicate if the parameter is approaching levels of concern such as the 0.3 mg/L MCL for iron and the 0.05 mg/L MCL for manganese. The asterisk in the first row of data indicates the values reproduced from the SWA Section 2.

Table 4.2.6.2-1 Total Iron, mg/L

Sampling Date Range		Minimum Value	Maximum Value	Mean	Median	Number of Samples
January 1990 *	**June 1999**	0.05	8.3	0.88	0.61	329
January 1999	**November 2006**	0.00	12.5	0.95	0.75	487
January 1999	**December 1999**	0.16	3.88	1.14	0.79	54
January 2000	**December 2000**	0.00	3.27	0.98	0.79	48
January 2001	**December 2001**	0.23	3.12	0.77	0.60	75
January 2002	**December 2002**	0.29	4.84	1.03	0.79	68
January 2003	**December 2003**	0.24	3.65	0.89	0.72	50
January 2004	**December 2004**	0.30	3.92	0.98	0.78	49
January 2005	**December 2005**	0.34	12.5	0.99	0.71	77
January 2006	**November 2006**	0.22	3.51	0.93	0.81	66

** Data from SWA Section 2*

In Tables 4.2.6.2-1 and 4.2.6.2-2 it is important to note the median and mean concentrations of iron and manganese are greater than their Secondary MCLs before the water is treated. This high incidence of iron and manganese in the drinking water supply warrants additional analyses of the upper watershed and tidal zone to identify where the metals may originate.

Table 4.2.6.2-2 Total Manganese, mg/L

Sampling Date Range		Minimum Value	Maximum Value	Mean	Median	Number of Samples
February 1990 *	June 1999	0.01	0.63	0.08	0.07	332
January 1999	November 2006	0.005	0.439	0.079	0.067	487
January 1999	December 1999	0.012	0.289	0.087	0.067	54
January 2000	December 2000	0.033	0.223	0.079	0.071	46
January 2001	December 2001	0.021	0.266	0.081	0.068	75
January 2002	December 2002	0.005	0.354	0.081	0.069	70
January 2003	December 2003	0.033	0.286	0.079	0.074	51
January 2004	December 2004	0.030	0.132	0.061	0.060	48
January 2005	December 2005	0.028	0.198	0.076	0.066	77
January 2006	November 2006	0.021	0.439	0.083	0.070	66

** Data from SWA Section 2*

Concentration data at the Baxter intake were also examined for any increasing or decreasing trends. The data in both iron and manganese did not increase or decrease significantly from 1999 to 2005.

In the northern section of the Delaware River Basin there are several abandoned coal, iron, and manganese mines. The mines have long been filled with water that over time has dissolved minerals containing iron and manganese from the exposed geologic formations. The water in the mines seeps back into both groundwater and surface water systems carrying high concentrations of metals and other solutes. The mines also contribute hardness and alkalinity to the water which can increase treatment costs.

In order to assess the impact of regions with known abandoned mines, a loading analysis of tributaries to the Delaware River and individual locations on the Delaware River is performed. Comparing different loadings is useful because it takes into account both concentration and streamflow, allowing small tributaries to be compared to large rivers. The term loading describes the amount, or weight, of a compound that passes by a specific river sampling location or a specific tributary, over a given period of time. In this analysis loading is expressed in pounds per day, and is calculated by multiplying concentration by streamflow.

Figures 4.2.6.2-2 and 4.2.6.2-3 below depict total iron and total manganese loadings at different locations on the Delaware River and specific tributaries. Box plot graphs identify the median daily loading value and the range of data falling between the twenty-fifth and seventy-fifth percentiles. Box plots are also useful in that they identify outliers and extreme values, many of which are higher than the scale presented in these graphs.

The sampling locations chosen move down the Delaware River watershed as the graphs read left to right. The graph presents three locations on the Delaware, including Callicoon, NY, above Easton, PA, and Trenton, NJ. The Lackawaxen and Lehigh Rivers, two major tributaries, are also presented. The Lackawaxen River watershed includes a large reservoir and hydroelectric dam, and was once part of a transportation system used to move coal from northern Pennsylvania across the Delaware to the Hudson River. The Lehigh River watershed is impacted by multiple abandoned coal mines that drain acidic and metal laden water to the Lehigh River and ultimately the Delaware River.

Figure 4.2.6.2-2 Total Iron Box Plots

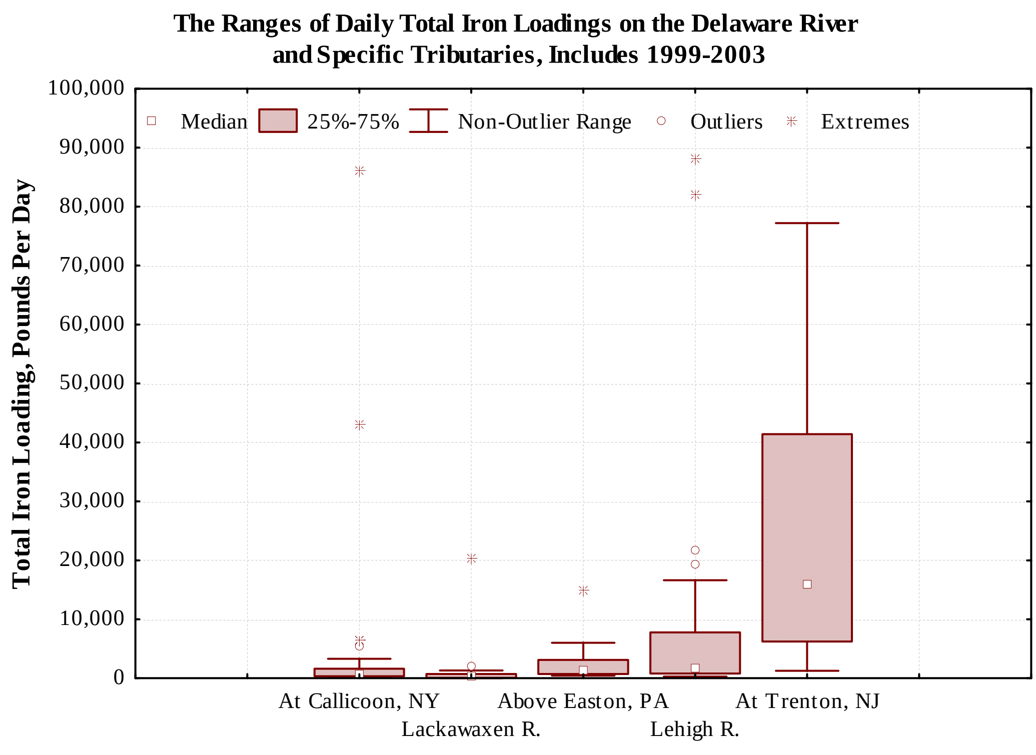


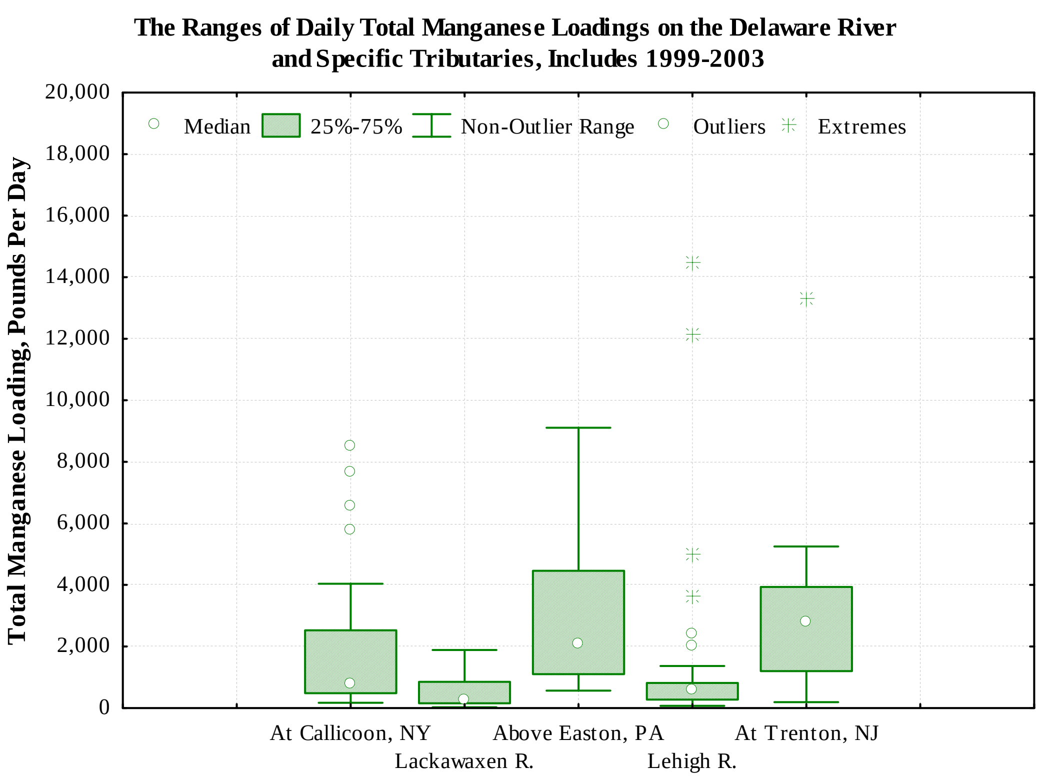
Figure 4.2.6.2-2 above presents the range of daily total iron loadings across the Delaware River watershed. Several clear patterns reveal themselves in the total iron loading analysis. Iron loadings are substantially higher in the lower watershed. The median

loading at Trenton, NJ is ten times larger than the loading at Callicoon, NY. The 1,360 square mile Lehigh River watershed, long suspected to be a source of iron, has a similar iron loading to the entire 10,400 square mile Delaware River watershed above Easton, PA. The ability of the vastly smaller Lehigh River watershed to contribute as much iron to the Delaware River as the upstream watershed indicates the Lehigh River is a significant source of iron. Polluted discharge from abandoned mines is a known source of iron to surface waters. The Lehigh River watershed contains 20.6 tributary miles and 29.45 river miles that are designated as impacted by abandoned mine drainage by the EPA 1998 303d list.

The range of daily loadings presented for Trenton, NJ is too high however, for the Lehigh River to be the only source of iron to the Delaware River. The large difference between the median loading at Trenton, NJ and the loadings observed from the Lehigh River and the Delaware River Above Easton, PA indicate the Delaware River has significant sources of iron in the watershed in addition to abandoned mine drainage. Identifying additional sources of iron is critical to fully addressing metals impacts on the Baxter treatment plant.

Manganese loadings, which are presented in Figure 4.2.6.2-3, do not follow the same watershed trend as iron loadings do.

Figure 4.2.6.2-3 Total Manganese Box Plots



The iron loadings analysis identified an increasing trend in loading from the northern reaches to the southern reaches of the Delaware River. This observation holds true for manganese, but the increase is not as drastic as with iron. The daily median loading of manganese gradually increases from the northern Delaware River at Callicoon, NY to southern most area at Trenton, NJ, the southern-most location presented in the graph. The Lackawaxen and Lehigh Rivers appear to be equal contributors of manganese to the Delaware River. Neither tributary creates a sharp increase in loadings on the Delaware River. Instead, the increases are very gradual. This indicates that a likely contributor of the metals to the tributary loadings may be the normal weathering of minerals and bedrock.

The increase observed in the median manganese loading from Easton, PA to Trenton, NJ, is not as steep as the increase identified in the iron analysis. This gradual increase identifies the Lehigh River as one potential source of manganese, but does not indicate that other large sources of manganese are present between Easton, PA and Trenton, NJ as seen in the iron analysis. Manganese is listed with iron as a parameter responsible for the designation by the EPA of the Lehigh River and its tributary miles as impacted by abandoned mine drainage on the 1998 303d list. The impacted stream miles of the Lehigh River likely contribute manganese to the source water in addition to natural weathering processes. The Lehigh River, however, appears to contribute greater amounts of iron, rather than manganese, to the Delaware River.

The lower section of the Delaware River Basin where the Baxter intake is located is within a tidal zone. In this zone the northern limit of tidal influence on the river reaches just south of Trenton. The source water delineation within the SWA Section 2 identifies tidal areas south of the Baxter intake that are included in Zones A and B. In order to analyze the quantities of iron and manganese in the tidal area above and below the Baxter intake, concentrations within the tidal zone are compared.

Concentrations are used in the following assessment of the tidal zone rather than loadings because the tidal mixing and volume fluctuations prevent an accurate calculation of river flow, which is a main component of the loading equation. Tidal fluctuation of the Atlantic Ocean reaches up the Delaware Estuary and into the river system, where Delaware River waters and Delaware Estuary waters mix.

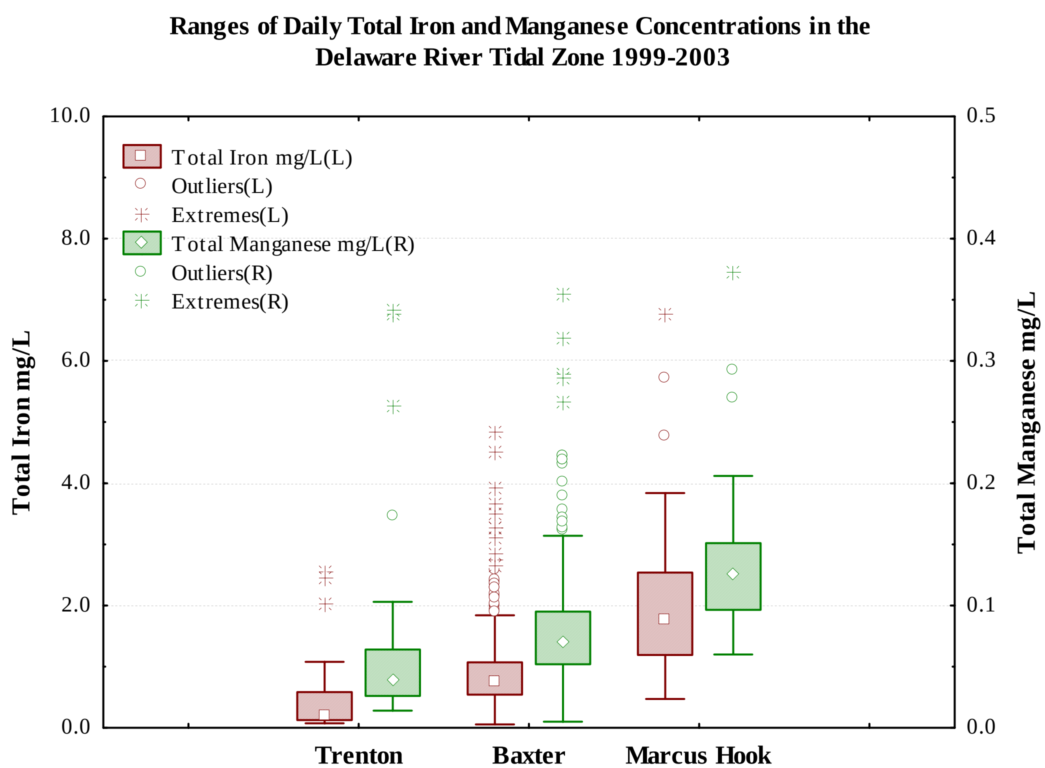
The locations chosen to compare iron and manganese concentrations are Trenton, NJ, the Baxter intake in the Torresdale section of Philadelphia, PA, and Marcus Hook, PA. Due to data limitations, Marcus Hook in Pennsylvania is used to represent the southern-most point of Zone B despite its being ten miles south of the Zone B boundary. The iron and manganese concentrations at Trenton represent the non-tidal Delaware River. Figure 4.2.6.2-4 depicts the iron and manganese concentrations across the tidal zone of the Baxter intake.

Iron and manganese concentrations both increase across the distance from Trenton to Marcus Hook. The concentrations at Marcus Hook are much higher than those at Trenton for both iron and manganese. This unexpected pattern indicates that one or more metal sources are present in the tidal zone, in addition to those from the upper watershed. Metals precipitate from the water column in saline water, and because the tidal zone is a mix of fresh and saline water it was expected that iron and manganese concentrations in this area would decrease. Two suspected contributors of metals in the tidal zone are the Rancocas Creek and metal laden sediments.

The Rancocas Creek was identified in the Baxter SWA as a contributor of metals to the tidal zone. The Rancocas Creek contained high point and non-point source loadings of both iron and manganese.

Anther likely contributor of metals to the source water within the tidal zone is the sediment of the Delaware River. Interactions between water and metals at the sediment interface are a common occurrence in river systems. A study specific to the Delaware River and its sediment-water interactions would be useful to identify the degree to which sediment is contributing metals to the source water. Multiple studies regarding the Delaware Estuary have been performed over the past few decades, but no recent studies have been identified that focus in detail on the lower Delaware River and tidal zone. The results of such a study would provide information that water resource professionals can use to identify and potentially mitigate water quality conditions threatening to source water.

Figure 4.2.6.2-4 Total Iron and Total Manganese Tidal Box Plots



Point source discharges containing high iron concentrations could also be a source of the increase in total iron observed from Trenton to Marcus Hook. The additional sources of iron are unknown. Identifying these sources is a priority and will indicate if the amount of metals in Baxter source water can be reduced.

4.2.7 Nitrate and Nitrite

Nitrate NO_3 and nitrite NO_2 are inorganic forms of nitrogen identified in the SWA Sections 1 and 2 as parameters that need to be closely monitored due to their increasing trends. Both inorganic forms of nitrogen are regulated by the Safe Drinking Water Act (SDWA); the MCLs are 10 mg/L of nitrate and 1 mg/L of nitrite. Nitrate and nitrite have similar sources, health effects, and source water quality implications.

4.2.7.1 Nitrate and Nitrite Background

The SWA Sections 1 and 2 concluded that nitrate levels have been historically increasing in the Delaware River Watershed and at the Baxter Water Treatment Plant intake. The water quality data spanned from the early 1970s until the late 1990s. SWA Section 1 presented an increase in annual mean nitrate concentration over three decades, as well as a slowing of such increases during the 1990s.

The SWA Section 2 identified nitrite is also a source water quality concern. The SWA calculated an annual mean concentration of the years 1990-1999 at 2.1mg/L, which is more than double the 1mg/L MCL. The high annual mean is skewed by one abnormally high data point that may represent an anomaly or a damaged sample. Recent nitrite data will help to identify what the concentration ranges of this parameter are, and whether or not such high concentrations have been seen since 2002.

Nitrate and nitrite are important parameters to measure when discussing drinking source water quality because of the direct and indirect implications for finished water quality and human health. Nitrate and nitrite do not directly affect the taste or odor of drinking water, but can have an indirect effect by nourishing algae that produce undesirable taste and odor compounds. Increased algal growth can also clog filters at the water treatment plant and increase treatment time and cost.

Nitrate and nitrite in drinking water are regulated by the SDWA because high concentrations are harmful to human health, in particular babies and young children. When ingested, nitrate reacts to become nitrite which then alters the structure of hemoglobin and inhibits the oxygen carrying capacity of red blood cells. This mechanism is why the MCL for nitrite is much lower than the MCL for nitrate; 1 mg/L and 10 mg/L respectively. The alteration of hemoglobin leads to suffocation called blue baby disease and can affect infants and young children. In adults, nitrate and nitrite concentrations above the MCL can cause spleen disease and hemorrhaging.

High levels of nitrate in source water are most common in groundwater beneath agricultural areas, areas of suburban development served by septic systems, and urban areas with leaking sewer lines. The conventional water treatment process does not directly target nitrate or nitrite removal. Additional treatment to remove nitrate and nitrite are only added if the drinking source water has high concentrations.

Nitrite and nitrate enter the source water through both point and non-point pollution sources. Point sources that contribute inorganic nitrogen include industrial and wastewater treatment plant discharge. Non-point source pollution from fertilizer runoff, waste from farm and domestic animals, and septic systems also contribute inorganic nitrogen to surface water.

4.2.7.2 Nitrate Analysis

According to the SWA, the nitrate concentrations in the Baxter source water area were not above or near the MCL value of 10mg/L. Due to the important direct and indirect affects of nitrate on drinking water and source water quality, and the increasing trend cited in the SWAs, the nitrate concentration at the Baxter intake is being reassessed.

Data used in the following analyses were obtained from two sources, the Delaware River Basin Commission and the Bureau of Laboratory Services. Nitrate concentrations from 1999-2001 in the analysis were sampled and processed by the Delaware River Basin Commission (DRBC) Boat Run Sampling Program. The water quality data were retrieved for the sampling location river mile (RM) 110.7 Torresdale. The data can be downloaded from the EPA database STORET at http://www.epa.gov/storet/dw_home.html, under Organization 31DelRBC, Project ID DRBC Boat Run Program. Nitrate Concentrations from the Baxter intake for 2002-2006 were recorded by the Philadelphia Water Department Bureau of Laboratory Services. DRBC data is used to represent the annual mean concentration for 1999, 2000, and 2001. The years 2002-2006 are represented by data collected at the Baxter Water Treatment Plant intake, which is on shore in relation to the DRBC data taken from the main channel.

The annual mean nitrate concentrations of drinking source water at the Baxter intake are graphically represented below in Figure 4.2.7.2-1. The annual mean concentrations are compared here because nitrate is not a parameter that follows a seasonal pattern, as identified in both SWA Sections 1 and 2. If nitrate exhibited a seasonal pattern, the annual mean concentration would not be the most appropriate value to analyze because it would mask seasonal concentration shifts.

The blue circles depicted below mark the values of the annual mean concentrations from 1999-2006. The best fit trend line in Figure 4.2.7.2-1, represented in black, shows no significant increasing or decreasing trend in the annual mean nitrate concentration at the Baxter intake from 1999 to 2006. This data supports the findings of the SWA Section 2 that identified nitrate concentration increases began leveling off in the 1990s.

Figure 4.2.7.2-1 Nitrate, mg/L

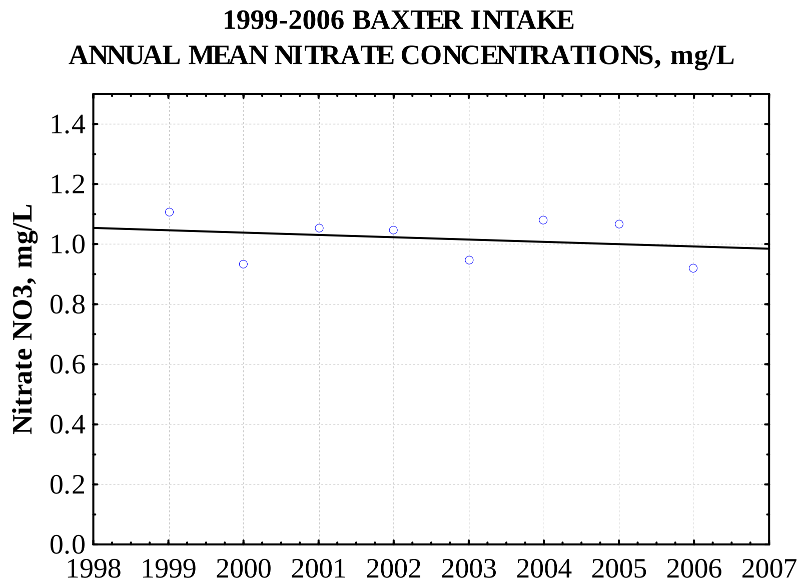


Table 4.2.7.2-1 below includes statistics presented in the SWA Section 2 and statistics for values from 1999 to 2006. The statistics presented are useful to describe the range that nitrate concentrations can cover over the course of a year, but will not give any indication of trend. The basic statistics are useful to indicate if the parameters are approaching levels of concern such as the 10 mg/L MCL. The asterisk in the first row of data indicates the values reproduced from the SWA Section 2.

Mean and median concentrations are calculated to assess if the nitrate concentration is highly variable throughout the course of a year. In the SWA Section 2 nitrate was found to be static, and the median and mean values in this analysis also support the conclusions that nitrate concentration is static throughout the year. A mean value is influenced by variable behavior, and the median value would eliminate any extreme highs and lows. The median and mean values within each year are similar to each other, which suggest that nitrate concentrations in the Baxter source water area do not vary between extreme highs and lows.

Table 4.2.7.2-1 Nitrate, mg/L

Sampling Date Range		Minimum Value	Maximum Value	Mean	Median	Number of Samples
January 1990 *	December 1997	0.85	2.53	1.19	1.17	59
March 1999***	November 2006	0.52	1.75	1.01	0.97	89
March 1999**	August 1999	0.75	1.32	1.11	1.23	7
March 2000**	October 2000	0.59	1.38	0.93	0.903	12
March 2001**	November 2001	0.68	1.39	1.05	1.05	12
June 2002	December 2002	0.52	1.31	1.01	0.97	7
January 2003	December 2003	0.64	1.34	0.95	0.96	12
January 2004	December 2004	0.78	1.75	1.08	0.97	12
January 2005	December 2005	0.52	1.47	1.06	1.11	12
January 2006	November 2006	0.64	1.26	0.92	0.92	12

** Data from SWA Section 2*
*** Data from DRBC Boat Run Sampling Program, Site at River Mile 110.7*
**** Data from DRBC Boat Run Sampling Program 1999-2001 and Baxter LIMS data from 2002-2006*

The Baxter intake is the only location in the source water area examined here because the nitrate concentrations are not increasing and have not approached the MCL, even during annual maximums. In summary, nitrate concentrations at the intake currently are not increasing, and do not indicate a future increase.

4.2.7.3 Nitrite Analysis

The annual mean concentration of nitrite from 1990-1999 calculated in the SWA Section 2 was more than double the MCL of 1 mg/L. The median concentration in the same analysis was 0.02 mg/L and suggests the mean value was influenced by uncharacteristic high and low values. The analysis from SWA Section 2 is repeated here using up to date data.

Data used in the following analysis were obtained from the Delaware River Basin Commission. Nitrite concentrations from 1999-2003 in the analysis were sampled and processed by the Delaware River Basin Commission (DRBC) Boat Run Sampling Program. The water quality data was retrieved for the sampling location river mile (RM) 110.7 Torresdale. The data can be downloaded from the EPA database STORET at http://www.epa.gov/storet/dw_home.html, under Organization 31DelRBC, Project ID DRBC Boat Run Program. River mile 110.7 is the location of the Baxter Water Treatment Plant, and the data withdrawn is meant to indicate conditions at the intake. The Baxter plant does not frequently monitor nitrite concentrations at the intake. Instead, the plant mainly monitors for nitrite in water that is delivered to customers.

The annual mean nitrite concentrations of drinking source water at the Baxter intake from 1999-2003 are graphically represented below in Figure 4.2.7.3-1. The annual mean concentrations are compared here because nitrite is not a parameter that follows a seasonal pattern, as identified in both SWA Sections 1 and 2. If nitrite exhibited a seasonal pattern, the annual mean concentration would not be the most appropriate value to analyze because it would mask seasonal concentration shifts.

The blue circles depicted below mark the values of the annual mean concentrations from 1999-2003. The best fit trend line in Figure 4.2.7.3-1, represented in black, follows a decreasing path. More recent nitrite data is required to determine if the decreasing trend line is statistically significant. This data supports the findings of the SWA Section 2 that identified nitrite concentration increases began leveling off in the 1990s. The DRBC Boat Run Sampling Program samples used to create Figure 4.2.7.3-1 are included in Table 4.2.7.3-1. The DRBC sampling site was located at River Mile 110.7 which is adjacent to the Baxter Water Treatment Plant on the Delaware River.

Figure 4.2.7.3-1 Nitrite, mg/L

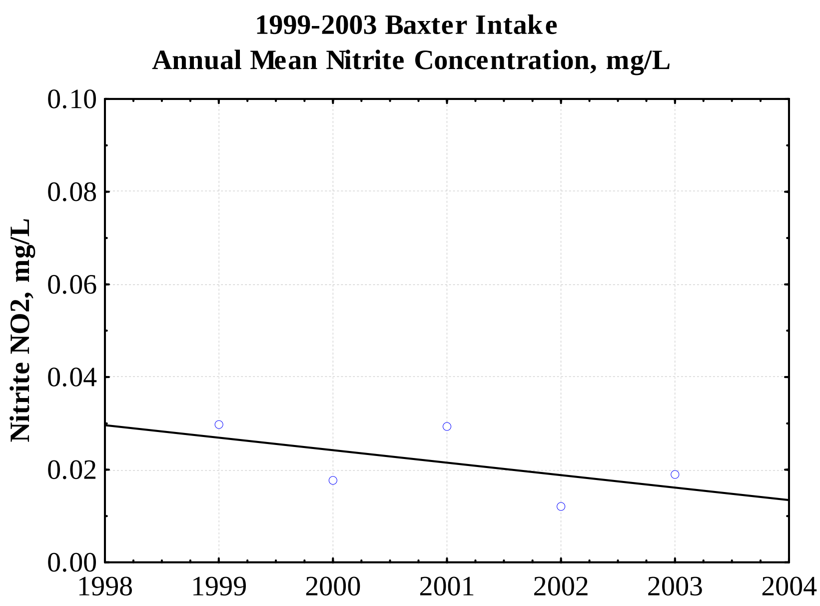


Table 4.2.7.3-1 below includes statistics presented in the SWA Section 2 and statistics for values from 1999 to 2003. The statistics presented are useful to describe the range that nitrite concentrations can cover over the course of a year, but will not give any indication of trend. The basic statistics are useful to indicate if the parameter is

approaching levels of concern such as the 1 mg/L MCL. The asterisk in the first row of data indicates the values reproduced from the SWA Section 2.

The mean and median values in Table 4.2.7.3-1 do not surpass or closely approach the nitrite MCL of 1 mg/L. The maximum concentration values for the five year time span also do not surpass or approach the nitrite MCL. The five year analysis identifies the nitrite concentration in the drinking source water displays a slight decreasing trend from 1999-2003. This data indicates that nitrite concentrations do not pose a threat to the drinking water quality of the Baxter Water Treatment Plant.

Table 4.2.7.3-1 Nitrite, mg/L

Sampling Date Range		Minimum Value	Maximum Value	Mean	Median	Number of Samples
January 1990 *	**June 1999**	0.02	26**	2.1	0.02	28
March 1999	**December 2003**	0.005	0.106	0.021	0.014	51
March 1999	**August 1999**	0.009	0.106	0.029	0.011	7
March 2000	**October 2000**	0.008	0.046	0.018	0.013	12
March 2001	**November 2001**	0.005	0.07	0.029	0.025	12
March 2002	**November 2002**	0.007	0.026	0.012	0.014	11
April 2003	**October 2003**	0.009	0.041	0.019	0.016	9

** Data from SWA Section 2*
***This data point is highly questionable*

The Baxter intake is the only location in the source water area examined here because the nitrite concentrations are not increasing and have not approached the MCL, even during annual maximums. In summary, nitrite concentrations at the intake currently are not increasing, and do not indicate a future increase. Point and non-point source contributions of nitrogen to the water supply continue to occur, but fortunately the historical increase has been halted and the concentration has been steady from 1999-2006.

4.2.8 Compounds of Potential Concern

4.2.8.1 Background Information

In addition to the regular monitoring of conventional parameters in our source waters, the Philadelphia Water Department conducts research and monitoring to identify, understand, and evaluate new parameters that are not regulated by the Safe Drinking Water Act. Compounds of Potential Concern (CPCs) are one particular group of compounds that the Philadelphia Water Department has invested considerable time and resources into researching and analyzing to stay at the forefront of this issue.

A government study completed in 2000 found that some of these CPCs can persist through wastewater or drinking water treatment processes and are detectable in our rivers, streams and, to a lesser extent, drinking water. These findings, along with reports of mixed-sex characteristics of fish and aquatic life, have raised questions from the public on the potential for human impacts from CPCs in the water environment. While no associations between CPCs and human health affects have been established, the Philadelphia Water Department is taking a proactive stance in evaluating the occurrence and impacts of CPCs.

The term "Compounds of Potential Concern" was recently selected by the Water Environment Federation as the most appropriate term for the broad category of compounds it is intended to cover. CPCs have previously been described as Emerging Contaminants, Pharmaceuticals and Personal Care Products (PPCPs), Endocrine Disrupting Compounds (EDCs), Micro constituents, and Nanomaterials.

CPCs include three subgroups of compounds:

Endocrine Disrupting Compounds (EDCs)

Endocrine Disrupting Compounds (EDCs) are substances that can mimic the structure and behavior of hormones generated by the endocrine system. Endocrine disrupting compounds can alter the way an organism or its offspring reproduces, grows, or develops.

EDCs may be contained in natural products such as soybeans, cabbage, and alfalfa, in natural hormones in animals, and in man-made substances such as soy products, detergents, pesticides, persistent organic contaminants, plastics, oral contraceptives, and hormone-replacement treatments. Products found or used in the home that may contain EDCs include cleaning products, carpets, furniture or electronic products treated with flame retardants, plastics, and pesticides.

The identification of a substance as an EDC does not necessarily mean that the compound is hazardous at observed environmental concentrations. However, there is growing concern that EDCs in surface water may pose a particular risk to aquatic organisms and possibly wildlife.

Pharmaceuticals and Personal Care Products (PPCPs)

Pharmaceuticals and Personal Care Products (PPCPs) encompass a wide range of chemical substances including prescription and over-the-counter therapeutic drugs, antimicrobials, steroids, fragrances, shampoos, laundry detergents, cosmetics, sun-screen agents, diagnostic agents, biopharmaceuticals, and many others. Their presence in the environment originates from the combined activities and actions of individual consumers as well as from veterinary and agricultural uses including:

- Flushing unused medications down the toilet or drain.
- Rinsing personal hygiene and household cleaning products down the drain.
- Pharmaceutical residues in human waste.
- The excretion by farm animals of veterinary drugs, including hormones and antibiotics, onto fields which then enter surface waters with runoff from rain events
- Improper disposal of commercial products.

PPCPs have been detected in lakes, surface water, treated wastewater discharges, groundwater, and to a lesser extent, drinking water. Hospitals, elderly care facilities, and private residences are believed to be the largest sources of pharmaceuticals entering wastewater treatment systems.

There is concern that pharmaceutical compounds (including natural and synthetic estrogens and antibiotics) in surface waters might cause hormone disruption in fish and promote antibiotic resistance in pathogens. The impacts, as well as the potential effects on human health, are subjects of ongoing research. To date, trace amounts of PPCPs found in drinking water have not been associated with adverse human health effects.

Nanomaterials

Nanomaterials are engineered materials and devices as small as one billionth of a meter resulting from the new field of nanotechnology. Nanoparticles are already used in many consumer products including cosmetics, foods, appliances, wrinkle-resistant clothes, and antimicrobial sprays. Because nanotechnology is a new and expanding field, the behavior of nanomaterials in the environment and their potential significance to public health is poorly understood.

Currently, EDCs and PPCPs are the focus of the Philadelphia Water Department's CPC research and monitoring. The detection and analysis of nanomaterials in the environment is a much more recent field of study and PWD is currently evaluating how to proceed in this area.

4.2.8.2 Philadelphia Water Department Actions

The Philadelphia Water Department's CPC research activities include data collection and analysis to determine the occurrence of CPCs in surface waters and treated drinking waters, data collection during drinking water treatment pilot projects to determine the ability of new and advanced treatment technologies to reduce CPCs, and research to remain informed about the state of the science regarding these compounds.

Some current and ongoing CPC activities that PWD participates in include:

- AWWARF #3085 – Toxicological Relevance of Endocrine Disruptors and Pharmaceuticals in Drinking Water
- EPA Region III Pharmaceutical Workgroup
- Rutgers University study of CPCs in Philadelphia river sediments, their fate, transport, and water quality impacts
- Ongoing monitoring of surface waters and treated drinking water for better understanding of sources, occurrence, and removal efficiencies
- Water Environment Research Foundation project on the "Fate of Pharmaceuticals and Personal Care Products through Wastewater Treatment Processes"
- USEPA-funded "Impact of Residual Pharmaceutical Agents and their Metabolites in Wastewater Effluents on Downstream Drinking Water Treatment Facilities"
- Partnering with Philadelphia's Streets Department, EPA, and DEP to develop a pharmaceutical take-back program in conjunction with the City's household hazardous waste events

In keeping with its mission to provide a sustainable source of optimal quality drinking water to the City of Philadelphia, the Philadelphia Water Department will remain proactive in studying and evaluating emerging contaminants that may impact drinking source water.

4.2.9 Disinfection Byproduct Precursors

The creation of disinfection byproducts (DBPs) is influenced by source water quality and treatment processes. DBPs are formed during the drinking water treatment process when natural organic matter (NOM) and bromide in the source water reacts with disinfection chemicals, commonly chlorine or ozone. The formation of DBPs can vary according to the concentration of precursors, dosage of disinfectant, and water temperature. At the Baxter Water Treatment plant the DBP precursors are bromide and organic matter measured as total organic carbon (TOC), dissolved organic carbon (DOC), and ultraviolet radiation absorbance at 254 nanometers (UV254).

There are over twenty unique DBPs that can occur due to variations in treatment and source water conditions. The EPA regulates four categories of DBPs under the Stage 2 Disinfection Byproducts Rule. The four categories of regulated DBPs and their MCLs are: bromate 0.01 mg/L, chlorite 1 mg/L, five haloacetic acids 0.6 mg/L, and trihalomethanes 0.8 mg/L. At the Baxter Water Treatment Plant, preventative measures against these compounds remove DBP precursors before the water is disinfected. Baxter has never violated any MCLs under the Stage 2 Disinfection Byproduct Rule. Although variables such as water temperature and chlorine dose can influence the formation of DBPs, source water with low concentrations of bromide, TOC, DOC, and UV254 is the best defense against DBP formation.

4.2.9.1 Bromide

As detailed in Section 4.2.2, bromide is naturally occurring in the Delaware River at very low levels. Bromide concentrations increase under low streamflow conditions and decrease due to dilution when streamflow rises. The brominated DBPs regulated under the Stage 2 Disinfection Byproduct Rule are bromate, bromoacetic acid, dibromoacetic acid, bromodichloromethane, dibromochloromethane, and bromoform. Bromoform is a known carcinogen and the other brominated DBPs are suspected carcinogens.

It is unknown how much the formation of brominated DBPs would increase if the concentration of bromide in the source water were to increase due to land cover and climate change effects on Delaware River hydrology. There is a need for additional research to identify any effect on brominated DBP formation that could occur if bromide concentrations in the Delaware River increased. A research project to detail this relationship is proposed later in this document in Section 5.6.

4.2.9.2 Total Organic Carbon and Dissolved Organic Carbon

The DBPs formed from TOC/DOC that have MCLs are chlorite, chloroform, monochloroacetic acid, dichloroacetic acid, and trichloroacetic acid. Many other haloacetic acid and trihalomethane DBPs exists but are not currently regulated.

Total organic carbon (TOC) is a measurement of the carbon within organic compounds contained in a water sample. This measurement excludes inorganic carbon formations common to surface water such as carbon dioxide and carbonic acid. Dissolved organic carbon (DOC) is the fraction of TOC that can pass through a 0.45 micron pore diameter filter. Compounds that compose the TOC and DOC measurements are derived from both natural sources and manufactured chemicals including but not limited to: plant litter, phytoplankton, humic substances, pesticides, herbicides, municipal wastewater, industrial wastewater, and many other organic compounds.

The concentration of TOC, and likely DOC, is the Delaware River is the lowest it has been in decades. This concentration drop is due to the implementation of wastewater treatment plants across the Delaware River watershed and the reduction of volatile and synthetic organic compounds through environmental regulation through the Clean Water Act.

Data used in the following analysis were obtained from the Philadelphia Water Department Bureau of Laboratory Services. Samples were measured at the Baxter Water Treatment Plant intake.

Table 4.2.9.2-1 below includes statistics presented in the SWA Section 2 and statistics for TOC concentrations from 1999 to 2006. The statistics presented are useful to describe the range that TOC concentrations can cover over the course of a year, but will not give any indication of trend. The asterisk in the first row of data indicates the values reproduced from the SWA Section 2.

Table 4.2.9.2-1 Total Organic Carbon Concentrations, mg/L

Sampling Date Range		Minimum Value	Maximum Value	Mean	Median	Number of Samples
July 1993 *	**May 1999**	0.7	5.4	2.8	2.6	250
June 1999	**December 2006**	0.11	15.5	2.78	2.63	471
January 1999	**December 1999**	2.0	5.4	2.87	2.7	53
January 2000	**December 2000**	1.99	5.32	3.04	2.97	47
January 2001	**December 2001**	1.96	4.35	2.74	2.58	53
January 2002	**December 2002**	2.02	5.52	3.15	2.92	53
January 2003	**December 2003**	1.96	15.5	2.89	2.62	66
January 2004	**December 2004**	1.81	4.93	2.74	2.51	105
January 2005	**December 2005**	1.61	4.35	2.39	2.23	52
January 2006	**December 2006**	0.11	3.88	2.43	2.39	65

** Data from SWA Section 2*

TOC concentrations can vary greatly within one year. TOC concentrations reached their highest point in the past fifteen years, 15.5 mg/L, in November 2003. The lowest TOC value, 0.11 mg/L, was recorded in February 2006. The range of TOC concentrations require that plant operators are vigilant in removing these DBP precursors before the water is disinfected.

DOC is directly correlated to the concentration of TOC. At the Baxter Water Treatment Plant over 80% of TOC is DOC. Due to the relationship to TOC, DOC is measured less frequently than TOC in the source water. TOC is used as a surrogate for DOC concentrations.

Section 4.3.6.6 of this report contains a point and non-point source prioritization of sub-watersheds and locations that contribute the greatest amount of TOC to the Delaware River. The sub-watersheds contributing the greatest amounts of TOC are the Neshaminy Creek and Middle Delaware. The Georgia Pacific Company, located on the Delaware River near the intake, contributes the greatest amount of TOC from a point source.

The prioritization is extremely useful in locating current sources of TOC. Identifying future sources of TOC/DOC is necessary in order to ensure the Baxter Water Treatment Plant can remove the DBP precursors and prevent DBP formation. An examination of the changes that may occur to DBP precursors under future land cover and climate change conditions is suggested as a source water protection initiative in Section 5.6.

4.2.9.3 UV254

UV254 is a measurement of the absorbance of a particular water sample of UV radiation at 254 nanometers. The absorbance value of this measurement is a surrogate measure of the amount of natural organic matter (NOM) within water. Mentioned earlier, TOC can be composed of both natural and manufactured carbon compounds and the TOC measurement reflects both carbon origins. The UV254 measurement only represents carbon of natural origin. The NOM fraction of TOC reacts with chlorine to form DBPs, and therefore UV254 is one of the best measurements to estimate the DBP formation potential of the source water.

The Baxter Water Treatment Plant currently bases the strength of DBP precursor removal steps on the UV254 absorbance of the source water. Source water with a low UV254 absorbance produces a smaller amount of DBPs, and source water with UV254 absorbance >0.1 is expected to produce a greater amount of DBPs. Treatment processes, specifically the dose of activated carbon, are adjusted to the UV254 absorbance reading of the day.

Data used in the following analysis were obtained from the Philadelphia Water Department Bureau of Laboratory Services. Samples were measured at the Baxter Water Treatment Plant intake.

Table 4.2.9.3-1 below includes statistics presented in the SWA Section 2 and statistics for UV254 values from 1999 to 2006. The statistics presented are useful to describe the range that UV254 absorbance can cover over the course of a year, but will not give any indication of trend. The asterisk in the first row of data indicates the values reproduced from the SWA Section 2.

Table 4.2.9.3-1 UV254 Absorbance

Sampling Date Range		Minimum Value	Maximum Value	Mean	Median	Number of Samples
July 1993 *	May 1999	0.017	0.205	0.09	0.081	168
March 1999	May 2006	0.001	0.269	0.102	0.093	212
March 1999	June 1999	0.053	0.108	0.076	0.071	14
November 2003	December 2003	0.076	0.152	0.114	0.115	15
January 2004	December 2004	0.055	0.269	0.112	0.100	104
January 2005	December 2005	0.066	0.203	0.103	0.097	50
January 2006	May 2006	0.001	0.127	0.071	0.072	29

** Data from SWA Section 2*

As understanding of the UV254 measurement grows, the frequency of sample collection has increased in more recent years. UV254 data was not collected often during the years of data presented in the SWA Section 2. In recent years the frequency of sample collection has increased to two samples per week.

Utilities across the Delaware River Study Area must always remain vigilant of the formation of DBPs. Although the Baxter Water Treatment Plant has never violated any DBP MCLs, these compounds remain important to reduce. A greater understanding of DBP precursors is needed before any efforts at reducing these compounds in the source water can be undertaken. One of the first steps towards regional understanding of DBP precursors is to widen the collection of UV254 data throughout the Study Area. Few utilities measure this parameter, and a wider network of data collection will help to understand the regional behavior and patterns of NOM. Section 5.6 of this plan discusses in more detail a strategy to increase the understanding of DBP precursors in the Delaware River Study Area.

4.2.10 Polychlorinated Biphenyls

4.2.10.1 Background Information

Polychlorinated biphenyls (PCBs) are a group of synthetic compounds once widely manufactured and used within the United States. PCBs are currently listed as a possible carcinogen by the United States Environmental Protection Agency (EPA), are responsible for human reproductive malfunction, and are a suspected endocrine disrupter.

PCBs were once used in electrical, heat transfer, and hydraulic equipment. They were also added to plasticizers in paint, plastics and rubber products, dye pigments, and carbonless paper. PCBs reach aquatic environments through atmospheric deposition into soils, waterways, and sediments. Industrial and municipal point sources, combined sewer overflows, and stormwater runoff will also carry PCBs into lakes, streams, and oceans.

When released into the environment, PCBs adsorb to silt, organic carbon particulates, and sediment rather than dissolve into water. This hydrophobic behavior results in sediment deposition of PCBs in aquatic ecosystems. PCBs also accumulate in fish tissue prompting many fish consumption advisories nationwide, including the Delaware River.

4.2.10.2 Delaware River PCB Total Maximum Daily Load (TMDL)

The states of Delaware, Pennsylvania, and New Jersey have combined their efforts in coordination with the EPA and Delaware River Basin Commission (DRBC) to implement a TMDL regarding PCBs in the Delaware River, Estuary, and Bay. The impetus for this action was the threat to consumers of fish in all areas of the Delaware Estuary system.

Calculation of the TMDL was divided into a two stage process based on the nature of the contaminant and size of the Study Area. Stage 1 was completed in 2003 and approved in 2004. The document is titled *United States Environmental Protection Agency Regions II and III, Total Maximum Daily Loads for Polychlorinated Biphenyls (PCBs) for Zones 2-5 of the Tidal Delaware River, 2004.* Stage 2 of the TMDL report was approved in 2006 and focuses solely on Zone 6 at the head of the Delaware Bay.

Due to the vast Delaware Basin area, separate TMDLs were derived for four individual zones. With Zone 1 representing the area of the Delaware River above Trenton, New Jersey and Zone 6 being the Delaware Bay south of Smyrna, Delaware, the TMDL Study Area is Zones 2-6 which include the area above Smyrna, Delaware and below Trenton, New Jersey. The TMDL Zones 2 and 3 are located within Delaware River Source Water Protection Plan Study Area Zones A and B.

The pollutant allocations established by the TMDL aim for total PCB concentrations to be 44.4 picograms per liter in Zones 2 and 3. Current PCB loadings are two to three magnitudes higher than the desired TMDL loadings. Significant reductions of this contaminant are desired in order to fulfill TMDL requirements and ideally lift future fish consumption advisories.

4.2.10.3 Baxter Source Water Quality Concerns

The drinking water treatment process removes PCBs from source water. The activated carbon, coagulation, flocculation, and filtration steps involved in the treatment process remove all particulates that PCBs could potentially be adsorbed to. PCBs are a widely publicized and researched water quality contaminant, but the chemical properties of the substance make it an insignificant drinking source water quality concern. PCBs are a known water quality contaminant within the Delaware River, but pose no threat to the drinking source water quality of the Baxter Water Treatment Plant. Fish consumption is the regulatory driver of PCBs.

4.2.11 Taste and Odor Compounds

Surface water is known to contain multiple compounds that produce unpleasant tastes and odors to people without impacting the safety of the water. Conventional drinking water treatment processes do not remove these compounds so the taste and odor characteristics carry over to the treated water. Taste and odor compounds are produced by many algal, bacterial, and fungal species. Table 4.2.11-1 below describes the taste and odor compounds recorded at the Baxter Water Treatment Plant intake location on the Delaware River.

Table 4.2.11-1 Taste and Odor Compounds

Compound	Taste and Smell	Removed During Treatment	Additional Removal Steps
Geosmin (trans-1,10-dimethyl-trans-9-decalol)	Earthy	No	Ozone, Activated Carbon
MIB (2-methylisoborneol)	Musty	No	Ozone, Activated Carbon
Nonadienal (trans-2,cis-6-nonadienal)	Cucumber	Yes	Permanganate

The taste and odor compounds recorded at Baxter are MIB (2-methylisoborneol), geosmin (trans-1,10-dimethyl-trans-9-decalol), and nonadienal (trans-2,cis-6-nonadienal). These compounds are capable of being smelled and tasted in the water at concentrations above 10 ng/L. MIB, geosmin, and nonadienal are secondary metabolites of cyanobacteria. It is unknown what role these compounds play in the life of cyanobacteria and why they are produced. It is also unknown if there are environmental triggers of these compounds.

Table 4.2.11-2 below presents the periods when geosmin and MIB exceeded 10 ng/L between 2000 and 2006 in the Delaware River. The water samples were collected at the Baxter Water Treatment Plant intake by the Philadelphia Water Department Bureau of Laboratory Services. Nonadienal is not included in Table 4.2.11-2 because only one incidence exceeding 10 ng/L has occurred since 2000. On April 17, 2001 nonadienal concentrations reached 23 ng/L.

Table 4.2.11-2 Taste and Odor Episodes > 10 ng/L

Geosmin	MIB
April 2002	May 2000
September 2003	May 2001
February 2004	December 2001
April 2006	May 2002
	May 2003
	May 2006

Geosmin and MIB both occur at the Baxter Water Treatment Plant in concentrations that can affect the aesthetics of treated water. MIB concentrations have exceeded 10 ng/L during the month of May between 2000 and 2006. Geosmin peaks do not present such a clear seasonal pattern and frequency.

The Philadelphia Water Department and nearby utilities are beginning to share data regarding these compounds in order to begin to examine regional patterns and locations of taste and odor compound blooms. This issue is a research priority of the Philadelphia Water Department as well as regional water utilities as public perception regarding water quality is greatly affected by the aesthetics of finished drinking water.

4.3 Activities of Concern

4.3.1 Population Growth and Land Cover Change

4.3.1.1 Introduction

Population growth and changes in land cover to accommodate growth are water supply protection concerns because they can alter both water quality and quantity. An assessment of current conditions, past trends, and future estimations of population and land cover are critical to assessing the threat of these activities to the Delaware River water supply. Population growth drives land cover change, and depending on where this occurs in the watershed, the water quality and quantity impacts can range from severe to minimal. This analysis will examine the relationship between population and land cover based on recent data and make preliminary projections of future conditions. This analysis will be concluded by a discussion of the water quality and quantity implications of population growth and land cover change.

4.3.1.2 Data Sources and Descriptions

Land Cover Data

Reliable characterization of the land cover within the Study Area was important for the source water assessment process and is also important for protection planning. The characterizations are the basis for estimating non-point source loadings and development driven source water quality threats. The USGS National Land Cover Data (NLCD) Sets are commonly used as the basis for land cover characterizations. The USGS has published two data sets that characterize land cover based on the years of the imagery; 1992 and 2001. The 2001 data set became publicly available in January 2007 and is used to characterize the land cover of the Delaware River Study Area in this protection plan. Ideally the 2001 data set could be directly compared to the 1992 data set to calculate and analyze land cover change patterns, rates, and trends. Great technical advancements in preprocessing and remote sensing have been made since the publication of the 1992 data set. These advancements make the 2001 data set on average 50% more accurate than the 1992 data set (Homer et al. 2004). The achievements in technology render the 1992 data set obsolete, reducing the opportunity to compare results with the 2001 data set.

The data available for land cover interpretation at the time of this plan is the USGS NLCD 2001 and 1992 data sets. The difference between the 2001 and 1992 data sets will be presented for broad comparisons only, not analysis. In September 2007, past the publication date of this plan, the USGS is planning to release a data set representing the change between the 1992 and 2001 data sets. A land cover change analysis of the Delaware River Study Area will only be feasible when the USGS publishes the corrected layer in fall 2007.

The NLCD was obtained from the USGS website, http://landcover.usgs.gov/natllandcover.html. The 2001 NLCD is a 29-class land cover classification based on a 2001 USGS 30-meter Landsat Thematic Mapper ™ flyover with supplemental interpretation. The 2001 NLCD was made publicly available in January 2007. The 2001 data set will present the land cover change composition of the states, counties, and sub-watersheds of the Delaware River Study Area.

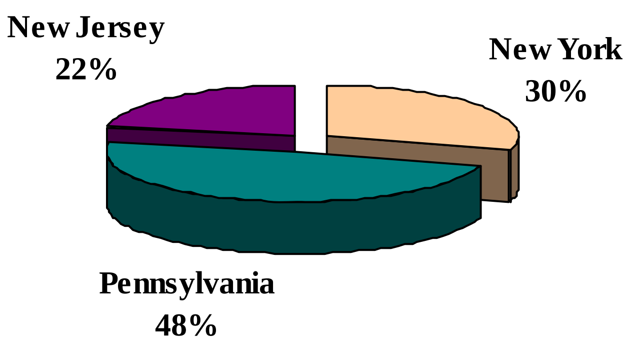
Population Data

The data used to analyze the population of the Delaware River Study Area was obtained from the United States Census Bureau at www.census.gov. The 1990 census and the 2000 census results are compared to measure the population change within the Delaware River Study Area along state, county, and sub-watershed boundaries.

4.3.1.3 State Land Cover and Population Analysis

A total of three states and thirty counties have land located within the Delaware River Study Area. The Delaware River Study Area is almost 8,000 square miles. Below is a pie chart showing the percentage of Study Area contained within each state. Pennsylvania by far has the largest land area within the Delaware River Study Area.

Figure 4.3.1.3-1 Percentages of Delaware River Study Area by State



Source: USGS National Land Cover Data 2001

The NLCD data provides general land covers such as developed, agricultural, and forested areas as well as more detailed land covers. When the land cover and population data is analyzed within geographic information systems software (GIS) the data can be broken down into state and watershed areas that are useful for land cover interpretation.

Land cover change is commonly driven by population change. Forest and agricultural lands become residential developments with supporting commercial, transportation, and institutional growth. Although in this plan we cannot calculate an accurate rate of land cover change, we can identify the population change across the Study Area. The U.S. Census' from 1990 and 2000 indicate that the population of the Delaware River Study Area grew by 7.6 % to over 4.1 million people. Table 4.3.1.3-1 below presents the census results from 1990 and 2000 specifically for the areas of each state within the Delaware River Study Area. Census block data is combined to calculate the populations within each state of the Study Area. Census blocks can also be combined to calculate the population of county and sub-watershed groupings.

Table 4.3.1.3-1 1990 and 2000 State Populations

States	2000 Census Population	1990 Census Population	% Change between 1990 and 2000 Census	State Percentage of Study Area Population
New Jersey	1,412,418	1,273,673	10.9 %	33.8 %
Pennsylvania	2,643,426	2,491,428	6.1 %	63.4 %
New York	117,069	111,693	4.8 %	2.8 %
Total	**4,172,913**	**3,876,794**	**7.6 %**	**100 %**

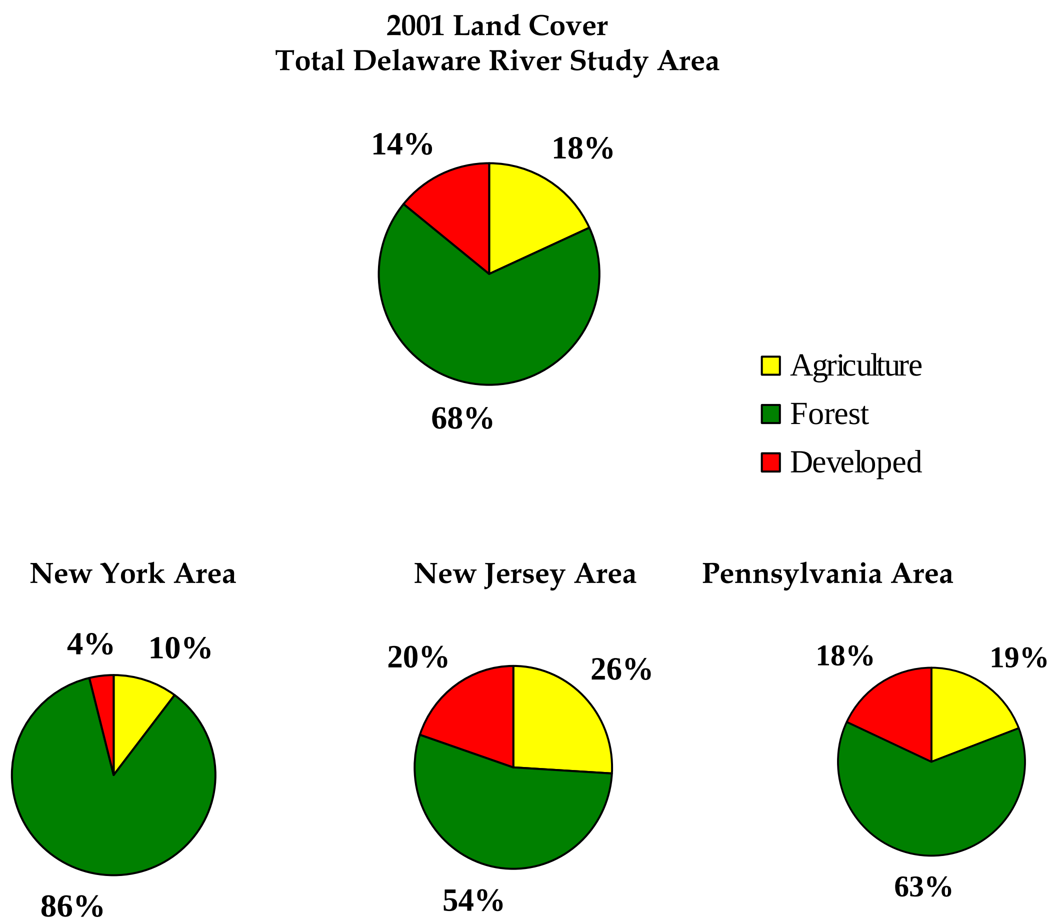
Source: U.S. Census Bureau 1990 and 2000
*Note: % Change between 1990 and 2000 Census= (2000 pop. - 1990 pop.) / 1990 pop. * 100*

Pennsylvania is home to the largest population within the Delaware River Study Area, 2.64 million people. New York state has the smallest population within the Study Area and also experienced the smallest growth from 1990-2000. The New York and Northern Pennsylvania portions of the Delaware River Study Area are home to the forested headwaters of the Delaware River where land cover conversion and large population growth is the least desirable. Population growth drives land cover change, and because Pennsylvania increased by the greatest number of people from 1990 to 2000, it can be expected that Pennsylvania experienced the greatest land cover change during that time period as well.

Between 1990 and 2000, both of the Pennsylvania and New Jersey populations increased by at least 130,000 people. The Pennsylvania area of the Delaware River Study Area is more than twice the size of the New Jersey area. This size difference indicates that within the Delaware River Study Area, New Jersey contains a greater population density than Pennsylvania.

Land cover composition of the Study Area as a whole and according to state are presented to give a general picture of the land cover of the Delaware River Study Area. The following chart identifies the general land cover of the total Delaware River Study Area, as well as the general land cover of the three state sections within the Delaware River Study Area.

Figure 4.3.1.3-2 Total and State 2001 Land Cover Compositions



Source: USGS National Land Cover Data 2001

Multiple land cover components are added together in order to describe the main three land covers; agricultural, developed, and forested lands. Table 4.3.1.3-2 below identifies the distinctions of each category.

Table 4.3.1.3-2 Land Cover Categories

Agricultural Land	Forested Land	Developed Land
Pasture/Hay	Woody Wetlands	Open Space
Cultivated Crops	Grassland/Herbaceous	Low Intensity
	Deciduous Forest	Medium Intensity
	Evergreen Forest	High Intensity
	Mixed Forest	Quarries/Strip Mines/Gravel Pits
	Shrubs and Scrubs	Transitional Lands
		Urban/Recreational Grasses

Source: USGS National Land Cover Data 2001

The NLCD identifies the majority of land cover in the Delaware River Study Area as forested, which is a major benefit to water quality. In New York where the headwaters of the Delaware River are located, the land cover is 86% forested, and just 4% developed. The large forested area in the headwater region of New York ensures a clean beginning for waters of the Delaware River.

Developed lands are mainly located in New Jersey and Pennsylvania compared to New York. As seen in Figure 4.3.1.3-3, developed areas coincide with the most populated regions in the southern portion of the Study Area where Philadelphia and Trenton are located. Figure 4.3.1.3-3 depicts the 2001 Land Cover of the Delaware River Study Area.

Although the 1992 and 2001 USGS NLCD should not be compared and analyzed in detail, a basic comparison of the land cover change in the three broad land cover categories across the three states offers an idea of general trends. The following Table 4.3.1.3-3 shows the general change between the 1992 and 2001 data sets for developed, forested, and agricultural land across the three states within the Delaware River Study Area.

Table 4.3.1.3-3 1992 and 2001 Land Cover Compositions

	Delaware River Study Area Land Cover Composition	
	1992	2001
Agriculture	18.1%	18.0%
Developed	9.2%	14.3%
Forested	72.7%	67.7%

Sources: USGS National Land Cover Data 1992 and 2001

Overall, this comparison shows Delaware River Study Area has lost 5 percent of its forested lands and increased its developed land area by 5 percent in the past ten years. The loss of forested land to development is a common pattern and does not present a new finding. The magnitude of the trend, a 5% decrease in ten years, is potentially incorrect and can not be fully assessed until the USGS publishes the comparison data set in fall 2007.

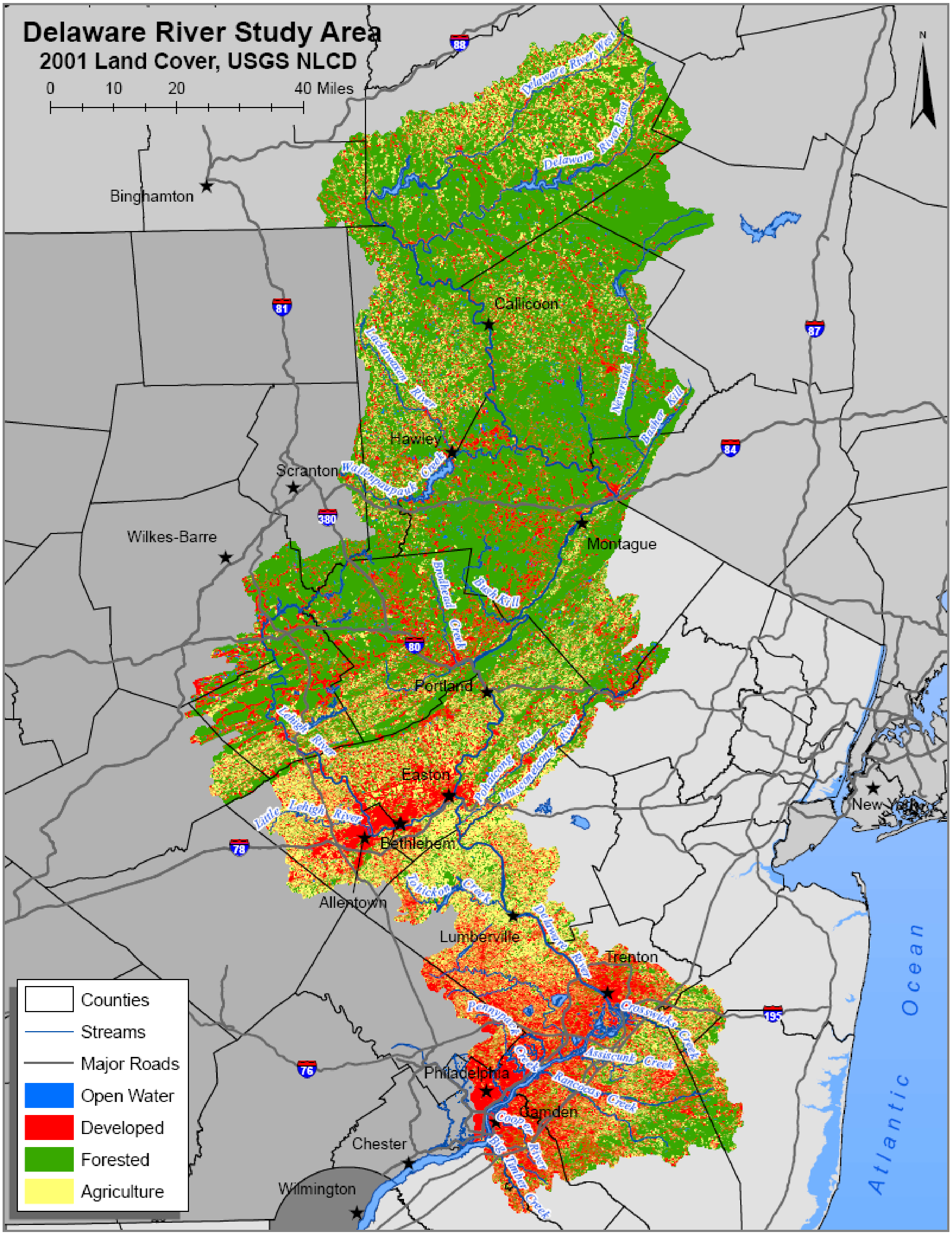
4.3.1.4 Sub-Watershed Land Cover and Population Analysis

Within the Delaware River Study Area there are sixteen distinct sub-watersheds. The losses of forested land and increases in newly developed land on a sub-watershed, rather than county scale can help identify sub-watersheds that may experience a decline in water quality. The Delaware River Study Area is very large, and identifying watersheds undergoing more rapid development than others can help to prioritize source water quality conservation and protection actions.

Historically, the sub-watersheds within the southern portion of the Study Area are much more developed than those in the northern portion up through New York. Development that occurs in these areas will likely be infill, re-development, or growth associated with existing towns. These types of development minimize the amount of forested and agricultural land consumed. In watersheds with less development, new construction typically expands beyond residential construction to include transportation infrastructure, commercial, and institutional supporting development.

Monitoring forest losses and development growth can provide a clue to potential water quality changes. Land cover is often examined on a sub-watershed scale and certain blanket assumptions can be made. Sub-watersheds with greater forested land cover tend to have better water quality and higher species richness and abundance compared with more developed watersheds.

Figure 4.3.1.3-3 Delaware River Study Area 2001 Land Cover



Due to the differences between the 1992 and 2001 NLCD sets mentioned earlier, a direct comparison of land cover change on a sub-watershed scale can not be calculated. A preliminary land cover change estimate can be made by basing development forecasts on current population growth and the ratio of developed acres to population. Once the USGS publishes a comparison data set of the 1992 and 2001 NLCD sets, the sub-watersheds will be re-examined. Until then, the preliminary development and population forecasts are calculated as a substitute.

In order to make a thirty year preliminary development forecast for each sub-watershed, the population for 2040 was estimated based on the rate of change in population from 1990 to 2000. The population percent change was calculated for each sub-watershed using the U.S. Census data from 1990 and 2000. By carrying the same rate of change per decade out to 2040, a preliminary minimum population estimate is made. Two reasons this method will produce a minimum estimate of population growth is because it does not take into account people moving into the watershed, and does not account for exponential population growth. Table 4.3.1.4-1 below presents the preliminary population estimates by sub-watershed.

Table 4.3.1.4-1 Preliminary Sub-Watershed Population Estimates

	Population			Population Projections Based on sub-watershed change			
Sub-Watershed	**1990**	**2000**	**% Change**	**2010**	**2020**	**2030**	**2040**
Crosswicks	106,381	107,886	1.4%	109,413	110,961	112,532	114,124
East Branch Delaware	16,956	17,831	5.2%	18,752	19,720	20,738	21,809
Lackawaxen	40,752	49,515	21.5%	60,162	73,099	88,818	107,917
Lehigh	546,488	605,196	10.7%	670,210	742,209	821,942	910,241
Middle Delaware	304,831	332,466	9.1%	362,606	395,479	431,332	470,436
Mongaup	156,666	200,215	27.8%	255,871	326,996	417,894	534,058
Neshaminy	279,705	334,236	19.5%	399,399	477,265	570,312	681,500
NJ Mercer Direct	191,260	201,470	5.3%	212,226	223,556	235,490	248,062
PA Bucks Direct	38,473	48,732	26.7%	61,727	78,188	99,037	125,447
Rancocas	203,051	223,251	9.9%	245,460	269,878	296,725	326,244
Tidal Bucks	130,168	128,647	-1.2%	127,145	125,659	124,191	122,741
Tidal NJ Lower	500,076	578,641	15.7%	669,550	774,741	896,458	1,037,298
Tidal NJ Upper	62,072	70,632	13.8%	80,372	91,456	104,068	118,420
Tidal PA Philadelphia	1,223,066	1,191,579	-2.6%	1,160,903	1,131,017	1,101,900	1,073,533
Tohickon	36,198	39,752	9.8%	43,655	47,942	52,649	57,818
Upper Delaware	40,651	42,861	5.4%	45,192	47,649	50,239	52,971
Total	**3,876,794**	**4,172,913**	**7.6%**	**4,522,643**	**4,935,816**	**5,424,328**	**6,002,618**

Source: U.S. Census 1990 and 2000

The U.S. Census data shows a population increase of 7.6% between 1990 and 2000. In 2000 the population of the Delaware River Study Area was over 4.1 million people. The estimated 2040 population is just over 6 million people. In order to calculate how much new development will occur to accommodate the 2040 population, an estimate was calculated based on the ratio of developed acres in 2001 to 2000 population. This ratio, developed acres per person, was multiplied by the estimated 2040 population to present a minimum developed area forecast per sub-watershed. Each unique sub-watershed ratio was multiplied by each estimated sub-watershed 2040 population. Table 4.3.1.4-2 presents the estimates of developed area below.

Table 4.3.1.4-2 Estimated Developed Square Miles by Sub-Watershed

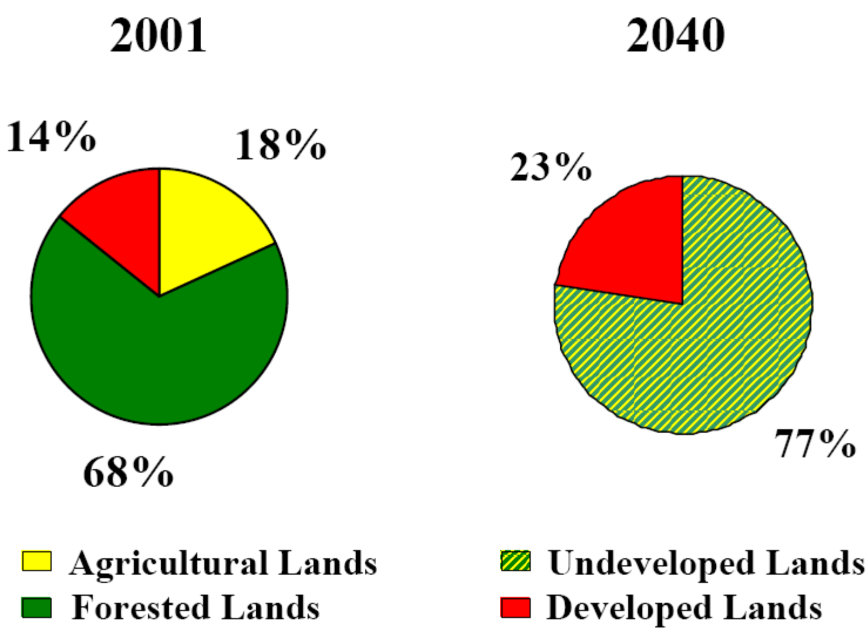
	Ratio Input			Estimated Developed Square Miles Based on Acres/Person Ratio			
Sub-Watershed	**2001 Developed Acres**	**2000 Population**	**Ratio Acres/Person**	**2010**	**2020**	**2030**	**2040**
Crosswicks	15,647.4	107,886	0.15	24.8	25.1	25.5	25.9
East Branch Delaware	13,761.0	17,831	0.77	22.6	23.8	25.0	26.3
Lackawaxen	27,362.6	49,515	0.55	51.9	63.1	76.7	93.2
Lehigh	152,827.6	605,196	0.25	264.4	292.9	324.3	359.2
Middle Delaware	73,634.2	332,466	0.22	125.5	136.9	149.3	162.8
Mongaup	88,107.4	200,215	0.44	175.9	224.8	287.3	367.2
Neshaminy	57,309.7	334,236	0.17	107.0	127.9	152.8	182.6
NJ Mercer Direct	29,692.9	201,470	0.15	48.9	51.5	54.2	57.1
PA Bucks Direct	7,492.7	48,732	0.15	14.8	18.8	23.8	30.1
Rancocas	36,103.4	223,251	0.16	62.0	68.2	75.0	82.4
Tidal Bucks	75,256.8	128,647	0.58	116.2	116.2	116.2	116.2
Tidal NJ Lower	13,486.2	578,641	0.02	24.4	28.2	32.6	37.8
Tidal NJ Upper	21,707.3	70,632	0.31	38.6	43.9	50.0	56.9
Tidal PA Philadelphia	75,489.0	1,191,579	0.06	118.5	118.5	118.5	118.5
Tohickon	5,465.6	39,752	0.14	9.4	10.3	11.3	12.4
Upper Delaware	30,830.2	42,861	0.72	50.8	53.6	56.5	59.5
Total	**724,174.0**	**4,172,913**	**-**	**1,255.8**	**1,403.6**	**1,579.0**	**1,788.1**

Sources: USGS National Land Cover Data 2001 and U.S. Census 1990 and 2000

Sub-watersheds that have a large ratio of acres per person in this analysis are predicted to develop the most amount of land between 2001 and 2040. This estimate assumes current development patterns and trends. The sub-watersheds with the largest ratio of acres per person are the East Branch Delaware and the Upper Delaware. These two watersheds are the headwaters of the Delaware River and are regions where development with a large ratio of acres per person is the least desirable. This prediction is estimating that development to accommodate new population growth will consume more land in the headwaters region than in other areas of the Study Area. This prediction indicates that the consumption of resources in the headwaters region of the Study Area must be reduced.

The available data cannot calculate accurately what proportion of agricultural or forested land is going to be developed. Overall, the estimates in Table 4.3.1.4-2 indicate that by 2040, developed land is going to increase by at least 9% of the total area of the Study Area. The pie charts below in Figure 4.3.1.4-1 compare the current Study Area 2001 land cover with the 2040 estimate.

Figure 4.3.1.4-1 Delaware Study Area Land Cover



The pie charts above show that developed land increased by 9% in the 2040 estimate and a combination of forest and agricultural land decreased by 9%. The calculation of how much forest may be lost in what location is very important to source water protection planning. Once the USGS data set is available this question will be answered in detail at the sub-watershed and county levels. Any large scale loss of forested land can have both water quality and quantity implications.

4.3.1.5 Water Quality and Quantity Implications

Population growth and land cover change can directly influence both water quality and quantity. The land cover analysis could not be performed in enough detail to estimate the magnitude of the various water quality and quantity changes. A description of the potential implications of population growth and land cover change is included instead. Table 4.3.1.5-1 below summarizes the water quality and quantity implications of population growth and land cover change.

Table 4.3.1.5-1 Land Cover Change Implications

Quality Implications	Quantity Implications
Salt Line Encroachment	Reduced Groundwater Recharge and Baseflow
Increased Bromide, Alkalinity, Metals, Sodium, Chloride	Increased Consumption
Increased Point Source Pollution	Increased Flooding
Increased Non-Point Source Pollution	

Reduced Groundwater Recharge and Baseflow

Population growth and development can reduce groundwater recharge and ultimately the baseflow of the Delaware River. Development creates new impervious surfaces such as roofs and parking lots where there once were absorptive surfaces such as forests and meadows. The impervious surfaces can reduce ground water recharge by blocking the infiltration of precipitation during storm events. The precipitation drains from impervious surfaces into stormwater infrastructure and creeks as surface runoff, not into the groundwater. Groundwater recharge is very important because it maintains baseflow. Baseflow is the amount of discharge in streams due to groundwater. If groundwater cannot be recharged as fully as it once was, baseflow will eventually decline. Baseflow is important to maintain within the Delaware River in order to keep the salt line south of the Baxter Water Treatment Plant. Baseflow should also be maintained because a reduction can increase the concentration of some parameters of concern such as bromide.

Increased Consumption

Population growth drives land cover change through new residential development and the supporting industries, commercial areas, and utilities. New communities will require services such as drinking water in locations that did not previously need them. The capacity of nearby water treatment plants may be expanded, or new water treatment plants will have to be built to provide water. In either case, the amount of water withdrawn from the Delaware River watershed for potable, non-potable, agricultural, and industrial purposes will increase.

Increased Flooding

Flooding frequency and intensity can increase due to land cover change. The conversion of forested or agricultural land into developed land increases the amount of impervious surfaces within the watershed. Impervious surfaces include roofs, driveways, roads, parking lots, and even many residential yards due to soil compacting during construction. Impervious surfaces prevent the percolation and absorption of rain water, forcing the drainage into stormwater infrastructure and creeks. This causes creeks and streams to reach their flood stages faster and stay full longer in watersheds with high impervious cover. Pervious surfaces such as forests and open space areas are important to maintain because they absorb the precipitation rather than create large volumes of surface runoff.

Increased bromide, alkalinity, metals, sodium, and chloride

Bromide, alkalinity, metals, sodium, and chloride will all increase in the Delaware River due to the reduction in baseflow and increase in pollution from population growth and development. Hydrologic changes in the Delaware River due to population growth and development, such as a reduction in baseflow, will alter the source water quality. Water quality parameters that have concentrations related to the flow of the river can be affected by a decline in baseflow. Bromide, alkalinity, iron, manganese, sodium, and chloride concentrations will increase if baseflow is reduced. The concentration of these parameters is tied to the ability of the baseflow to dilute. Without dilution, the concentration of these conservative parameters will increase. Iron and manganese can also increase in the Delaware River due to non-point source pollution from urbanized areas and point source pollution from municipal and industrial discharges. Sodium and chloride will increase due to population growth and development because of the lack of dilution as well as increased input from road salts in non-point pollution, and point-source pollution containing wastewater treatment plant effluent, water softeners, and sodium hypochlorite disinfectant.

Salt Line Encroachment

Population growth and land cover change can influence the location of the salt line within the tidal zone. The salt line is the location where more dense saline water from the Delaware Bay forms an interface with the less dense fresh water from the Delaware River. The concentration of sodium and chloride are so high behind the salt front, that if the salt line were to reach the Baxter Water Treatment Plant, the intake would have to be closed to prevent contamination of the plant. Any decrease in baseflow conditions of the Delaware River can cause the salt line to advance up the Delaware River towards the Baxter Water Treatment Plant. As previously mentioned, new development and an increase in impervious surfaces within the watershed can prevent groundwater recharge and decrease the baseflow of the Delaware River. Baseflow is essential to keeping the salt line south of Baxter, especially in drought and seasonally dry conditions. The freshwater flow from the Delaware River mixes with the more saline Delaware Bay water within the tidal zone. As the salt front moves north up the river at high tide, freshwater flow from the Delaware River blocks how far north the salt front can move.

Increased Point Source Pollution

Point source pollution, mainly from wastewater treatment plants, will increase due to population growth. The new population will increase the amount of wastewater created, treated, and discharged into the Delaware River. An increase in wastewater effluent is a source water concern due to pathogens released, such as *Cryptosporidium*. The Baxter Water Treatment Plant currently has very low levels of *Cryptosporidium*, and was classified in Bin 1 for the Long Term 2 Surface Water Treatment Rule. The Bin 1 classification is for source water with very high quality and no need for additional treatment steps to remove pathogens. Increased wastewater discharges may elevate the presence of *Cryptosporidium* in the source water and force the Baxter Water Treatment Plant to take expensive additional steps to remove pathogens.

Increased Non-Point Source Pollution

Non-point source pollution increases due to population growth and new development. Non-point source pollution includes the nutrients, metals, and suspended solids contained in runoff from impervious surfaces, residential lawns, and other developed areas. As the size of the surfaces that contribute non-point source pollution increases, the volume of non-point source pollution will increase, and the effect of this pollution will impact the source water quality of the Delaware River. Non-point source pollution can carry bacteria from pet waste, pesticides, herbicides, and fertilizers from manicured lawns, suspended solids, gasoline from stations and driveways, and oil.

4.3.2 Climate Change

Climate Change is an activity of concern that could negatively impact the source water of the Baxter Water Treatment Plant. Climate change could affect both the source water quality and quantity of the Delaware River Study Area through sea level rise and hydrologic changes.

A report by the Union of Concerned Scientists titled *Climate Change in the U.S. Northeast*, published October 2006, describes anticipated alterations in precipitation patterns, temperature, humidity, heat index, and sea level. The report predicts future climate patterns under a high emissions scenario and a low emissions scenario. Table 4.3.2-1 below summarizes the conclusions from both scenarios.

Conclusions from this report are mentioned here and discussed in a source water perspective to identify any anticipated water quality and quantity changes within the Delaware River Study Area.

Table 4.3.2-1 Predicted Climate Change Effects on Northeast Region

	High Emissions Scenario	Low Emissions Scenario
Winter Warming	Extra 8 to 12 F	Extra 5 to 7.5 F
Summer Warming	Extra 6 to 14 F	Extra 3 to 7 F
Days where temp. > 90 F	Average 60 Days	Average 30 Days
Days where temp. > 100 F	14 to 28	Average 3
Winter Snow Season	Time cut by 50%	Time cut by 25%
Short Term Drought (3 month length)	Once per year	Only slightly higher than today
Spring Arrival	Three weeks early	Two weeks early
Summer Arrival	Three weeks early and three weeks late departure	One week early and one week late departure
Sea Level Rise	8 inches to 3 feet	3 inches to 2 feet
Changes Under Both Scenarios		
10% increase in extreme rainfall events		
20% increase in maximum rainfall per five day period		
Increased winter precipitation by 20 to 30%		
More dry summer and fall seasons		
Extended periods of low streamflow		
Increased evaporation		
Expanded growing season		
Reduced soil moisture		

Source: Union of Concerned Scientists, Climate Change in the U.S. Northeast, October 2006
This report can be found at www.northeastclimateimpacts.org

4.3.2.1 Sea Level Rise

Climate change driven sea level rise is due to two factors; melting of glaciers and polar ice caps, and thermal expansion. The combination of these two forces working together is estimated to result in an increase of seas level from 4-21 inches or 8-33 inches under the low and high emissions scenarios respectively. Sea level change of this magnitude not only threatens coastal areas, but can force the salt line north up the Delaware River towards the Baxter Water Treatment Plant.

The salt line, or salt wedge, is the interface where dense water from the Delaware Bay meets less dense fresh water from the Delaware River. The meeting of dense salt water and fresh water forms a clearly defined boundary of water the Baxter Water Treatment Plant is able to use as a supply. Water south of the salt wedge is far too saline for Baxter to treat, and any flow of such salty water into the Baxter settling basins would act as a contaminant. The Baxter Water Treatment Plant can only use as its supply the fresh water that is located north of the salt line.

If sea level were to rise, the salt line could move farther north within the Delaware River tidal zone towards the Baxter Water Treatment Plant. The volume of water flowing north and south during high and low tides would be greater than current conditions.

An increase in the sea level of the world wide oceans would be reflected in an increase in the level of the Delaware Bay. The volume that currently moves north and south in the tidal zone would be increased under sea level rise scenarios, therefore moving the salt line farther north than it commonly vacillates.

The exact range in the tidal zone where the salt line could move has not been calculated for climate change conditions. Without knowing where the salt line could move to, the ability of water resource management policy and reservoir release coordination to keep the salt line south of the Baxter intake is questionable. The Philadelphia Water Department will encourage as a source water protection initiative the modeling of the salt line as it relates to predicted climate changes. For more detailed information on the salt line please visit www.state.nj.us/drbc .

4.3.2.2 Hydrologic Changes

Climate change is expected to alter the hydrology of the Delaware River and other large river systems in the Northeast U.S. The increases in evaporation, loss in soil moisture, increased winter precipitation, more severe rain storms, and season length changes are just some of the factors that could alter hydrology.

Streamflow is expected to decrease below summer averages and increase over winter averages, in total becoming very dynamic between seasons. Alterations in streamflow have two major effects on the source water quality of the Delaware River:

1) Salt Line Movement

2) Water Quality Changes

The movement of the salt line north in the tidal zone and water quality changes will both be caused by a decline in the discharge of the Delaware River. Currently under drought conditions, reservoirs within the Study Area release their holdings to keep the salt line south of the Baxter Water Treatment Plant. In future predictions, the reservoirs may be called upon to release more water, more frequently. This pattern will likely precipitate a change in water resource management policy currently defined through Delaware River Basin Commission resolutions. The Philadelphia Water Department sees a need for a new salt line modeling effort that accounts for current climate change predictions regarding Delaware River discharge. The new modeling effort is suggested as a source water protection initiative in Section 5.2.3 of this plan. The new modeling effort will provide information regarding the suitability of the present reservoir release policy and if it is sufficient to keep the salt line south of Baxter under climate change conditions.

The water quality changes that may result from climate change are due to the loss of discharge and ultimately dilution power. Parameters that are correlated to streamflow are where water quality changes will occur. These parameters of concern to source water quality are alkalinity, bromide, chloride, sodium, and disinfection byproduct precursors. Without the streamflow diluting these parameters of concern they will increase. A more detailed explanation of the relationship between hydrology and water quality can be found in Sections 4.2 and 4.3.3. Climate change is an activity of concern to the Baxter Water Treatment Plant if these parameters become elevated for extended periods of time, as predicted in longer summers, more evaporation, lower soil moisture, and reduced streamflow.

4.3.3 Spills and Contamination Events

Spills and contamination events, accidental or intentional, are an ever present threat to the source water quality of the Delaware River. Spills and contamination events can occur directly in the Delaware River, or reach the water supply indirectly through a leak in a buried pipeline, car, or truck accident. The Delaware Valley Early Warning System, described in Section 8 was established to notify drinking water utilities in the event of any contamination within the Delaware River watershed.

The source water quality threat from each spill and contamination event will be unique. The Philadelphia Water Department has developed a time-of-travel model that can be used to calculate the amount of time it would take a contaminant to flow towards the Baxter Water Treatment Plant. This model can be used for emergency response preparations as well as actual events.

Two prominent threats are the rupture of a buried underground pipeline and a spill within the tidal zone near the Baxter Water Treatment Plant. The underground oil and gas pipelines are explained in detail below. Also following is a description of the recent oil spill from the Athos I tanker in 2004 that helps to outline how the event occurred and what the source water quality threats were. A full understanding of the underground oil and gas pipeline system and previous accidents, such as the Athos I spill, can be used to improve emergency response in the unfortunate occasion of another spill or contamination event.

4.3.3.1 Underground Oil and Gas Pipelines

Pipelines carrying natural gas, crude oil, and refined petroleum products are networked beneath the Delaware River Study Area. The pipelines become a source water quality issue in the event of a crack, leak, or rupture. Figure 4.1.1-1 at the beginning of the water quality section displays the known locations of oil and gas pipelines within the Delaware River Study Area. In total there are 280 miles of known underground petroleum pipelines. Table 4.3.3.1-1 presents what is contained in that network.

Table 4.3.3.1-1 Study Area Pipeline Miles

Total Study Area Pipeline Miles	**280 Miles**
Pipeline Substance	**Miles**
Natural Gas	151
Refined Petroleum Products	62
Refined Petroleum, Crude Oil	67

The ages and exact locations of all pipelines within the Delaware River Study Area are largely unknown. The pipelines could potentially release thousands of gallons of petroleum into surface and groundwater resources. Petroleum suppliers are not required to submit pipeline information to local and federal governments; all known information was supplied voluntarily. The advancing age of these pipeline systems is a Baxter source water quality issue, and more information is necessary regarding the condition of these structures.

4.3.3.2 Athos I Oil Spill

On November 26, 2004 around nine o'clock at night, the 750 foot single-hulled Athos I oil tanker was punctured while attempting to dock at the CITGO asphalt refinery in Paulsboro, New Jersey. As tug boats maneuvered the vessel to the refinery, the Athos I was damaged by debris in the shipping channel that created a 1′ x 6′ opening and 1′ x 2′ opening. Due to the punctured hull, a total of 265, 000 gallons of Venezuelan heavy crude oil were released into the Delaware River. Following the leak, the vessel was emptied at the CITGO refinery and repaired at the Naval Shipyard in Philadelphia.

Potential causes are a large piece of curved metal, an abandoned anchor, and an 8′ x 4′ slab of concrete all found within the path of the Athos I near the CITGO dock. The curved metal has been forensically linked through paint residue to the Athos I hull, and the role of other two pieces of debris has not been established.

The oil spill directly impacted 57 miles of coastline on the Delaware River from the Tacony-Palmyra Bridge south to the Smyrna River in Delaware. Cleanup was concluded on November 21, 2005 by the Incident Unified Command, consisting of the Coast Guard and environmental representatives from Pennsylvania, New Jersey, and Delaware. A measured 221,910 gallons of oil and oily liquid along with 17, 761 tons of oily solids (oil and clean up materials) were collected.

The oil spill was in the direct vicinity of the John Heinz National Wildlife Refuge, Little Tinicum Island, and Pea Patch Island. All three natural areas are located along fall and spring avian migration routes. Quick and diligent responses from volunteers and the Tri-State bird rescue effectively cleaned and released almost four hundred birds, while two hundred birds are estimated to have perished in the contamination.

Cleanup and decontamination costs have totaled over $175 million. The National Pollution Funds Center has contributed $50 million, while the remaining money has come from Athos I owner, Tsakos Shipping. Tsakos Shipping has contributed beyond the $100 million required by the Oil Pollution Act of 1990. The Athos I spill is the fourth worst oil spill in the Delaware River and Delaware Bay area since 1975, when over 11.1 million gallons of Algerian crude were released from the Corinthos vessel near Marcus Hook.

The Baxter intake did not have to close during the Athos I spill, but the situation was closely monitored. The spill model was used to accurately predict the upstream extent of the oil spill. The oil spill occurred on the southern border of the Zone A source water area delineation at Paulsboro, New Jersey and spread to locations within Zone A. Of serious concern was the northern reach of the spill near the Tacony-Palmyra Bridge that came within three miles of the Baxter intake. Although oil never reached the intake and a majority of the oil spilled was recovered, oil that has settled onto river bed sediments can be dislodged and circulated during storm events posing a current threat.

4.3.4 Municipal Wastewater Treatment

The discharge from municipal wastewater treatment plants (WWTPs) is a source water activity of concern due to the pathogens, salts, nutrients, contaminants of potential concern, and disinfection byproduct precursors contained in the effluent. WWTPs are largely responsible for the improvement in the water quality of the Delaware River in the past fifty years. However, there is still concern with particular parameters in the discharge from these plants. *Cryptosporidium*, contaminants of potential concern, sodium, and chloride are the main source water quality concerns in WWTP effluent. These water quality parameters are explained in detail in Section 4.2.

Future increases in discharge from WWTPs driven by population growth in the Study Area can decrease the source water quality of the Delaware River. Additional controls on WWTP discharge will be required to maintain current water quality in the face of increasing discharge amounts driven by population growth. Year round disinfection of WWTP discharge is one way to reduce the threat to the source water from pathogens.

The closest WWTP to the Baxter Water Treatment Plant is the Northeast Philadelphia WWTP. The Northeast plant is located near the Betsy Ross Bridge in the Bridesburg section of the city. Originally constructed in 1923, the Northeast WWTP is the oldest of three wastewater treatment plants that serve Philadelphia. The most recent renovations to the plant were between 1979 and 1990. The plant has received recognition and numerous awards from the Association of Metropolitan Sewerage Agencies for their performance and adherence to clean water standards.

The Northeast WWTP cleans and discharges into the Delaware River almost 190 million gallons of wastewater per day originating from Northeast Philadelphia and parts of Bucks and Montgomery Counties. The Northeast WWTP is six miles downstream of the Baxter Water Treatment Plant intake and is within source water Zone A.

The proximity of the Northeast WWTP is not a threat to the Baxter Water Treatment Plant. This plant has received multiple accolades for its performance and Baxter has avoided having to install additional removal technologies for *Cryptosporidium* based on the high quality of the Delaware River. Although wastewater treatment effluent can still contain nutrients, pathogens, pharmaceuticals, and metals that evaded the treatment process, the source water quality is threatened more by the expansion of upstream dischargers than the Northeast WWTP.

4.3.5 Stormwater and Combined Sewer Overflows

Discharges from stormwater and combined sewer outfalls are activities of concern that threaten the source water quality. Contained in the drainage are high total suspended sediments and turbidity as well as *Cryptosporidium* and pathogenic bacteria such as fecal coliform. Combined sewers receive sewage as well as stormwater, and can overflow during precipitation events. The drainage from stormwater and combined sewer outfalls directly threaten the general water quality and ecological health of receiving waters. The Baxter Water Treatment Plant is capable of removing a majority of the contaminants contained in the drainage, and thus reduces the threat of these sources of pollution to consumers.

The threat from stormwater and combined sewer overflows (CSOs) can increase due to population growth that drives land cover change from natural to developed lands. As communities develop and expand, the areas that contribute stormwater runoff expand as well. The Delaware River is likely to receive ever increasing stormwater discharges as communities upstream of Philadelphia grow and develop. The Baxter Water Treatment Plant can remove the majority of contaminants in these discharges. However, increasing development upstream and discharges within Zone A are two main concerns regarding stormwater and combined sewer overflows.

In the Zone A portion of Philadelphia County, there are 91 combined sewer outfalls and 329 stormwater outfalls that drain into the Delaware River directly or through tributaries before reaching the river. Table 4.3.5-1 below identifies the number of stormwater outfalls and combined sewer outfalls that are located in Zone A within Philadelphia County.

Table 4.3.5-1 Stormwater and Combined Sewer Outfalls in Philadelphia Zone A

Receiving Watershed	Number of Stormwater Outfalls	Number of Combined Sewer Outfalls
Delaware River	16	55
Pennypack Creek	132	5
Poquessing Creek	147	-
Tacony/Frankford Creek	1	31

The Philadelphia Water Department holds one stormwater permit and three combined sewer outfall permits with the National Pollution Discharge Elimination System (NPDES) that govern all the outfalls described above. Each permit represents multiple outfalls. The Philadelphia Water Department Office of Watersheds manages the permit requirements through its Stormwater and Combined Sewer Overflow Management Programs. The goal of the programs is to not only fulfill permit requirements, but also to prevent and mitigate the damage to water quality and streams from these drainages by reducing the amount of stormwater reaching the drains.

4.3.5.1 Stormwater Management Program

The Stormwater Management Program, SMP, within the Office of Watersheds at the Philadelphia Water Department works to reduce the impact of stormwater on receiving streams. The SMP ultimately aims to reduce the amount of stormwater that enters the drainage system through advocating infiltration and retention management practices and design. The Philadelphia Water Department holds one stormwater permit with the NPDES that governs multiple outfalls. In accordance with the permit requirements, the SMP was established to prevent pollutants from reaching stormwater and prevent polluted stormwater from discharging into local water bodies. The SMP incorporates innovative engineering, environmental science, best management practices, stream restoration, and capital improvements to go above and beyond the permit requirements.

Multiple stormwater management projects have been implemented within the Philadelphia portion of the Delaware River watershed, as well as the Tacony/Frankford Creek, Pennypack Creek, and Poquessing Creek. Projects include plan review, water quality monitoring and analyses, best management practice implementation, and debris removal. The SMP utilizes a new plan and development review process to ensure that stormwater management is incorporated into any new construction within Philadelphia County. The SMP has initiated multiple water quality analyses; they include bacteria source tracking, wet weather monitoring, chemical testing, biological assessments, and habitat assessments. The SMP has also used innovative stormwater retrofitting at Fox Chase Farms to reduce the amount of bacteria carried to the Pennypack Creek. In the tidal Delaware River, a skimming vessel purchased by the Office of Watersheds routinely removes floating debris directly from the Delaware River.

4.3.5.2 Combined Sewer Overflow Management Program

The Combined Sewer Overflow Management Program, CSOMP, within the Office of Watersheds at the Philadelphia Water Department works to implement technically viable, cost-effective improvements and operational changes that mitigate the impacts of combined sewer overflows. The CSOMP, through a Long Term Control Plan, has established three phases of action to manage CSOs within Philadelphia County.

Phase I identifies nine minimum controls to reduce CSO impacts through low-cost and short-term actions that do not require extensive construction or engineering. One of the Phase I minimum controls for example is to ensure the public is adequately informed of the incidence, location, and impact of CSOs.

Phase II involves completing capital improvement projects that will increase the storage capacity, reduce the occurrence of overflows, and decrease the amount of stormwater entering the system. Phase II plans and carries out large scale construction and engineering infrastructure projects.

Phase III of the Long Term Control Plan for the CSOMP commits the City of Philadelphia to watershed based management and planning that will identify and appropriate a long-term water quality control strategy. Phase III involves intense scrutiny of the regional water quality to identify baseline goals and means of achieving them through the reduction of combined sewer overflow pollution.

4.3.5.3 Future Goals and Projects

Although the City of Philadelphia has multiple combined sewer overflows and stormwater outfalls, the CSOMP and SMP are hard at work combating the problem through technical, scientific, management, and education and outreach means. The overall goals of the CSOMP and the SMP are perfectly aligned in that they both aim to improve and preserve regional water quality through the reduction of water that reaches the drainage infrastructure. Within the Office of Watersheds, the CSOMP and SMP will continue to fulfill all NPDES permit obligations and sponsor projects that reach above and beyond the state and federal requirements. These programs also incorporate source water protection goals in their development and implementation.

4.3.6 Point and Non-Point Source Prioritization

During the source water assessment process, a susceptibility analysis was completed *for each public water supply intake* within the Delaware River Study Area for the following ten parameters: chloride, *Cryptosporidium*, fecal coliform, metals, nitrates, petroleum hydrocarbons, total phosphorus, total organic compounds (TOC), total suspended solids (TSS), and volatile organic compounds. The results of the susceptibility analyses can be found in the intake-specific reports generated during the source water assessments, which are available for public review at the Pennsylvania Department of Environmental Protection (PADEP) regional offices.

For the implementation phase of the source water program, prioritization results are re-calculated in this protection plan. The prioritizations are completed on a watershed-wide basis and include only the parameters that were found to be the greatest potential threat to each drinking water intake during the assessments. These contaminants are *Cryptosporidium,* fecal coliform, nutrients (nitrate and total phosphorus), total organic carbon (TOC), and total suspended solids (TSS). As a supplement to the individual parameter prioritization results, a combined prioritization for all six parameters was completed.

4.3.6.1 Point Source Prioritization Methodology

As explained in the Baxter Source Water Assessment, Section 2.2.2 Point Source Contaminant Inventory, an inventory of potential sources of contamination was developed with all sites included in the Permit Compliance System, Resource Conservation and Recovery Act, Above Ground Storage Tank, and Toxic Release Inventory databases. Through a series of screening processes, the potential sources of contamination were reduced to the most significant point sources *for a specific intake*. A final ranking of these most significant sources was carried out to produce a list of the top 100 sites for each intake. This final ranking is based on the following criteria and criteria weights:

1. Relative Impact at Intake (weight 12 percent): a measure of the expected concentration as a ratio of a relevant water quality standard.

2. Time of Travel (weight 5 percent): calculated from the location of the source to the intake based on high flow conditions.

3. Potential for Release/Controls (weight 14 percent): a qualitative criterion measuring the likelihood of accidental releases.

4. Potential for Release Frequency (weight 14 percent): based on the type of source, this could range from daily (permitted discharges) to rare (accidental spills)

5. Violation Type/Frequency (weight 10 percent): a measure of the performance of the source in meeting regulatory requirements.

6. Location (weight 5 percent): relative to the zone delineation of the intake.

7. Existing Removal Capacity (weight 10 percent): a measure of the ability of the existing water treatment system to remove the released contaminant from the raw water.

8. Impact on Treatment Operation (weight 10 percent): a measure of possible impacts of the contaminant on the operation of the treatment plant

9. Potential Health Impacts (weight 20 percent): a rough measure of the toxicity of the pollutant or mix of pollutants.

It should be noted that the Permit Compliance System database identified wastewater and sewage disposal facilities as either major facilities with discharges of more than 1 million gallons per day (MGD) or minor facilities with discharges of less than 1 MGD. Since no effluent data were available for minor discharges and limited data were available for major discharges, an assumption was made for the average discharge rate and concentration of contaminants. Default flows of 1 MGD for large facilities and 0.1 MGD for small facilities were used. Some major facilities had concentration data. For others, assumed concentrations were used, based on the site SIC code and median concentrations for similar facilities for which data were available. Table 4.3.6.1-1 on the following page shows the assumed concentrations used during the source water assessments and in this prioritization. Slight changes in assumptions were made as additional data are now available since the source water assessments were completed.

Table 4.3.6.1-1 Assumed Concentrations for Sources with No Available Data

Contaminant	Minor Sources (2002 Assessments)		Minor Sources (2007 Prioritization)		Major Sources (2002 Assessments)		Major Sources (2007 Prioritization)	
Cryptosporidium (oocysts/day)	3,780,000.00	Based on 10 per liter at a flow of 100,000 gpd.	3,780,000.00	Based on 10 per liter at a flow of 100,000 gpd.	37,800,000.00	Based on 10 per liter at a flow of 1000,000 gpd.	37,800,000.00	Based on 10 per liter at a flow of 1000,000 gpd.
Fecal Coliform (#/day)	75,600,000	Based on 2,000 #/100 ml at a flow of 100,000 gpd.	75,600,000	Based on 2,000 #/100 ml at a flow of 100,000 gpd.	756,000,000	Based on 2,000 #/100 ml at a flow of 1000,000 gpd.	756,000,000	Based on 2,000 #/100 ml at a flow of 1000,000 gpd.
Nutrients-Conservative (lbs nitrate-nitrogen per day)	7.2	Based on median effluent quantity of 2 lbs/day ammonia and conversion factor of 3.6lbs nitrate-n per lb ammonia	7.2	Based on median effluent quantity of 2 lbs/day ammonia and conversion factor of 3.6lbs nitrate-n per lb ammonia.	96.66	Based on median effluent quantity of 26.85 lbs/day ammonia and conversion factor of 3.6lbs nitrate-n per lb ammonia.	96.66	Based on median effluent quantity of 26.85 lbs/day ammonia and conversion factor of 3.6lbs nitrate-n per lb ammonia.
Nutrients-Non Conservative (lbs P/day)	1.668	Based on typical effluent limit of 2 mg/l and a flow of 100,000 gpd.	1.668	Based on typical effluent limit of 2 mg/l and a flow of 100,000 gpd.	10	Based on median effluent quantity of 10 lbs/day phosphorous.	10.8	Based on median effluent quantity of 10.8 lbs/day phosphorous.
DBP Precursors (lbs TOC/day)	41.65	Based on 1/10th the quantity of major sources.	39.7	Based on 1.1 lbs CBOD per lb TOC and a median CBOD discharge of 43.6 lbs/day.	416.56	Based on 1.6 lbs TOC per lb BOD and a median BOD discharge of 260.35 lbs/day).	115.45	Based on 1.1 lbs CBOD per lb TOC and a median CBOD discharge of 127 lbs/day.
Turbidity (lbs TSS/day)	25.3	Based on 1/10th the quantity of major sources.	24.2	Based on 1/10th the quantity of major sources.	253	Based on median discharge of 253 lbs TSS/day.	242	Based on median discharge of 242 lbs TSS/day.

More detailed information on the approach used to determine the final ranking can be found in Section 2.2.4 of the Baxter Source Water Assessment. To determine the highest priority sources within *the entire watershed*, the Philadelphia Water Department used the results of the susceptibility analysis for point sources for each of the intakes found in the Source Water Assessments. The primary difference in this updated analysis is that priorities for dischargers were established based on their impact to all water supply impacts, not just the single intake for which the original assessment was performed. The main focus is the National Pollution Discharge Elimination System (NPDES) permitted dischargers in the watershed as they were the largest group of potential sources identified during the susceptibility analysis. The Philadelphia Water Department classified any NPDES point sources identified as a high, moderately-high, or moderate priority during the susceptibility analysis. PWD then reduced these sources to a final list of potential high priority sources and updated the information available on the sources using the Permit Compliance database. The final ranking is based on the following criteria and criteria weights:

1. Source Quantities (**weight 55 percent**): actual load amounts were used when available. When no data were available, estimated loads were used by calculating the median of actual load data from similar facilities. Higher loads resulted in a higher priority rank.

2. Discharge Monitoring Report Violations (**weight 20 percent**): reported violations between the years 1997 and 2003 were totaled, with facilities ranked higher if they had more reported violations.

3. Intake Withdrawal Weight (**weight 5 percent**): total estimated annual withdrawal from all intakes for which a source has been identified as a highest, moderately high, or moderate priority pollutant source within the intake's Zone B delineation. The greater the amount of public water supply withdrawals a source could impact, the higher its priority.

4. Number of Intakes within Zone A (**weight 20 percent**): total number of intakes from which the source is located within the five hour time of travel.

The intake withdrawal score, in effect, reflects the significance of the intake based upon its average daily withdrawal when determining watershed-wide priorities. A source identified as a potential source for two large intakes could receive a higher watershed-wide priority rating than a source that is identified as a potentially significant source for four small intakes. Table 4.3.6.1-2 shows the number of gallons each intake withdraws from the river each day, and the weight assigned to each intake for the prioritization based upon the average number of gallons withdrawn daily. Some water suppliers withdraw water from more than one intake. Actual intake withdrawal data was used to calculate the intake scores.

Table 4.3.6.1-2 Delaware River Study Area Intake Withdrawal Summary

Intake	Withdrawal (MGD)	Withdrawal (MGY)	Intake Score
BCWS - New Hope Waterworks	0.01	3.65	0.00%
Yardley	4	1460	1.89%
Morrisville	2.4	876	1.14%
Neshaminy	12	4380	5.68%
BCWS - Middletown	0	0	0.00%
Lower Bucks JMA	12	4380	5.68%
Bristol	6	2190	2.84%
PWD Baxter	175	63875	82.78%
Total	**211.41**	**77164.65**	**100.00%**

MGD= Millions Gallons Per Day
MGY= Million Gallons Per Year

4.3.6.2 Non-Point Source Prioritization Methodology

Non-Point source pollution is prioritized in this Protection Plan in a similar manner as point source pollution. As explained in the Baxter Source Water Assessment, Section 2.2.2 and 2.2.3, a loading model was developed to estimate pollutant loads from rainfall runoff throughout the Study Area. To determine the highest priority sub-watersheds within the entire Study Area, the Philadelphia Water Department uses the same loading model from the susceptibility analysis in the Source Water Assessment to identify priority non-point sources for all intakes within the Study Area. Sub-watersheds within the Delaware River Study Area are prioritized according to their impact as non-point pollution sources of *Cryptosporidium*, fecal coliform, nutrients (nitrate and total phosphorus), Total Organic Carbon, and Total Suspended Solids. A combined prioritization of all six parameters is also calculated. For the nutrients prioritization which includes more than one contaminant, if a source is identified as a priority for both nitrate and nitrite it is weighted more heavily than a source which ranks high for only one of the parameters.

Criteria were assigned weights similar to those used for point sources for the watershed-wide prioritizations of non-point sources. The final ranking is based on the following criteria and criteria weights: source quantities (**55% weight**); intake withdrawal weight (**15% weight**); number of intakes within Zone A (**35% weight**).

For a more detailed explanation of the susceptibility analysis and the EVAMIX method used to perform the prioritizations, please refer to the Baxter Source Water Assessment.

4.3.6.3 Combined Prioritization Results

The following set of tables and figures shows the prioritization results based upon the criteria scores for all six combined contaminants, which include *Cryptosporidium*, fecal coliform, nitrate, total phosphorus, total organic carbon (TOC), and total suspended solids (TSS).

The combined non-point pollution priority sub-watersheds are scattered throughout the Delaware River Study Area, as seen in Figure 4.3.6.3-1. There is a large proportion of the Neshaminy Creek watershed included in the top 40 priority non-point source pollution contributing sub-watersheds. Top ranks 1-4 are included in the Neshaminy Creek watershed. The combined analysis identifies that the Neshaminy Creek watershed is the main source of non-point source pollution in the Study Area.

The cluster of point source locations in the lower Delaware River indicates the river is still a resource for both industrial intakes and dischargers. The highest priority point source discharge with potential to affect the source water quality is the Coastal Eagle Point Oil Company. This specific point source placed within the top 5 ranks for the TSS, TOC, and pathogens rankings.

Ten of the top 15 priority point sources are municipal dischargers, indicating the Baxter Water Treatment Plant and all of the intakes in the Lower Delaware are currently at risk from the effluent of these facilities. Wastewater treatment plant discharge was indicated in the source water quality section as a contributing factor to pathogens such as *Cryptosporidium*, nitrate, nitrite, sodium, and chloride. The following pages present Tables 4.3.6.3-1 and 4.3.6.3-2 that identify the top 40 non-point and point source rankings. A map of the locations of the top 40 non-point and point source rankings are presented in Figure 4.3.6.3-1.

Table 4.3.6.3-1 Combined Non-Point Source Prioritizations

ID	Source Name	Fecal Coliform Col/Day	Crypto. Oocysts/Day	N Lbs/Day	TP Lbs/Day	TSS Lbs/Day	TOC Lbs/Day	Intake Weight	# Intakes Zone A	Rank
90619	Mill Creek-619	4.03E+11	1.42E+07	220.21	35.54	15024.66	704.57	92.43	3	**1**
90602	Core Creek-602	3.60E+11	1.20E+07	183.30	29.09	12047.60	610.78	92.43	3	**2**
90583	NESHAMINY R-583	9.60E+11	3.42E+07	549.18	85.84	104583.81	1826.53	92.43	1	**3**
90632	Mill Creek-632	2.98E+11	1.05E+07	162.76	26.27	11105.09	520.77	92.43	3	**4**
90645	Rockledge Branch-645	1.21E+12	4.11E+07	495.27	55.21	131722.13	2166.37	86.75	2	**5**
90394	POHATCONG R-394	1.77E+12	5.58E+07	895.51	123.50	149280.69	3083.59	88.65	0	**6**
90622	NESHAMINY R-622	2.36E+11	8.08E+06	124.41	19.92	8346.77	405.86	92.43	3	**7**
90572	Delaware River-572	5.26E+11	1.74E+07	248.33	43.22	18016.61	897.70	88.64	3	**8**
90352	MUSCONETCONG R-352	1.41E+12	4.43E+07	733.56	101.71	106786.12	2439.41	88.65	0	**9**
90294	MCMICHAEL CR-294	1.19E+12	4.16E+07	757.51	109.46	127792.94	2231.23	88.65	0	**10**
90600	Newtown Creek-600	2.36E+11	8.09E+06	124.54	19.95	8355.51	406.29	92.43	2	**11**
90459	MUSCONETCONG R-459	1.32E+12	4.16E+07	687.69	95.35	100108.26	2286.87	88.65	0	**12**
90444	Unknown-444	1.22E+12	4.03E+07	676.84	95.55	112392.65	2149.88	88.65	0	**13**
90601	NESHAMINY R-601	4.90E+11	1.70E+07	286.69	41.65	47951.34	908.42	92.43	1	**14**
90164	LITTLE BUSH KILL-164	1.20E+12	3.86E+07	633.49	83.12	130340.72	2149.27	88.65	0	**15**
90649	Delaware River-649	6.36E+11	2.46E+07	281.89	32.73	63956.69	1193.52	86.75	2	**16**
90373	Aquashicola Creek-373	1.19E+12	3.89E+07	660.55	94.75	99308.76	2089.43	88.65	0	**17**
90576	Mill Creek-576	4.63E+11	1.57E+07	244.55	37.82	46147.04	851.11	92.43	1	**18**
90172	Unknown-172	1.16E+12	3.73E+07	611.97	80.30	125912.36	2076.25	88.65	0	**19**
90522	Lockatong Creek-522	1.41E+09	1.30E+07	316.97	62.75	29495.31	417.95	88.65	2	**20**
90610	Little Neshaminy Creek-610	3.74E+11	1.35E+07	241.93	34.77	44709.85	724.19	92.43	1	**21**
90566	NESHAMINY R-566	9.00E+11	2.97E+07	454.34	72.60	29981.87	1508.19	92.43	0	**22**
90573	Mill Creek-573	3.99E+11	1.35E+07	210.95	32.62	39805.57	734.15	92.43	1	**23**
90613	Little Neshaminy Creek-613	4.56E+11	1.52E+07	212.20	36.90	15478.85	776.17	92.43	1	**24**
90321	Cherry Creek-321	9.65E+11	3.38E+07	615.33	88.92	103807.72	1812.45	88.65	0	**25**
90447	Trout Creek-447	1.08E+12	3.54E+07	600.81	86.18	90327.50	1900.47	88.65	0	**26**
90349	Martins Creek-349	1.02E+12	3.49E+07	593.44	84.77	99908.73	1863.28	88.65	0	**27**

ID	Source Name	Fecal Coliform Col/Day	Crypto. Oocysts/Day	N Lbs/Day	TP Lbs/Day	TSS Lbs/Day	TOC Lbs/Day	Intake Weight	# Intakes Zone A	Rank
90641	Byberry Creek-641	3.88E+11	1.23E+07	228.14	30.38	39335.66	699.05	86.75	2	**28**
90651	Unknown-651	5.88E+11	1.55E+07	186.00	30.10	11395.48	913.60	86.75	2	**29**
90270	PAULINS KILL-270	1.03E+12	3.18E+07	530.14	73.83	82748.95	1792.26	88.65	0	**30**
90470	Monocacy Creek-470	9.04E+11	3.00E+07	487.83	69.06	83143.83	1627.92	88.65	0	**31**
90236	Marshall Creek-236	7.99E+11	2.80E+07	509.64	73.65	85976.92	1501.13	88.65	0	**32**
90617	Little Neshaminy Creek-617	4.91E+11	1.77E+07	317.12	45.58	58604.89	949.26	92.43	0	**33**
90637	NESHAMINY R-637	3.35E+11	1.01E+07	129.97	13.65	32909.55	577.99	86.75	2	**34**
90415	Unknown-415	8.58E+11	2.84E+07	477.58	67.42	79303.88	1516.95	88.65	0	**35**
90743	RANCOCAS CR-743	3.62E+11	8.62E+06	134.87	14.45	22247.58	587.78	86.75	2	**36**
90606	Little Neshaminy Creek-606	4.60E+11	1.66E+07	297.24	42.72	54931.56	889.76	92.43	0	**37**
90300	Pocono Creek-300	7.34E+11	2.57E+07	468.17	67.65	78980.13	1378.97	88.65	0	**38**
90656	Walton Run-656	2.19E+11	6.97E+06	128.79	17.15	22204.97	394.61	86.75	2	**39**
90340	PAULINS KILL-340	8.42E+11	2.60E+07	433.57	60.38	67675.91	1465.79	88.65	0	**40**

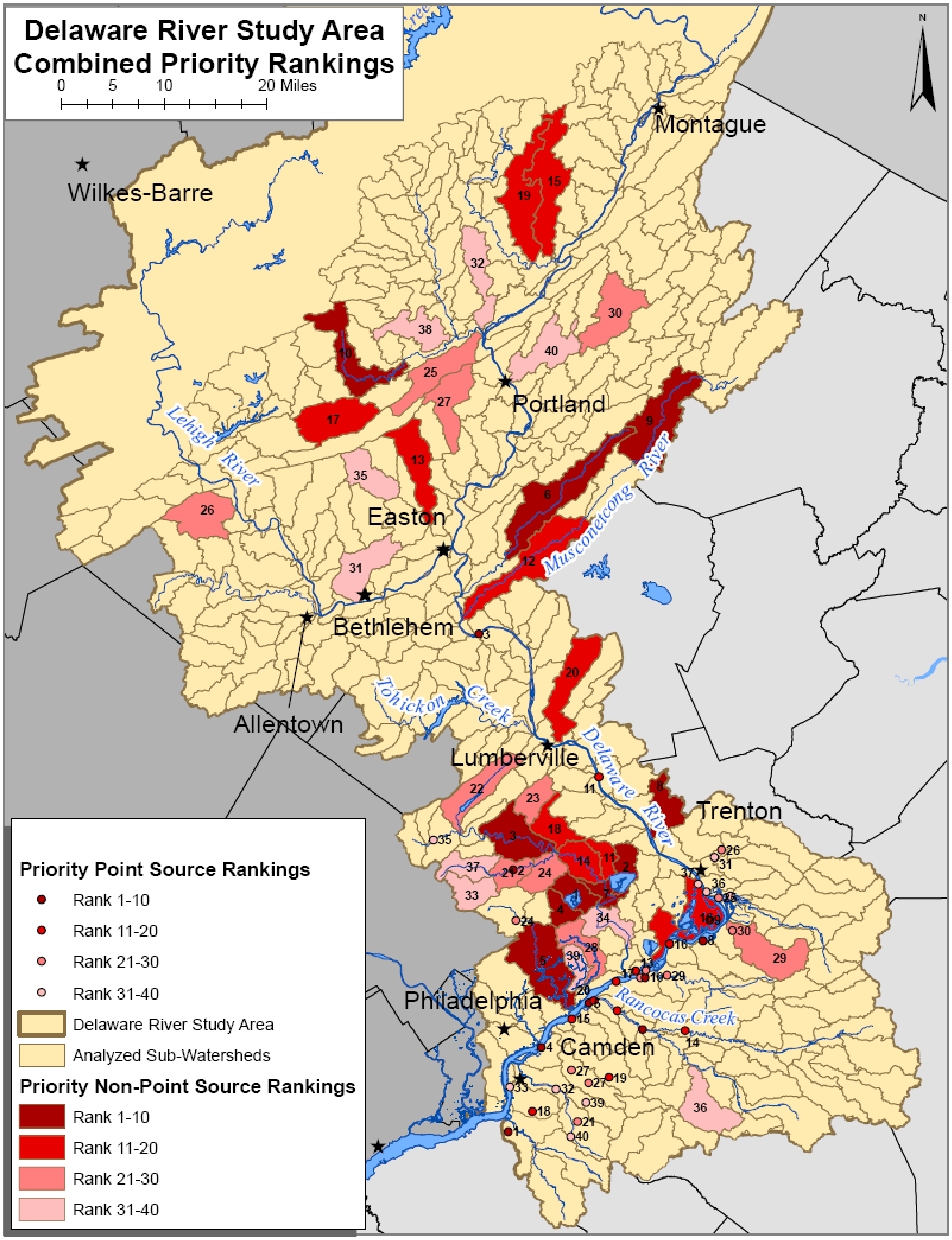
Table 4.3.6.3-2 Combined Point Source Prioritizations

ID	Source Name	Fecal Coliform Col./Day	Crypto. Oocysts/Day	N Lbs./Day	TP Lbs./Day	TSS Lbs./Day	TOC Lbs./Day	DMR Violations	Intake Weight	# Intakes Zone A	Rank
6932	COASTAL EAGLE POINT OIL CO	7.56E+08	3.78E+07	22004.568	8.08	6.12E+04	2.40E+05	330	17.22	0	**1**
1323	WARMINSTER TWP. MUN. AUTH.	7.56E+08	3.78E+07	1977.48	217	1.26E+04	1.40E+03	18	98.10	1	**2**
1211	JERSEY CENTRAL POWER & LIGHT	7.56E+08	3.78E+07	59.04	8.08	1.89E+02	1.40E+03	777	94.32	0	**3**
1515	GEORGIA PACIFIC CORPORATION	7.56E+08	3.78E+07	59.04	8.08	1.00E+02	2.97E+05	48	92.43	1	**4**
1332	DELRAN SEWERAGE AUTHORITY	7.56E+08	3.78E+07	59.04	8.08	1.89E+02	1.40E+03	199	92.43	3	**5**

ID	Source Name	Fecal Coliform Col./Day	Crypto. Oocysts/Day	N Lbs./Day	TP Lbs./Day	TSS Lbs./Day	TOC Lbs./Day	DMR Violations	% of Water Impacted	# Intakes Zone A	Rank
1463	MT LAUREL TWP MUA	7.56E+08	3.78E+07	59.04	8.08	1.89E+02	1.40E+03	192	92.43	3	**6**
1410	ROEBLING INDUSTRIES	7.56E+08	3.78E+07	59.04	8.08	1.89E+02	1.40E+03	141	92.43	3	**8**
1395	UNITED STATES STEEL GROUP-USX	7.56E+08	3.78E+07	59.04	8.08	1.42E+03	1.25E+04	103	92.43	3	**9**
1443	BURLINGTON CITY STP	7.56E+08	3.78E+07	59.04	8.08	1.89E+02	1.40E+03	118	92.43	3	**10**
1123	LAMBERTVILLE SEWAGE AUTHORITY	7.56E+08	3.78E+07	59.04	8.08	1.89E+02	1.40E+03	2	94.32	5	**11**
1341	WILLINGBORO WATER PCP	7.56E+08	3.78E+07	59.04	8.08	1.89E+02	1.40E+03	103	92.43	3	**12**
1434	BRISTOL TWP WP CONTROL PLANT	7.56E+08	3.78E+07	629.13598	8.08	4.60E+02	8.15E+02	70	92.43	3	**13**
1467	MOUNT HOLLY SEWERAGE AUTHORITY	7.56E+08	3.78E+07	59.04	8.08	1.89E+02	1.40E+03	58	92.43	3	**14**
1350	CINNAMINSON STP	7.56E+08	3.78E+07	1139.4	8.08	2.15E+03	6.45E+03	14	92.43	3	**15**
1413	FLORENCE TOWNSHIP STP	7.56E+08	3.78E+07	59.04	8.08	1.89E+02	1.40E+03	45	92.43	3	**16**
1447	BEVERLY SEWERAGE AUTHORITY	7.56E+08	3.78E+07	59.04	8.08	1.89E+02	1.40E+03	43	92.43	3	**17**
1594	AUDUBON BOROUGH STP	7.56E+08	3.78E+07	59.04	8.08	1.89E+02	1.40E+03	214	92.43	1	**18**
1558	RAMBLEWOOD STP	7.56E+08	3.78E+07	59.04	8.08	1.89E+02	1.40E+03	30	92.43	3	**19**
1330	RIVERSIDE STP	7.56E+08	3.78E+07	59.04	8.08	1.89E+02	1.40E+03	24	92.43	3	**20**
1488	WOODCREST STP	7.56E+08	3.78E+07	59.04	8.08	1.89E+02	1.40E+03	196	92.43	1	**21**
1444	COLORITE POLYMERS COMPANY	7.56E+08	3.78E+07	59.04	8.08	1.89E+02	1.40E+03	16	92.43	3	**22**
1435	PSE&G BURLINGTON GENERATING ST	7.56E+08	3.78E+07	59.04	8.08	1.89E+02	1.40E+03	16	92.43	3	**22**
1391	UPPER MORELAND-HAT.	7.56E+08	3.78E+07	59.04	8.08	1.89E+02	1.40E+03	13	92.43	3	**24**

ID	Source Name	Fecal Coliform Col./Day	Crypto. Oocysts/Day	N Lbs./Day	TP Lbs./Day	TSS Lbs./Day	TOC Lbs./Day	DMR Violations	% of Water Impacted	# Intakes Zone A	Rank
1375	PSE&G MERCER GENERATING STA	7.56E+08	3.78E+07	59.04	8.08	1.89E+02	1.40E+03	10	92.43	3	**25**
1295	EWING-LAWRENCE SA	7.56E+08	3.78E+07	59.04	8.08	1.89E+02	1.40E+03	101	92.43	2	**26**
1549	CHERRY HILL TOWNSHIP	7.56E+08	3.78E+07	59.04	8.08	1.89E+02	1.40E+03	7	92.43	3	**27**
1561	CHERRY HILL TOWNSHIP	7.56E+08	3.78E+07	59.04	8.08	1.89E+02	1.40E+03	7	92.43	3	**27**
1440	LA GORCE SQUARE PLANT	7.56E+08	3.78E+07	59.04	8.08	1.89E+02	1.40E+03	5	92.43	3	**29**
1401	BLACK'S CREEK WWTP	7.56E+08	3.78E+07	59.04	8.08	1.89E+02	1.40E+03	0	92.43	3	**30**
1309	FEDERATED METALS	7.56E+08	3.78E+07	59.04	8.08	1.89E+02	1.40E+03	51	92.43	2	**31**
1568	COOPER RIVER STP	7.56E+08	3.78E+07	59.04	8.08	1.89E+02	1.40E+03	129	92.43	1	**32**
1563	CAMDEN COUNTY M.U.A.	7.56E+08	3.78E+07	59.04	8.08	1.89E+02	1.40E+03	115	92.43	1	**33**
1371	HAMILTON TOWNSHIP WPCF	7.56E+08	3.78E+07	59.04	8.08	1.89E+02	1.40E+03	22	92.43	2	**34**
1266	HATFIELD TWP MUN AUTH	7.56E+08	3.78E+07	59.04	8.08	1.89E+02	1.40E+03	442	98.10	0	**35**
1366	TRENTON SEWER UTILITY	7.56E+08	3.78E+07	59.04	8.08	1.89E+02	1.40E+03	18	92.43	2	**36**
1362	MORRISVILLE BORO MUN AUTH-STP	7.56E+08	3.78E+07	59.04	8.08	1.89E+02	1.40E+03	14	92.43	2	**37**
1325	ASBURY PARK WTP	7.56E+08	3.78E+07	59.04	8.08	6.63E+03	1.03E+04	6	92.43	1	**38**
1581	CHERRY HILL TOWNSHIP	7.56E+08	3.78E+07	59.04	8.08	1.89E+02	1.40E+03	38	92.43	1	**39**
1502	SOMERDALE BORO STP	7.56E+08	3.78E+07	59.04	8.08	1.89E+02	1.40E+03	19	92.43	1	**40**

Figure 4.3.6.3-1 Combined Non-Point and Point Prioritization Locations



4.3.6.4 Nutrient Prioritization Results

Clearly visible from Figure 4.3.6.4-1 is the cluster of priority non-point source pollution contributing sub-watersheds in the Neshaminy Creek watershed. Four of the top five priority sub-watersheds are located in the Neshaminy Creek watershed. Nutrient non-point source pollution can create noxious algae blooms and contribute nitrate and nitrite to the drinking water, which ultimately are not removed by the treatment plant. This analysis clearly identifies that the Neshaminy Creek watershed is a priority for nutrient reduction within the Delaware River Study Area.

There are a large number of priority sub-watersheds in the middle of the Study Area near the towns of Bethlehem, Easton, and Portland, Pennsylvania. The Pohatcong and Musconetcong Rivers both have high priority sub-watersheds for non-point source pollution. The number of priority sub-watersheds north of Trenton indicates that the Baxter Water Treatment Plant is downstream of many high nutrient loading sub-watersheds.

The point source prioritization results show that the majority of point source nutrient loadings within the Delaware River Study Area come from wastewater treatment plant discharges. The nutrient discharges, specifically phosphorus, can affect source water quality in that they increase the available food source for algae and bacteria known to cause taste and odor compounds. The nutrient discharges also increase the amounts of nitrate and nitrite within the water supply. As outlined in Section 4.2.7 both nitrate and nitrite are not removed from the water supply and can cause detrimental health effects.

The following pages present Tables 4.3.6.4-1 and 4.3.6.4-2 that identify the top 40 non-point and point source rankings. A map of the locations of the top 40 non-point and point source rankings are presented in Figure 4.3.6.4-1.

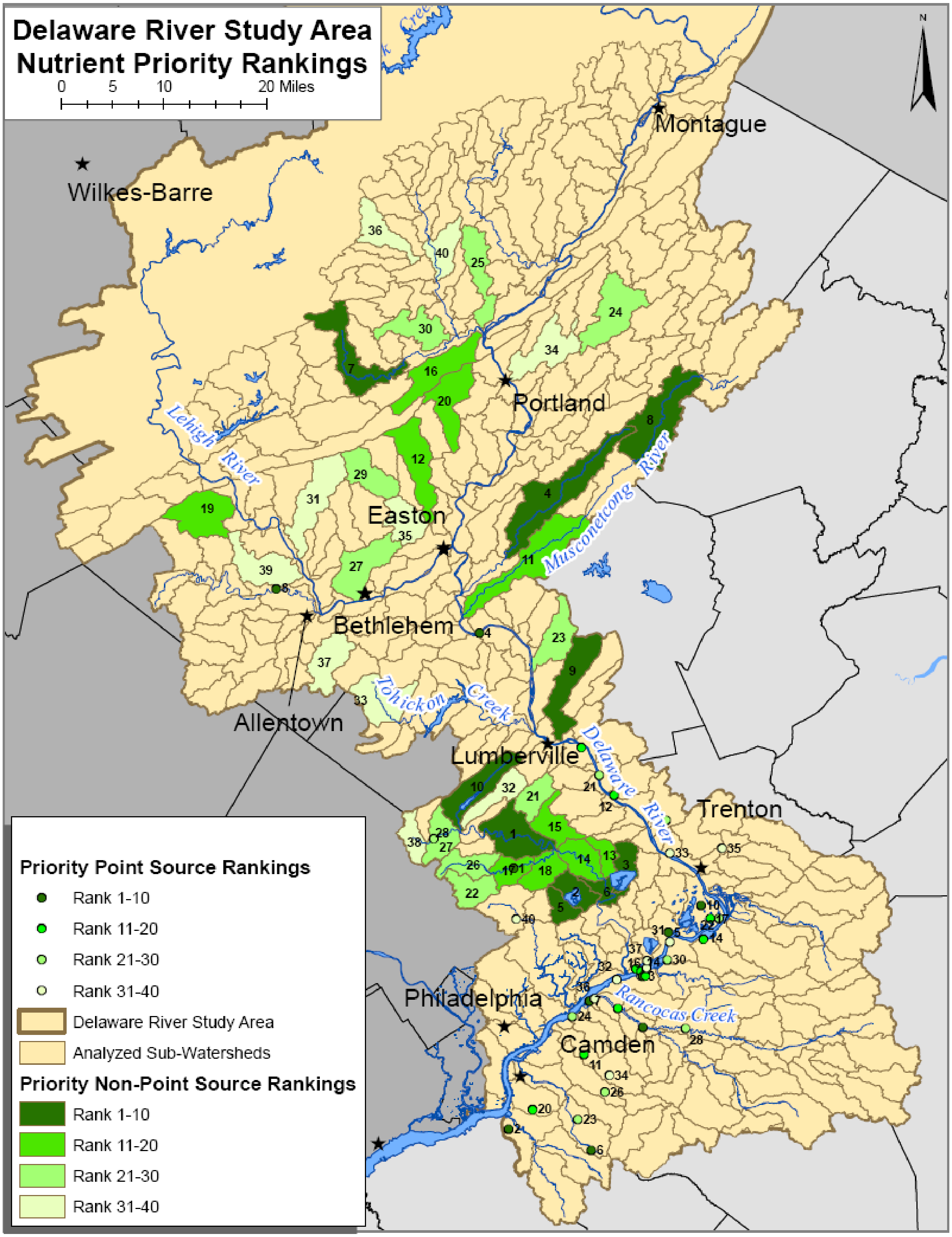
Table 4.3.6.4-1 Nutrient Non-Point Source Prioritizations

ID	Source Name	N Lbs/Day	TP Lbs/Day	Intake Weight	# Intakes Zone A	Rank
90583	NESHAMINY R-583	549.18	85.84	92.43	1	**1**
90619	Mill Creek-619	220.21	35.54	92.43	3	**2**
90602	Core Creek-602	183.30	29.09	92.43	3	**3**
90394	POHATCONG R-394	895.51	123.50	88.65	0	**4**
90632	Mill Creek-632	162.76	26.27	92.43	3	**5**
90622	NESHAMINY R-622	124.41	19.92	92.43	3	**6**
90294	MCMICHAEL CR-294	757.51	109.46	88.65	0	**7**
90352	MUSCONETCONG R-352	733.56	101.71	88.65	0	**8**
90522	Lockatong Creek-522	316.97	62.75	88.65	2	**9**
90566	NESHAMINY R-566	454.34	72.60	92.43	0	**10**
90459	MUSCONETCONG R-459	687.69	95.35	88.65	0	**11**
90444	Unknown-444	676.84	95.55	88.65	0	**12**
90600	Newtown Creek-600	124.54	19.95	92.43	2	**13**
90601	NESHAMINY R-601	286.69	41.65	92.43	1	**14**
90576	Mill Creek-576	244.55	37.82	92.43	1	**15**
90321	Cherry Creek-321	615.33	88.92	88.65	0	**16**
90610	Little Neshaminy Creek-610	241.93	34.77	92.43	1	**17**
90613	Little Neshaminy Creek-613	212.20	36.90	92.43	1	**18**
90447	Trout Creek-447	600.81	86.18	88.65	0	**19**
90349	Martins Creek-349	593.44	84.77	88.65	0	**20**
90573	Mill Creek-573	210.95	32.62	92.43	1	**21**
90617	Little Neshaminy Creek-617	317.12	45.58	92.43	0	**22**
90496	Nishisakawick Creek-496	352.51	53.50	88.65	1	**23**
90270	PAULINS KILL-270	530.14	73.83	88.65	0	**24**
90236	Marshall Creek-236	509.64	73.65	88.65	0	**25**
90606	Little Neshaminy Creek-606	297.24	42.72	92.43	0	**26**
90470	Monocacy Creek-470	487.83	69.06	88.65	0	**27**
90586	West Branch Neshaminy Creek-586	244.24	42.81	92.43	0	**28**
90415	Unknown-415	477.58	67.42	88.65	0	**29**
90300	Pocono Creek-300	468.17	67.65	88.65	0	**30**
90419	Hokendauqua Creek-419	441.70	68.21	88.65	0	**31**
90571	Pine Run-571	209.28	36.48	92.43	0	**32**
90541	TOHICKON CR-541	412.51	65.17	88.65	0	**33**
90340	PAULINS KILL-340	433.57	60.38	88.65	0	**34**
90453	Shoeneck Creek-453	424.82	59.97	88.65	0	**35**
90217	BRODHEAD CR-217	414.27	59.86	88.65	0	**36**
90521	Saucon Creek-521	408.58	59.12	88.65	0	**37**
90588	West Branch Neshaminy Creek-588	165.79	29.06	92.43	0	**38**
90468	Coplay Creek-468	396.51	54.63	88.65	0	**39**
90228	BRODHEAD CR-228	374.47	54.11	88.65	0	**40**

Table 4.3.6.4-2 Nutrient Point Source Prioritization Results

Source Name	N Lbs/Day	TP Lbs/Day	DRM Violations	Intake Weight	# Intakes Zone A	Rank
WARMINSTER TWP. MUN. AUTH.	1977.48	217	18	98.10	1	**1**
COASTAL EAGLE POINT OIL CO	22004.57	8.08	330	17.22	0	**2**
BURLINGTON TWP MAIN STP	59.04	8.08	431	92.43	3	**3**
JERSEY CENTRAL POWER & LIGHT	59.04	8.08	777	94.32	0	**4**
LOWER BUCKS COUNTY JOINT M.A.	5756.40	8.08	48	92.43	3	**5**
LINDENWOLD BOROUGH SEWAGE	59.04	8.08	349	92.43	1	**6**
DELRAN SEWERAGE AUTHORITY	59.04	8.08	199	92.43	3	**7**
MALLINCKRODT CHEMICAL, INC.	298.80	72	261	94.32	0	**8**
MT LAUREL TWP MUA	59.04	8.08	192	92.43	3	**9**
PRE FINISH METALS, INC.	59.04	8.08	177	92.43	3	**10**
MOORESTOWN TOWNSHIP STP	59.04	8.08	161	92.43	3	**11**
MERCER CO CORRECTION CTR STP	0.71	0.463	123	94.32	4	**12**
MONMOUTH CO BAYSHORE OUTFALL	59.04	8.08	140	94.32	3	**13**
PUBLIC SERVICE ELECTRIC & GAS	59.04	8.08	141	92.43	3	**14**
ROEBLING INDUSTRIES	59.04	8.08	141	92.43	3	**14**
BURLINGTON CITY STP	59.04	8.08	118	92.43	3	**16**
UNITED STATES STEEL GROUP-USX	59.04	8.08	103	92.43	3	**17**
WILLINGBORO WATER PCP	59.04	8.08	103	92.43	3	**17**
BRISTOL TWP WP CONTROL PLANT	629.14	8.08	70	92.43	3	**19**
AUDUBON BOROUGH STP	59.04	8.08	214	92.43	1	**20**
LAMBERTVILLE SEWAGE AUTHORITY	59.04	8.08	2	94.32	5	**21**
STEPAN CHEMICAL CO INC	59.04	8.08	77	92.43	3	**22**
WOODCREST STP	59.04	8.08	196	92.43	1	**23**
CINNAMINSON STP	1139.40	8.08	14	92.43	3	**24**
PUBLIC WORKS DEPT OF	2.16	0.8	30	94.32	4	**25**
WOODSTREAM STP	59.04	8.08	62	92.43	3	**26**
HATFIELD TWP MUN AUTH	59.04	8.08	442	98.10	0	**27**
MOUNT HOLLY SEWERAGE AUTHORITY	59.04	8.08	58	92.43	3	**28**
HERCULES INCORPORATED	59.04	8.08	46	92.43	3	**30**
FLORENCE TOWNSHIP STP	59.04	8.08	45	92.43	3	**31**
BEVERLY SEWERAGE AUTHORITY	59.04	8.08	43	92.43	3	**32**
ROLLER BEARING CO OF AMERICA	2.16	0.8	2	94.32	4	**33**
RAMBLEWOOD STP	59.04	8.08	30	92.43	3	**34**
EWING-LAWRENCE SA	59.04	8.08	101	92.43	2	**35**
RIVERSIDE STP	59.04	8.08	24	92.43	3	**36**
ROHM & HAAS COMPANY	59.04	8.08	20	92.43	3	**37**
COLORITE POLYMERS COMPANY	59.04	8.08	16	92.43	3	**38**
PSE&G BURLINGTON GENERATING ST	59.04	8.08	16	92.43	3	**38**
UPPER MORELAND-HATBORO JNT SEW	59.04	8.08	13	92.43	3	**40**

Figure 4.3.6.4-1 Nutrient Non-Point and Point Prioritization Locations



4.3.6.5 Pathogen Prioritization Results

The main pathogen of concern from non-point and point source pollution is *Cryptosporidium*. This pathogen is very difficult to remove during the drinking water treatment process and can persist in the environment for long periods of time. *Cryptosporidium* and fecal coliform bacteria are examined in this prioritization analysis.

The Neshaminy Creek watershed is again the location of the top priority sub-watersheds that contribute non-point source pollution, this time pathogens, to the Delaware River Study Area. Pathogens in non-point source pollution come from agricultural areas, specifically pasture and livestock areas where *Cryptosporidium* is found in the waste of young animals, especially calves.

Other sub-watersheds that are a high priority for pathogen loadings are in the Pohatcong and Musconetcong sub-watersheds. These regions are far north of the Baxter Water Treatment Plant and indicate that significant loads of *Cryptosporidium* are found across the Delaware River Study Area.

Humans can also transmit *Cryptosporidium* in their waste, which is why wastewater treatment plants compose the majority of priority point sources ranked for their contribution of pathogens. The high priority point sources that contribute high loadings of pathogens are mostly found in the tidal zone south of Trenton, NJ near the location of the Baxter Water Treatment Plant intake.

The following pages present Tables 4.3.6.5-1 and 4.3.6.5-2 that identify the top 40 non-point and point source rankings. A map of the locations of the top 40 non-point and point source rankings are presented in Figure 4.3.6.5-1.

Table 4.3.6.5-1 Pathogen Non-Point Source Prioritizations

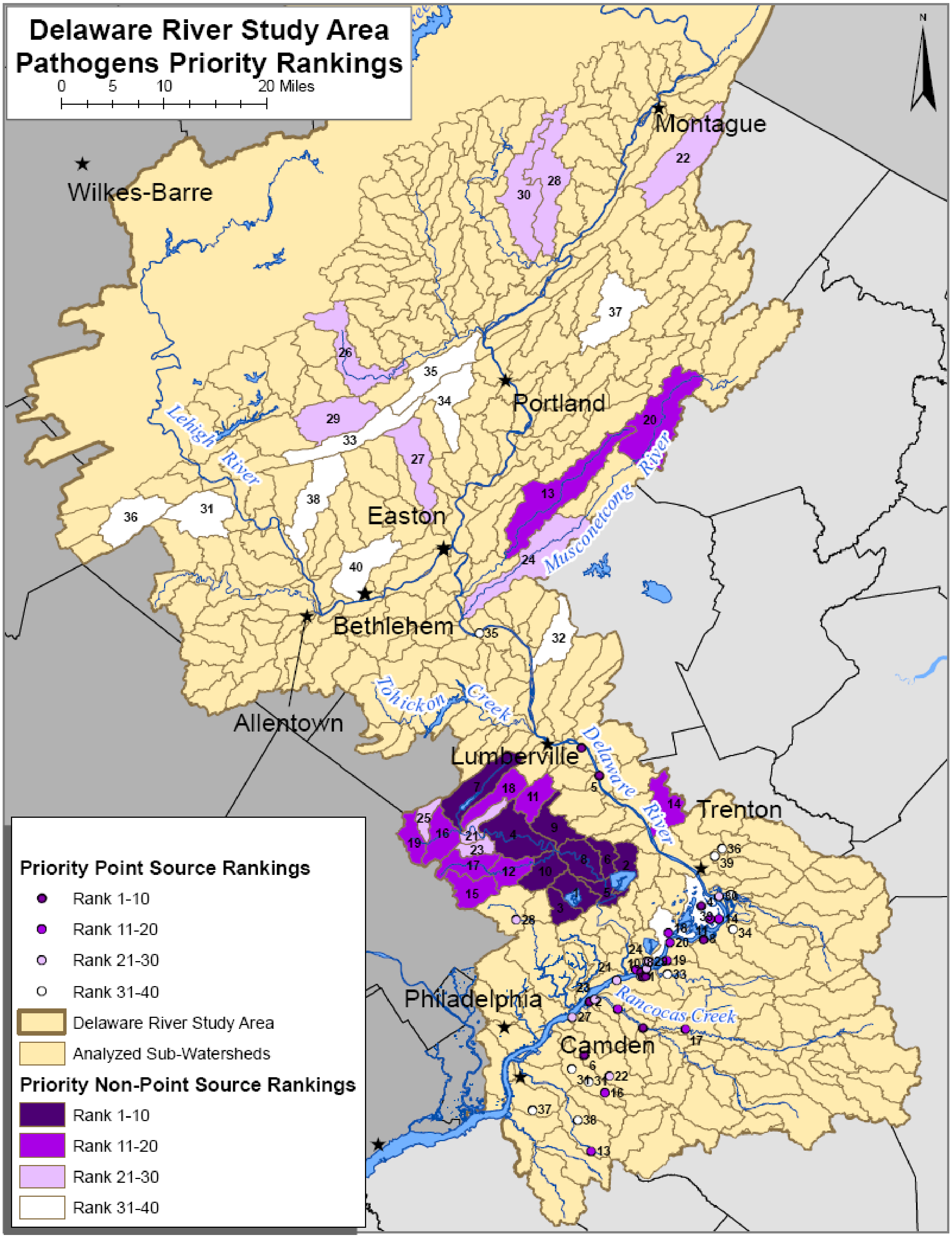
ID	Source Name	Fecal Col. Col./Day	Crypto. Oocysts/Day	Intake Weight	# Intakes Zone A	Rank
90619	Mill Creek-619	4.03E+11	1.42E+07	92.43	3	**1**
90602	Core Creek-602	3.60E+11	1.20E+07	92.43	3	**2**
90632	Mill Creek-632	2.98E+11	1.05E+07	92.43	3	**3**
90583	NESHAMINY R-583	9.60E+11	3.42E+07	92.43	1	**4**
90622	NESHAMINY R-622	2.36E+11	8.08E+06	92.43	3	**5**
90600	Newtown Creek-600	2.36E+11	8.09E+06	92.43	2	**6**
90566	NESHAMINY R-566	9.00E+11	2.97E+07	92.43	0	**7**
90601	NESHAMINY R-601	4.90E+11	1.70E+07	92.43	1	**8**
90576	Mill Creek-576	4.63E+11	1.57E+07	92.43	1	**9**
90613	Little Neshaminy Creek-613	4.56E+11	1.52E+07	92.43	1	**10**
90573	Mill Creek-573	3.99E+11	1.35E+07	92.43	1	**11**
90610	Little Neshaminy Creek-610	3.74E+11	1.35E+07	92.43	1	**12**
90394	POHATCONG R-394	1.77E+12	5.58E+07	88.65	0	**13**
90572	Delaware River-572	5.26E+11	1.74E+07	88.64	3	**14**
90617	Little Neshaminy Creek-617	4.91E+11	1.77E+07	92.43	0	**15**
90586	West Branch Neshaminy Creek-586	4.93E+11	1.69E+07	92.43	0	**16**
90606	Little Neshaminy Creek-606	4.60E+11	1.66E+07	92.43	0	**17**
90571	Pine Run-571	4.44E+11	1.50E+07	92.43	0	**18**
90588	West Branch Neshaminy Creek-588	3.35E+11	1.15E+07	92.43	0	**19**
90352	MUSCONETCONG R-352	1.41E+12	4.43E+07	88.65	0	**20**
90580	NESHAMINY R-580	2.76E+11	9.82E+06	92.43	0	**21**
90163	FLAT BROOK-163	1.39E+12	4.22E+07	88.65	0	**22**
90598	Mill Creek-598	2.11E+11	7.51E+06	92.43	0	**23**
90459	MUSCONETCONG R-459	1.32E+12	4.16E+07	88.65	0	**24**
90581	West Branch Neshaminy Creek-581	2.01E+11	6.89E+06	92.43	0	**25**
90294	MCMICHAEL CR-294	1.19E+12	4.16E+07	88.65	0	**26**
90444	Unknown-444	1.22E+12	4.03E+07	88.65	0	**27**
90164	LITTLE BUSH KILL-164	1.20E+12	3.86E+07	88.65	0	**28**
90373	Aquashicola Creek-373	1.19E+12	3.89E+07	88.65	0	**29**
90172	Unknown-172	1.16E+12	3.73E+07	88.65	0	**30**
90447	Trout Creek-447	1.08E+12	3.54E+07	88.65	0	**31**
90496	Nishisakawick Creek-496	7.11E+11	2.22E+07	88.65	1	**32**
90374	Aquashicola Creek-374	1.07E+12	3.49E+07	88.65	0	**33**
90349	Martins Creek-349	1.02E+12	3.49E+07	88.65	0	**34**
90321	Cherry Creek-321	9.65E+11	3.38E+07	88.65	0	**35**
90452	Lizard Creek-452	9.98E+11	3.27E+07	88.65	0	**36**
90270	PAULINS KILL-270	1.03E+12	3.18E+07	88.65	0	**37**
90419	Hokendauqua Creek-419	9.55E+11	2.91E+07	88.65	0	**38**
90649	Delaware River-649	6.36E+11	2.46E+07	86.75	2	**39**
90470	Monocacy Creek-470	9.04E+11	3.00E+07	88.65	0	**40**

Table 4.3.6.5-2 Pathogen Point Source Prioritizations

ID	Source Name	Fecal Col. Col./Day	Crypto. Oocysts/Day	DMR Violations	Intake Weight	# Intakes Zone A	Rank
1445	BURLINGTON TWP MAIN STP	7.56E+08	3.78E+07	431	92.43	3	**1**
1332	DELRAN SEWERAGE AUTHORITY	7.56E+08	3.78E+07	199	92.43	3	**2**
1463	MT LAUREL TWP MUA	7.56E+08	3.78E+07	192	92.43	3	**3**
1386	PRE FINISH METALS, INC.	7.56E+08	3.78E+07	177	92.43	3	**4**
1123	LAMBERTVILLE SEWAGE AUTHORITY	7.56E+08	3.78E+07	2	94.32	5	**5**
1537	MOORESTOWN TOWNSHIP STP	7.56E+08	3.78E+07	161	92.43	3	**6**
1116	MONMOUTH CO BAYSHORE OUTFALL	7.56E+08	3.78E+07	140	94.32	3	**7**
1436	PUBLIC SERVICE ELECTRIC & GAS	7.56E+08	3.78E+07	141	92.43	3	**8**
1410	ROEBLING INDUSTRIES	7.56E+08	3.78E+07	141	92.43	3	**8**
1443	BURLINGTON CITY STP	7.56E+08	3.78E+07	118	92.43	3	**10**
1395	UNITED STATES STEEL GROUP-USX	7.56E+08	3.78E+07	103	92.43	3	**11**
1341	WILLINGBORO WATER PCP	7.56E+08	3.78E+07	103	92.43	3	**11**
1618	LINDENWOLD BOROUGH SEWAGE	7.56E+08	3.78E+07	349	92.43	1	**13**
1396	STEPAN CHEMICAL CO INC	7.56E+08	3.78E+07	77	92.43	3	**14**
1434	BRISTOL TWP WP CONTROL PLANT	7.56E+08	3.78E+07	70	92.43	3	**15**
1573	WOODSTREAM STP	7.56E+08	3.78E+07	62	92.43	3	**16**
1467	MT. HOLLY SEWERAGE AUTHORITY	7.56E+08	3.78E+07	58	92.43	3	**17**
1403	LOWER BUCKS COUNTY JOINT M.A.	7.56E+08	3.78E+07	48	92.43	3	**18**
1430	HERCULES INCORPORATED	7.56E+08	3.78E+07	46	92.43	3	**19**
1413	FLORENCE TOWNSHIP STP	7.56E+08	3.78E+07	45	92.43	3	**20**
1447	BEVERLY SEWERAGE AUTHORITY	7.56E+08	3.78E+07	43	92.43	3	**21**
1558	RAMBLEWOOD STP	7.56E+08	3.78E+07	30	92.43	3	**22**
1330	RIVERSIDE STP	7.56E+08	3.78E+07	24	92.43	3	**23**
1427	ROHM & HAAS COMPANY	7.56E+08	3.78E+07	20	92.43	3	**24**
1444	COLORITE POLYMERS COMPANY	7.56E+08	3.78E+07	16	92.43	3	**25**
1435	PSE&G BURLINGTON GENERATING ST	7.56E+08	3.78E+07	16	92.43	3	**25**
1350	CINNAMINSON STP	7.56E+08	3.78E+07	14	92.43	3	**27**

ID	Source Name	Fecal Col. Col./Day	Crypto. Oocysts/Day	DMR Violations	Intake Weight	# Intakes Zone A	Rank
1391	UPPER MORELAND-HATBORO JNT SEW	7.56E+08	3.78E+07	13	92.43	3	**28**
1429	BRISTOL BORO WAT & SEW AUTH	7.56E+08	3.78E+07	12	92.43	3	**29**
1375	PSE&G MERCER GENERATING STA	7.56E+08	3.78E+07	10	92.43	3	**30**
1549	CHERRY HILL TOWNSHIP	7.56E+08	3.78E+07	7	92.43	3	**31**
1561	CHERRY HILL TOWNSHIP	7.56E+08	3.78E+07	7	92.43	3	**31**
1440	LA GORCE SQUARE PLANT	7.56E+08	3.78E+07	5	92.43	3	**33**
1401	BLACK'S CREEK WWTP	7.56E+08	3.78E+07	0	92.43	3	**34**
1211	JERSEY CENTRAL POWER & LIGHT	7.56E+08	3.78E+07	777	94.32	0	**35**
1295	EWING-LAWRENCE SA	7.56E+08	3.78E+07	101	92.43	2	**36**
1594	AUDUBON BOROUGH STP	7.56E+08	3.78E+07	214	92.43	1	**37**
1488	WOODCREST STP	7.56E+08	3.78E+07	196	92.43	1	**38**
1309	FEDERATED METALS	7.56E+08	3.78E+07	51	92.43	2	**39**
1371	HAMILTON TOWNSHIP WPCF	7.56E+08	3.78E+07	22	92.43	2	**40**

Figure 4.3.6.5-1 Pathogen Non-Point and Point Prioritization Locations



4.3.6.6 Total Organic Carbon Prioritization Results

Total Organic Carbon (TOC) can come from many sources, including agriculture, decaying leaves and algae, and sewage discharge. TOC can be an indicator of disinfection by-product formation potential, which is a concern for drinking water systems that disinfect with chlorination. The nature of the organic matter from various sources can be significantly different and have different impacts on the formation of disinfection by-products when reacting with chlorine. This analysis does not take these differences into account and therefore only provides an initial, broad look at disinfection by-product precursors.

The non-point source priority watersheds for TOC loading are predominantly located in the Neshaminy Creek watershed. The Tidal PA Bucks, Pohatcong, Musconetcong, and Crosswicks sub-watersheds also are priority areas for TOC loading. This prioritization shows multiple sources of disinfection byproduct precursors within the Delaware River Study Area.

All of the priority TOC point source dischargers are located south of the Lehigh River. The dischargers are mostly clustered around the Trenton – Philadelphia region. TOC from point sources is often due to wastewater treatment plants.

The following pages present Tables 4.3.6.6-1 and 4.3.6.6-2 that identify the top 40 non-point and point source rankings. A map of the locations of the top 40 non-point and point source rankings are presented in Figure 4.3.6.6-1.

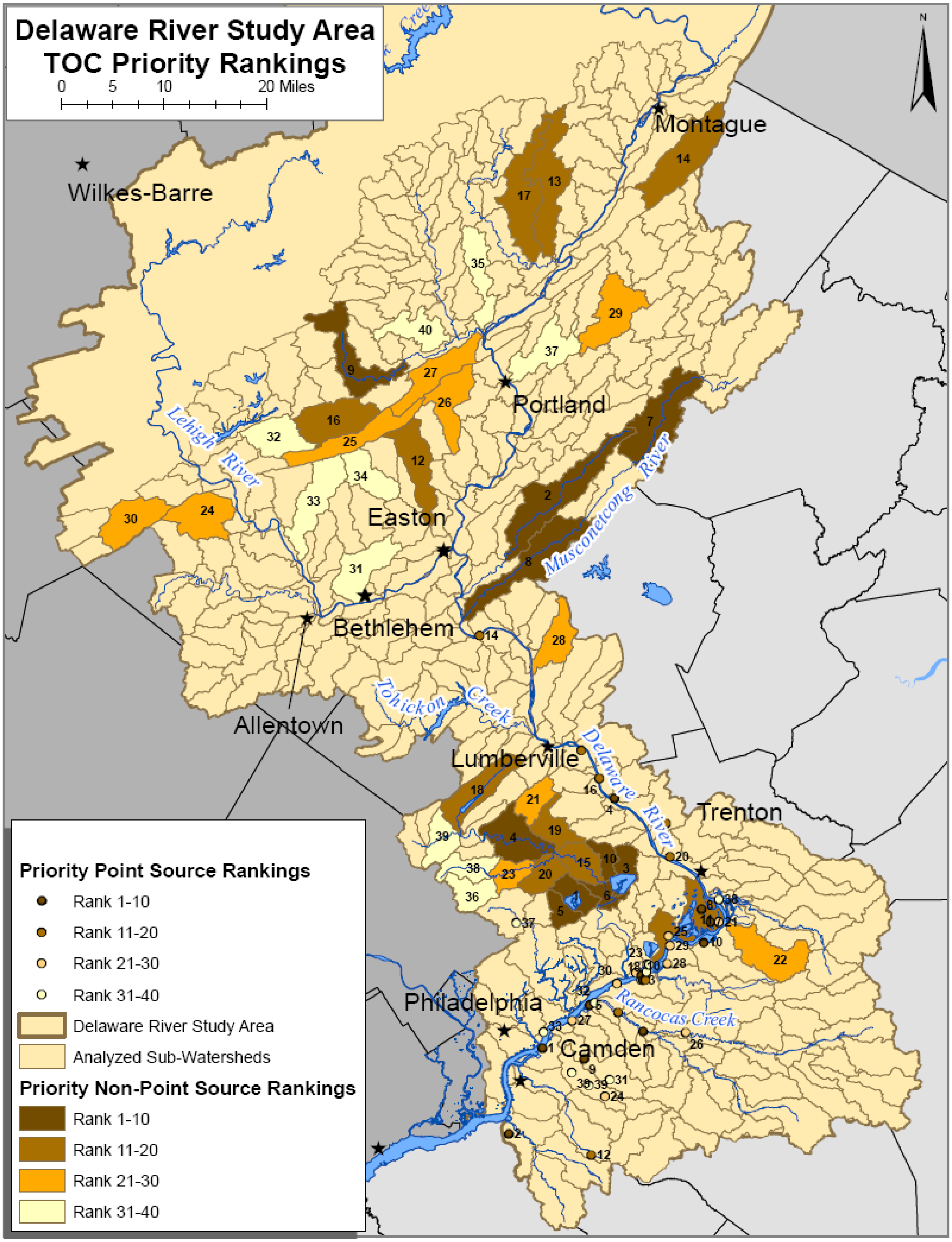
Table 4.3.6.6-1 Total Organic Carbon Non-Point Source Prioritizations

ID	Source Name	TOC Lbs/Day	Intake Weight	# Intakes Zone A	Rank
90619	Mill Creek-619	704.57	92.43	3	**1**
90394	POHATCONG R-394	3083.59	88.65	0	**2**
90602	Core Creek-602	610.78	92.43	3	**3**
90583	NESHAMINY R-583	1826.53	92.43	1	**4**
90632	Mill Creek-632	520.77	92.43	3	**5**
90622	NESHAMINY R-622	405.86	92.43	3	**6**
90352	MUSCONETCONG R-352	2439.41	88.65	0	**7**
90459	MUSCONETCONG R-459	2286.87	88.65	0	**8**
90294	MCMICHAEL CR-294	2231.23	88.65	0	**9**
90600	Newtown Creek-600	406.29	92.43	2	**10**
90649	Delaware River-649	1193.52	86.75	2	**11**
90444	Unknown-444	2149.88	88.65	0	**12**
90164	LITTLE BUSH KILL-164	2149.27	88.65	0	**13**
90163	FLAT BROOK-163	2102.00	88.65	0	**14**
90601	NESHAMINY R-601	908.42	92.43	1	**15**
90373	Aquashicola Creek-373	2089.43	88.65	0	**16**
90172	Unknown-172	2076.25	88.65	0	**17**
90566	NESHAMINY R-566	1508.19	92.43	0	**18**
90576	Mill Creek-576	851.11	92.43	1	**19**
90613	Little Neshaminy Creek-613	776.17	92.43	1	**20**
90573	Mill Creek-573	734.15	92.43	1	**21**
90651	Unknown-651	913.60	86.75	2	**22**
90610	Little Neshaminy Creek-610	724.19	92.43	1	**23**
90447	Trout Creek-447	1900.47	88.65	0	**24**
90374	Aquashicola Creek-374	1875.23	88.65	0	**25**
90349	Martins Creek-349	1863.28	88.65	0	**26**
90321	Cherry Creek-321	1812.45	88.65	0	**27**
90496	Nishisakawick Creek-496	1164.07	88.65	1	**28**
90270	PAULINS KILL-270	1792.26	88.65	0	**29**
90452	Lizard Creek-452	1753.92	88.65	0	**30**
90470	Monocacy Creek-470	1627.92	88.65	0	**31**
90387	Aquashicola Creek-387	1545.54	88.65	0	**32**
90419	Hokendauqua Creek-419	1527.97	88.65	0	**33**
90415	Unknown-415	1516.95	88.65	0	**34**
90236	Marshall Creek-236	1501.13	88.65	0	**35**
90617	Little Neshaminy Creek-617	949.26	92.43	0	**36**
90340	PAULINS KILL-340	1465.79	88.65	0	**37**
90606	Little Neshaminy Creek-606	889.76	92.43	0	**38**
90586	West Branch Neshaminy Creek-586	854.87	92.43	0	**39**
90300	Pocono Creek-300	1378.97	88.65	0	**40**

Table 4.3.6.6-2 Total Organic Carbon Point Source Prioritizations

ID	Source Name	TOC Lbs/Day	DMR Violations	Intake Weight	# Intakes Zone A	Rank
1512	GEORGIA PACIFIC CORPORATION	297196.8	0	92.43	1	**1**
6932	COASTAL EAGLE POINT OIL CO	239788	330	17.22	0	**2**
1445	BURLINGTON TWP MAIN STP	1395.2	431	92.43	3	**3**
1243	MERCER CO CORRECTION CTR STP	235.90	123	94.32	4	**4**
1332	DELRAN SEWERAGE AUTHORITY	1395.2	199	92.43	3	**5**
1463	MT LAUREL TWP MUA	1395.2	192	92.43	3	**6**
1395	UNITED STATES STEEL GROUP-USX	12494.4	103	92.43	3	**7**
1386	PRE FINISH METALS, INC.	1395.2	177	92.43	3	**8**
1537	MOORESTOWN TOWNSHIP STP	1395.2	161	92.43	3	**9**
1436	PUBLIC SERVICE ELECTRIC & GAS	1395.2	141	92.43	3	**10**
1410	ROEBLING INDUSTRIES	1395.2	141	92.43	3	**10**
1618	LINDENWOLD BOROUGH SEWAGE	1395.2	349	92.43	1	**12**
1116	MONMOUTH CO BAYSHORE OUTFALL	1395.2	140	94.32	3	**13**
1211	JERSEY CENTRAL POWER & LIGHT	1395.2	777	94.32	0	**14**
1254	PUBLIC WORKS DEPT OF	115	30	94.32	4	**15**
1123	LAMBERTVILLE SEWAGE AUTHORITY	1395.2	2	94.32	5	**16**
1252	JANSSEN PHARMACEUTICA	115	20	94.32	4	**17**
1443	BURLINGTON CITY STP	1395.2	118	92.43	3	**18**
1341	WILLINGBORO WATER PCP	1395.2	103	92.43	3	**19**
1299	ROLLER BEARING CO OF AMERICA	115	2	94.32	4	**20**
1396	STEPAN CHEMICAL CO INC	1395.2	77	92.43	3	**21**
1434	BRISTOL TWP WP CONTROL PLANT	815.36	70	92.43	3	**22**
1427	ROHM & HAAS COMPANY	1395.2	20	92.43	3	**23**
1573	WOODSTREAM STP	1395.2	62	92.43	3	**24**
1403	LOWER BUCKS COUNTY JOINT M.A.	3268.8	48	92.43	3	**25**
1467	MOUNT HOLLY SEWERAGE AUTHORITY	1395.2	58	92.43	3	**26**
1350	CINNAMINSON STP	6454.72	14	92.43	3	**27**
1430	HERCULES INCORPORATED	1395.2	46	92.43	3	**28**
1413	FLORENCE TOWNSHIP STP	1395.2	45	92.43	3	**29**
1447	BEVERLY SEWERAGE AUTHORITY	1395.2	43	92.43	3	**30**
1558	RAMBLEWOOD STP	1395.2	30	92.43	3	**31**
1330	RIVERSIDE STP	1395.2	24	92.43	3	**32**
6948	ROHM & HAAS COMPANY	1395.2	3	17.22	2	**33**
1444	COLORITE POLYMERS COMPANY	1395.2	16	92.43	3	**34**
1435	PSE&G BURLINGTON GENERATING ST	1395.2	16	92.43	3	**34**
1429	BRISTOL BORO WAT & SEW AUTH	1633.76	12	92.43	3	**36**
1391	UPPER MORELAND-HATBORO JNT SEW	1395.2	13	92.43	3	**37**
1375	PSE&G MERCER GENERATING STA	1395.2	10	92.43	3	**38**
1549	CHERRY HILL TOWNSHIP	1395.2	7	92.43	3	**39**
1561	CHERRY HILL TOWNSHIP	1395.2	7	92.43	3	**39**

Figure 4.3.6.6-1 Total Organic Carbon Non-Point and Point Prioritization Locations



4.3.6.7 Total Suspended Solids Prioritization Results

Total Suspended Solids (TSS) is used as a surrogate for turbidity contributions in this analysis. High turbidity levels can indicate the water contains many fine particles for pathogens, metals, and contaminants to adsorb to. Total Suspended Solids and turbidity have a direct relationship, and TSS data is more widely available from point source dischargers. Point source and non-point source loadings high in total suspended solids can be interpreted to contain high turbidity readings.

The non-point source pollution priority sub-watersheds for TSS loadings are again mainly in the Neshaminy Creek watershed. The Tidal PA Bucks, Pohatcong, Musconetcong sub-watersheds and areas within Monroe County, Pennsylvania also are priority areas for TSS loading. This prioritization shows multiple sources of TSS loadings within the Delaware River Study Area. TSS contributions can come from agricultural land as well as suburban and urban areas. Counties that are developing without stormwater management protocols or ordinances in place could likely contribute large amounts of total suspended solids to the Delaware River Study Area.

The highest priority point source discharger of total suspended solids is the Coastal Eagle Point Oil Company. The majority of the remaining high priority dischargers are wastewater treatment plants located between Trenton, NJ and Philadelphia, PA.

The following pages present Tables 4.3.6.7-1 and 4.3.6.7-2 that identify the top 40 non-point and point source rankings. A map of the locations of the top 40 non-point and point source rankings are presented in Figure 4.3.6.7-1.

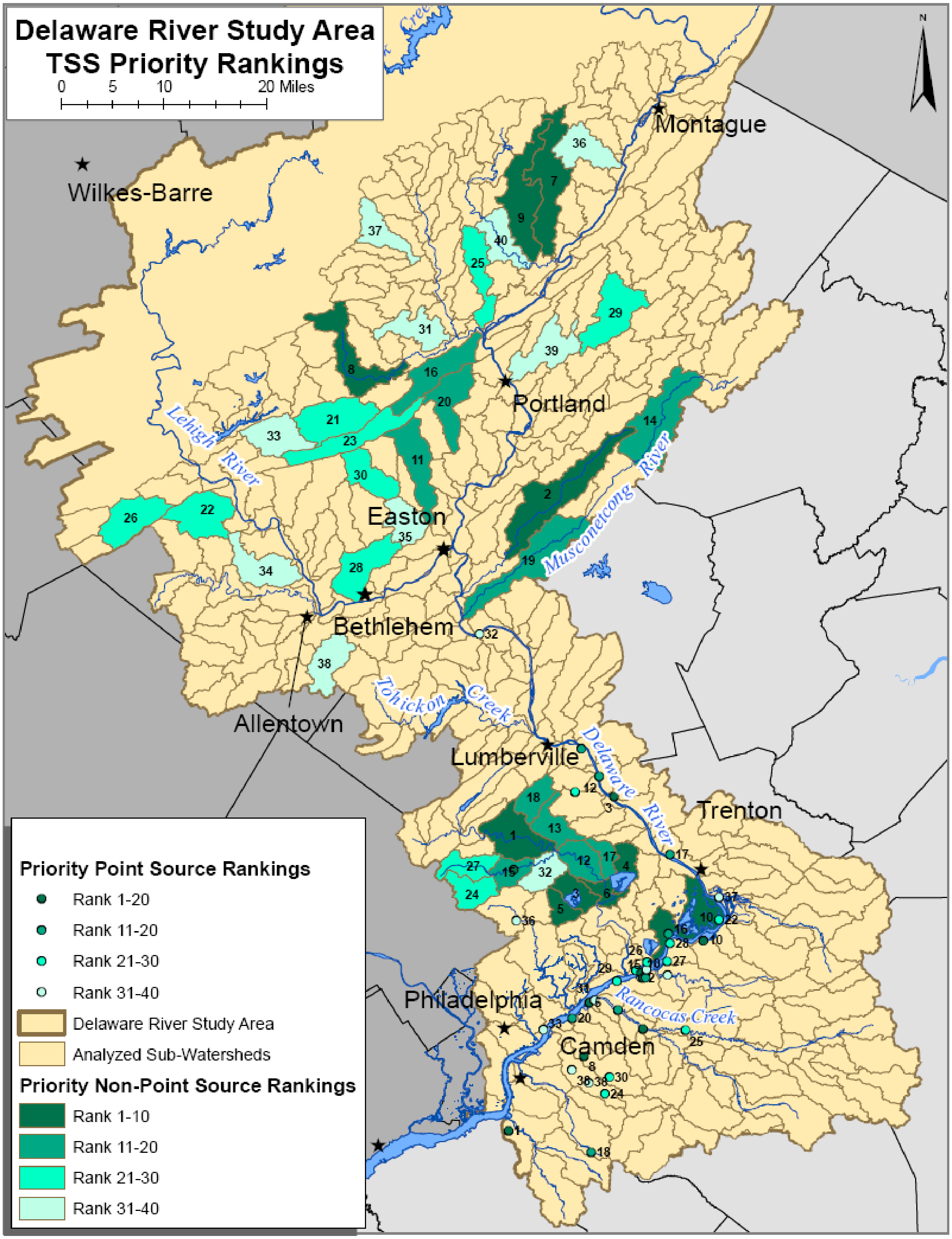
Table 4.3.6.7-1 Total Suspended Solids Non-Point Source Prioritizations

ID	Source Name	TSS Lbs/Day	Intake Weight	# Intakes Zone A	Rank
90583	NESHAMINY R-583	1.05E+05	92.43	1	**1**
90394	POHATCONG R-394	1.49E+05	88.65	0	**2**
90619	Mill Creek-619	1.50E+04	92.43	3	**3**
90602	Core Creek-602	1.20E+04	92.43	3	**4**
90632	Mill Creek-632	1.11E+04	92.43	3	**5**
90622	NESHAMINY R-622	8.35E+03	92.43	3	**6**
90164	LITTLE BUSH KILL-164	1.30E+05	88.65	0	**7**
90294	MCMICHAEL CR-294	1.28E+05	88.65	0	**8**
90172	Unknown-172	1.26E+05	88.65	0	**9**
90649	Delaware River-649	6.40E+04	86.75	2	**10**
90444	Unknown-444	1.12E+05	88.65	0	**11**
90601	NESHAMINY R-601	4.80E+04	92.43	1	**12**
90576	Mill Creek-576	4.61E+04	92.43	1	**13**
90352	MUSCONETCONG R-352	1.07E+05	88.65	0	**14**
90610	Little Neshaminy Creek-610	4.47E+04	92.43	1	**15**
90321	Cherry Creek-321	1.04E+05	88.65	0	**16**
90600	Newtown Creek-600	8.36E+03	92.43	2	**17**
90573	Mill Creek-573	3.98E+04	92.43	1	**18**
90459	MUSCONETCONG R-459	1.00E+05	88.65	0	**19**
90349	Martins Creek-349	9.99E+04	88.65	0	**20**
90373	Aquashicola Creek-373	9.93E+04	88.65	0	**21**
90447	Trout Creek-447	9.03E+04	88.65	0	**22**
90374	Aquashicola Creek-374	8.91E+04	88.65	0	**23**
90617	Little Neshaminy Creek-617	5.86E+04	92.43	0	**24**
90236	Marshall Creek-236	8.60E+04	88.65	0	**25**
90452	Lizard Creek-452	8.34E+04	88.65	0	**26**
90606	Little Neshaminy Creek-606	5.49E+04	92.43	0	**27**
90470	Monocacy Creek-470	8.31E+04	88.65	0	**28**
90270	PAULINS KILL-270	8.27E+04	88.65	0	**29**
90415	Unknown-415	7.93E+04	88.65	0	**30**
90300	Pocono Creek-300	7.90E+04	88.65	0	**31**
90613	Little Neshaminy Creek-613	1.55E+04	92.43	1	**32**
90387	Aquashicola Creek-387	7.35E+04	88.65	0	**33**
90468	Coplay Creek-468	7.22E+04	88.65	0	**34**
90453	Shoeneck Creek-453	7.05E+04	88.65	0	**35**
90174	Dingmans Creek-174	7.04E+04	88.65	0	**36**
90217	BRODHEAD CR-217	6.99E+04	88.65	0	**37**
90521	Saucon Creek-521	6.81E+04	88.65	0	**38**
90340	PAULINS KILL-340	6.77E+04	88.65	0	**39**
90220	BUSH KILL-220	6.63E+04	88.65	0	**40**

Table 4.3.6.7-2 Total Suspended Solids Point Source Prioritizations

ID	Source Name	TSS Lbs/Day	DMR Violations	Intake Weight	# Intakes Zone A	Rank
6932	COASTAL EAGLE POINT OIL CO	61237.14	330	17.22	0	**1**
1445	BURLINGTON TWP MAIN STP	189	431	92.43	3	**2**
1243	MERCER CO CORRECTION CTR STP	140.32	123	94.32	4	**3**
1323	WARMINSTER TWP. MUN. AUTH.	12628	18	98.10	1	**4**
1332	DELRAN SEWERAGE AUTHORITY	189	199	92.43	3	**5**
1463	MT LAUREL TWP MUA	189	192	92.43	3	**6**
1386	PRE FINISH METALS, INC.	189	177	92.43	3	**7**
1537	MOORESTOWN TOWNSHIP STP	189	161	92.43	3	**8**
1254	PUBLIC WORKS DEPT OF	17	30	94.32	4	**9**
1436	PUBLIC SERVICE ELECTRIC & GAS	189	141	92.43	3	**10**
1410	ROEBLING INDUSTRIES	189	141	92.43	3	**10**
1123	LAMBERTVILLE SEWAGE AUTHORITY	189	2	94.32	5	**12**
1116	MONMOUTH CO BAYSHORE OUTFALL	189	140	94.32	3	**13**
1252	JANSSEN PHARMACEUTICA	17	20	94.32	4	**14**
1443	BURLINGTON CITY STP	189	118	92.43	3	**15**
1403	LOWER BUCKS COUNTY JOINT M.A.	2190.7	48	92.43	3	**16**
1299	ROLLER BEARING CO OF AMERICA	17	2	94.32	4	**17**
1618	LINDENWOLD BOROUGH SEWAGE	189	349	92.43	1	**18**
1341	WILLINGBORO WATER PCP	189	103	92.43	3	**19**
1350	CINNAMINSON STP	2145.9	14	92.43	3	**20**
1434	BRISTOL TWP WP CONTROL PLANT	459.6	70	92.43	3	**21**
1396	STEPAN CHEMICAL CO INC	189	77	92.43	3	**22**
1124	NORTHEAST MONMOUTH COUNTY RSA	22845	33	94.32	0	**23**
1573	WOODSTREAM STP	189	62	92.43	3	**24**
1467	MOUNT HOLLY SEWERAGE AUTHORITY	189	58	92.43	3	**25**
1427	ROHM & HAAS COMPANY	189	20	92.43	3	**26**
1430	HERCULES INCORPORATED	189	46	92.43	3	**27**
1413	FLORENCE TOWNSHIP STP	189	45	92.43	3	**28**
1447	BEVERLY SEWERAGE AUTHORITY	189	43	92.43	3	**29**
1558	RAMBLEWOOD STP	189	30	92.43	3	**30**
1330	RIVERSIDE STP	189	24	92.43	3	**31**
1211	JERSEY CENTRAL POWER & LIGHT	189	777	94.32	0	**32**
6948	ROHM & HAAS COMPANY	189	3	17.22	2	**33**
1444	COLORITE POLYMERS COMPANY	189	16	92.43	3	**34**
1435	PSE&G BURLINGTON GENERATING ST	189	16	92.43	3	**34**
1391	UPPER MORELAND-HATBORO JNT SEW	189	13	92.43	3	**36**
1375	PSE&G MERCER GENERATING STA	189	10	92.43	3	**37**
1549	CHERRY HILL TOWNSHIP	189	7	92.43	3	**38**
1561	CHERRY HILL TOWNSHIP	189	7	92.43	3	**38**
1440	LA GORCE SQUARE PLANT	189	5	92.43	3	**40**

Figure 4.3.6.7-1 Total Suspended Solids Non-Point and Point Prioritization Locations



Section 5

Source Water Protection Initiatives

The present source water quality of the Delaware River makes this resource a desirable drinking water supply. However, potential exists for this high quality water to change due to population growth, land cover change, and climate change. The Philadelphia Water Department will use source water protection measures to counter the current and future water supply threats and concerns identified throughout Section 4. Source Water Protection is a collaborative approach involving regional partners working to maintain and improve the source water quality of the Delaware River.

Due to the large size of the Delaware River Study Area, stakeholders often find it difficult to successfully cut across regulatory, municipal, and jurisdictional boundaries to implement their projects and programs. However, the successful implementation of source water protection projects is critical to maintaining the quality and quantity of the water supply. In recognition of this problem, the majority of projects identified within this section are all designed to utilize watershed wide partnerships and provide benefits to all watershed stakeholders, not just the City of Philadelphia.

The implementation projects identified closely correspond to the findings of the water quality and land cover analyses performed in Section 4. The immense size of the Delaware River Study Area and the location of Philadelphia at the mouth of the Delaware River necessitate a broad geographic range of source water protection initiatives. Although the physical jurisdiction of the Philadelphia Water Department is limited to Philadelphia County, it can perform source water protection activities beyond its borders through encouraging the sharing of water quality information, facilitating and initiating research, and coordinating stakeholders in the Delaware River Study Area. Six comprehensive projects are identified in this section that will improve the source water quality of the Delaware River for Philadelphia and other water suppliers in the region.

5.1 Source Water Protection Initiative 1

Enhance and Make Permanent the DRBC Special Protection Water Resolution

The Philadelphia Water Department (PWD) supports the permanency of the Delaware River Basin Commission (DRBC) Special Protection Waters Resolution (SPW). PWD also supports the enhancement of the SPW to both require wastewater treatment plant dischargers within the Delaware River watershed to perform year round disinfection, and to include forest and canopy protection into current non-point source pollution controls.

The SPW Resolution was adopted in 1992 for areas between the Delaware Water Gap and the northernmost reaches of the Delaware River Watershed. The Special Protection

Waters area was expanded temporarily to include the entire Delaware River watershed north of Trenton, NJ. The temporary expansion has been renewed through September 30, 2007. The Philadelphia Water Department would like the temporary expansion made permanent so the total Special Protection Waters area includes the Delaware River Watershed north of Trenton, NJ.

The SPW Resolution aims to protect waters with exceptional scenic, recreational, ecological, and/or water supply values. The SPW Resolution includes multiple regulations, summarized and listed below.

1. No new or expanded wastewater discharge permits in SPW until all non-discharge and load reduction alternatives have been exhausted.
2. The minimal acceptable treatment processes for all new or expanding wastewater treatment plants will be the best available technology.
3. Wastewater treatment plants that discharge >10,000 gallons per day are subject to DRBC review.
4. Discharge and withdrawal projects within SPW and subject to DRBC review must submit a Non-Point Source Pollution Control Plan that describes best management practices within the service area designed to control any increases in non-point source pollution resulting from plant expansion or creation.

**More information about the Special Protection Waters Resolution can be found at www.state.nj.us/DRBC*

The SPW Resolution can be enhanced to provide even greater protections to the source water quality of the Delaware River. One important enhancement is including mandatory year round disinfection for all wastewater treatment plants and explicit forest and canopy cover protections in the Non-Point Source Pollution Control Plans.

The Delaware River at the Baxter intake is currently low in *Cryptosporidium* oocysts. The Baxter Water Treatment Plant placed in Bin 1 of the Long Term 2 Enhanced Surface Water Treatment Rule. Bin 1 signifies the lowest counts of *Cryptosporidium* oocysts and does not require plants to perform additional removal or disinfection steps. The amount of wastewater created and discharged upstream of the Baxter intake is likely to increase due to population growth. The increased volume of effluent, if released without being disinfected, could increase the pathogens present at the Baxter intake and the plant may lose its Bin 1 status. Currently only seasonal disinfection is required under the SPW Resolution. The Philadelphia Water Department advocates that year round disinfection, enforced through the SPW Resolution, will significantly limit pathogen increases in the drinking water supply during future population growth.

Another critical enhancement advocated by PWD is including the preservation of large trees, forested areas, and minimum canopy cover in Non-Point Source Pollution Control Plans required by the SPW. The current non-point source controls require that discharge or withdrawal expansion projects subject to DRBC review must submit a Non-

Point Source Pollution Control Plan. The Non-Point Source Pollution Control Plan must calculate the amount of non-point source pollution created by the expansion project, and identify best management practices (BMPs) to control any expected increases and volume and pollutant loadings. The BMPs can be implemented at the project site or any location within the service area. Acceptable BMPs are both structural and non-structural. Examples of structural BMPs include building low-flow, naturalized stormwater detention basins, constructed wetlands, and infiltration trenches. Non-structural BMPs are often local ordinances, development density restrictions, and environmental programs that aim to protect open space, tree cover, and stream bank vegetation.

The DRBC is currently examining ways to alter the SPW Resolution that would promote greater use of available non-structural BMPs, such as low impact development and preserving natural landscapes. The proposed changes would enhance the SPW Resolution to provide forest protection, minimize site disturbance, maximize pervious areas, and preserve landscapes. The proposed changes would help maintain the water quality benefits provided by natural, especially forested, areas. The Philadelphia Water Department supports adoption of these changes.

The Philadelphia Water Department will reach out to the DRBC and the Pennsylvania Department of Environmental Protection to advocate for and support the enhancement and permanence of the SPW Resolution.

5.2 Source Water Protection Initiative 2

Forest Protection and Conservation Development Initiative

Step 1 Support ongoing forest protection initiatives by working with counties, municipalities, land trusts, the Smart Growth Alliance, and other environmental conservation groups.

The Philadelphia Water Department will recruit and facilitate the development of a watershed-based advisory committee (municipalities, regulators, environmental advocates, and land trusts). The focus of the advisory committee will be one of education, advocacy, and implementation via existing regulatory regiments regarding the need for forest and tree protection ordinances, source water protection in County Open Space Plans, source water protection priority maps, and the connection among forests, water quality, and flooding prevention. This campaign will focus on counties, municipalities, land trusts, conservation groups and other environmental organizations within the Delaware River Study Area. Through providing information about the benefits of source water protection and the means with which to execute it, the Philadelphia Water Department will support ongoing forest protection initiatives within the Delaware River Study Area.

One initiative the Philadelphia Water Department would like to support throughout the Study Area is the incorporation of canopy cover and tree protection ordinances into Pennsylvania Act 167 and Erosion and Sedimentation construction controls.

Pennsylvania Act 167 requires each county to create a Stormwater Management Plan that includes an assessment of current stormwater infrastructure, its performance, a survey of future development projects and the potential stormwater impact of those project sites, criteria and standards for new development sites, and a prioritization of actions. Act 167 is very broad in that it allows for structural and non-structural best management practices (BMPs) as well as ordinances to effectively manage stormwater. These characteristics make this act an ideal place to incorporate specific forest protection ordinances to maintain and improve source water quality. The ordinances could aim to prevent developers from clear cutting sites, and force developers to save large trees of a specific size. Ordinances could be written in a way to favor smart development and residential designs which aim to preserve open space, and emphasize the critical role of forest protection in stormwater management.

Similar to the county Stormwater Management Plans, county Open Space Plans are also ideal locations for source water protection ordinances. Open Space Plans engage county planners in identifying the direction of development within each county in Pennsylvania. The planning efforts allow counties to measure the amount of current open space they have, as well as identify the amount and location of open space they would like to have in the future. Open Space Planning is an ideal vehicle through which to engage specific counties in source water protection. The Philadelphia Water Department can do this by providing source water protection priority maps to priority counties and municipalities via land trusts and other groups performing on-the-ground preservation and outreach work in the Delaware River Study Area.

The Philadelphia Water Department has developed source water protection priority maps for the Schuylkill River watershed, which can be replicated to cover the Delaware River Study Area. The maps take into account multiple land covers and specific hydrological features that are key to maintaining source water quality. The Philadelphia Water Department first identifies these key source water protection areas: forested lands, headwaters, reservoir watersheds, exceptional value streams, cold water fisheries, groundwater recharge areas, source water assessment Zone A's, drinking water wells, and agricultural areas. Each feature is assigned a unique score, which enables scores to be combined in locations that fall into two or more source water protection areas. The method produces a prioritization of source water protection areas within a county or watershed. This mapping can be very useful for Open Space Planning because it will help counties identify their most valuable resources to protect in order to maintain the local drinking water supply.

The Philadelphia Water Department can also support ongoing source water protection activities in the Delaware River Study Area by writing a white paper about the connection among source water quality, forested areas, and the relationship to flooding. Writing a technical document will enable the Philadelphia Water Department to provide counties, municipalities, and other organizations the scientific reasons for protecting forested lands to maintain source water quality. Such a document would help not only with education and outreach, but also with garnering funding support and grants to carry out additional activities.

Step 2 Meet with the Pennsylvania Department of Conservation and Natural Resources (DCNR) about purchasing, or means to conserve, forested lands for source water protection.

The Philadelphia Water Department will initiate a dialogue with DCNR about the role forests play in maintaining source water quality. The goal of this dialogue is to raise the profile of the Delaware River as a water supply that must be protected in the eyes of the DCNR.

The role of the Pennsylvania DCNR is to manage the state forest lands and state parks, and establish community partnerships to enhance the natural resources of Pennsylvania. In the Delaware River Study Area alone, the DCNR manages 78,617 acres of state forest land. The DCNR owns and manages a significant amount of forest land in the Delaware River Study Area, located in the Mongaup and Lackawaxen sub-watersheds. DCNR also provides multiple grants each year to communities and various organizations who aim to improve local natural resources.

Given DCNR's role in protecting forests and natural resources, PWD views the agency as an important ally in mitigating forest loss in Pennsylvania. Pennsylvania is under intense development pressure and has more forested lands to potentially lose to development than the New Jersey and New York portions of the Study Area. By engaging DCNR, PWD hopes the Department will consider source water protection in their forest conservation and grant activities, thus helping maintain the high source water quality of the Delaware River.

Step 3 Explore funding options for purchasing land or easements in the name of source water protection.

The Philadelphia Water Department alone would not be able to fund the purchase of land throughout the Delaware River Study Area. Partnerships would have to be forged that align the mutual beneficiaries of land preservation. Drinking water utilities, land trusts, conservation organizations, agricultural cooperatives, individual farm owners, watershed organizations, and flooding prevention groups are just some examples of those who would benefit from purchases of land for conservation.

In exploring funding options, the Philadelphia Water Department will reach out to the New York City Department of Environmental Protection. New York City has preserved thousands of acres in its water supply watersheds through direct purchasing of land and conservation easements. Reaching out to New York City will help begin a dialogue about the pitfalls and road blocks to purchasing and conserving land in the name of source water protection. Ideally the Philadelphia Water Department would be able to learn about experiences in the New York region and transfer the successes of the New York City program to the Delaware River Study Area.

The Philadelphia Water Department will take into serious consideration any advice received from the New York experience. The history of city land purchases for water resources is littered with tales of antagonistic relationships and slighted rural communities; most notable are the actions of Los Angeles in the middle of the twentieth century. The Philadelphia Water Department wants to avoid antagonizing large land owners or rural communities trying to develop. The Philadelphia Water Department would like to provide development options and resources that will allow for both source water protection and low impact development. The Philadelphia Water Department would like to engage as many beneficiaries of the conservation purchases as possible for both funding strength and public momentum behind source water protection.

5.3 Source Water Protection Initiative 3

Delaware River Salinity Reduction Initiative

Section 4 of this document, Drinking Source Water Quality, indicated that sodium and chloride are increasing throughout the Delaware River Study Area. The Philadelphia Water Department will use source water protection activities to halt the upward trend and reduce the levels of salinity in the Delaware River. The first thing the Philadelphia Water Department must do regarding this issue is research specific contributions of sodium from watershed sources such as road salt applications, wastewater treatment plants, sodium hypochlorite disinfection, and water softening chemicals. Before any sources can be targeted for reduction projects, the loadings of sodium from sub-watershed sources must be identified in order to prioritize activities.

The first research on sodium will be performed at the Philadelphia Water Department. Understanding the Philadelphia system will improve our knowledge of sodium contributions from wastewater treatment plants and drinking water treatment plants for several reasons. Most importantly, sodium is not removed during drinking water treatment and wastewater treatment. Any sodium that is in the water supply will return to the water supply through wastewater treatment plant discharges. A significant second source within these processes is the use of sodium based chemicals, including the disinfectant sodium hypochlorite and sodium based water softeners.

Both drinking water and wastewater treatment plants in Philadelphia, and throughout the Study Area, use sodium hypochlorite as a disinfecting chemical. The contribution to the overall sodium concentration of the finished drinking water from this chemical alone can range from 1-3 mg/L. The use of this chemical can be a significant source of sodium in the Study Area, given that once it enters the water supply at the drinking water treatment plant, it is never removed. The Philadelphia Water Department will study the movement of sodium through its drinking water and wastewater treatment plants to gain understanding of how sodium concentrations move and change among facilities through the Study Area. If sodium hypochlorite is found to be a significant source, alternatives such as potassium hypochlorite will be explored.

The results of the investigations at the Philadelphia Water Department facilities will provide insight into how other drinking water and wastewater treatment facilities contribute sodium. The sources of sodium from Philadelphia can be scaled up or down to estimate the contributions from water treatment facilities within the Study Area. One more sodium source, road salt, must be explored before the final sodium loadings from each sub-watershed can be estimated.

De-icing materials such as road salt have long been known to contribute sodium and chloride to fresh waters. De-icing materials can vary from sodium chloride to combinations of gravel and sand. Although new de-icing mixtures are replacing sodium chloride, the sodium and chloride concentrations throughout the Study Area are steadily increasing. The Philadelphia Water Department needs to investigate if this is due to an increase in the transportation surface area that needs to be de-iced, the amount of salt in the de-icing materials, or an increase in the application of de-icing materials. The answer will likely be a combination of these possibilities but the Philadelphia Water Department will require details of de-icing processes throughout the Study Area to reach any conclusions.

The findings of the de-icing materials research and the sodium loadings from drinking water and wastewater sources will enable the calculation of estimated loadings from sub-watersheds throughout the Study Area. The Philadelphia Water Department will estimate the loadings from sub-watersheds in order to focus any future activities on the highest priority areas. Once the research is completed the Philadelphia Water Department may communicate to the New York, New Jersey, and Pennsylvania Departments of Transportation the need to reduce the impact of de-icing materials on fresh water salinity. The Philadelphia Water Department would like to reduce salinity in the Study Area through research first and then through targeted outreach to communicate any key findings.

5.4 Source Water Protection Initiative 4

Delaware Valley Climate Change Initiative

The Philadelphia Water Department would like to partner with the Partnership for the Delaware Estuary (PDE) to explore climate change issues relating to the salt line and water quality of the Delaware River. The PDE Science and Technical Advisory Committee has begun reaching out to regional research institutions, universities, agencies, and other entities to collaborate on climate change research. The PDE would like to draw the attention of climate change research to the Delaware River and Estuary. The Philadelphia Water Department has major concerns regarding salt line movement and water quality changes that may occur due to climate change, and therefore wants to be aware of all research that focuses on this issue in the Delaware River.

One of the main research initiatives the Philadelphia Water Department would like to facilitate is a new model of tidal salt line movement based on current climate change predictions for sea level rise and altered fresh water flow. Movement of the salt line closer to the Baxter intake is a major threat to the Philadelphia Water Department and relies on the preventative releases of water from reservoirs in New York and Pennsylvania during threatening conditions. The Philadelphia Water Department believes that a new model is warranted given that climate change can move the salt line due to sea level rise and through alterations of fresh water flow. Current release amounts and minimum flow levels may not remain effective at salt line control under climate change conditions. The Delaware River Basin Commission resolutions governing reservoir releases and minimum flows must be re-examined under climate change conditions, and this cannot be done without a new model of the salt line.

The PDE has taken the lead in garnering support for regional climate change research initiatives. The Philadelphia Water Department will identify opportunities to support PDE in its research into salt line movement and potential hydrologic changes within the Delaware River.

5.5 Source Water Protection Initiative 5

Early Warning System Expansion

In order to further protect the water supply of the Delaware River Study Area, the Philadelphia Water Department will expand the Delaware Valley Early Warning System (EWS). The EWS will be expanded to strengthen its response mechanism in the event of terrorist attacks or catastrophes, the notification system will be expanded to include industrial intakes and dischargers, and stand alone time of travel models will be developed to help utilities prepare emergency response plans. The EWS is explained in detail in Section 8 of this plan.

The EWS currently notifies drinking water utilities in the event of an accidental contamination event or spill in the Delaware River and Schuylkill River. In order to expand the EWS to comprehensively respond to terrorist activity or a catastrophe, new emergency standard operating procedures must be developed. The EWS must identify the appropriate federal agencies with which to conduct two way communications if any catastrophic events or attacks directly to the water supply were to occur. The federal agencies must have protocols in place to contact the EWS, and EWS users must be able to contact federal agencies if they notice anything that raises suspicions. Agencies to target for EWS expansion in this manner include; the Department of Homeland Security, Northeast Regional Terrorism Task Force, and Philadelphia Office of Emergency Management. Currently the EWS does not have such protocols in place, and the Philadelphia Water Department would like to initiate discussions among federal agencies and EWS members to increase the terrorism response and notification capabilities of the EWS.

The EWS membership will be expanded to include industrial intakes and dischargers within the Delaware River Study Area. Industrial intakes, as well as drinking water utilities, have vested interests in the quality of the water in the Delaware River. The EWS was initially designed to accommodate drinking water intakes, but now can be expanded to include other water users. Industrial dischargers are important to include in the EWS because if any spills or accidents were to occur from these facilities, the EWS can provide rapid notification to other members.

The final expansion of the EWS is not through its membership or response capabilities, but in the information provided to its members. The Philadelphia Water Department has developed a time of travel model that will be provided to all members of the EWS. The time of travel model calculates how fast a spill can travel towards a specific intake, providing utility operators with a time frame to prepare emergency responses. The current EWS notification system uses a time of travel model, but the system does not offer a testing environment. Any testing conducted through EWS would trigger the live notification system. The development of this stand alone model will allow utilities to prepare emergency response plans based on hypothetical accidents in multiple upstream locations. The time of travel model has been developed, and is further discussed in Appendix 2.

5.6 Source Water Protection Initiative 6

Regional Disinfection Byproduct Precursor Investigation

Disinfection byproducts result from the drinking water treatment process when specific water quality parameters, disinfection byproduct precursors, come into contact with disinfectants such as chlorine or ozone. Disinfection byproducts are regulated under the Safe Drinking Water Act and many are suspected carcinogens. At the Baxter Water Treatment Plant, the disinfection byproduct precursors of concern are total organic carbon (TOC), dissolved organic carbon (DOC), UV absorbance at 254 nanometers (UV254), and bromide. The Philadelphia Water Department will research these precursors and ultimately work to reduce their prevalence in the Delaware River Study Area. The Philadelphia Water Department has identified four steps towards controlling these substances.

Step 1 Perform a literature search that identifies any climate change concentration effects and land cover change concentration effects for bromide, DOC, TOC, and UV254.

Climate change and land cover change are two activities of concern discussed throughout this plan for their abilities to alter source water quality and quantity. The specific effects these activities could have on disinfection byproduct precursor concentrations are of great interest to the Philadelphia Water Department. Scientific literature and journals will be explored to identify any known effects of land cover and climate change on TOC, DOC, UV254, and bromide.

Step 2 Work with the Bureau of Laboratory Services to investigate the formation of bromide based disinfection byproducts caused by increased bromide concentrations in the source water.

One expected finding from Step 1 is the potential for bromide concentrations to increase due to reduced fresh water flow caused by land cover change and climate change. Bromide is regulated by the streamflow of the Delaware River, and any events that reduce streamflow will increase bromide concentrations. The Bureau of Laboratory Services is one of the research and investigation divisions of the Philadelphia Water Department. The Bureau of Laboratory Services specializes in research into the water quality of the finished drinking water and the chemical changes it undergoes throughout the treatment process. The Bureau of Laboratory Services is ideally suited to begin investigations into how increasing bromide in the source water may increase the formation potential of brominated disinfection byproducts. The findings of such a research effort will prioritize the control of bromide in source water protection activities.

Step 3 Identify regional sources of TOC, DOC, UV254, and bromide.

The Philadelphia Water Department will investigate sources of TOC, DOC, UV254, and bromide within the Delaware River Study Area. Although the sources of these compounds are known to be natural, the Philadelphia Water Department would like to gain a greater understanding of the sources of these compounds. The findings from Step 1 will help to guide the search for locations of concern within the watershed where land cover changes may be impacting levels of disinfection byproduct precursors within the Study Area. Ideally the Philadelphia Water Department would like to reduce the concentrations of these compounds in the source water through source water protection, but this can only be done through applying the findings of Step 1 specifically to the Delaware River Study Area.

Step 4 Work with regional partners to enhance the network of data gathering and sharing regarding UV254

UV254 is a measurement of the absorbance of UV radiation at 254 nanometers within a specific water sample. UV254 is known to represent the fraction of dissolved organic matter that contributes to the formation of disinfection byproducts. The Baxter Water Treatment Plant routinely uses UV254 as an indicator of the disinfection byproducts formation potential. When UV254 absorbance increases, so does the formation potential of disinfection byproducts.

The Philadelphia Water Department uses UV254 as a bellwether of disinfection byproduct formation, but few other utilities in the Delaware River Study Area use this parameter. The Philadelphia Water Department would like to enhance the number of utilities that record this parameter. A greater number of utilities that collect this data will lend strength to the research efforts in Steps 1 and 3. Developing a robust data set of UV254 absorbance throughout the Study Area will enable the Philadelphia Water Department along with other utilities to study the patterns, trends, and sources of high UV254 absorbance water through the water supply.

The Philadelphia Water Department is currently working to expand the recording of UV254 data in the Study Area through a partnership with the Early Warning System and the U.S. Geologic Survey (USGS). The Philadelphia Water Department will also encourage collection and distribution of UV254 data to members of the Delaware Valley Early Warning System. USGS plans to install a real time meter to sample for UV254 and DOC. The USGS research interest lies in the fate of organic contaminants in the water supply. Data recorded for that research can also be used to study UV254 patterns in the Delaware River Study Area. The UV254 and DOC meter installed by the USGS is ideal because it will be located at Trenton, NJ where the USGS currently has a real time streamflow meter and other sampling devices that describe the exact water quality conditions at each sampling time.

5.7 Source Water Protection Initiatives Expected Costs and Timelines

The source water protection initiatives described in Sections 5.1-5.6 are detailed in this section. Each source water protection initiative is broken down into prioritized sub-projects. The sub-projects are assigned expected costs, project partners, priority as well as timelines for data collection and analysis, design, and implementation. The following table is a summary of the six source water protection initiatives including the geographic scope and objective.

Table 5.7-1 Source Water Protection Initiative Summary

Source Water Protection Initiative	Geographic Scope	Objective
Enhance and Make Permanent Special Protection Waters Resolution	Entire Study Area	Use the Special Protection Waters Resolution as a vehicle to protect the Delaware River from municipal point source and non-point source pollution
Forest Protection	Entire Study Area	Reduce the amount of forests consumed for development and increase the profile of forests as important to source water protection.
Delaware River Salinity Reduction	Entire Study Area	Research the various sources of sodium and chloride in the Study Area and develop a source water protection strategy to reduce them.
Climate Change – Salt Line and Water Quality	Entire Study Area	Use up to date climate change forecasts to model salt line movement and freshwater flow in order to predict future conditions and identify policy needs.
Early Warning System Expansion	Entire Study Area	Expand the Early Warning System into a terrorism response mechanism, and include industrial dischargers and intakes as members.
Regional Disinfection Byproduct Precursor Investigation	Entire Study Area	Research the sources of disinfection byproduct precursors and any changes that may occur in these sources due to land cover and climate changes.

The geographic scope of all proposed source water protection initiatives extends across the entire Study Area. The source water protection initiatives and sub-projects are relevant to diverse audiences and geographic regions throughout the Study Area. The inclusiveness of these proposed actions was designed to maximize the source water protection benefits for the Delaware River, not just the Philadelphia region. Many of the sub-projects identified in the following tables include communicating information to and sharing research findings with Study Area municipalities, counties, state agencies, and land trusts. This inclusive approach enables the Philadelphia Water Department to practice source water protection beyond the jurisdiction of Philadelphia County.

The following Tables 5.7-2A-G list the sub-projects of each source water protection initiative, expected costs, potential partners, and project priority. Additional partnerships may be forged once a project is designed and implemented; the lists presented are not conclusive. The priority of the projects was decided by the consensus of the Source Water Management Program at the Philadelphia Water Department, as well as the opinions of water resource officials at state and federal agencies.

Table 5.7-2A Special Protection Waters Resolution Initiative Details

Enhance and Make Permanent Special Protection Waters Resolution Initiative			
Sub-Project	**Estimated Cost**	**Potential Partners**	**Priority**
Identify DRBC Support	$3,420	DRBC	High
Identify PA-DEP Support	$3,420	PA-DEP	High
Identify Support of Delaware River Utilities	$3,600	Delaware River water utilities	High
Present Argument to PA-DEP	$3,780	PA-DEP	High
Present Argument to DRBC	$3,150	DRBC	High
Total	**$17,370**		

Table 5.7-2B Climate Change Initiative Details

Climate Change – Salt Line and Water Quality Initiative			
Sub-Project	**Estimated Cost**	**Potential Partners**	**Priority**
Reach out to PDE to express our desire to be included in climate change research	$1,260	PWD, PDE	Medium
Explore partners to fund updated salt line and fresh water flow model that incorporates climate change forecasts	$6,030	PWD, PDE, PA-DEP, EPA Region III, DRBC, NJ-DEP, NY-DEC	Medium
Model Development	$250,000	PWD	Medium
Total Cost	**$257,290**		

Table 5.7-2C Forest Protection Initiative Details

Forest Protection Initiative			
Sub-Project	**Estimated Cost**	**Potential Partners**	**Priority**
White Paper on forest/water quality/flood control relationship	$9,630	PWD	Medium
Create source water protection priority maps for counties	$16,020	PWD, counties	Medium
Facilitate the formation of a regional forest stewardship committee	$4,680	Land Trusts, PA-DEP, DCNR, Counties/Mun.	Medium
Meet with regional forest stewardship committee to discuss forest/water quality/flood control relationship, priority maps, open space plans, and links with Act 167 and E&S controls	$5,760	PA-DEP, DCNR, counties, municipalities	Medium
Meet with DCNR to discuss land purchases and preservation in the name of source water protection	$5,580	DCNR	Medium
Explore funding options for purchasing forested lands	$4,680	Newly established committee	Medium
Initiate a discussion with New York City about their successes and guidance for purchasing land for source water protection	$1,980	NYC DEP	Medium
Total	**$48,330**		

Table 5.7-2D Delaware River Salinity Reduction Initiative Details

Delaware River Salinity Reduction Initiative			
Sub-Project	**Estimated Cost**	**Potential Partners**	**Priority**
Research the fate of sodium in the PWD drinking and waste water treatment plants	$12,420	PWD	Low
Research the contribution of sodium hypochlorite in the PWD systems and in the Study Area	$900	PWD	Low
Quantify the amount of road salt applied throughout the Study Area	$7,200	PennDOT, NJDOT, NYDOT, counties, municipalities	Low
Calculate loading of sodium from all Study Area waste water treatment plants	$900	PWD	Low
Calculate the sub-watershed loading of sodium from the sources identified in previous tasks	$3,600	PWD	Low
Share the research findings with target audiences	$5,580	PA-DEP, NJ-DEP, NYC-DEC, PennDOT, NJDOT, NYDOT	Low
Identify source water protection methods to reduce sodium	$3,600	PWD	Low
Total	**$34,200**		

Table 5.7-2E Early Warning System Expansion Initiative Details

Early Warning System Expansion Initiative			
Sub-Project	**Estimated Cost**	**Potential Partners**	**Priority**
Identify all industrial dischargers and intakes in Study Area and reach out to include them in the EWS	$3,600	PWD, EWS, DRBC	High
Draft a protocol for two way communication between federal terrorism response agencies and the EWS	$5,490	PWD, EWS, DRBC, DHS, CG	High
Install road signage alerting emergency responders to their presence in the drinking water supply	$7,200	PWD, PennDOT, NJDOT, NYDOT	High
Modify the lower Delaware River spill model to incorporate tidal influence	$50,000	PWD, DRBC, EPA, CG, ACE, USGS	Low
Provide EWS members with a time of travel model for the entire Study Area	$5,220	PWD, EWS	High
Total Cost	**$71,510**		

Table 5.7-2F Regional Disinfection Byproduct Precursor Investigation Details

Regional Disinfection Byproduct Precursor Investigation			
Sub-Project	**Estimated Cost**	**Potential Partners**	**Priority**
Perform a literature search of climate change effects on TOC, DOC, UV254, and bromide	$5,400	PWD	Medium
Perform a literature search of land cover change effects on TOC, DOC, UV254, and bromide	$5,400	PWD	Medium
Identify any changes in DBP formation associated with the findings from the literature searches	$14,400	PWD, BLS	Medium
Identify regional sources of TOC, DOC, UV254, and bromide	$3,600	PWD, USGS, EPA Region III, DRBC	Medium
Work with regional partners to enhance the data collection of UV254	$5,220	PWD, EWS, drinking water utilities	Medium
Support the installation of a real time DOC, UV254 meter at Trenton, NJ	$3,600	PWD, USGS	Medium
Total Cost	**$37,620**		

Table 5.7-2G Additional Delaware River Source Water Protection Projects Details

Additional Delaware River Source Water Protection Projects			
Sub-Project	**Estimated Cost**	**Potential Partners**	**Priority**
Research the environmental triggers and sources of taste and odor compounds	$3,600	PWD	Low
Establish pharmaceutical take back program in Philadelphia	$9,090	PWD, EPA Region III	High
Identify the threat of flooding to the Baxter intake	$4,140	PWD	Low
Coordinate with the Delaware River Conservation Plan	$3,600	PWD	Medium
Coordinate with the Tookany/Tacony-Frankford Creek Integrated Watershed Management Plan	$3,600	PWD, TTFWP	Medium
Total Cost	**$24,030**		

**All project partner abbreviations listed below*

Table 5.7-3 Summary of Source Water Protection Initiative Costs

Source Water Protection Initiative	Total Cost	Priority
Enhance and Make Permanent Special Protection Waters Resolution Initiative	$17,370	High
Forest Protection Initiative	$48,330	Medium
Delaware River Salinity Reduction Initiative	$34,200	Low
Climate Change – Salt Line and Water Quality Initiative	$257,290	Medium
Early Warning System Expansion Initiative	$71,510	High
Regional Disinfection Byproduct Precursor Investigation	$37,620	Medium
Additional Delaware River Source Water Protection Projects	$24,030	Low
Total Cost	**$490,350**	

The following Tables 5.7-3A-G include the timeline for data collection and evaluation, planning and design, and implementation of each source water protection initiative sub-project. The time frames are for general guidance and may be subject to change.

Table 5.7-4A Special Protection Waters Resolution Initiative Timeline

Enhance and Make Permanent Special Protection Waters Resolution Initiative						
	Data Collection and Evaluation		Planning and Design		Implementation	
	Start	End	Start	End	Start	End
Identify DRBC Support	Summer 2007	Fall 2007	NA	NA	NA	NA
Identify PA-DEP Support	Summer 2007	Fall 2007	NA	NA	NA	NA
Identify Support of Delaware River Utilities	Summer 2007	Fall 2007	NA	NA	NA	NA
Present Argument to PA-DEP	NA	NA	Fall 2007	Fall 2007	Fall 2007	Winter 2007
Present Argument to DRBC	NA	NA	Fall 2007	Fall 2007	Fall 2007	Winter 2007

NA = Not Applicable

Table 5.7-4B Forest Protection Initiative Timeline

Forest Protection Initiative						
	Data Collection and Evaluation		Planning and Design		Implementation	
	Start	End	Start	End	Start	End
White Paper on forest/water quality/flood control relationship	Summer 2007	Winter 2007	NA	NA	NA	NA
Create source water protection priority maps for counties	NA	NA	NA	NA	Winter 2007	Summer 2008
Facilitate the formation of a regional forest stewardship committee	NA	NA	NA	NA	Winter 2007	Summer 2008
Meet with regional forest stewardship committee to discuss forest/water quality/flood control relationship, priority maps, open space plans, and links with Act 167 and E&S controls	NA	NA	NA	NA	Winter 2007	Summer 2008
Meet with DCNR to discuss land purchases and preservation in the name of source water protection	Fall 2007	Fall 2007	Winter 2007	Winter 2007	NA	NA
Explore funding options for purchasing forested lands	NA	NA	NA	NA	Winter 2007	Winter 2007
Initiate a discussion with New York City about their successes and guidance for purchasing land for source water protection	Fall 2007	Spring 2008	NA	NA	NA	NA

NA = Not Applicable

Table 5.7-4C Delaware River Salinity Reduction Initiative Timeline

Delaware River Salinity Reduction Initiative						
	Data Collection and Evaluation		**Planning and Design**		**Implementation**	
	Start	**End**	**Start**	**End**	**Start**	**End**
Research the fate of sodium in the PWD drinking and waste water treatment plants	Winter 2007	Spring 2008	NA	NA	NA	NA
Research the contribution of sodium hypochlorite in the PWD systems and in the Study Area	Winter 2007	Spring 2008	NA	NA	NA	NA
Quantify the amount of road salt applied throughout the Study Area	Winter 2007	Spring 2008	NA	NA	NA	NA
Calculate loading of sodium from all Study Area waste water treatment plants	Spring 2008	Spring 2008	NA	NA	NA	NA
Calculate the sub-watershed loading of sodium from the sources identified in previous tasks	Spring 2008	Spring 2008	NA	NA	NA	NA
Share the research findings with target audiences	NA	NA	NA	NA	Summer 2008	Summer 2008
Identify source water protection methods to reduce sodium	Fall 2008	Winter 2008	NA	NA	NA	NA

NA = Not Applicable

Table 5.7-4D Climate Change Initiative Timeline

Climate Change – Salt Line and Water Quality Initiative						
	Data Collection and Evaluation		**Planning and Design**		**Implementation**	
	Start	**End**	**Start**	**End**	**Start**	**End**
Reach out to PDE to express our desire to be included in climate change research	NA	NA	NA	NA	Summer 2007	Summer 2007
Explore partners to fund updated salt line and fresh water flow model that incorporates climate change forecasts	Winter 2007	Spring 2008	NA	NA	NA	NA
Model Development	Spring 2008	Spring 2009	NA	NA	NA	NA

NA = Not Applicable

Table 5.7-4E Early Warning System Expansion Initiative Timeline

Early Warning System Expansion Initiative	Data Collection and Evaluation		Planning and Design		Implementation	
	Start	End	Start	End	Start	End
Identify all industrial dischargers and intakes in Study Area and reach out to include them in the EWS	Summer 2007	Summer 2007	NA	NA	NA	NA
Draft a protocol for two way communication between federal terrorism response agencies and the EWS	NA	NA	NA	NA	Fall 2007	Fall 2007
Install road signage alerting emergency responders to their presence in the drinking water supply	NA	NA	Spring 2008	Summer 2008	NA	NA
Modify the lower Delaware River spill model to incorporate tidal influence	NA	NA	Summer 2008	Fall 2008	NA	NA
Provide EWS members with a time of travel model for the entire Study Area	NA	NA	Spring 2008	Spring 2008	Summer 2008	Fall 2008

NA = Not Applicable

Table 5.7-4F Regional Disinfection Byproduct Precursor Investigation Timeline

Regional Disinfection Byproduct Precursor Investigation	Data Collection and Evaluation		Planning and Design		Implementation	
	Start	End	Start	End	Start	End
Perform a literature search of climate change effects on TOC, DOC, UV254, and bromide	Summer 2008	Summer 2008	NA	NA	NA	NA
Perform a literature search of land cover change effects on TOC, DOC, UV254, and bromide	Summer 2008	Summer 2008	NA	NA	NA	NA
Identify any changes in DBP formation associated with the findings from the literature searches	Fall 2008	Spring 2009	NA	NA	NA	NA
Identify regional sources of TOC, DOC, UV254, and bromide	Winter 2008	Summer 2009	NA	NA	NA	NA
Work with regional partners to enhance the data collection of UV254	NA	NA	NA	NA	Summer 2008	Fall 2008
Support the installation of a real time DOC, UV254 meter at Trenton, NJ	NA	NA	NA	NA	Summer 2007	Summer 2007

NA = Not Applicable

Table 5.7-4G Additional Source Water Protection Projects Timeline

Additional Source Water Protection Projects						
	Data Collection and Evaluation		Planning and Design		Implementation	
	Start	End	Start	End	Start	End
Establish pharmaceutical take back program in Philadelphia	Summer 2007	Summer 2007	Fall 2007	Winter 2007	Spring 2008	Fall 2008
Identify the threat of flooding to the Baxter intake	Winter 2007	Spring 2008	NA	NA	NA	NA
Coordinate with the Delaware River Conservation Plan	NA	NA	NA	NA	Fall 2010	Summer 2011
Coordinate with the Tookany/Tacony-Frankford Creek Integrated Watershed Management Plan	NA	NA	NA	NA	Fall 2009	Summer 2010
Research the environmental triggers and sources of taste and odor compounds	Summer 2007	Winter 2008	NA	NA	NA	NA

NA = Not Applicable

Table 5.7-5 Project Partner Abbreviations

ACE	U.S. Army Corps of Engineers
BLS	Bureau of Laboratory Services, Philadelphia Water Department
CG	U.S. Coast Guard
DCNR	Department of Conservation and Natural Resources
DHS	Department of Homeland Security
DRBC	Delaware River Basin Commission
EPA Region III	U.S. Environmental Protection Agency, Region III
NJDEP	New Jersey Department of Environmental Protection
NJDOT	New Jersey Department of Transportation
NLT	Natural Lands Trust
NYC-DEP	New York City Department of Environmental Protection
NYS-DEC	New York Department of Environmental Conservation
NYDOT	New York Department of Transportation
PA-DEP	Pennsylvania Department of Environmental Protection
PennDOT	Pennsylvania Department of Transportation
PDE	Partnership for the Delaware Estuary
PDPH	Philadelphia Department of Public Health
PWD	Philadelphia Water Department
TTFWP	Tookany/Tacony-Frankford Watershed Partnership

Section 6

Funding Sources

6.1 Funding Sources

There are many state, federal, private, and non-profit organizations within the Delaware Valley that offer grant and cost sharing programs for projects that focus on the Delaware River. The sources of funding listed below all have specific goals that all lead to the conservation and preservation of the Delaware River as a natural resource, economic driver, and recreational outlet. These sources represent many well known watershed funding programs, but do not include all sources available. In many cases, the studies and projects listed in Section 5 of this document will be funded through staff hours and in-kind services provided by the Philadelphia Water Department (PWD). PWD may seek supplemental funding from among the below sources to help support implementation.

EPA Clean Water Act – Section 319 Grants

The Clean Water Act Section 319 Grants are distributed from the Environmental Protection Agency (EPA) to each state. Pennsylvania funds are then distributed through the competitive grant process of the Growing Greener Program, further described below. Smaller size grants derived from Section 319 funding are distributed through the Pennsylvania Association of Conservation Districts. These self described mini-grants are for amounts up to $2,500, and are awarded to watershed groups who partner with Pennsylvania conservation districts to increase local awareness of non-point source pollution.

EPA Targeted Watersheds Grant Program

The annual EPA Targeted Watersheds Grant Program disperses grants near one million dollars to multiple watershed programs throughout the country. Award applications, which must have approval of the state governor, are evaluated based on innovation, measurement of environmental results, broad support, active involvement of more than one governmental entity, and breadth of the outreach program. Applications which adhere most to these tenets, and which therefore demonstrate the most promising watershed-based approaches to water quality, are selected as award recipients. Grants stipulate how funds are spent, and the short term and long term results expected. In 2004 the Schuylkill Action Network was awarded a grant in excess of $1 million. The Schuylkill River is a major tributary to the Delaware River, but just south of the Delaware source water study area zones A and B.

National Fish and Wildlife Foundation

The National Fish and Wildlife Foundation, NFWF, is a non-profit organization that dedicates its work to the conservation of habitat for fish, wildlife, and plant species. The NFWF provides matching grants to organizations that invest in conservation and sustainability. In 2006 the NFWF re-offered a special grant series titled the Delaware Estuary Watershed Grants Program. This program included $800,000 for projects that aimed to restore fish and wildlife habitat, shoreline and littoral habitat, fish passages and shellfish, horseshoe crab and shorebird habitat, and support watershed planning and stewardship. In previous years the Delaware Estuary Watershed Grant Program spent in total over $8 million in grant and matched funding on projects. The range of this program reaches from Trenton, NJ south to the head of the Delaware Bay at Cape Henlopen, DE.

Natural Resource Conservation Service – Conservation Reserve Program

The Natural Resource Conservation Service – Conservation Reserve Program (CRP) is an extension of the U.S. Department of Agriculture. This program provides funding to farmers interested in improving the water quality of streams adjacent to their land, enhancing wildlife habitat, as well as reducing erosion of valuable top soil. The CRP provides grant and cost sharing options that benefit source water quality such as installing riparian buffers, filter-strips, and convert eroding land into vegetative cover.

Natural Resource Conservation Service – Environmental Quality Incentives Program

The Natural Resource Conservation Service – Environmental Quality Incentives Program (EQIP) is an extension of the U.S. Department of Agriculture. EQIP provides cost sharing funds for conservation practices that are voluntarily installed on farms and ranches. The conservation practices aim to improve water quality and quantity, erosion and sediment control, reduce non-point source pollution, and improve grazing land.

Partnership for the Delaware Estuary

The Partnership for the Delaware Estuary, PDE, is a non-profit organization that is one of 28 National Estuary Programs. PDE implements the goals and recommendations of the Comprehensive Conservation and Management Plan written in 1996 as a requirement of the National Estuary Program. During 2006, PDE funded a study by the

University of Maryland's Environmental Finance Center to investigate the feasibility of a regional funding and financing entity for scientific research and the protection and restoration of the Delaware Watershed. The recommendations of the study were to assemble a regional financing strategy and task force comprised of legislators and other decision-makers to ensure implementation of fee based programs such as docking and piloting fees. Such programs could introduce significant income for implementing priority projects in the watershed.

Pennsylvania Department of Conservation and Natural Resources

The Pennsylvania Department of Conservation and Natural Resources, DCNR, Community Conservation Partnerships Program joins non-profit, private, and municipal organizations behind the goal of conserving the natural and cultural heritage of Pennsylvania. The DCNR offers multiple grants, training, technical assistance, and information exchange programs through the Community Conservation Partnerships Program. The multiple programs can be used to fund source water protection activities such as open space planning and management, land acquisition, conservation, and watershed organization development.

Pennsylvania DEP - Coastal Zone Management Program

The Pennsylvania Department of Environmental Protection's Coastal Zone Management Program, CZM, implements management program policies in the Pennsylvania coastal regions on the Delaware River and Lake Erie. The CZM program policies focus on coastal hazards, dredging and spill disposal, fisheries management, wetlands, port activities, historic site protection, energy facilities sites, intergovernmental coordination, public involvement, ocean resources, and public access to recreation. In 2006, over $350,000 in grants were awarded for projects located within the Delaware source water study area zones A and B.

Pennsylvania DEP - Growing Greener

Pennsylvania's Growing Greener Program, signed into law by Governor Tom Ridge in 1999, committed approximately $650 million over a period of five years toward preserving farmland and open space, cleaning up abandoned mines and restoring watersheds, and providing new and upgraded water and sewage systems. In June 2002, Governor Mark Schweiker extended the growing greener program through 2012. As a means to not only supplement the Growing Greener Fund, but also expand it, Governor Edward Rendell has proposed the Growing Greener II program. Growing Greener II contains $625 million to be spent over six years. The proposed spending would be funded by raising fees on garbage dumping, adding a dumping fee on industrial waste, and adding a fee on release of toxic chemicals to the environment. In light of Growing Greener's past history supporting watershed restoration projects, and of the governor's newly expanded program, the competitive Growing Greener grants are an ideal source of funding for projects within the Delaware River watershed in Pennsylvania. Grants are expected to be distributed once per year in amounts ranging from approximately $4,000 to over $1,000,000.

Pennsylvania Fish and Boat Commission

The Pennsylvania Fish and Boat Commission, FBC, is a state agency with the mission to provide Pennsylvania citizens with fishing and boating opportunities through the protection and management of aquatic resources. The FBC has multiple grant opportunities that relate to source water protection. The Landowner Incentive Program, Sport Fishing and Aquatic Resource Education Grant Program, and state Wildlife Grants all can protect drinking water resources through land acquisition, education and outreach, restoration, conservation, and research. The FBC is currently funding the Academy of Natural Sciences in Philadelphia to study the American Eel in Pennsylvania tributaries to the Delaware River.

Pennsylvania League of Women Voters – Water Resources Education Network

The Water Resources Education Network, WREN, is sponsored by the Pennsylvania League of Women Voters. The WREN offers grants to individuals and organizations that carry out educational projects that protect community drinking water sources. WREN also provides scholarship money to individuals who want to attend conferences or classes that will provide training related to water resource education and management.

William Penn Foundation

The funding goal of the William Penn Foundation is "to promote vital communities within a healthy regional ecosystem". The Foundation works to meet this goal by providing funds to improve the region's watershed resources through land preservation, policy development, and the implementation and construction of various demonstration projects. The William Penn Foundation has long recognized the importance of the Delaware River watershed within the Philadelphia Region. Within 2005 and 2006, the Foundation granted over $15 million in funding for land acquisition, conservation, watershed organization development, policy and planning projects in the watershed.

Table 6.1-1 Funding Sources

Organization and Special Grant Program		Website
Environmental Protection Agency		
	Targeted Watershed Grants	http://www.epa.gov/twg/index.html
National Fish and Wildlife Foundation		
	Delaware Estuary Watershed Grant Program	www.nfwf.org
Natural Resources Conservation Service		
	Conservation Reserve Program	http://www.nrcs.usda.gov/programs/crp/
	Environmental Quality Initiatives Program	http://www.nrcs.usda.gov/programs/eqip/
Partnership for the Delaware Estuary		http://www.delawareestuary.org/
PA Association of Conservation Districts		
	Section 319 Grants	http://www.pacd.org/products/
PA Department of Conservation and Natural Resources		
	Community Conservation Partnerships Program	http://www.dcnr.state.pa.us/
PA Department of Environmental Protection		
PA DEP	Coastal Zone Management	http://www.dep.state.pa.us/river/sec309.htm
PA DEP	Growing Greener	http://www.depweb.state.pa.us/growinggreener
PA DEP	Section 319 Grants	http://www.depweb.state.pa.us/growinggreener
PA Fish and Boat Commission		
	Landowner Incentive Program, Sport Fishing and Aquatic Resource Education Grant Program, State Wildlife Grants	http://www.fish.state.pa.us/
PA League of Women Voters		
	WREN	http://www.pa.lwv.org/wren/index.html
William Penn Foundation		
	Environment and Communities	http://www.williampennfoundation.org/

Section 7

Public Participation and Outreach

7.1 Introduction

A strong public participation and outreach program is instrumental in the successful implementation of this protection plan. In order to effectively address public participation and outreach, the Philadelphia Water Department (PWD) implemented a ten part approach:

1. PWD Citizen's Advisory Council
2. Poquessing Creek Watershed Steering Committee
3. Neshaminy Creek Watershed Steering Committee
4. PWD Water Quality Committee
5. Delaware Valley Early Warning System Steering Committee
6. Delaware Estuary Program Estuary Implementation Committee
7. Delaware Regional Water Resources Committee
8. PWD Watershed Information Center
9. Partnership for the Delaware Estuary Workshops
10. Fairmount Water Works Interpretive Center

The goals of this approach are two-fold. The first is to seek public input on the Delaware Source Water Protection plan. Central to this goal is to provide education on threats to the Delaware River, seek input on actions PWD is taking to address those threats, and encourage audiences to take their own actions to protect this important resource. The second is to engage, get input from, and generate support for the plan among water system users, community leaders, landowners, government agency representatives and other critical decision-makers in the watershed.

PWD Citizens Advisory Committee

PWD's Citizens Advisory Committee (CAC) is the first of several means to access public input into the protection plan. The CAC, whose meetings and activities are facilitated by the Partnership for the Delaware Estuary (PDE), includes representatives from environmental and community organizations, concerned citizens and business owners, and public agencies, including the Pennsylvania Department of Environmental Protection (PA-DEP) and Philadelphia Department of Public Health (PDPH). The Chairman of the CAC is Drew Brown, and he can be reached at (215) 685-6098. The CAC was formed by PWD as part of a commitment by the agency to develop a public education and participation program to focus attention on stormwater runoff pollution prevention. Meetings are held quarterly at various locations in Philadelphia. The general public is notified of the meeting place and time via local newspapers and new members are always encouraged to attend.

The CAC was presented with the Delaware Source Water Protection Plan in April 2007. The committee identified that its main concern was the presence of pharmaceuticals in the water supply. PWD is exploring ways to return unwanted medications, including educating long-term health care facilities about proper disposal techniques, and utilizing household hazardous waste return drives or drop-off boxes at pharmacies for returning unwanted medications. The committee offered to help raise awareness and participate in any campaigns PWD is designing to remove pharmaceuticals from the water supply.

The CAC itself conducts numerous activities that help encourage good practices for helping protect the water supply in the Delaware River.

The purpose of the CAC is twofold:

1) Encourage changes in individual behavior that will improve surface-water quality

2) Develop an informed citizenry that will support City-proposed water quality improvement programs needed to comply with state and federal regulations

The CAC's target audiences include:

- Businesses contributing to stormwater pollution, such as building contractors, landscapers, and automobile repair shops;
- Government agencies and non-profit groups interested in clean water, such as watershed and environmental groups, estuary programs, and environmental organizations;
- Institutions well positioned to deliver behavior-changing messages to their constituencies and the general public, such as the Philadelphia Zoo, the Franklin Institute, and the Academy of Natural Sciences.

- The transportation sector, including SEPTA, PennDOT, and organizations involving motor vehicle owner interests; and

- School District of Philadelphia, universities, colleges, and other academic institutions.

The CAC implements its goals by targeting its programs to specific audiences. Examples of these programs include the following educational initiatives:

Earth Day Storm Drain Marking Project – Held annually for eight years, this program identifies volunteers who are willing to adopt storm drains, which they, with support from PWD, will maintain on an ongoing basis.

Annual "Clean Water Begins & Ends with You" Drawing Contest – The CAC annually coordinates a drawing contest for all Philadelphia students in grades K-12. The winning drawings are published in a calendar and printed on car-card advertisements that are posted on SEPTA buses and subway cars usually during the month of April. The winning students are recognized at an awards ceremony.

Water Education Resource Guide –This guide, which currently includes 102 organizations that offer water-related education information and programs, is updated and expanded annually.

Philadelphia Flower Show – The CAC works with PWD to develop the theme for an exhibit at the annual Philadelphia Flower Show.

Coast Day – PWD and the CAC take a leadership role in planning the annual Pennsylvania Coast Day Celebration, which takes place in the fall at the Fairmount Water Works.

Poquessing Creek Watershed Partnership Steering Committee

The Poquessing Creek watershed was identified by the Source Water Assessments as a major contributor of stormwater runoff in close proximity to the Baxter Water Treatment Plant. In order to gauge public reaction to the protection plan and seek feedback from major decision-makers in this priority watershed, PWD presented the plan to the Poquessing Creek Watershed Partnership Steering Committee (PCWPSC).

The Poquessing Creek Watershed Partnership was created during the Poquessing Creek River Conservation Plan development process in March 2005. A Steering Committee for the partnership was convened quarterly to lead the development of the River Conservation Plan. The PCWPSC is composed of representatives from local organizations, businesses, and municipalities. The Steering Committee invites the public to all meetings. The representative members of the PCWPSC are listed below in

Table 7.1-1. The PCWPSC is chaired by Joanne Dahme of the Philadelphia Water Department.

Table 7.1-1 Poquessing Creek Watershed Partnership

Poquessing Creek Watershed Partnership Steering Committee		
Lower Southampton EAC	Bensalem Township	Bucks County Planning Commission
Philadelphia Water Department	Friends of the Poquessing	Brandywine Realty Trust
Northeast Philadelphia Airport	Benjamin Rush State Park	Forbes Environmental Consulting
Northeast Philadelphia Trail Association	PA House of Representatives	Pennsylvania Environmental Council
Fairmount Park Commission	Northeast Philadelphia Radio Control Club	Philadelphia City Planning

The PCWPSC was presented with the findings and preliminary recommendations of this protection plan in April 2007 at a Sense of Place workshop hosted with the Partnership for the Delaware Estuary. The feedback centered on integrating source water protection with local interests. The group expressed a desire to participate in any local programs that would originate from the Delaware Source Water Protection Plan. The group also supported the concerns identified in the plan related to the health effects of sodium in drinking water. Members of the audience closely watched their sodium intake and agreed with the need for an initiative to keep sodium levels in drinking water low.

Lower Neshaminy Creek Watershed Steering Committee

The Delaware River Source Water Assessment Sections 1 and 2, as well as the water quality analysis in this document, identified the Neshaminy Creek watershed as a high priority area due to large amounts of point and non-point source pollution. Given the high priority assigned to the Neshaminy, PWD sought to conduct outreach in this watershed to access input on the plan from major decision makers and the public. To conduct this outreach, PWD will present plan findings and request input from the Lower Neshaminy Creek Steering Committee in June 2007.

The Lower Neshaminy Creek Steering Committee was created in July 2002 during the development of the Neshaminy Creek River Conservation Plans, and the committee remains active today in order to implement planned improvements to the watershed. The Steering Committee is composed of representatives from the entire Neshaminy Creek watershed. The meeting in June to present the plan will be advertised to the public. The Steering Committee is chaired by Susan Myerov of the Heritage Conservancy.

Table 7.1-2 Lower Neshaminy Creek Watershed Steering Committee

Lower Neshaminy Creek Watershed Steering Committee		
Langhorne Manor Borough	Neshaminy Floodwater Association	Hulmeville Borough
Bucks County Planning Commission	Upper Southampton Township	Bucks County Conservation District
Langhorne Borough	Middletown Township	CKS Engineering
Aqua America Water Company	Northampton Township	Lower Southampton Township
Pennsylvania Environmental Council	Bucks County Parks and Recreation	Langhorne Open Space Inc.

PWD Water Quality Committee

To support communication with major internal decision-makers, plan findings were presented to the PWD Water Quality Committee. The Water Quality Committee includes representatives from a variety of PWD divisions and units, including: Water Treatment, Distribution, Bureau of Laboratory Services, Wastewater Treatment, Collector Systems, Planning and Research, Office of Watersheds, and Public Affairs. The committee was formed in 1995 with the mission to ensure better communications regarding potential water quality and customer communication. The committee has tackled many projects over the years, the largest one being the development of a "Microbial Action Plan" and was instrumental in the creation of the department's Safe Drinking Water Act mandated Consumer Confidence Report. The Water Quality Committee works in partnership with PWD's Citizens Advisory Committee to develop customer information that is consumer friendly and relevant. The committee is currently chaired by Ed Grusheski, Public Affairs Manager, and meets on a monthly basis.

The Delaware Source Water Protection Plan was presented to the Water Quality Committee in April 2007. The committee suggested a study of sodium and the role of sodium hypochlorite disinfection within the Philadelphia Water Department utility system prior to launching an investigation of sodium sources within the Delaware River watershed. The committee offered to facilitate this research effort and expressed interest in the results. The Water Quality Committee also recommended we bring attention to the efforts of the Smart Growth Alliance, Highlands Coalition, and the 10,000 Friends Report that highlights the cost of sprawl development.

Delaware Valley Early Warning System Steering Committee

The next three outreach venues provided opportunities to present the plan to water suppliers, planners, public agencies, and other important players whose decisions and actions affect the entire Delaware River watershed.

The Delaware Valley Early Warning System (EWS) is an integrated monitoring, notification, and communication system designed to provide advance warning of surface water contamination events in the Schuylkill and lower Delaware River watersheds. The EWS Steering Committee includes representatives from all water suppliers in the Delaware Basin served by the network, as well as advisors from state and federal agencies. Input from this committee on the plan is critical given its role in source water quality protection and emergency response in the Delaware River watershed.

The EWS Steering Committee was presented with the preliminary findings of the Delaware River Source Water Protection Plan in April 2007. During and following the presentation, many suggestions were given for how best to approach the need for forest protection in the watershed. Recommendations included linking forest loss to increased flooding since flooding issues currently have congressional attention, advocating for forest protection by outlining multiple shared benefits, and raising water quality concerns with PA-DEP in order to support the permanence of Delaware River Basin Commission Special Protection Waters.

EWS Steering Committee advisors and members are listed in Table 7.1-3. The EWS Steering Committee is chaired by Jason Hunt of the Philadelphia Water Department.

Table 7.1-3 Delaware Valley Early Warning System Steering Committee

Delaware Valley EWS Steering Committee Advisors		
Pennsylvania Department of Environmental Protection	New Jersey Department of Environmental Protection	Coast Guard
U.S. Geologic Survey	Delaware River Basin Commission	Environmental Protection Agency, Region III

Delaware Valley EWS Steering Committee Members		
Philadelphia Water Department	New Jersey American Water Company	Pennsylvania American Water Company
Pennsylvania Power and Light	Trenton Water Works	Aqua Pennsylvania
Morrisville Municipal Authority	New Jersey Water and Sewer Authority	Middlesex Water Company
American Water Security	Chester County Health Department	Bucks County Health Department
Reading Area Water and Sewer Authority	Western Berks Water Authority	Camp, Dresser, and McKee
Pottstown Borough Water Authority	Phoenixville Municipal Water Works	Easton Suburban Water Authority
Pennsylvania Power and Light	Montgomery County Health Department	Lower Bucks County Joint Municipal Authority

Delaware Estuary Program Estuary Implementation Committee

The Delaware Estuary Program Estuary Implementation Committee coordinates implementation of the Comprehensive Conservation and Management Plan for the Delaware River Estuary. The Estuary Implementation Committee plays a critical role in the direction and success of the Delaware Estuary Program. The Delaware Estuary Program is one of twenty-eight National Estuary Programs designed to improve the quality of estuaries of national significance.

The Delaware Estuary Program coordinates a network of regional partners who all strive to enhance the quality and profile of the Delaware Estuary. The Estuary Implementation Committee is composed of multiple state and federal agency representatives, who represent various interests within the Delaware Valley region. The members of the Estuary Implementation Committee are listed below in Table 7.1-4. The Implementation Committee is chaired by Kathy Klein of the Partnership for the Delaware Estuary.

Table 7.1-4 Estuary Implementation Committee

Delaware Estuary Program Estuary Implementation Committee		
U.S. Fish and Wildlife Service	National Park Service	Delaware Department of Natural Resources and Environmental Control
Pennsylvania Department of Environmental Protection	New Jersey Department of Environmental Protection	Partnership for the Delaware Estuary
Environmental Protection Agency, Region III	Environmental Protection Agency, Region II	Philadelphia Water Department
U.S. Geologic Survey	Delaware River Basin Commission	

The Estuary Implementation Committee meets quarterly at the offices of the Partnership for the Delaware Estuary in Wilmington, Delaware. In April 2007 the committee was presented with the findings and preliminary recommendations of the Delaware Source Water Protection Plan. The presentation of the plan initiated a broad discussion of the relationship between land cover and water quality. All agencies and organizations on the Estuary Implementation Committee shared equal concern about the threat to water quality of urban/suburban sprawl and the loss of natural resources.

Delaware Regional Water Resources Committee (DRWRC)

The Delaware Regional Water Resources Committee (DRWRC) is composed of drinking water utility representatives, the Pennsylvania Department of Environmental Protection, the Delaware River Basin Commission, regional universities, environmental organizations, counties, and municipalities. The priorities of the DRWRC are to maintain an adequate and reliable supply of water for human and ecological needs, integrate the management of land and water resources to increase the quality of life in the Delaware River Basin, manage the waterway corridors, facilitate cooperation between institutions with competing water resource interests, and increase the education and involvement of the public in water resources stewardship.

On Friday May 11, 2007, the DRWRC was presented with the major findings of the Delaware Source Water Protection Plan. The presentation was designed to draw the attention of the committee to the current and future source water concerns that are directly related to regional environmental policy. The discussion focused on the importance of maintaining the salt line through minimum flow requirements and reservoir releases, the critical need for a new salt line model that accounts for climate change effects on fresh water flow and sea level rise, a re-examination of DRBC resolutions to ensure they are adequate to control the salt line under climate change conditions, the need for year round disinfection of all waste water treatment plants, and the critical need for forest protection ordinances in regional and state policy.

The DRWRC held a brief discussion of the policy suggestions offered by the Philadelphia Water Department. Many members were open to the idea that the salt line will need to be modeled under climate change conditions in order to address if current minimum flow and reservoir release policies are adequate to protect the water supply of Philadelphia from salt water intrusion. The presentation also helped to raise concerns the Philadelphia Water Department has regarding the discharge from waste water treatment plants and the spread of *Cryptosporidium*.

PWD's Watershed Information Center

In order to facilitate public access to documents and information, PWD developed a web-based "Watershed Information Center" in 2006. The Center is a regional resource of Southeastern Pennsylvania watershed-related information that centrally locates technical, management, and administrative tools and capabilities to support those involved in watershed planning. The Watershed Information Center offers the public easy access to information about PWD's programs and activities, many of which address the findings of its source water assessments and protection plans. A copy of the Delaware Rive Source Water Protection Plan will be available to the public on in the Watershed Information Center, located at www.PhillyRiverInfo.org and www.SoutheastPARiverInfo.org.

Partnership for the Delaware Estuary Workshops

In support of its outreach goals, PWD hired the Partnership for the Delaware Estuary, Inc., (PDE) to conduct several source water oriented educational workshops. The workshops, which were conducted in the Pennypack, Poquessing, and Neshaminy watersheds, set out to inform local schools, businesses and non-profits of inexpensive programs that teach land management practices to help protect water quality. These programs include:

Clean Water Partners – Clean Water Partners (CWP) is a program that educates small to medium-sized businesses about the types of best management practices that can be implemented on their sites to reduce non-point source pollution. CWP is a voluntary, non-regulatory program. With funding from Growing Greener, the Partnership piloted CWP in West Whiteland Township in Chester County and in the Roxborough and Chinatown neighborhoods in the City of Philadelphia involving more than 30 businesses. The program is currently being expanded to include municipalities throughout the Delaware River watershed.

Sense of Place - Sense of Place demonstrates the value of conservation partnerships between nonprofits, municipalities, and schools. The project has provided a model for a watershed approach to land management by controlling invasive plants, reducing pesticide and fertilizer use, and improving wildlife habitat, thereby reducing the negative impacts of stormwater runoff on our waterways.

Corporate Environmental Stewardship - The Corporate Environmental Stewardship program provides corporations and industry with the technical expertise necessary to properly manage and enhance their company's property. This program has assisted corporations in restoring wetlands, protecting fish and wildlife habitat, preserving open space, and protecting water quality.

Fairmount Water Works Interpretive Center

The Fairmount Water Works Interpretive Center, a program under the Philadelphia Water Department, opened in fall 2003. The 9,000 square feet facility is located at river level on the Schuylkill and highlights education exhibits under the topic, "Water is Our World." Through the various exhibits, visitors learn about their role in reducing non-point source pollution and achieving the goal of fishable and swimmable water quality. Since its inception in 2003 the center has received over 100,000 visitors.

Exhibits at the Fairmount Water Works Interpretive Center highlight the important role of source water protection in maintaining a high quality drinking water supply, as well as actions audiences can take to protect and improve water quality.

Section 8

Delaware Valley Early Warning System

8.1 Background

The Delaware Valley Early Warning System (EWS) is an integrated monitoring, notification, and communication system designed to provide advance warning of surface water contamination events in the Schuylkill and lower Delaware River watersheds. The EWS was developed in 2002 with funding provided by the Pennsylvania Department of Environmental Protection (PA-DEP) and the United States Environmental Protection Agency (EPA) and was deployed as a fully functional system in 2004. The Philadelphia Water Department (PWD) initiated the development of the EWS after identifying the need for such a system while collaborating with upstream treatment plant operators during the completion of the Source Water Assessments for the Schuylkill and Lower Delaware Rivers between 1998 and 2000. The Delaware Valley EWS covers the entire length of the Schuylkill River as well as the Delaware River from Chester, PA (just downstream of Philadelphia) to the New York state border.

8.2 Delaware Valley Early Warning System

A key recommendation of the Source Water Assessments for the Delaware River was to develop a watershed-wide Early Warning Monitoring Network to provide early detection and notification of discharges to or changes in the quality of the surface water supply. PWD pursued this recommendation, and in 2002 and 2003, developed the EWS.

The EWS is comprised of 4 principal components; the EWS Partnership, the notification system, the monitoring network, and the web-based database and portal. The EWS Partnership is comprised of stakeholders and includes representatives from both public and private drinking water treatment plants in the coverage area, industries who withdraw water from the Schuylkill and Delaware rivers for daily operations, and representatives of government agencies from both PA and NJ. The notification system includes both automated telephone notification and web-based notification capabilities. The monitoring network is comprised of on-line water quality and flow monitoring stations located at USGS sites and water treatment plant intakes throughout both watersheds. The web-site and database portal are the backbone of the EWS and are fully integrated with the notification system and monitoring network.

The telephone notification system is a powerful tool that allows a caller to initiate emergency notifications to multiple recipients through a single call. The system accepts calls from emergency responders, water utility personnel, and municipal and industrial dischargers. The system records event information provided via touch-tone responses to a standard question and answer process, and makes telephone and email notifications to affected EWS participants. This automated process reduces the burden on the emergency responders and other information providers by providing multiple and redundant calls to system participants, and also reduces the possibility that a notification could get lost or mis-routed.

The EWS website provides a dynamic and interactive user interface to the EWS database, allowing users to access and share event and water quality information via the internet. Various user interface formats are available, including forms for reporting and viewing the details of a water quality event, maps to identify the location of an event, graphs that present water quality, and a time of travel estimator. The time of travel estimator uses real-time flow data from USGS gauging stations to provide plug-flow travel time estimates for each downstream intake based on current river conditions. These tools allow PWD and the other water purveyors within the Schuylkill and Delaware River watersheds to be more informed about water quality throughout the watershed and thereby be better prepared to react to changing or emergency conditions.

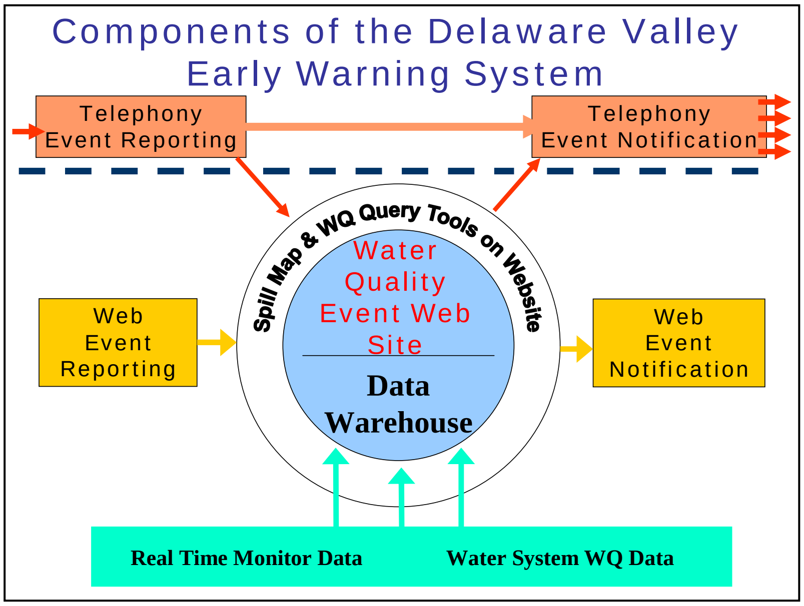
The water quality monitoring network compiles both near real-time and historic water quality data. The near real-time network utilizes continuous water quality monitors that are located at select water treatment plant intakes and USGS gauging stations and transmits data collected at those locations to the EWS server, thus making the data accessible via the website. The water quality monitoring network provides water suppliers with near real-time information about water quality upstream of their intakes so that they can anticipate changes in water quality and adjust their treatment accordingly. Real-time monitoring is currently limited to simple water quality parameters such as turbidity and pH, but the network will be expanded in future years as monitoring technologies advance and as other monitoring needs are identified. In addition to the near real-time data, utilities will submit the results of their routine operational monitoring, creating a historical database against which real-time data can be compared. The system has the potential to incorporate sophisticated monitoring equipment like gas chromatographs and bio-monitors that can detect changes in water quality that might result from major discharges or intentional contamination.

One of the unique features of the Delaware Valley EWS is that the system operates essentially unmanned. Once an event is reported via telephone or the Internet, the system will automatically perform the time-of-travel estimations, and notify downstream users. System users can then report updates and additional information on the website as the event develops.

8.3 Early Warning System Protocol

The EWS can be used to fulfill several different source water protection needs. First and foremost, it is a communication and notification system that emergency response personnel and water suppliers can use to share information about source water contamination events. Second, it provides access to water quality data throughout the watershed thus alerting water suppliers to a change in water quality long before it reaches their intake. In the future, dischargers will be encouraged (preferably required) to use the EWS to make downstream notifications of overflows, spills and accidental discharges. The technical features of the EWS are illustrated in Figure 8.3-1 and described in detail below.

Figure 8.3-1 Components of the Early Warning System



Emergency response personnel and water suppliers often observe a water quality event or are notified by the public. A water quality event can be anything from a transportation accident, to a fire, to a sewage overflow, to illegal dumping, which results in a discharge to the river or sewer system. Upon being made aware of and confirming an event the responding party can use the EWS to notify downstream users by calling the EWS telephone notification system or by reporting the event to the EWS website (www.DelawareValleyEWS.org). In reporting the event, the responding party will supply information about the time, location, risk level, cause, and result of the event. The EWS uses the location information to identify the appropriate parties to notify. The system currently determines whether the event occurred in the Schuylkill or Delaware watershed and notifies all participating water suppliers, emergency response personnel and agencies within that watershed. In the near-future, the system will use location information to identify and notify only those participants downstream of the event. Notifications are made by phone for high risk events or by email for lower risk events (additional flexibility for notifications is a future goal of the system). If a telephone notification is delivered, the notification consists of a standard message that informs the recipient that a water quality event has occurred followed by specific information about time and location of the event and, if available, a message from the reporting party. If an email notification is sent, the email message contains critical information including the time, location and description of the event, and advises the recipient to go to the web-site for additional information. The recipient of the notification will then either call the telephone system or log onto the website to receive more information. The web-site will have an event report with all of the information that the responding party provided. The web-site also has a time-of-travel estimator that uses real-time USGS flow data to estimate the time at which the contaminant will arrive at the downstream intakes.

Downstream water suppliers can also access water quality data associated with the event. The water suppliers can use the time-of-travel and water quality information to plan their response strategies. As the event progresses, the information provided on the web-site can be updated by the initiator of the report or by other participants as they learn more about the event. In this way, the water supply community can communicate and be kept abreast of the event as it unfolds. All of this occurs in a secure environment.

The EWS water quality monitoring network collects continuous water quality data from select drinking water intakes along the main stem Delaware River and transmits that information to the EWS server, thus making it available to the EWS participants via the EWS web-site. Currently, there are three water quality monitoring stations in the Delaware River watershed EWS monitoring network. In the Delaware River watershed there are fourteen participating water suppliers. Water suppliers can log on to the EWS web-site on a daily basis to see water quality information from these locations, which span from Easton, Pennsylvania to Philadelphia. This type of analysis will allow water suppliers to identify changes in water quality associated with both natural and accidental contamination events. For example, storm events and algae events are two naturally occurring events that will impact the water treatment process. Fortunately, both are easily identifiable using simple on-line monitors like turbidity and pH. A downstream utility can track changes in these parameters and know when they need to initiate a treatment process change in order to effectively treat the water. Similarly, significant accidental spills to the river may be detected in through changes in pH or conductivity. The EWS water quality monitoring network will allow water suppliers to be more proactive, rather than reactive when it comes to responding to changes in water quality.

PWD worked closely with PA-DEP's Emergency Response team in the development of the EWS. During this process both PWD and PA-DEP agreed that one of the mutual goals is to have dischargers add the EWS to their downstream notification list. In this way PWD could insure that downstream water suppliers receive information about overflows, spills and accidental discharges. PWD is in the process of working with PA-DEP to make this happen. This will likely necessitate DEP incorporating the EWS into the dischargers' permit requirements. If such a requirement is implemented, the discharger would call the EWS telephone system or enter the event into the EWS web-site to initiate downstream notifications. Having dischargers contact the EWS directly will increase the number and geographic diversity of downstream notifications with just a single phone call.

The Delaware Valley EWS has tremendous potential to reduce the time in which water suppliers become aware of and react to water quality events of all kinds. The system is a tool designed to help water suppliers respond to the accidental, terrorist and natural water quality events that cannot be prevented by standard source water protection measures. In this way, the EWS is a perfect complement to a well developed source water protection program.

Section 9

Contingency Planning

Contaminant Response Plans for Accidental or Deliberate Release into Source or Potable Waters

9.1 Introduction

Effective response to the threat of contamination to potable water from chemical, biological or radiological agents is a major concern to the Philadelphia Water Department. The Philadelphia Water Department has contingency plans in place to protect the Baxter Water Treatment Plant in the event of an accidental or deliberate contamination. The guidelines and actions presented here in the contingency plan incorporate these concerns into an action plan for water pollution events. The objective of this document is to provide a comprehensive response plan for water plant operators and managers. The previous section discussed the Delaware Valley Early Warning System. The plans and protocols in this section are the response of the Philadelphia Water Department to a threat identified through the Early Warning System or other emergency channels.

9.2 Definition of Pollution Events Affecting Drinking Water

Accidental, Non-significant Pollution Event- water contamination affecting PWD's drinking source water or process water which results from an accidental release of any material which has no measurable impact upon finished water quality (i.e., incidental contamination of source water resulting from a boating or vehicle traffic accident). After a determination is made, the response involves routine plant notification and control laboratory monitoring.

Accidental, Significant Pollution Event- water contamination affecting PWD's drinking source water or process water which results from an accidental release of any material which has a likely and detectable impact upon finished water quality. A treatment process response to mitigate any water quality impact is expected. These may include the application of powdered activated carbon, the chlorination of the raw water basin intake or the shutdown of a plant's intake to allow for the passage of the contaminant. Examples of this type of incident include the release of significant quantities of a contaminant resulting from a tank truck traffic accident or the runoff from an industrial fire. After a determination is made, a response requires routine plant notification and control laboratory monitoring of process and source waters. An appropriate response also requires water treatment mitigation, immediate notification to the affected facility and communication to PWD management. The Industrial Waste Unit (IWU) should be notified of the source water contamination incident. IWU is expected to conduct a source water investigation and to assure that the proper steps are taken to halt any continuing pollution and to reduce the levels of released contaminants.

Deliberate Contamination Event- water contamination affecting PWD's drinking source water or process water which results from a deliberate act to contaminate the drinking water supply or to disrupt the water treatment process. This determination will be complex and difficult since the judgment refers to the intent of the polluter. As an example, this category does not include the deliberate release of several quarts of motor oil into a storm sewer inlet. However, the discharge of a much larger amount of oil into a storm sewer, in the vicinity of a water intake structure or into a water plant basin or tank would be considered a deliberate act. Clearly, any contaminant introduced into a treatment plant where the source is neither from natural sources, nor can be explained as an accidental in-plant spill should be considered a deliberate event. The intent of the polluter who introduces a contaminant into the source water is more difficult to determine. Heretofore, all source water contamination events have been considered accidents. For a contamination event to be considered deliberate it must contain certain elements; the type, amount or concentration of the contaminants likely to affect finished water quality, and the absence of any reasonable physical evidence to explain the source and location of the contaminant other than a deliberate act. Credible reports (see definition later in this document) of an individual observed to release materials around a water intake would be included as a deliberate act. General and specific water treatment process options for credible threats are also presented in this document. Until proven otherwise, the initial assumption should be that the impact of the contaminant release is significant. An appropriate response requires water treatment plant mitigation, including the immediate notification of the affected facility; the immediate interruption of routine plant operations until the incident is assessed; an investigation by IWU and communication to PWD management, the Philadelphia Police Department and the PA-DEP. Source water and process monitoring must be initiated immediately.

9.3 Informational Source of Contamination or Future Threat

Code: HC-high credibility, UC-unassigned credibility

HC Visual evidence of a substance release (i.e., containers observed in water, other sensory determination based on sheen, particles, color, odor)

HC Confirmation of river contamination communicated from an upstream utility

HC Information from Philadelphia Health Department of a waterborne illness in the community

HC Visual observation by a reliable source (i.e., PWD employee, Police) of a substance being released

HC Analytical detection of contamination by a Water Treatment Plant (WTP)or Bureau of Laboratory Sciences (BLS) laboratory

UC Report, by a questionable source (i.e., anonymous phone call), of a visual observation of a substance release

UC Referral to PWD via phone from city, state or federal agencies of threat of contamination

UC General information from Police, FBI or other similar agencies of a future threat

9.4 Investigative and Communication Actions

Codes:

1. Perform for all sources

2. Perform whenever contaminant has, or will, affect the public

3. Perform at the direction of PWD management

Code 1

1 Contact the Police Department (911), inform PWD WTPs Manager, Operations Manager, Deputy Commissioner and Water Commissioner

1 Contact affected plant and its management

1 As applicable, investigate scene for evidence of forced entry or substance release (as appropriate, use IWU for investigative and sampling services)

1 As applicable, collect appropriate samples and contact BLS for analyses

1 Inform Load Control Center

Code 2

2 Inform PA-DEP

2 Inform Philadelphia Health Department

2 Inform Public Affairs Division

2 Inform members of Water Quality Committee (may be accomplished via email during normal business hours)

2 Inform applicable wholesale customers

Code 3

3 Inform EPA – Region 3

9.5 General Treatment Options for Highly Credible Threats

The strategy includes:

Raw Water Pumping Station shutdown (at the appropriate time given location of the contaminant and time of travel issues).

Plant shutdown (at the appropriate time given location of the contaminant and time of travel issues).

Isolation of contaminated plant elements (use of bypass capabilities to restore facility operation).

Identification and quantification of contamination.

Mitigation of contamination via treatment or discharge of water to waste.

The following treatment options should be followed, at the appropriate time, for all threats of high credibility (HC):

Application of powdered activated carbon to the rapid mix (a dosage of 100 #/MG).

For instances when contamination is believed to have affected either the river or the raw water basin, application of raw water basin influent chlorine to meet plant effluent residual requirements.

For instances when the contamination is believed to have affected processes downstream of the rapid mix, application of chlorine to the rapid mix to meet plant effluent residual requirements.

Shut down of ammonia (only with the approval of PWD management).

9.6 Specific Treatment Options for Credible Threats

9.6.1 Baxter Water Treatment Plant

If contaminant is in the raw water basin, cease pumping and open raw water basin (RWB) by-pass gates.

If contaminant is in the river, skip tidal fill cycle.

Shutdown of raw water basin may require minimum treatment rates to maintain water over filters.

Flocculation/Sedimentation (F/S) basins and filters drain to raw water basin. Isolate raw water basin prior to draining those basins.

9.6.2 Queen Lane Water Treatment Plant

Isolation of RWB by use of bypass.

Draining of F/S and filters are OK to sewer.

9.6.3 Belmont Water Treatment Plant

Isolation of RWB by use of bypass.

If contamination of RWB is limited to one basin, isolate.

Draining of F/S and filters are OK to sewer.

9.7 Initial Responsibilities

1. Water Treatment Standby is responsible for any immediate decision to shut intakes. Decisions must be made in conjunction with the Load Control Standby engineer upon verification that there is a known contamination problem at the intakes. PWD Operations Management must be notified if there is a decision to close an intake.

2. If information is such that no immediate impact to any intake can be definitively derived, then that decision should be deferred until more information can be determined.

3. Immediate contact should be made to Industrial Waste Unit (IWU) Standby. If intake(s) are believed vulnerable then IWU Standby must proceed immediately to intake to assess situation. IWU will proceed to spill or contaminant source to gather additional information. If intakes are not in immediate peril, then IWU may proceed alone to verify spill and gather all pertinent information.

4. Contact should be made with WTP control lab(s) to give them all information known. If necessary, increased odors or finished water taste and odor tests should be conducted, with instructions to notify Standby engineer of any unusual taste and odors detected. Control labs should be advised of expected odors or tastes from spill type.

5. Whether by Industrial Waste or Standby engineer, samples of river water containing spill should be brought to control lab to assess problem and familiarize chemists with spill odors, if applicable. Samples should be taken in glass jars so as not to interfere with odor.

6. When spill has been verified, immediate attempts to contact plant manager(s) or plant engineer(s) should be taken. Standby engineer remains in charge of plant control lab(s) until relieved by affected plant(s) management. In case of major spill in off-hours, when only one member of plant management might be reached, Standby engineer should be available to assist plant(s) in sample taking or other tasks as directed by the plant(s) management.

7. Until relieved by affected plant(s) management, Standby engineer is responsible for all decisions and contact with support group such as IWU, BLS, and Load Control. This includes immediate consultation with Load Control Management (See Load Control Emergency Notification Procedures) if the intake(s) are ordered or expected to be ordered closed, and decisions on sampling, such as types, locations, and number of samples, as well as coordination with BLS (See BLS Emergency Notification Procedures) if analytical support is necessary. Water Treatment, whether it's the Standby engineer or the affected plant(s) management, is ultimately in charge and responsible for the spill response to protect water quality. Therefore, it is recommended that the response be measured and limited to that which can be practically controlled at all times so as not to increase confusion. The goal is to minimize activities which can have a deleterious effect on the response.

9.8 Response Plant Checklist for Spills/Contaminants

The following is a checklist that should be used as a guide by WT's Standby Engineer when gathering information concerning a potential spill or contaminant at an intake.

Information to obtain, if possible, at time of notification:

Name of person reporting contamination.

Date and time of notification.

Date and time of spill.

Identify contaminant.

Location of contaminant and time it was observed.

Identify source of contaminant.

Identify quantity of contaminant and flow information (is the release a one time limited discharge or a continuous flow?)

Identify responsible party for contamination and contact information.

Identify responsible party for containment and/or clean up of spill.

Identify authorities (including PWD employees) on site or in-route to spill and contact information such as cellular phone #'s or pager #'s.

Identify raw water intakes affected.

Determine estimated duration of spill affecting intake.

Contact Water System Transport Operator (LdC operator if not being notified, by such) and give all known information from above, and where you will be and how they can contact you. Remember, from now on, Load Control will be the communications center for this episode and they must always know where you are and how to reach you.

Information to obtain immediately from affected plants

Identify impact on water treatment capacity:

Determine raw and finished water basin elevations.

Determine current treatment rate.

Determine ability of plant to avoid treating spill by using available storage to allow spill to pass by intake (joint WTP/LdC decision).

Identify treatment feasibility:

Determine ability of conventional treatment and/or powdered activated carbon to handle contaminant. (Jar tests using sample water from the spill provided by the stand-by engineer may be necessary for this.)

Determine available carbon storage, if applicable, and feed rate capabilities and compare with estimated spill duration.

Coordinated strategy:

With all the information assembled, develop with Load Control a strategy for this event that insures a safe potable water supply while balancing the needs of the entire water system and economy.

Directions for contacting Load Control

Operational responsibilities:

Load Control regulates the water supply system, including raw water supply rates.

Water Treatment regulates the treatment process, including determining feasibility of treatment of raw water.

Load Control's standby engineer and water treatment's standby engineer jointly decide response strategy to any potential contaminant spill that imperils water quality, including the decision to close the intake or treat the affected waters. The Load Control standby engineer directs the Load Control operator and the Treatment standby engineer will direct the activities of the plant(s) operators and chemical technicians.

Communications:

All watershed contamination events are to be called into the Load Control operator, the Water Transport System Operator (WTSO).

The Load Control operator will notify water treatment's standby engineer, the Industrial Waste Unit's standby technician, and the Load Control standby engineer.

The WTSO will act as the communications center for the entire response and therefore must be kept continually up-to-date and must be able to contact all involved parties at all times. Communications during these events are crucial.

The Water Transport System Operator may be contacted by:

Primary phone number: 215-685-9609

Secondary phone number 215-685-9636

Instructions for contacting the industrial waste unit

Responsibilities:

The Industrial Waste Unit investigates spills that may impact the Water Treatment Plants. The IWU responder's primary responsibility is to use his or her knowledge and experience to insure that the spill is properly contained and/or cleaned-up so as not to affect raw water quality. This may include attempting to identify a source when one is not known or using their resources to contain the spill if the responsible party can not be identified or is unable to adequately respond.

Communications:

Industrial Waste Unit maintains a technician on standby who is contacted on all reported spills. The Load Control operator should have the schedule and be able to contact IWU's standby person and to provide Water Treatment with his/her name, cellular phone and pager number. The Load Control operator is usually kept up-to-date on this list. However, just in case, a current listing of the Industrial Waste's Personnel and numbers is provided below. Please use the 215 area code before the number.

NAME	BEEPER #	HOME #	OFFICE #
Thomas Healey, Chief	507-0289	632-9908	685-6233
Evan Schofield	507-0304	677-7819	685-8068

Joseph Morrow	507-0361	365-4896	685-8034
Robert Gonsiewski	507-0302	934-7932	685-8093
Joseph Cerrone	507-0386	969-5380	685-8030

9.9 Directions for Contacting Bureau of Laboratory Services

Responsibilities:

The Bureau of Laboratory Services (BLS) has no formal responsibilities relating to a contaminant spill event except for its continual role to provide the necessary laboratory and analytical support to the affected operational units, including Water Treatment and Industrial Waste. BLS may also be able to provide some field services, as requested. The labs can provide 24 hour analytical support, either in-house or on contract.

Communications:

Since BLS does not have a standby program, in order to contact a responsible laboratory manager, a phone call down the list is required to locate the first person available.

EMERGENCY TELEPHONE NUMBERS:

	OFFICE:	HOME:	BEEPER:
Geoffrey Brock, Director	685-1402	849-0232	507-0022
Jung Choi, Manager, SRA	685-1407	676-4891	507-0023
Gary Burlingame, Supervisor, SRA	685-1417	333-2171	none
Patrick Frazer, Project Biologist, SRA	685-1456	425-1424	507-0025
Eugene Gasiewski, Manager, Inorganics	685-1404	722-0116	none
Joe Roman, Supervisor, Inorganics	685-1409	342-6326	none
Cindy Rettig, Supervisor, Biology Lab	685-1428	728-1982	none
Earl Peterkin, Supervisor, Organics Lab	685-1439	477-8113	none

PWD WATER TREATMENT PLANTS

SOURCE OR POTABLE WATER CONTAMINATION INCIDENT REPORT

☐ Delaware or Schuylkill River; flow ____ cfs ☐ Bx/QL/BL Intake ☐ Bx/QL/BL Plant

____

____

Person Responding to Incident:

Name & Job Title: _________________________ ☐ Baxter ☐ Queen Lane ☐ Belmont

Date/time: ________________________________ ☐ IWU ☐ Other _____________

Person or Organization Initiating Information About the Contamination Incident:

Name & Job Title: ___________________ ☐ Chemist ☐ Ld Control ☐ BLS ☐ IWU ☐ Police

Date/time : _________ Location: ______________________ ☐ Plt Mgmt ☐ Stby Engr ☐ PA-DEP

Contaminant Information:

Contaminant Type: ☐ Chemical ☐ Biological ☐ Radiological ☐ Toxic Compound ☐ Unknown

Intake Location Affected: ☐ Baxter ☐ Queen Lane ☐ Belmont ☐ Other _______________

Contaminant Source : ☐ Date/Time Observed ___________ Contact Name / # : ________________

Contaminant Flow : ☐ Continuous ☐ Slug ☐ ____ Gallons ☐ ____ Drums ☐ ____ Rate or hrs Contaminant Clean-up Contact/Contractor name/#: ____

Cause of Incident/Type of Failure:

☐ Highway Accident ☐ Storm Event ☐ Sewage Spill into River ☐ Loss of Power

☐ Sewage Treatment Plant Discharge ☐ Purposeful Act ☐ Other
____

Water Treatment Plant Information:

☐ RWB Elev. ______ ft./MG ☐ FWB Storage Elev. ______ ft./MG ☐ Trtmt Rate _______MGD ☐ Treatment Chemicals on Y/N ☐ Potassium Permanganate Y/N ☐ Powdered Carbon Y/N

☐ Contaminant Treated with ☐ KMnO4 dose; _____#/MG ☐ Carbon dose ; _____ #/MG

☐ Recommendation: ☐ Treat Contaminant ☐ Shut Down Intake ☐ Shut Down WT Plant

Response: ☐ Phone Response Only ☐ Site Visit Required ☐ Emergency Crew Dispatched

Phone Calls: (Names and/or Agencies Contacted; Police, PA-DEP, EPA, PWD)

No.	Date & Time	Person / # Contacted	Action Taken

Written description of incident, including remedial action, follow-up & recommendation:

Watershed Contaminant Incident Report (WsCIR.doc), Jan 2001

ADDENDUM #1 - CRITICAL PHONE NUMBERS OR E-MAIL ADDRESSES			
	Office #	**Pager #**	**E-mail Address**
Philadelphia Police Department	911		
PWD Management			
Water Commissioner Kumar Kishinchand	215-685-6102	215-507-4000	Kumar.Kishinchand@Phila.Gov
Deputy Water Commissioner Richard Roy	215-685-6103	215-768-5867	Richard.Roy@Phila.Gov
Deputy Director of Operations Bruce Aptowicz	215-685-6205	215-507-0006	Bruce.Aptowicz@Phila.Gov
Water Treatment Plants Manager William Wankoff	215-685-6257	215-507-0048	William.Wankoff@Phila.Gov
Water Treatment Plant Managers			
Baxter WTP Manager - Kate Guest	215-685-8020	215-507-0355	Kate.Guest@Phila.Gov
Baxter WTP Process Control Room - 24 hour #	215-685-8055		
Belmont WTP Manager – John Muldowney	215-685-0200	215-507-0096	John.Muldowney@Phila.Gov
Belmont WTP Process Control Room - 24 hour #	215-685-0227		
Queen Lane WTP Manager – Jerry Kuziw	215-685-2101	215-507-0027	Jerry.Kuziw@Phila.Gov
Queen Lane WTP Process Control Room - 24 hour #	215-685-2117		
24 hour hotline	City Hall Operator @ 215-686-4514/5		
Industrial Wastes Unit			
IWU Manager Thomas Healey	215-685-6233	215-507-0289	Thomas.Healey@Phila.Gov
IWU 24 hour hot line	City Hall Operator @ 215-686-4514/5		
Load Control Center			
Load Control Center Manager George Kunkel	215-685-9635	215-507-0280	George.Kunkel@Phila.Gov
Load Control Center 24 hour hot line	215-685-9609		
Bureau of Laboratory Services			
Director - Geoffrey Brock	215-685-1402	215-507-0022	Geoffrey .Brock@Phila.Gov
SRA Manager - Jung Choi	215-685-1407	215-507-0023	Jung.Choi@Phila.gov
PA Department of Environmental Protection			
Water Supply Manager Gerry Centofanti	1-610-832-6045	None	GCentofant@State.PA.US
24 hour hotline	1-610-832-6000		
Philadelphia Health Department			
24 hour hotline	City Hall Operator @ 215-686-4514/5		
Public Affairs Division			
General Manager Ed Grusheski	215-685-6110	215-507-0038	Ed.Grusheski@Phila.Gov
24 hour hotline	E-desk @ 1-215-685-6300		

PWD Wholesale Customers			
Bucks County Water & Sewer Authority - Ben Jones	215-343-2538	None	BJones@BCWSA.Net
Bucks County Water & Sewer Authority - 24 hour #	215-343-3946		
Philadelphia Suburban Water Company- Prestin Luitweiler	1-610-645-1132	610-975-8468	LuitweilerP@surburbanwater.com
Philadelphia Suburban Water Company - 24 hour #	1-610-525-6370		
US Environ. Protection Agency – Region III			
24 hour hotline	215-814-9016		
PWD Water Quality Committee			
Bruce Aptowicz	215-685-6205	215-507-0006	Bruce.Aptowicz@Phila.Gov
Gary Burlingame	215-685-1417	215-306-3143	Gary.Burlingame@Phila.Gov
Jung Choi	215-685-1407	215-507-0023	Jung.Choi@Phila.gov
J. Barry Davis	215-685-6116	None	J Barry.Davis@Phila.gov
Ed Grusheski	215-685-6110	215-507-0038	Ed.Grusheski@Phila.Gov
Dr Caroline Johnson	215-685-6741	215-507-4292	Caroline.Johnson@Phila.Gov
Paul Kohl	215-685-6320	None	Paul.Kohl@Phila.Gov
Debra McCarty	215-685-6258	215-507-0008	Debra.McCarty@Phila.Gov
Drew Mihocko	215-685-6203	215-507-0003	Drew.Mihocko@Phila.Gov
Howard Neukrug	215-685-6319	None	Howard.Neukrug@Phila.Gov
Michael Pickel	215-685-6034	None	Michael.Pickel@Phila.Gov
Matthew Smith	215-685-6318	None	Matthew.Smith@Phila.Gov
William Wankoff	215-685-6257	215-507-0048	William.Wankoff@Phila.Gov
Charles Zitomer	215-685-6209	215-507-0290	Charles.Zitomer@Phila.Gov
file: SecWtp_PH# 12/5/01			

9.10 Alternative Supplies

In the event of a catastrophic event that renders one or both of PWD's river sources unusable, PWD developed a multiphase plan that will allow for continued supply of water (potable and non-potable) for up to an extended period of time. This plan involves implementing emergency pumping facilities to allow for available supply to be distributed throughout the entire city if one supply is still usable. Or, if both supplies are affected the Department will proceed with the initiation of a broad public awareness campaign to alert consumers not to ingest the tap water, filling and isolation of reservoirs and tanks as much as possible prior to the shutting of the intake(s), distribution of stored/potable water via tank trucks, and treatment and distribution of contaminated water for uses such as fire fighting. This procedure is detailed in the City of Philadelphia – Water Department's Emergency Operational Procedure of the Water Supply System in Event of a Prolonged Raw Water Source Outage.

If the contamination event is projected to outlast the potable supply, the city would seek alternative supplies from neighboring purveyors. However, it is generally believed that any event of a magnitude sufficient to cause prolonged contamination of both the Schuylkill and Delaware River supplies would also be severe enough to affect the regional water supply and thereby leave the entire region in a water crisis.

Section 10

New Water Supply Sources

10.1 New Water Supply Sources

The City of Philadelphia does not foresee a need to establish a new water supply in the Delaware River watershed. The City of Philadelphia's population has steadily declined over the past fifty years. It is expected that by the 2010 U.S. Census, Philadelphia will lose its place as the fifth largest city in the country to Phoenix, Arizona.

PWD currently sells water to distributors outside of the city limits. PWD sells water to multiple Aqua America branches as well as the Bucks County Water and Sewer Authority. Listed below are the purchasers of PWD water as well as the volumes purchased from 2002-2006.

Table 10.1-1 Water Purchasers

Purchaser	Average MGD Purchased in Recent Years				4-Year Average MGD
	2003	2004	2005	2006	
Bucks County Water and Sewer Authority	15.3	15.3	15.3	15.3	15.3
Aqua America, Tinicum Township	4.5	2.7	2.1	1.8	2.78
Aqua America, Cheltenham Township	0.6	1.7	1.8	2.0	1.53

Note: MGD = million gallons per day

Section 11

Goals

Goal 1

Ensure the Baxter Water Treatment Plant is adequately protected under regional water policy from climate change effects on the salt line and streamflow.

Regional water policy must adapt to climate change forecasts for the Delaware Valley in order to provide protection against salt line encroachment, reduced streamflow, and droughts. There is a need for regional water policy governing reservoir releases and minimum flow requirements to be examined for efficacy under climate change conditions. Predictions of climate change for the U.S. Northeast region identified by the Union of Concerned Scientists indicate significant hydrologic and sea level changes. Predicted climate changes discussed in Section 4.3.2 may render Delaware River Basin Commission (DRBC) resolutions ineffective at maintaining streamflow powerful enough to keep the salt line from reaching the Baxter intake under elevated sea level and/or future drought conditions.

Modeling of the Delaware River salt line and hydrology under predicted climate change conditions must be performed to evaluate reservoir release and minimum flow policies. DRBC and state policy makers must update regional water policy if the new modeling effort identifies that current policy can not control the salt line location under climate change conditions.

Goal 2

Prevent the Baxter Water Treatment Plant from losing Bin 1 status under the Long Term 2 Enhanced Surface Water Treatment Rule

The low *Cryptosporidium* concentration of the Delaware River at Philadelphia, as evidenced by Baxter's Bin 1 status, is critical to maintain. Future increases in the concentration of *Cryptosporidium* are expected due to an increase in the volume of wastewater created by expanding populations. Increases in *Cryptosporidium* in the Delaware River will not only adversely affect the Baxter Water Treatment Plant, but many other drinking water utilities. Background information on *Cryptosporidium* and its regulations can be found in Section 4.2.5 of this plan.

The Philadelphia Water Department plans to offset increases in *Cryptosporidium* by working with regional partners to establish year round disinfection of wastewater treatment plant effluent upstream of the Baxter plant. Disinfection processes, such as ultraviolet light treatment, will inactivate the pathogens contained in wastewater. The DRBC Special Protection Waters Resolution is the ideal regulatory vehicle for year round disinfection, detailed in Section 5.1. The Philadelphia Water Department will advocate to the DRBC and PA-DEP for enhancement and permanency of the Special Protection Waters Resolution to prevent future increases in *Cryptosporidium*, and maintain the Bin 1 status of the Baxter Water Treatment Plant.

Goal 3

Become a regional leader and facilitator of efforts to offset the effects of land cover change on the water quality and quantity of the Delaware River.

Analyses within this plan identify land cover change as a threat to the water quality and quantity of the water supply to the Baxter Water Treatment Plant (Sections 4.3.1). The Philadelphia Water Department has outlined a source water protection initiative in Section 5.2 that aims to preserve the forested lands and open space within the Delaware River watershed. Partnerships among stakeholders in the Delaware River watershed are critical to complete the actions described in Section 5.2; including counties, municipalities, state agencies, non-profit organizations, land trusts, and utilities.

Through the use of source water protection measures to conserve forests, the Philadelphia Water Department would like to become the regional voice for land preservation as a means to maintain water quality. Ideally, the partnerships forged through Philadelphia Water Department source water protection activities will remain viable and strive to preserve forested lands and open space throughout the Delaware River watershed.

Goal 4

Raise the profile of the Delaware River as a drinking water supply that needs to be maintained and protected in the eyes of the public, government, and regulatory communities.

Although the Delaware River provides drinking water to millions of people, it is not initially thought of as a drinking water supply. At first thought the Delaware River conjures up dramatic images of American history including the legendary crossing of George Washington, heavy industry surrounding Philadelphia in the southern watershed, and pristine fishing and recreational areas in the northern watershed. The disassociation between the image of the Delaware River and its use as a regional water supply detracts from the true value of the Delaware River. It is not only prevalent symbolically in American history, but plays an irreplaceable role in American present and future.

The Delaware River watershed will be the water supply to over 6 million people by 2040 (Section 4.3.1). It is a resource that must be maintained in quality and quantity. Through the source water protection initiatives detailed in Section 5, the Philadelphia Water Department aims to raise the profile of the Delaware River as a water supplier to counties, municipalities, non-profit organizations, land trusts, and regulatory agencies. Through connecting the Delaware River with the image of a drinking water supply, the Philadelphia Water Department hopes to encourage regional stakeholders to consider source water protection in their approach to land management, development, and environmental regulation.

APPENDIX:

Appendix 1 Delaware River Watershed 2001 Land Cover

2001 Land Cover Percent Composition by Sub-Watershed

	Crosswicks	East Branch Delaware	Lackawaxen	Lehigh	Middle Delaware	Mongaup	Neshaminy	NJ Mercer Direct
SUMMARY LAND COVER								
Developed	15.7 %	2.6 %	7.3 %	17.5 %	11.6 %	9.0 %	47.5 %	30.0 %
Forested	43.0 %	90.3 %	75.7 %	60.3 %	51.9 %	85.2 %	6.5 %	38.4 %
Agricultural	35.1 %	5.7 %	14.7 %	20.5 %	34.4 %	3.3 %	45.3 %	30.2 %
Total	**100 %**	**100 %**	**100 %**	**100 %**	**100 %**	**100 %**	**100 %**	**100 %**

	Crosswicks	East Branch Delaware	Lackawaxen	Lehigh	Middle Delaware	Mongaup	Neshaminy	NJ Mercer Direct
DETAILED LAND COVER								
Open Water	6.1 %	1.4 %	2.3 %	1.6 %	2.1 %	2.5 %	0.7 %	1.4 %
Developed, Open Space	5.4 %	2.2 %	6.3 %	9.5 %	7.3 %	7.2 %	21.4 %	11.1 %
Developed, Low Intensity	5.4 %	0.3 %	0.7 %	5.1 %	2.9 %	1.2 %	17.7 %	10.8 %
Developed, Medium Intensity	3.3 %	0.1 %	0.2 %	2.2 %	1.1 %	0.4 %	6.3 %	5.7 %
Developed, High Intensity	1.6 %	-	0.1 %	0.7 %	0.3 %	0.1 %	2.1 %	2.4 %
Barren Land	4.5 %	0.2 %	-	0.5 %	1.0 %	0.1 %	0.5 %	2.2 %
Deciduous Forest	19.4 %	75.3 %	57.8 %	48.1 %	38.2 %	59.0 %	3.1 %	27.9 %
Evergreen Forest	4.5 %	4.5 %	3.1 %	4.7 %	0.5 %	6.2 %	0.9 %	0.9 %
Grassland/Herbaceous	-	0.6 %	0.5 %	0.1 %	0.1 %	0.2 %	-	-
Mixed Forest	0.3 %	7.4 %	9.1 %	2.4 %	6.2 %	14.4 %	-	-
Shrub/Scrub	-	0.3 %	0.6 %	0.2 %	0.7 %	0.7 %	-	-
Woody Wetlands	12.3 %	1.9 %	4.0 %	4.2 %	4.6 %	4.4 %	1.3 %	6.1 %
Emergent Herbacous Wetlands	2.0 %	0.1 %	0.5 %	0.2 %	0.4 %	0.3 %	0.8 %	1.2 %
Pasture/Hay	12.1 %	4.8 %	13.4 %	9.0 %	11.1 %	2.0 %	23.3 %	10.5 %
Cultivated Crops	23.1 %	0.9 %	1.3 %	11.5 %	23.3 %	1.2 %	21.9 %	19.7 %
Total	**100 %**	**100 %**	**100 %**	**100 %**	**100 %**	**100 %**	**100 %**	**100 %**

2001 Land Cover Percent Composition by Sub-Watershed

	PA Bucks Direct	Rancocas	Tidal NJ Lower	Tidal NJ Upper	Tidal PA Bucks	Tidal PA Philadelphia	Tohickon	Upper Delaware
SUMMARY LAND COVER								
Developed	12.9 %	16.2 %	63.7 %	19.4 %	60.0 %	77.6 %	7.0 %	4.0 %
Forested	37.7 %	65.0 %	23.5 %	35.2 %	19.3 %	11.9 %	53.0 %	76.8 %
Agricultural	47.5 %	18.1 %	9.4 %	42.5 %	9.3 %	6.6 %	38.3 %	17.7 %
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
DETAILED LAND COVER								
Open Water	2.0 %	0.7 %	3.4 %	2.9 %	11.4 %	3.9 %	1.7 %	1.4 %
Developed, Open Space	6.8 %	6.3 %	19.4 %	5.8 %	14.3 %	18.7 %	2.3 %	3.6 %
Developed, Low Intensity	6.1 %	6.9 %	25.6 %	7.8 %	24.6 %	18.2 %	2.8 %	0.3 %
Developed, Medium Intensity	-	2.4 %	13.4 %	4.5 %	14.8 %	23.3 %	1.4 %	0.1 %
Developed, High Intensity	-	0.6 %	5.4 %	1.3 %	6.5 %	17.4 %	0.4 %	-
Barren Land	0.6 %	2.7 %	0.8 %	3.5 %	0.5 %	0.5 %	1.4 %	0.4 %
Deciduous Forest	33.1 %	19.6 %	14.2 %	18.2 %	8.8 %	9.2 %	45.8 %	58.1 %
Evergreen Forest	1.6 %	22.3 %	1.2 %	0.4 %	0.4 %	0.6 %	2.9 %	5.0 %
Grassland/Herbaceous	-	-	-	-	-	-	-	0.6 %
Mixed Forest	-	0.5 %	0.1 %	-	-	-	-	11.1 %
Shrub/Scrub	-	-	-	-	-	-	-	0.5 %
Woody Wetlands	1.5 %	18.1 %	6.4 %	11.0 %	7.8 %	1.2 %	1.7 %	1.1 %
Emergent Herbacous Wetlands	0.9 %	1.7 %	0.8 %	2.1 %	1.8 %	0.4 %	1.2 %	0.1 %
Pasture/Hay	21.3 %	6.0 %	2.5 %	14.7 %	3.1 %	3.0 %	13.7 %	15.3 %
Cultivated Crops	26.1 %	12.1 %	6.9 %	27.8 %	6.2 %	3.6 %	24.6 %	2.4 %
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

List of Acronyms

ACE	U.S. Army Corps of Engineers
AHA	American Heart Association
AMD	Abandoned Mine Drainage
BLS	Bureau of Laboratory Services, Philadelphia Water Department
BMP	Best Management Practice
CAC	Citizens Advisory Council
CFS	Cubic Feet Per Second
CG	U.S. Coast Guard
CPCs	Compounds of Potential Concern
CRP	Conservation Reserve Program
CSO	Combined Sewer Overflows
CSOMP	Combined Sewer Overflow Management Program
CWA	Clean Water Act
CWP	Clean Water Partners
CZM	Coastal Zone Management Program
DBP	Disinfection Byproduct
DCNR	Department of Conservation and Natural Resources
DHS	Department of Homeland Security
DMR	Discharge Monitoring Report
DOC	Dissolved Organic Carbon
DRBC	Delaware River Basin Commission
DRWRC	Delaware Regional Water Resources Committee
EDCs	Endocrine Disrupting Compounds
EPA Region III	U.S. Environmental Protection Agency, Region III
EQUIP	Environmental Quality Incentives Program
EWS	Early Warning System
FBC	Pennsylvania Fish and Boat Commission
F/S	Flocculation Sedimentation
HC	High Credibility
IWU	Industrial Waste Unit
LOWESS	Locally Weighted Exponential Scatterplot Smoothing
LT2	Long Term 2 Enhanced Surface Water Treatment Rule
MCL	Maximum Contaminant Level
MG	Million Gallons
MGD	Million Gallons per Day
MIB	2-Methylisoborneol
N	Nitrogen
NA	Not Applicable
NFWF	National Fish and Wildlife Foundation
NJ-DEP	New Jersey Department of Environmental Protection
NJ-DOT	New Jersey Department of Transportation
NLCD	National Land Cover Data Set
NLT	Natural Lands Trust

NOM	Natural Organic Matter
NPDES	National Pollution Discharge Elimination System
NYC-DEP	New York City Department of Environmental Protection
NYS-DEC	New York Department of Environmental Conservation
NYDOT	New York Department of Transportation
PA-DEP	Pennsylvania Department of Environmental Protection
PCB	Polychlorinated Biphenyl
PCWPSC	Poquessing Creek Watershed Partnership Steering Committee
PennDOT	Pennsylvania Department of Transportation
PDE	Partnership for the Delaware Estuary
PDPH	Philadelphia Department of Public Health
PPCPs	Pharmaceuticals and Personal Care Products
PWD	Philadelphia Water Department
RWB	Raw Water Basin
SDWA	Safe Drinking Water Act
SEPTA	Southeastern Pennsylvania Transportation Authority
SKT	Seasonal Kendall Test
SMP	Stormwater Management Program
SPW	Special Protection Waters
SWA	Source Water Assessment
TMDL	Total Maximum Daily Load
TOC	Total Organic Carbon
TP	Total Phosphorus
TTFWP	Tookany/Tacony-Frankford Watershed Partnership
TSS	Total Suspended Solids
UC	Unassigned Credibility
USGS	U.S. Geologic Survey
UV254	Ultraviolet Absorbance at 254 Nanometers
WREN	Water Resources Education Network
WTSO	Water Transport System Operator
WWTP	Wastewater Treatment Plant

References

Bryant, T.L. and J.R. Pennock, eds. 1988. *The Delaware Estuary: Rediscovering a Forgotten Resource*. University of Delaware Sea Grant College Program.

Homer, C. et al. 2004. Development of a 2001 national land-cover database for the United States. Photogrammetric Engineering and Remote Sensing. 70:829-840.

Jaworski, N.A. and L.J. Hetling. 1996. Water quality trends of the mid-Atlantic and northeast watersheds over the past 100 years. Conference proceedings, Watersheds 1996. Pages 980-983. 1998.

Majumdar, D.K., Millar, E.W., Sage, L.E. eds. 1988. *Ecology and Restoration of the Delaware River Basin*. The Pennsylvania Academy of Science. Typehouse, Phillipsburg, NJ.

Marrazzo, W.J. and S. Panzitta. 1984. *Progress on the Delaware River clean-up program. Options for Reaching Water Quality Goals, American Water Reosources Association*. Pages 13-21.

New Jersey Department of Environmental Protection. 2006. New Jersey Integrated Water Quality Monitoring and Assessment Report.

New York State Department of Environmental Conservation. 2004. New York State Water Quality 2004.

Philadelphia Water Department. 2005. Consumer Confidence Report, Baxter Water Treatment Plant.

Philadelphia Water Department. 2002. Source Water Assessment Report for the Baxter Water Treatment Plant. Section 1 General Delaware River Watershed. Pennsylvania Department of Environmental Protection.

Philadelphia Water Department. 2002. Source Water Assessment Report for the Baxter Water Treatment Plant. Section 2 Delaware River Intake. Pennsylvania Department of Environmental Protection.

Pennsylvania Department of Environmental Protection. 2006. Pennsylvania Integrated Water Quality Monitoring and Assessment Report.

Rhone, R.D. 1902. *Anthracite Coal Mines and Mining*. From *The American Monthly Review of Reviews*. August 30, 2001. http://www.history.ohiostate.edu/projects/coal/AnthraciteDescription/AnthraciteRhone.htm

Roberts, C.M. 1989. The *Delaware River Basin: Rich Past, Demanding Future*. Trenton: Delaware River Basin Commission.

Toffey, W.E. 1982. *Philadelphia's River Resources* (Technical Paper). Pages 5-45.

Union of Concerned Scientists. 2006. Climate Change in the U.S. Northeast. www.northeastclimateimpacts.org

United States Department of Agriculture. Natural Resources Conservation Service. Pennsylvania Soil Survey. *Pennsylvania Soil Survey. Official Series Descriptions*. http://www.pa.nrcs.usda.gov/soils/passrsp.htm

United States Department of Agriculture. Soil Conservation Service. 1975. Soil Survey of Bucks and Philadelphia Counties Pennsylvania, United States Department of Agriculture Soil Conservation Service. Washington, D.C.

United States Environmental Protection Agency. Long Term 2 Enhanced Surface Water Treatment Rule. http://www.epa.gov/safewater/disinfection/lt2/regulations.html

United States Environmental Protection Agency Regions II and III. 2004. *Total Maximum Daily Loads for Polychlorinated Biphenyls (PCBs) for Zones 2-5 of the Tidal Delaware River.*

United States Geologic Survey. 2005. Computer Program for the Kendall Family of Tests. Scientific Investigations Report 2005-5275.

United States Geological Survey. 1999. *National Water Quality Assessment Program, Delaware River Basin*. http://nj.usgs.gov/delr/index/html

Webster, G., ed. 1996. *The Delaware Estuary: Discover Its Secrets. A Management Plan for the Delaware Estuary*. Trenton: The Delaware Estuary Program.