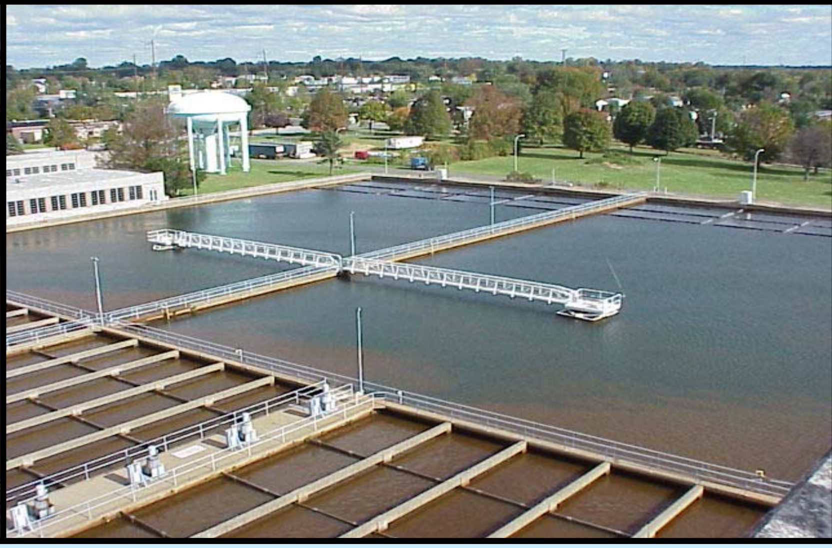

PHILADELPHIA WATER DEPARTMENT
BAXTER WATER TREATMENT PLANT (PWSID# 1510001)
SOURCE WATER ASSESSMENT REPORT

This report was produced for the Pennsylvania Department of Environmental Protection in accordance with the Source Water Assessment and Protection Plan.

Philadelphia PWD Water Department

Prepared by The Philadelphia Water Department

June 12, 2002

<u>*With support from:*</u>
Bucks County Water and Sewer
Philadelphia Suburban Water Company
Pennsylvania American Water Company
Pennsylvania Department of Environmental Protection
Camp Dresser & McKee

Delaware River SWA
Protect Our Health from Source to Tap

Office of Watersheds
philadelphia water

PADEP Contract: ME350056

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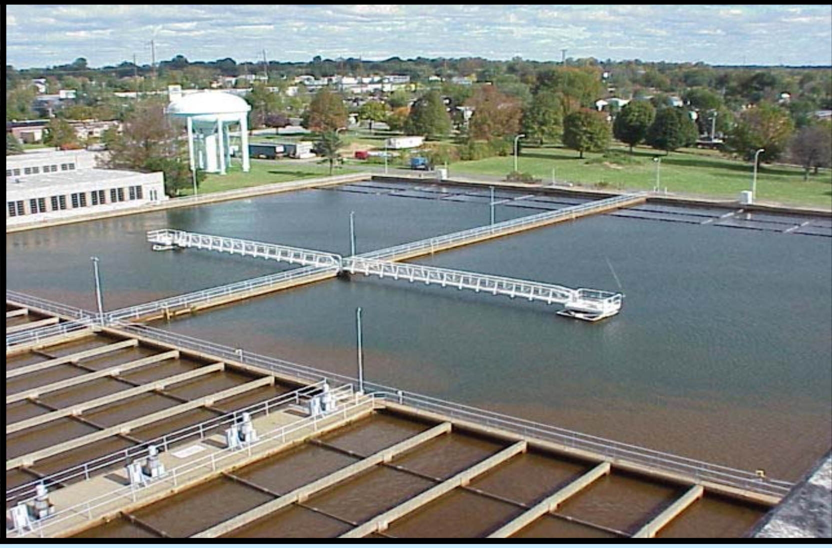

PHILADELPHIA WATER DEPARTMENT
BAXTER WATER TREATMENT PLANT (PWSID# 1510001)
SOURCE WATER ASSESSMENT REPORT
SECTION 1: GENERAL DELAWARE RIVER WATERSHED

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philadelphia water

Executive Summary – Delaware River Watershed Assessment

The 1996 Safe Drinking Water Act Amendments required the assessment of all source water supplies across the country to identify potential sources of contamination, the vulnerability and susceptibility of water supplies to that contamination, and public availability of the information. In response to this charge, the Delaware River Source Water Assessment Partnership, comprised of the Pennsylvania Department of Environmental Protection, the Philadelphia Water Department, the Philadelphia Suburban Water Company, the Pennsylvania American Water Company, and the Bucks County Water and Sewer Authority conducted an assessment with stakeholders to identify water supply protection priorities in the Delaware River Watershed. The following summary includes two main sections. One section discusses the various characteristics and observations made through collection of watershed wide information. The remaining section provides a brief listing of the main recommendations based on the observations and analysis of watershed data.

Observations & Characterization

- Although the Delaware River has been utilized for thousands of years, the quality of the water source began decreasing rapidly from the time of initial European settlement in the early seventeenth century until corrective, preventive, and protective measures were taken beginning in the 1970's and 80's.

- Direct dumping of waste into the river, poor farming practices, the erosion and runoff that resulted from excessive land clearing, and developments in industrialization, transportation, and coal mining all contributed to the watershed's pollution problems.

- The Delaware River clean-up effort that began in the 1960s now serves as a model of successful interstate water resource management.

- The Delaware River Watershed encompasses 40 counties within Pennsylvania, New Jersey, New York, and Delaware. The SWAP study area includes 30 of these counties.

- The Delaware River provides drinking water to 17million people or 10% of the U.S. population.

- According to DRBC, 7,337 MGD total amount of water used each day in the watershed. Approximately 67% is used to generate power in New Jersey. Most of the remaining water is returned to the basin's streams and aquifers with the exception of about 311MGD in consumptive uses within the basin and 900MGD that is diverted out of the basin to New York City and northeastern New Jersey.

- PSE&G in Salem, NJ is the largest of all surface water users within the watershed, taking roughly 1,983 MGD.

- The Philadelphia Water Department, which takes about 361MGD from both the Delaware River and the Schuylkill River, is the largest municipal user. Approximately 311MGD can be used.

- In the Delaware River Basin, 88% of the total amount of water withdrawals is taken from the surface water supplies, whereas 12% comes from groundwater sources. Surface sources supply 60% of the water that is used consumptively, with the remaining 40% coming from groundwater stores.

- The Delaware River Watershed is composed of a number of smaller sub-watersheds, the most notable of which include: the Lehigh River, Crosswicks Creek, Musconetcong River, Rancocas Creek, Neshaminy Creek, and Tohickon Creek watersheds.

- The majority of developed land is located within the southern portion of the SWAP study area, between Lehigh County and Philadelphia County. The majority of the land within the study area remains forested, although a pattern of suburban sprawl has emerged.

- Philadelphia has the highest population density of any county within the watershed.

- The most immense population gains are forecasted to occur within the suburban and rural communities located on the fringe of urbanized areas.

- The development of agricultural and rural lands is a cause for concern because it may lead to a loss of habitat for wildlife and an increase in erosion and pollution, which may adversely affect drinking water supply.

- Over 5,000 potential point sources were identified within the Delaware River Watershed. Most of these potential sources do not and will never discharge into the Delaware River, but may store, generate, or transport hazardous chemicals.

- Sewer systems, dry cleaners, and machine/metal working shops were among the most frequently identified potential point sources.

- The highest concentrations of potential point sources were located in the most highly developed sub-watersheds.

- The Tidal PA Philadelphia, NJ Tidal Lower and Tidal PA Bucks had the greatest number of dischargers per acre of drainage area.

- Delaware River water quality has significantly improved over the past twenty years. As the impacts of point sources 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.

- Of the 14,299 miles of streams and creeks within the Delaware River Watershed, 35% (5,056 miles) have been assessed to determine their compliance with applicable water quality standards. Nearly 65% of the assessed stream miles have attained applicable water quality standards.

- Although water quality data suggests that pathogens are a concern throughout the entire watershed, very few segments are listed as having pathogens as the primary cause of impairment.

- Flow alterations, phosphorus (nutrient), and toxic chemicals fish tissue and sediment were identified as the most significant causes of impairment within watershed.

- Stormwater runoff from urban and suburban areas was identified as the cause of almost half of the impaired stream lengths within the watershed.

- Federal, state, and private grants have provided almost $20 million for environmental projects within the Delaware River SWAP study area over the past several years. Almost 60% of the grants awarded were used for protection/restoration projects.

- Grants were awarded to 54 recipients, with county and municipal groups receiving the majority of funds.

Watershed Recommendations

- Current grant funding appears to be focused appropriately on restoration with most of the grant money going to state organizations. It is recommended that the states make this money available to local municipalities to implement local protection efforts if these monies are not already available.

- Overall, both sewer system capacity and integrity as well as treatment plant capacity during wet weather periods represent the greatest and most difficult sewage related issue in the watershed. Infrastructure improvements for adequate wastewater collection and treatment systems are needed to address infiltration and inflow or system capacity issues. These improvements will eliminate events such as overflowing manholes of raw sewage into downstream water supplies.

- Raw sewage discharges upstream of water supply intakes by communities through CSOs or SSOs need to be monitored, evaluated, and improved. These discharges can significantly impact pathogen concentrations in downstream water supply.

- Compliance requirements for industries and municipalities discharging wastewater into the protection priority corridor between Camden and Easton should be enforced.

- Encouragement of rigorous and regular revision and implementation of ACT 537 Sewage Facilities Management Plans in Montgomery, Bucks, Mercer, and Lehigh Counties. In addition the sewage facility related issues from SWAs should be incorporated into the ACT 537 plan with emphasis on monitoring and measuring progress towards addressing identified problems.

- Wastewater dischargers should be encouraged and given incentives to switch to ultraviolet light disinfection and/or filtration of effluents to reduce *Cryptosporidium* pathogen levels and viability from discharges. Permits for discharge from new wastewater facilities or plant expansions should include ultraviolet light disinfection requirements.

- It is recommended that the DRBC and three PADEP regions covering the Delaware River Watershed develop a watershed wide approach to addressing permit requirements. One suggestion would be a uniform fecal coliform discharge limit for any wastewater discharge upstream of a drinking water intake in the watershed.

- The Phase II stormwater regulations should be fully implemented and enforced throughout the watershed, with first priority for compliance monitoring and inspection recommendation for communities discharging into protection priority areas for drinking water supplies.

- The Delaware River Basin in coordination with the Delaware Riverkeeper, PADEP, and NJDEP should set a goal for achieving a certain number of specific BMPs within the next 10 years. For Example, 1,000 acres of riparian buffers, 1,000 stream miles protected, etc.

- Interaction and communication with petroleum pipeline owners and operators, railroads, and road or bridge construction crews needs to be developed and improved. It is important for these stakeholders to understand water supply issues and impacts from catastrophic accidents and right of way spraying of herbicides. Therefore a series of emergency response workshops needs to be held to raise awareness of the issue.

- Given the catastrophic impacts from spills and accidents, an early warning system similar to that on the Ohio River should be installed along the mainstem Delaware River to provide water suppliers warning and accurate real time data when spills and accidents occur. It is recommended that the USGS should be involved in the implementation of the early warning system.

- New permits should be banned for new storage tanks and facilities that uses or store toxic chemicals including petroleum products within the 100-year floodplain of the river and its tributaries. PADEP should also develop and implement a long-term plan relocate, reduce, or eliminate tanks and sources with toxic chemicals that are currently located within the floodplain.

- An accurate time of travel study needs to be conducted on the Delaware River to determine the time various spills will take to arrive at various water supply intakes and the amount of dilution under various flow scenarios. This should be incorporated into a computer model for emergency planning simulations using various chemicals and scenarios. This is also an important component necessary to make information from the early warning system more useful. The USGS should be involved in the implementation of this effort.

- Signage should be developed in sensitive water supply areas along roadways and bridges that include phone numbers to contact water suppliers during emergencies and spills. The signs should include a unique identification number corresponding to a known location for the water supplier.

- A special workshop with street departments and PennDot should be held to develop a strategy to reduce salt impacts from road salt application. This may include strategies to acquire special funding for salt misting trucks to reduce salt application in sensitive areas.

- Agricultural land that is preserved should have specific riparian buffer and streambank fencing requirements included in its preservation status.

- Additional incentives and efforts should be allocated to develop, monitor, and implement nutrient management and conservation plans for farms in sensitive water supply areas.

- Active agricultural lands adjacent to streams in sensitive water supply areas should be required to have riparian buffers or streambank fencing to reduce impacts from livestock activity, pasture runoff, and crop runoff.

- The targeting of USDA funding for water quality protection under EQIP and enrollment of CRP lands should give consideration to sensitive water supply areas, and the programs should be more accessible to farmers. To maximize water supply protection, water suppliers should be consulted in connection with the allocation of EQIP and CRP funds. A goal should be set by the USDA, DRBC, PADEP, and NJDEP to have approximately 25-50% of all agricultural lands in sensitive water supply areas to have streambank fencing or riparian buffers by 2010.

- Areas of intense or concentrated agricultural activity should also be prioritized for protection and mitigation efforts.

- Special erosion controls and ordinances to reduce stormwater impacts from future development and erosion are needed in protection priority areas for water supplies.

- Conservation Districts need more assistance in addressing erosion control and stormwater runoff issues from development.

- The operation and discharge of contaminants and algae from the many reservoirs in the watershed are suspected of having impacts on water supplies. These areas need to be monitored and investigated or communication about these discharges and the timing of their impacts needs to be better understood.

- The U.S. Fish and Wildlife, PA Game Commission, park managers, golf course managers, and water suppliers should develop and implement a regional management plan to address the exploding population of non-migratory Canada Geese

- Township officials along the protection priority corridor should be educated about stormwater impacts on water supplies through meetings, workshops, or mailings.

- The results of the local source water assessments need to be presented directly to local township officials. The common issues from multiple water supplies should also be provided to show how everybody lives downstream and feels the impact from pollution.

- A combined and coordinated efforts to establish data protocols for proper data comparison (GIS or otherwise) between the various states in the Delaware River Basin needs to be established. Currently most data cannot be compared between states.

- Accurate watershed-wide land use GIS coverage is necessary for TMDLS and runoff impact estimates.

- GIS coverage of farms, types of agriculture, farming density, and EQUP/CRP lands, or lands with conservation easements, should be developed for the entire watershed. GIS coverage of sanitary and stormwater collection systems and outfalls in water communities should also be developed.

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Section 1 – General Delaware River Watershed

1.1 Introduction

Key Points

- **The Delaware River Source Water Assessment Partnership, comprised of the Pennsylvania Department of Environmental Protection and the Philadelphia Water Department, is collecting and evaluating the data necessary to identify water supply protection priorities in the Delaware River Watershed.**

The ability to obtain safe and potable drinking water has always been a key component in the location and development of communities. The quantity and quality of the drinking water supply has often defined a community's ability to grow and succeed. Therefore, protecting, maintaining, and improving the quality of a community's water supply is vital in ensuring its future.

The importance of water supply integrity has been recognized throughout the United States by municipalities and water suppliers who have implemented efforts to protect the drinking water supplies of their communities. From rural wells to the rivers supplying potable water to big cities, everyone is getting involved in protecting the source of their drinking water.

In addition to local efforts, Federal regulations, resources, and initiatives have been implemented to protect drinking water sources. These include the Clean Water Act (CWA), Resource Conservation and Recovery Act (RCRA), Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) and the Safe Drinking Water Act (SDWA).

Most recently, the Safe Drinking Water Act Reauthorization in 1996 included a specific component for source water protection called the Source Water Assessments (SWAs). The SWAs may be best defined as a process involving water suppliers, watershed organizations and other stakeholders, who together identify the protection priorities of the water supply. Water suppliers will be required to make this information available to the public in their Consumer Confidence Reports in order to help the public understand the source of their drinking water and the challenges that must be met to protect it. It is important to note that these assessments are of the raw water sources prior to drinking water treatment, not assessments of the performance or compliance of public water systems.

As part of its Federal requirement to conduct the SWAs, the Pennsylvania Department of Environmental Protection (PADEP) sought to involve water suppliers and the community in the SWA process. It is believed that the partnership approach increases the potential for public, community, and water supplier involvement to address source water issues after the assessments have been completed.

Using this partnership approach, the Delaware River Source Water Assessment Partnership was formed. The partnership includes water suppliers working with the state to conduct the assessments. The State contractor, the Philadelphia Water Department, has volunteered to lead the Delaware River Source Water Assessment Partnership, and conduct source water assessments for 8 surface water supplies within the Lower Delaware River Watershed.

1.1.1 New Requirements Under SDWA

Key Points

- **The 1996 amendments to the Safe Drinking Water Act require States to implement Source Water Assessment Programs.**

The Environmental Protection Agency (EPA) has supported the efforts of States and communities to protect their water sources from contamination since 1986 with the establishment of the Wellhead Protection (WHP) Program and other Federal initiatives. Encouraged by the WHP Program's success, the EPA has set new goals for source water protection. By 2005, the EPA's goal is to have either Source Water Protection, Wellhead Protection, or Watershed Protection Programs in place for 60% of the country's population served by community water (EPA State Source Water Assessment and Protection Programs Guidance, August 1997, EPA 816-R-97-009, Office of Water 4606).

The amendments to the 1996 Safe Drinking Water Act include requirements for each state to establish and implement Source Water Assessment Programs (SWAPs) that accomplish the following:

1. Set forth the state's strategic approach to conducting the assessments

2. Delineate the boundaries of the areas providing source waters for public water supply (PWS)

3. Identify, to the extent practical, the origins of regulated and certain unregulated contaminants in the delineated area in order to determine the susceptibility of PWSs to such contaminants

4. Complete the assessments within two years after EPA approval, with an opportunity to extend this period up to 18 months

5. Make the results of the source water assessments available to the public.

The intent of Congress in requiring the SWAs was to show water suppliers, municipalities, and the public the potential challenges facing their sources of drinking water and to develop local voluntary support for source water protection programs.

The PADEP has already been working diligently to meet these requirements by developing an approved SWA Program and Plan and by hiring contractors to help assess a portion of its 14,000 water sources. In addition, the PADEP has set aside resources and monies in the form of grants for communities that apply to develop local source water protection plans after assessments are finished. These plans were designed to be linked to the Growing Greener Grant application process. Additional preference would be given to grant applications that can show that the proposed activities are linked to an approved Source Water Protection Plan or River Conservation Plan for that community. Therefore, local organizations seeking funds to conduct protection efforts will eventually be better equipped to make strides in protecting local water supplies.

1.1.2 Designation of a SWAP Study Area

Key Points

- **The Source Water Assessment Partnership has chosen to create a separate study area for the Delaware River Watershed assessment.**
- **The SWAP study area boundaries are primarily used for intake specific information in the report.**

Because of the large size of the watershed, the Source Water Assessment Partnership has chosen to create a separate study area for the Delaware River Watershed assessment. The SWAP study area is the entire watershed coverage modified to exclude part of the Lower Delaware subshed. It includes the entire upstream portion of the Delaware River Watershed, extending into New York State.

The SWAP study area boundaries are primarily used for intake specific information in the report. The southern boundary was chosen based upon the location of the Baxter Water Treatment Plant in Philadelphia County as the southernmost intake within the Delaware Estuary. The area below the Schuylkill and Delaware River confluence will not impact this intake. In addition, the delineation of the SWAP study area also includes the area within a 25-hour time of travel, which is required under the SWA guidelines set forth by the Pennsylvania Department of Environmental Protection. Most of the contaminant source inventories will concentrate on those areas within 25 hours travel time of the intakes, and thus exclude those portions of the intake in New York State when prioritizing the potential contaminant sources. Figure 1.1.2-1 shows the boundaries of the SWAP study area.

Figure 1.1.2-1 Delaware River Watershed and SWAP Study Area Boundaries

1.2 Background and History

1.2.1 Description of the Delaware River Watershed

Key Points

- **The 330-mile long Delaware River is divided into 6 zones for purposes of classification and monitoring.**
- **The river serves a variety of important residential and industrial functions, including fishing, transportation, power, cooling, and recreational purposes, but most importantly, as a source of drinking water.**
- **The Delaware River provides drinking water to 17 million people or 10% of the U.S. population.**

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) at a rate of 2,890 cubic feet per second (cfs), the Delaware then flows approximately 80 miles to the tidal waters of Trenton, New Jersey at a 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 a 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 as it meets 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 1.2.1-1 presents a map of the entire Delaware River Drainage Basin, its major subwatersheds, and its tributaries.

Figure 1.2.1- 1 Map of Delaware River Drainage Basin

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. For classification and monitoring purposes, the river has been divided into six separate zones. Each zone represents a particular leg of the Delaware River's journey from its headwaters to the Atlantic Ocean (DRBC, 1994).

Zone 1 encompasses the non-tidal portion of the river, from its headwaters in Hancock, NY to Trenton, NJ, according to the Delaware River Basin Commission's Geographic Zoning of the Delaware River Watershed. One hundred seven miles of this 198-mile zone were included in the National Wild and Scenic River System (NWSRS) in 1978. Established in 1968, the NWSRS is a class of rivers that have been selected to be protected because Congress decided that they "with their immediate environments, possess outstandingly remarkable scenic, recreational, geologic, fish and wildlife, historic, cultural or other similar values, shall be preserved in free-flowing condition, and that they and their immediate environments shall be protected for the benefit and enjoyment of present and future generations to protect the water quality of such rivers and to fulfill other vital national conservation purposes" (National Park Service, Wild and Scenic Rivers, http://www.nps.gov/rivers).

The whitewater section of this zone, between Narrowsburg, NY and Port Jervis, NY, consists of 36.5 miles of 30 Class I and 6 Class II rapids, which flow through an area of the watershed that at one time saw a great deal of colonial logging and coal mining, but has since recovered. There is minimal development in this sparsely populated stretch of the Delaware, which is used mainly for recreational activities such as fishing, boating, etc. It consists mostly of forested mountains and riverbanks inhabited by a diversity of wildlife. The high quality water that flows through the upper half of this zone is sustained by cold water releases from three New York City-owned reservoirs (Cannonsville, Neversink, and Pepacton). The 77 miles from the Water Gap to the falls at Trenton, NJ is characterized by a mix of both rural and urban areas. Above the confluence with the Lehigh River, the Delaware's second largest tributary, the river follows a relatively tranquil course through forests and mountainous state parks where people enjoy boating, fishing, swimming, camping, and other recreational river activities. Thirty-six and a half miles of this zone are part of the Water Gap, a scenic area that extends from near Stroudsburg, PA to the river's confluence with the Lehigh River at the Forks of the Delaware at Easton, PA. The scenic beauty of the Water Gap draws many tourists and vacationers who make recreational use of the region's mix of gentle waters and rapids that flow between the high cliffs of the Kittatinny Mountains of the

Appalachian Range, some of which reach heights of more than 1,000 feet. While agriculture is still dominant in the top half of this section, it gives way to more populated and developed areas in the lower Lehigh Valley where industrial towns such as Allentown, Bethlehem, and Easton in Pennsylvania, and Phillipsburg and Trenton in New Jersey, serve as major manufacturing centers. Consequently, there are many more surface water withdrawals and wastewater discharges in this lower section of the zone than there are above the Water Gap. However, water quality in Zone 1 is still considered to be good due to the fact that this stretch is above the watershed's largest source of pollution (the Philadelphia/Camden area).

A distinguishing feature of the lower section of Zone 1 is its extensive canal system. The 51 miles from the area near the Forks of the Delaware to the falls at Trenton are characterized by numerous canal linkages connecting various sections of the river. This area contains more canals serving a single river valley than any other region in the U.S. Many small connective streams are also found at this section, which contributed to the colonial economy by providing power for the numerous mills that were built upon their banks shortly after European settlement (Fulcomer and Corbett, 1981).

Zones 2, 3, and 4 divide the freshwater, tidal portion of the river--the 54 miles between Trenton and the upper boundary of Zone 5 at Wilmington, DE. Zone 2 covers 25 miles; Zone 3, 13 miles; and Zone 4, 16 miles. These three zones encompass the majority of the most polluted stretch of the river, where water quality is the lowest: the highly populated and heavily developed and industrialized area between Trenton and Wilmington, DE, which includes the Philadelphia waterfront. This stretch also includes the Delaware's confluence with the Schuylkill River, it's largest tributary, which drains 15% of the river basin.

Along with Zones 5 and 6, Zones 2, 3, and 4 comprise the "Delaware Estuary." The estuary is home to one of the world's most highly concentrated areas of industry where the local economy is driven by chemical, shipbuilding, food processing, steel, and utility plants (Heritage Conservancy). The second-largest oil refining center in the U.S. and the second largest port in the U.S., in terms of tonnage travelling through it are also located within the Delaware Estuary. On account of such a high concentration of people and industry, there are many demands made on the estuary's water. Numerous withdrawals and wastewater discharges affect water quality in these zones, which is classified as intermediate/average at best, with seasonal fluctuations. This current classification, which represents a tremendous improvement from the condition of the river in previous years, is the result of 40 years of pollution clean-up efforts that began in the 1960s. Much remains to be done, however, in order to bring this section of the river up to par with the water quality standards set forth in the Federal Clean Water Act of 1972, which laid the groundwork for national water pollution control methods (Majumdar, Miller, and Sage, 1988 and DRBC, 1994). Current water quality concerns include the presence of toxic compounds and nutrient loadings in the estuary, which also affect dissolved oxygen (DO) levels and prevent these zones from meeting the Delaware River Basin Commission's "fishable" and "swimmable" standards (Sutton, O'Herron II, and Zappalorti, 1996).

Zone 5 covers the 31 miles from Wilmington to the upper boundary of Zone 6 just above the river's confluence with the Delaware Bay. Zone 6 itself consists of the Delaware Bay, a rural area from Liston, DE to the Atlantic Ocean, which is characterized by salt marshes and farmland, and serves as an unloading point for ships with large amounts of cargo. Since the Delaware's channel is maintained at 40 feet for navigation, larger ships transfer their loads to smaller vessels here in order to send them upstream. Due to the good water quality in this zone, the bay serves both commercial and recreational interests. Fishing, boating, and swimming are common in the bay, but there is concern that increases in population and industry in this area are negatively altering the estuarine ecosystem and may adversely affect water quality in the near future (USGS NAWQA, 1999).

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 travelling on it every day. Sixty-seven and a half million tons of cargo moved along it in 1980, most of which consisted of petroleum, ore, and sugar (Toffey, 1982). With no dams on its main stem, it is also one of the few remaining 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.

As discussed in detail in section 1.2.2, when the Europeans 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 the bald eagle, bluebird, merganser, osprey, pheasant, ruffled geese, turkey, and the woodpecker. 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 Watershed, and the estuary in particular, was quite a different topographical picture in pre-colonial times. It 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.

1.2.2 History of the Delaware River Watershed

Key Points

- **The early European settlers in the Delaware River Watershed began a 300-year legacy of pollution in the 1600s that would not be abated until protective measures were deemed a priority in the mid-1900s.**
- **Direct dumping of waste into the river, poor farming practices, the erosion and runoff that resulted from excessive land clearing, and developments in industrialization, transportation, and coal mining all contributed to the watershed's pollution problems.**
- **Significant improvements in water quality have been made in the Delaware River since its darkest days in the 1940s, when pollution threatened the fishing, shipping, and transportation industries, as well as the health and well-being of watershed inhabitants who depended on it.**
- **Except for seasonal violations of a few parameters such as dissolved oxygen and fecal coliform in the estuary area and occasional toxic contaminant and nutrient loading alerts in certain river zones, the Delaware now meets the current water quality standards.**
- **The Delaware River clean-up effort that began in the 1960s now serves as a model of successful interstate water resource management.**

1.2.2.1 Colonial Settlement

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 and 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, that situation began to change for the worse 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).

Until colonial times, well-drained high ground, marshland, and extensive woodlands all made for a diverse river basin, and many of the current geographical areas in the watershed still bear their original Native American names, which indicated some aspect of the land's physiography or natural conditions. For example, "Kittatinny," a mountain in the northern part of the watershed, means "mighty mountain;" Cohocksink means "pinelands"; "Wissahickon" means "catfish"; "Passyunk", "a level place below hills"; and "Kingsessing" denotes a place where there is a bog (Toffey, 1982). Unlike their nomenclature, however, the Native Americans themselves disappeared due to westward migration relatively soon after European settlement and subsequent domination of 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, which 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.

After Henry Hudson's brief initial stay in 1609 on the Delaware Bay (named in 1610 by English Captain Samuel Argall after Thomas West, Lord De La Warr, the governor of the Virginia colony [Bryant and Pennock, 1988]), the Scandinavian settlers sailed in through the bay area and also established villages in Lewes and New Castle (formerly Fort Casimir) in Delaware; Salem and Greenwich in New Jersey; and Upland (now Chester) in Pennsylvania (Roberts). They 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.

1.2.2.2 Industrialization

The Delaware Estuary area was a prime choice for colonial settlement since it naturally lent itself to the establishment and success of a new civilization. Opportunities abounded for fishing, transportation, and trade, and soon the new European settlements in the region were connected to the rest of the world through the development of the port city of Philadelphia, an area of high, dry land conveniently bordered by the Schuylkill River on the left and the Delaware on the right. Colonists wasted no time clearing the woodland and filling in much of the wetlands to make way for homes and farms and to procure fuel. Through the use of dikes, dams, and grading of the land, former marshes were soon transformed into fertile farming ground, and throughout the 1700s agriculture was one of the foremost industries in the region, in addition to commerce and trade. Increasing numbers of European immigrants provided plenty of hands to work the land, and Philadelphia thus grew into a major commercial city, which soon became the nation's core of shipbuilding and world's largest freshwater port.

By the 1770s, the Delaware Estuary region, from the bay area up to present-day Trenton, had become the locus of industry in America. An abundance of the necessary resources: coal, iron, water, and wood, drove industrial production (Heritage Conservancy,), and the economy of the area gradually shifted from predominantly agricultural to a more manufacturing-based system. In addition to tanneries, glass works, 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. (DEP, http://www.dep.state.pa.us/dep/deputate/enved/go_with_inspector/coalmine/Anth racite_Coal_Mining.htm). Coal was also discovered at the headwaters of the Schuylkill in the late 1700s. Besides being a valuable fuel resource, the mines provided a number of jobs and a new economic backbone for the region. Consequently, many mining towns were established in these coal counties, staffed in large part by the European immigrants that were flooding into America at the time. The massive amounts of anthracite that these regions yielded contributed greatly to the economy of the colonies. In the 11 years between 1860 and 1871, approximately 300,000 acres of coal lands were bought or leased by the leading coal companies (DEP, http://www.dep.state.pa.us/dep/deputate/mines/reclaimpa/interestingfacts/A%20BRIEF%20HISTORY%20OF%20COAL%20MINING.html), and in 1914, employment in this industry peaked with about 181,000 men working the mines in Pennsylvania. Mining reached its hey day in 1917 when more than 100 million tons of coal were mined from the Wilkes-Barre/Scranton region (DEP, http://www.dep.state.pa.us/dep/deputate/enved/go_with_inspector/coalmine/Anthracite_Coal_Mining.htm).

The coal was shipped down canals on the Susquehanna and Schuylkill rivers, over land via wagons, or by rail on the Lehigh Valley Railroad to eastern markets in cities like Philadelphia for use in the rapidly developing iron and steel industries, as well as for the new trains, which required large amounts of fuel. The coal pier at Port Richmond on the Delaware is a current reminder of those days gone by. Pollution from past and present mining operations is another reminder of the significant amount of mining that was and still is carried out in this section of the watershed. 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 acid mine drainage from mining operations since the 1700s. In fact, acid 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. Since then, additional legislation has been necessary to protect water resources within the watershed (DEP, http://www.dep.state.pa.us/dep/deputate/enved/go_with_inspector/coalmine/Environmental_Laws.htm), and thirteen AMD treatment plants have been built throughout Pennsylvania (at a cost of $20.7 million) to treat AMD discharges.

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 limits of the river's resources. Problems soon developed as a result of the drastic changes the new settlers were making to the land and waterways within the watershed. The clearing of such great expanses of wooded areas left formerly tree-covered land open and vulnerable to erosion. Soil and sediment ran off into the rivers. Sewage from new farms to the mid-1800s, the colonists had buried their sewage in privies in their backyards, but when they realized burial posed a threat to public health, they began discharging it directly into the water by way of drains that carried the untreated waste from the inland areas (Toffey, 1982). These pollutants and the nutrients that washed from farmland changed the chemical balance of the river and adversely affected aquatic life and water quality. In addition, the filling in of wetlands and tidal flatlands for the construction of buildings significantly decreased the shoreline and polluted the wetlands, which also were often the dumping grounds for untreated sewage. Vital areas of shallow waters that had previously sustained diverse aquatic life and provided spawning ground for fish were lost to pollution and development. It is believed that only 500 of an estimated 7,000 acres of shallows that existed at the time of Philadelphia's founding were still viable three hundred years later in 1982 (Toffey, 1982).

The majority of the damage done to the river and shoreline was concentrated mainly 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 one English visitor to the Philadelphia harbor in 1769 succinctly put it, the Delaware Waterfront near Philadelphia was a "mess," a finding confirmed by the first pollution survey conducted in 1799, which found that pollution from ships, sewers, and contaminated wetlands was threatening the health of the river (Webster, 1996). Soon, the health of colonists themselves, who relied on the Delaware for drinking water, was also in jeopardy. Rivers polluted with human and industrial waste were held responsible for cholera outbreaks from tannery pollution in the 1700s, a vicious yellow fever epidemic that killed 10% of Philadelphia's population in one year alone in the 1790s, and outbreaks of typhoid in the 1890s that plagued urban areas in the watershed**.**

Pollution levels continued to increase as the Industrial Revolution reached full swing in the mid-1800s. Former fishing towns such as Fishtown, Kensington, and Richmond took on new roles as manufacturing centers, and more piers were built to ship coal, wood, and other goods from these coastal centers (Toffey, 1982). Small industrial mills on the waterfront morphed into large factories with greater discharges of waste. Coal, iron steel, gunpowder, and textile mills, shipbuilding factories, tanneries, and chemical industries, etc., all used and abused the Delaware River.

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 even breathe near the river 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. It appeared that colonial industrialization efforts within the estuary region perhaps had not been justified by the damaging means it had taken to reach them. 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 a Pyrrhic victory for the region as a whole, on account of 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).

Riverfront land suffered from industrialization and overuse as well. Factories and transportation thoroughfares had replaced trees and wild land, leaving the waterfront with little remaining open recreational space or aesthetic value. One such area in which these effects were felt particularly strongly was about 2-3 miles below the Fairmount Dam on the Schuylkill River, where even the few remaining large estates and the Gray's Ferry gardens were cleared away during the Industrial Revolution to accommodate more factories and railroads (Toffey, 1982).

1.2.2.3 Transportation

Contributing to the region's economic success and pollution in the early 1800s were the extensive transportation networks constructed during this time. Canals and railroads, which linked regional centers of agriculture and commerce, facilitated the widespread movement of people and products and played a large role in the population and economic growth of the region. Two major canals that contributed to the transformation of the watershed in eastern Pennsylvania were the Lehigh Canal and the Delaware Canal. The former was used to transport anthracite coal through the Lehigh River Valley from Mauch Chunk to Easton, PA; the latter moved coal, lumber, and agricultural products from Easton to Philadelphia and other East Coast markets. Linking the Delaware Valley to eastern New Jersey were the Delaware and Raritan Canal and the Morris Canal (Fulcomer and Corbett, 1981). Canals were especially influential along the Schuylkill River, whose waters were too fast and shallow to allow easy transportation prior to their construction.

The new water linkages were vital to inland travel and especially important in the shipment of coal from the Upper Schuylkill area and other mining regions farther north in the watershed downstream to Philadelphia. On March 15, 1784, the Legislature of Pennsylvania ratified an act that was "for the purpose of improving the navigation of the Schuylkill (river) so as to make it passable at all times, enabling the inhabitants to bring their produce to market, furnishing the county adjoining the same and the City of Philadelphia with coal, masts, boards," etc. (DEP, http://www.dep.state.pa.us/dep/deputate/enved/go_with_inspector/coalmine/anthracite.htm). Unfortunately, canals were also instrumental in carrying pollution from outlying areas, particularly from coal mines, downstream into the rivers. Besides polluting drinking water, the millions of tons of culm that were dumped or leaked from the mines ruined fish habitats, backed up behind dams, and reduced the ability of the rivers to manage stormwater (Toffey, 1982).

The speed of railroads, which were introduced in the early 1800s, made them a more convenient form of transportation, which was responsible for driving much of the urban development in the watershed, and by the 1930s, the canal system was virtually obsolete. Some canals were filled in to make roads, while others simply fell into disuse, later to become landmarks and state park attractions (Heritage Conservancy). Although trains continued to be used for the transportation of agricultural products, by the 1840s the rail lines were also heavily relied upon for industrial purposes: to move raw materials to factories and finished manufactured goods to markets and ports. In fact, many rail terminals were built right up to the Delaware River to hasten exportation. Initially, such easy access to the riverfront brought more residents into contact with the area, where they sought various forms of recreation such as walks along the waterfront. However, much of the waterfront's recreational value was lost as it became more industrialized and polluted, and the rails then provided a means of escape from the busy area's smoke-spewing factories and foul-smelling river. Trains, and later streetcars and improved roads, took people farther inland away from the waterfront "mess," and contributed to the growth of Philadelphia's suburbs.

1.2.2.4 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. Eighty percent of the water systems in the U.S. tap a ground water source for their water supply, with 10-20% of people using their own private wells for drinking water. However, the majority of the American population (66%) is served by a surface water system (EPA, http://www.epa.gov/safewater/faq/faq.html#source). 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 streamflows, 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.

Delaware River Basin Consumptive Use

Table 1.2.2-1 Estimated and Projected In-Basin 122-Day Average (June – September) Million Gallons per Day (MGD)

Category	1991	2000	2010	2020
Municipal	203.4	228	255	284
Rural	27.1	30	32	36
Industrial	46.8	52	56	61
Power	78.1	77	87	99
Agricultural Irrigation	144.7	154	161	169
Golf Irrigation	12.8	13	14	15
Institutions	4.2	5	5	5
Livestock	12.4	12	12	12
Ski Areas	0.0	0	0	0
TOTAL	**529.5**	**571**	**622**	**681**

Table 1.2.2-2 Estimated and Projected In-Basin Average Annual Consumptive Use (MGD)

Category	1991	2000	2010	2020
Municipal	114.0	128	143	159
Rural	15.2	17	18	20
Industrial	41.5	46	50	54
Power	69.8	69	78	88
Agricultural Irrigation	51.9	55	58	60
Golf Irrigation	5.9	6	6	7
Institutions	4.1	4	5	5
Livestock	7.2	7	7	7
Ski Areas	1.2	1	1	1
TOTAL	**310.8**	**333**	**366**	**401**

Table 1.2.2-3 Estimated and Projected Average Annual Exports and Imports of Water (MGD)

Category	1991	2000	2010	2020
Export	796.8	907	910	910
Import	32.1	42	42	42

Table 1.2.2-4 Total of In-Basin Average Annual Depletive Use Plus Net Exports of Water (MGD)

Category	1991	2000	2010	2020
Total Net MGD	1,076	1,199	1,235	1,270

Source: Delaware River Basin Commission, http://www.state.nj.us/drbc/tableii6.txt

The estimated total amount of water used each day in the watershed in 1991 was 7,337 MGD according to the DRBC (USGS NAWQA, 1999). The majority (69%) of that was used to generate power in New Jersey, and most of the remaining water was used by the public (15%) and industry (15%). Most of that water is used non-consumptively, meaning it is returned to the basin's streams and aquifers, with the exception of about 311 MGD in consumptive uses within the basin and 900 MGD that are diverted out of the basin to New York City and northeastern New Jersey (USGS NAWQA, 1999). PSE&G in Salem, NJ is the largest of all surface water users within the watershed, taking roughly 1,983 MGD (DRBC, http://www.state.nj.us/drbc/top10wd.txt). The Philadelphia Water Department (PWD), which takes about 361 MGD from both the Delaware River (~50%) and the Schuylkill River (~50%), is the largest municipal user. (See Table 1.2.2-5).

Table 1.2.2 -5 Top Ten Water Users in the Delaware River Basin

Rank	Name	MGD Withdrawal	MGD Depletive	County
Pennsylvania				
1	PECO-Eddystone	541.957	1.528	DELAWARE
2	Philadelphia Water Department	361.109	36.111	PHILADELPHIA
3	Metropolitan Edison-Portland	257.575	1.097	NORTHAMPTON
4	PECO-Delaware	180.626	0.090	PHILADELPHIA
5	Bethlehem Steel	156.246	2.871	NORTHAMPTON
6	PECO-Cromby	146.257	0.622	CHESTER
7	PP&L-Martins Creek	97.589	2.533	NORTHAMPTON
8	Philadelphia Surburban WCo	84.580	10.941	MONTGOMERY
9	BP Oil Corp	82.542	0.989	DELAWARE
10	USX Corp, Fairless	43.584	2.179	BUCKS
New Jersey				
1	PSEG-Salem	1,982.959	11.621	SALEM
2	PSEG-Mercer	492.778	2.870	MERCER
3	Atlantic City Electric-Deepwater	127.362	0.344	SALEM
4	NJ Water Supply Auth-D&R Canal Export	85.423	51.254	HUNTERDON
5	EI DuPont-Chambers	67.605	0.822	SALEM
6	US Silica Co-Dewatering	52.172	0.072	CUMBERLAND
7	PSEG-Hope Creek	50.935	12.775	SALEM
8	EI DuPont-Repauno	37.715	0.041	GLOUCESTER
9	Trenton Water Works	30.387	3.039	MERCER
10	NJ American Water Co-Haddon	22.900	2.290	CAMDEN
Delaware				
1	Delmarva P&L-Edgemoor	487.931	1.968	NEW CASTLE
2	Star Enterprise	321.410	6.861	NEW CASTLE
3	Wilmington City	28.786	2.879	NEW CASTLE
4	General Chemical	23.155	0.741	NEW CASTLE
5	United Water Delaware	22.955	3.443	NEW CASTLE
6	Artesian Water Co	9.384	0.939	NEW CASTLE
7	EI DuPont-Edgemoor	6.400	0.807	NEW CASTLE
8	SPI Polyols	6.072	0.160	NEW CASTLE
9	Dover City	5.128	0.513	KENT
10	NVF Co, Yorklyn	2.226	0.040	NEW CASTLE
New York				
1	NYC Diversion	700.071	700.071	DELAWARE
2	Port Jervis City	1.665	0.167	ORANGE
3	Monticello Village	1.264	0.126	SULLIVAN
4	South Fallsburg Water District	1.172	0.117	SULLIVAN
5	Kraft Foods	0.883	0.088	DELAWARE
6	Liberty Village	0.751	0.075	SULLIVAN
7	Walton Village	0.633	0.063	DELAWARE
8	Hancock Village	0.573	0.057	DELAWARE
9	Lake Louise Marie	0.422	0.042	SULLIVAN
10	Deposit Village	0.409	0.041	BROOME

Source: Delaware River Basin Commission, http://www.state.nj.us/drbc/top10wd.txt

1.2.2.5 Historical Improvements in Source Water Quality

Although the Delaware River has been utilized for thousands of years, the quality of the water source began decreasing rapidly from the time of initial European settlement in the early 17th century until corrective, preventative, and protective measures were taken beginning in the 20th century. The river's pollution problem developed from abuse and overuse over time, especially in the heavily populated and industrialized estuary region of the Lower Delaware River, into which colonists dumped their domestic, agricultural, and industrial waste. Additionally, contaminants from buried waste leaked into groundwater supplies over the years.

The majority of early colonial Philadelphia's water supply came from wells until the end of the 18th century, when a yellow fever epidemic hit the city in 1793. In 1798, it was discovered that cesspools of buried waste, which were too close to the city's water supplies, were contaminating groundwater. Waste was then dumped into canals, which carried it into the rivers. Lacking wastewater treatment technology and the foresight to predict the problems that would result from their actions, colonists continually dumped millions of tons of raw sewage into the streams and rivers, which increased contaminant and nutrient levels and decreased the pH and dissolved oxygen (DO) in the waters. Thus, their actions adversely affected aquatic life and water quality. Corrective measures to improve the quality of drinking water were undertaken at the beginning of the 19th century. However, preventative measures regarding protecting the quality of the rivers and streams as resources were not initiated until later.

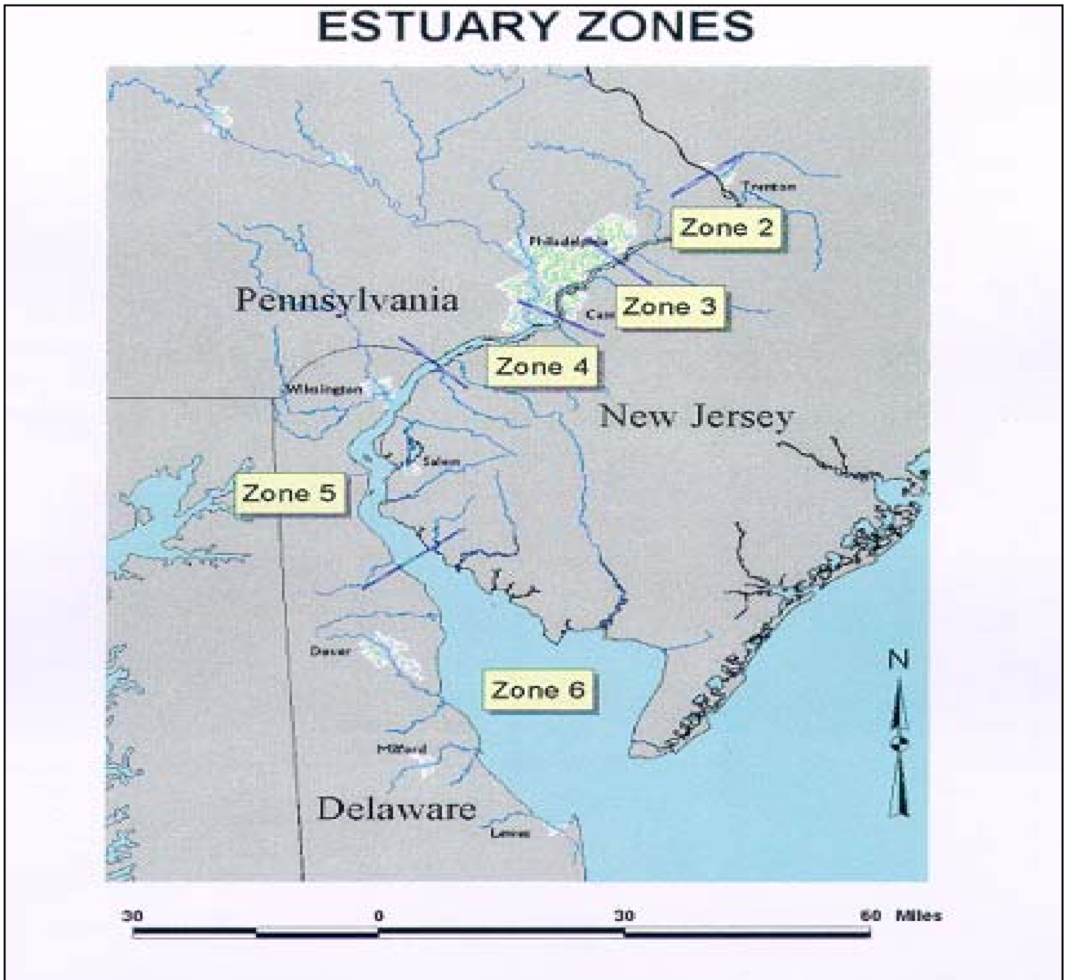
As one of the earliest, most significant, and most polluted areas in the watershed, the City of Philadelphia provides an interesting case study on water quality improvement for drinking purposes. In 1801, Philadelphia began pumping untreated water from the Schuylkill River to supply the city's residents with a reliable source of drinking water. The only primitive form of purification that the water received in the early 1800s was settlement in still reservoirs in order to remove debris. However, as the city became more populated and industrialized, increasing pollution in the rivers led to problems that could not be settled out: odors, tastes and typhoid. Filtration over sand beds was the next step. An 1899 report that resulted from seven studies made between 1858 and 1899 on water sources and treatment led to the construction of 5 "slow sand" filtration treatment plants between 1902 and 1911. Water was first sent through pre-filters of coke or sponge, then it passed over sand beds, and eventually settled in raw water basins. The new filtration system cut the typhoid death rate in the city by one- fourth. Shortly after chlorine treatment was initiated in 1913, typhoid was eradicated.

In order to remove the odors and tastes that were still problematic in Philadelphia's otherwise safe drinking water, chemical treatments with carbon, ozone, and chlorine dioxide were also necessary in the 1940s and early 1950s when Philadelphia's rivers were for all intents and purposes, "open sewers". Despite its pollution crisis, the city developed a successful method for treating river water in order to make it drinkable. Philadelphia continued paving the way in water purification when in 1976 it became the first city in the country to build a plant to research the best ways of removing trace organics, odors, and tastes from drinking water (City of Philadelphia, 1989).

In the 1920s, Philadelphia and Trenton, two of the biggest sources of pollution on the river, both made individual attempts to clean up their wastewater acts by building a wastewater treatment plant in their respective cities in order to cleanse city sewage of most of its harmful components before returning the water to the Delaware River. It was not until after WWII, (during which water quality improvement initiatives were put on hold) that two more regional wastewater treatment plants were built in Philadelphia: the Southwest Plant in 1954, and the Southeast Plant in 1955. However, the first concerted basin-wide efforts to make sustainable improvements in the quality of the watershed's source water resources were not officially implemented until the Interstate Commission on the Delaware River Basin (INCODEL) was founded in 1936. INCODEL, whose members consisted of the four basin states Delaware, New Jersey, New York, and Pennsylvania, was primarily organized as an advisory committee in order to develop solutions to the water pollution problem within the basin and to strategize about how to deal with concerns regarding increasing population and industrial development, which would affect the watershed in the near future. To that end, INCODEL soon expanded its focus to include conservation, water supply, and other issues facing the Delaware River Basin (Delaware Public Archives, http://www.state.de.us/sos/dpa/collections/aghist/0903.htm).

INCODEL's most significant accomplishments include dividing the Delaware River into six water "zones" for monitoring purposes (See Figure 1.2.2-1), establishing water quality standards for those zones, and upgrading sewage treatment plants. According to the Council on Environmental Quality (1975), the number of communities with "adequate" sewage collection and treatment plants increased from 20 to 75% under INCODEL (Marrazzo & Panzitta, 1984). However, this pioneer river management organization had no legal authority to enforce its recommendations, and for this reason, a new organization was necessary in order to enforce water quality initiatives and regulations (Roberts). As a result of the signing of the Delaware River Basin Compact in 1961, INCODEL morphed into the present watershed guardian, the Delaware River Basin Commission (DRBC), a revamped group with an expanded vision for protecting the watershed and its resources and with the legal power it needed to enforce its regulations. The chief members of the DRBC are the governors of the four basin states (NY, PA, NJ, and DE), and a federal representative appointed by the President of the United States. Prior to the formation of the DRBC, it took 43 state, 14 interstate, and 19 federal agencies to monitor the basin (DRBC, http://www.state.nj.us/drbc/over.htm). Under this new, unified and more efficient Delaware River Basin Commission authority, the first of its kind in its unique collaboration between State and Federal water management officials, many improvements have been made in the quality of the basin's water resources over the last four decades.

Figure 1.2.2-1 Estuary Zones



Source:: Delaware River Basin Commission

Shortly after taking over the duties of INCODEL, the DRBC took part in a $1.2 million Delaware clean-up program. In 1967, the DRBC began water quality studies and set higher water quality standards based on a computer model that determined the Delaware's waste assimilative capacity. The model led to a DRBC mandate for an 88% reduction in oxygen-demanding waste (BOD) for 90 major dischargers to be accomplished through new wasteload allocations. In addition, water pollution control programs in the 1960s also required the construction of secondary wastewater treatment facilities at more than 90 discharge sites in the estuary (Roberts, and Marrazzo and Panzitta, 1984).

Perhaps the most influential piece of legislation to date is the Clean Water Act of 1972, the nation's first water resource protection legislation. Originally passed as the Federal Water Pollution Control Act in 1948 (Chapter 758; PL 845), the goal was to improve the condition of ground and surface waters by eliminating or reducing pollution in interstate water bodies. Amended in 1972 and referred to as the Clean Water Act (CWA), this law has since been expanded over the years to include many other water quality programs that have contributed to the continuous improvements in the quality of the nation's water. The Clean Water Act is responsible for the implementation of secondary treatment in municipal wastewater treatment plants (City of Philadelphia Water Department, http://170.115.80.16/water/protect.html) and the institution of water quality standards, discharge limitations, and permits (U.S. Department of the Interior, Bureau of Reclamation, http://www.usbr.gov/laws/cleanwat.html).

The act also established the Total Maximum Daily Load (TMDL) program, which affects more than 20,000 river segments, lakes, and estuaries, and attempts to limit excessive discharges of pollution in our water supplies. According to the EPA, a TMDL is "the amount of pollutants that may be present in the water and still meet water quality standards" (EPA, http://gwpc.site.net/news/nws-epa_impaired_waters_rule.htm). A TMDL takes into account such pollutants as fecal coliform, sediment, nutrients, shellfish, organics, metals, pH, and other materials that decrease dissolved oxygen (Water Online, http://www.wateronline.com/content/news/article.asp?docid={14DA2CA3-12C0-11D5-A770-00D0B7694F32}&VNETCOOKIE=NO).

The nation's water systems, and we as users, are daily reaping the benefits of the Clean Water Act and its subsequent amendments. The fruits of these legislative labors have been noted in the Delaware since the beginning of the DRBC's clean-up efforts in the 1960s. To this day there has been a reported 76% decrease in the amount of BOD discharged into the Delaware Estuary (DRBC, 2002) and DO levels have steadily increased in vulnerable zones of the river since 1965, particularly in the heavily industrialized estuary area. (Krejmas, Harkness, and Carswell, Jr., 2000, The Report of the River Master of the Delaware River for the period Dec.1, 1997--Nov.30, 1998, p. 78). As a result, many fish populations that had nearly disappeared before pollution abatement efforts were made have since reappeared in greater numbers (i.e. herring, shad, sturgeon, and other anadromous fish).

Since the CWA, other legislative efforts have been made to improve the quality of water in the Delaware River Basin as we continue to recognize the importance of water quality control. Recent legislation includes protective measures for both our surface and groundwater resources as sources of our drinking water, as well as quality control for treatment plants. In April of 2000, the EPA announced that as part of the new amendments to the Safe Drinking Water Act signed by President Clinton in 1996, a new law will require states to survey the sources of all drinking water systems, including publicly-used groundwater systems, that may be vulnerable to contamination in order to preserve water quality by protecting groundwater supplies from *E. coli* and other disease-causing viruses and bacteria. Currently, only contaminated surface water systems require corrective measures, such as disinfection, to be taken, but the new law will mandate similar actions for contaminated groundwater supplies, as well as alterations to defective supply systems (EPA, http://gwpc.site.net/News/nws-EPAgwsourceprot.htm).

In May of 2001 the EPA issued the Filter Backwash Recycling Rule (FBRR), as required by the Safe Drinking Water Act, in order to reduce microbial contamination by pathogens such as *Cryptosporidium* in drinking water supplies. The FBRR, which is estimated to affect 35 million people, puts an end to the filter "backwashing" that routinely takes place in many drinking water treatment plants that clean filters by pumping water backwards through them to remove particulates, a process that increases the risk of contamination because the backwash water is often recycled back into the plant containing high levels of microbes (EPA, http://gwpc.site.net/news/nws-epa_issues_drinking_water_rule.htm and EPA, http://gwpc.site.net/news/nws-epa_administrator_whitman_further_prot_drinking_water.htm).

In addition, the EPA is still trying to make headway in the fight against acid mine drainage damage to our waterways. Pennsylvania and the Federal government has spent almost $500 million since 1967 to remedy pollution from abandoned surface and deep mines, but more than $15 billion worth of cleanup work still needs to be completed. AMD is still a problem in Pond Creek and Sandy Run Creek in the Lehigh River Basin (central Delaware River Basin). These cleanup efforts are funded by a 35 cent per ton federal fee on coal being mined today, state reclamation funds from fees, and forfeited reclamation bonds (DEP, http://www.dep.state.pa.us/dep/deputate/enved/go_with_inspector/coalmine/Coal_Mining_in_Pennsylvania.htm). In April of 2000, the EPA proposed changes to current discharge guidelines for mines, which would increase the rate at which abandoned mines are reclaimed, thereby using the leftover coal while improving water quality by decreasing the risk of contamination to water sources (Ground Water Protection Council, http://gwpc.site.net/news/nws-july30-01.htm). These new guidelines would be a crucial protective step in the prevention of more AMD damage to watershed waterways, because although there was a sharp decrease in anthracite production after World War II, mining has increased more than 150 percent since 1990 due to new uses of coal in cogeneration, industrial and residential heating, and as a source of fuel for electric power plants.

Presently, anthracite is mined in eight Pennsylvania counties: Schuylkill, Carbon, Luzerne, Northumberland, Lackawanna, Columbia, Dauphin and Sullivan (ranked in order of production), and Pennsylvania is the fourth largest coal-producing state in the United States after Wyoming, West Virginia and Kentucky. More than $1.5 billion in coal sales are responsible for about one percent of the gross state economic product of Pennsylvania. Keeping in mind that mining efforts continue in these areas to this day, it is important that efforts be made to curb pollution from these operations in order to preserve the health of our waterways (DEP, http://www.dep.state.pa.us/dep/deputate/enved/go_with_inspector/coalmine/Anthracite_Coal_Mining.htm).

While it is not anywhere near as pristine as it was in pre-colonial days, water quality in the Delaware River today is the best it has been in over 100 years due to ongoing pollution control, prevention programs and legislation, which were initiated by the DRBC in the 1960s and are carried on today by the DRBC, the EPA, and associated organizations. As a whole, the river exceeds current standards, with the exceptions of seasonal violations of DO and fecal coliform levels in the estuary area, as well as toxic contaminants and nutrient loading alerts, which often result in fish advisories for certain affected sections of the river. However, the tremendous improvement that has been made since the Delaware River's darkest days represents the priority that has been placed on improving and preserving our water resources in the last four decades. The time and effort that will be invested in protecting and bettering the watershed in the future will continue this trend of improvement.

1.2.3 Physiography, Topography, and Soils

Key Points

- **The Delaware River Watershed is composed of a number of smaller subwatersheds, the most notable of which include: the Lehigh River, Crosswicks Creek, Musconetcong River, Rancocas Creek, Neshaminy Creek, and Tohickon Creek watersheds.**
- **The watershed is also divided into five physiographic provinces, each with its own unique geology, groundwater, and soil composition. From north to south, the five provinces are: the Appalachian Plateau, the Valley and Ridge, the New England Upland, the Piedmont, and the Atlantic Coastal Plain.**
- **In 1999, after it was discovered that development was adversely affecting groundwater levels in certain areas, the Delaware River Basin Commission adopted regulations that established groundwater withdrawal limits for 76 watersheds that are within, or partly within, the Groundwater Protected Area of Southeastern Pennsylvania, in order to protect this important resource.**

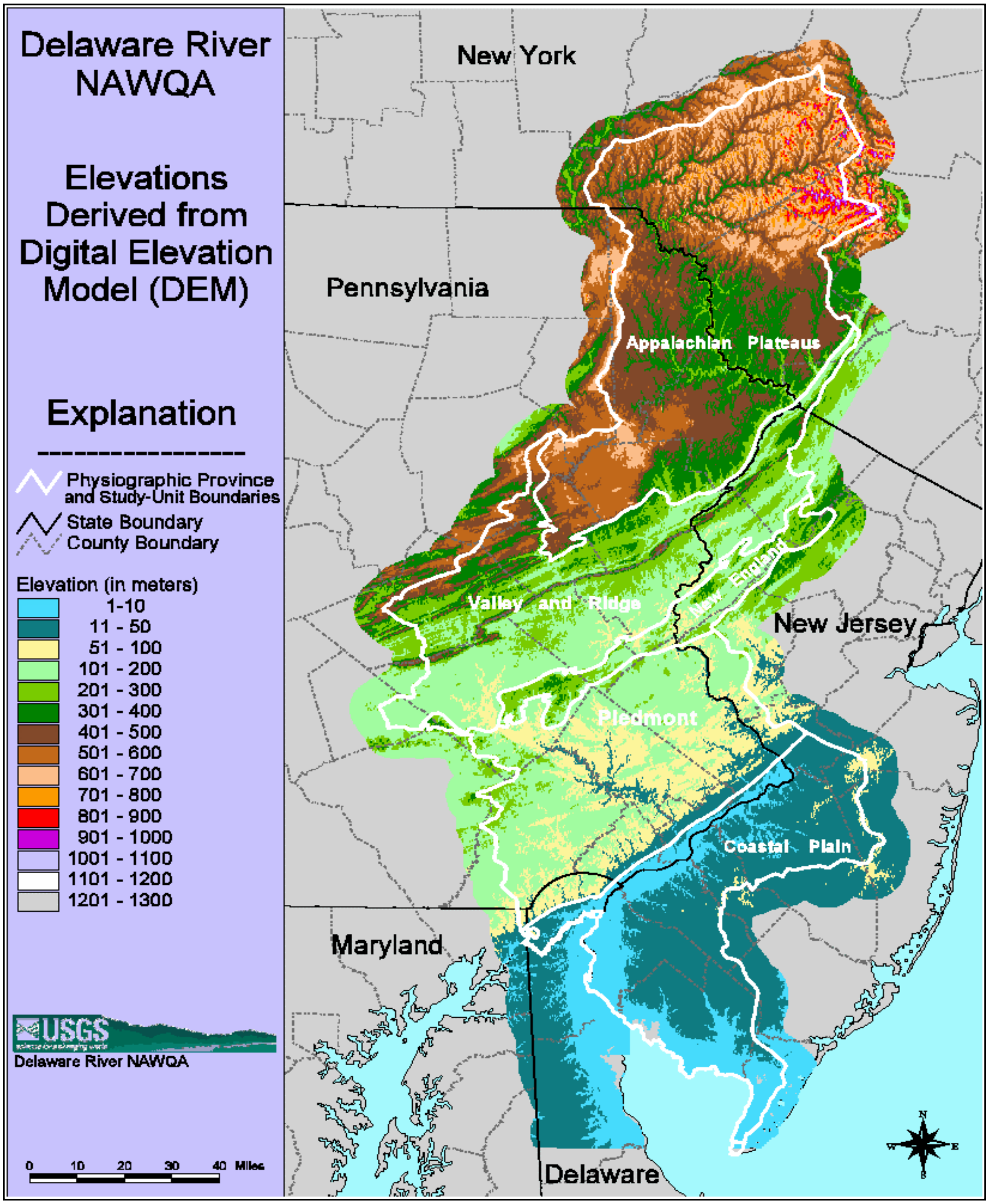
1.2.3.1 Physiography and Topography

The Delaware River Watershed covers a variety of physiographically distinct regional provinces. A physiographic province is an area of land that is composed of a particular type(s) of rock as a result of having undergone certain environmental processes over time which distinguish it from other surrounding areas. Each province is distinguishable by its physical landforms, unique rock formations, and groundwater characteristics.

From north to south, the five physiographical provinces in the Delaware Watershed are: the Appalachian Plateau, the Valley and Ridge, the New England Upland, the Piedmont, and the Atlantic Coastal Plain. (See Figure 1.2.3-1)

Elevations of the Appalachian Plateau generally range from about 300 – 700 meters throughout the area, (roughly 980 – 2,300 feet) with some peaks in New York reaching over 900 meters (3,100 feet) above sea level. The Plateau contains relatively straight valleys with irregular ridges and stretches across the northeastern part of Pennsylvania into New York. The Valley and Ridge Province is comprised of the mountains in the Appalachian Mountain section and rolling farmlands in the Great Valley. Elevations in the Valley and Ridge Province range up to 550 meters (1,800) feet above mean sea level (msl). The New England Upland Province is a very narrow area separating the Valley and Ridge Province and the Piedmont Region in both eastern Pennsylvania and western New Jersey. The New England Province includes the Reading Prong, which is composed of the small mountains east of Reading. The Triassic Lowland of the Piedmont Province is characterized by rich farmland and low rolling hills, whereas the Piedmont Uplands include steep hills with urban development. The rolling hills of the Piedmont Province reach about 150 meters (500 feet) above mean sea level (msl). The Atlantic Coastal Plain Province is mainly lowlands with numerous streams and marshlands at about 30 meters (100 feet) above msl.

Figure 1.2.3-1 Physiographic Provinces and Elevations of the Delaware River Watershed



Source: USGS NAWQA Study

1.2.3.2 Subwatershed Physical Settings

Within the larger Delaware River Watershed, there are a number of smaller subwatersheds that drain the lands surrounding the Delaware's 216 tributaries. Outlined below are some of the major subwatersheds enveloped within the 13,539 square mile Delaware River Watershed, including the Lehigh River, Crosswicks Creek, Musconetcong River, Rancocas Creek, Neshaminy Creek, and Tohickon Creek Watersheds, as well as some of the upper subwatersheds and the tidal areas of the lower subwatershed. These are shown in Figure 1.2.3-2.

Upper Delaware Watershed
The Upper Delaware Watershed is home to the headwaters of the Delaware River at the Cannonsville Reservoir. The West Branch Delaware gets its start in Schoharie County, New York, where it travels down through Delaware County and converges with the East Branch Delaware River along the Pennsylvania - New York border near Hancock, New York. The watershed extends further down the Delaware covering parts of both Wayne County, Pennsylvania and Sullivan County, New York and finally ends with a small piece of northern Pike County, Pennsylvania. The watershed is contained in the Appalachian Plateau Province.

East Branch Delaware Watershed
The East Branch Delaware River Watershed is the only subwatershed located completely in New York. The watershed drains 837 square miles of parts of four different counties. The East Branch Delaware River is home to the Pepacton Reservoir, which is the largest reservoir in the Delaware River Watershed with a surface area of about 10 square miles and a capacity of almost 150 billion gallons of water.

Lackawaxen River Watershed
The Lackawaxen River headwaters are located in northeastern Wayne County, Pennsylvania. The river stretches 27 miles before draining into the Delaware River at Lackawaxen, PA along the Pennsylvania - New York border. Contained solely in Pennsylvania, the watershed covers an area of 596 square miles of Wayne and Pike Counties.

Mongaup Creek Watershed
The Mongaup Creek Watershed covers an area of 1.5 square miles and is located in parts of Pennsylvania, New Jersey, and New York. The watershed encompasses the Bushkill, Brodhead, McMichael, and Basher Kill Creeks, and the Neversink River. As the second largest subwatershed in the Delaware River Basin, its reaches include Sullivan, Ulster, and Orange Counties in New York, Pike, and Monroe Counties in Pennsylvania, and Sussex, and Warren Counties in New Jersey.

Lehigh River Watershed
The Lehigh River Watershed covers 1,360 square miles, and the 107-mile Lehigh River itself serves as a geopolitical boundary between many of the eastern Pennsylvania counties through which it travels. These counties include Berks, Wayne, Lackawanna, Monroe, Luzerne, Carbon, Lehigh, and Northampton. The Lehigh River originates with

a series of glacial bogs and marshes in the area of Pocono Peak Lake, where elevation peaks at 2,100 feet above sea level, near the town of Gouldsboro. During the course of the river's 103-mile journey to its confluence with the Delaware River in Easton, the elevation drops nearly 1,900 feet. Throughout the 17th and 18th centuries, the Lehigh River was referred to as the "West Branch" of the Delaware River. The area of confluence with the Delaware River was called the "Forks of the Delaware." The name "Lehigh" is actually the anglicized version of the Lenni Lenape Indian word "Lechewuekink" which means, "where there are forks."

The Lehigh River played an integral role in the industrialization of the surrounding region. A 72-mile canal system was developed between 1827 and 1829 in order to capitalize on the proximity of the Lehigh River to Eastern Pennsylvania's natural resources, such as coal, and bringing these resources to the marketplaces downstream. After 1934, the canal system, formally known as the Lehigh Navigation Canal System, became part of a larger system of canals including the Morris Canal, which linked the Lehigh River to New York Harbor, and the Delaware Canal, which in turn linked the river to Philadelphia. In 1855, the peak year of its operation, the Lehigh Navigation Canal System carried over 1,000,000 tons of anthracite coal from Carbon County to Easton, Pennsylvania. The vast white pine forest that lined the banks of the upper Lehigh River aided in making Pennsylvania the greatest lumber-producing state in the 1860s. These historic banks of the Lehigh later became the heart of America's iron industry, considering that between 1850 and 1880, approximately one-fourth of America's annual iron production took place there (LEO and the SERVIT Group, <http://www.leo.lehigh.edu/envirosci/watershed/fastfacts.html>, Wildlands Conservancy, <http://www.wildlandspa.org/programs/rivers/lehigh/lehigh_home.html>, and Greenworks Productions,< http://www.greenworks.tv/sojourn/lehigh.htm>).

Middle Delaware Watershed

The Middle Delaware Watershed is primarily located in New Jersey and can be seen as the area between McMichael Creek and Tohickon Creek. The watershed drains an area of 990 square miles and is contained partially within Sussex, Warren, and Hunterdon Counties in New Jersey and Northampton and Bucks Counties in Pennsylvania. The two main tributaries that drain into the Delaware River in this watershed are the Musconetcong and Pohatcong Rivers. The Lehigh River Watershed also drains into the Delaware in the Middle Delaware Watershed, but is not considered to be part of the Middle Delaware Watershed. The largest tributary within this watershed is the Musconetcong River. The Musconetcong River, which joins the Delaware in Rieglesville, is 44 miles in length and flows past state parks, forests, towns, historic villages, vital industries, and one of New Jersey's most scenic agricultural valleys. The Musconetcong River Watershed is a 157.6 square mile area of land that drains to the Musconetcong River. This watershed includes portions of Hunterdon, Morris, Warren, and Sussex Counties as well as all or parts of 25 municipalities. The largest tributary stream to the Musconetcong River is Lubbers Run . http://www.musconetcong.homestead.com/surf~ns4.html).

Tohickon Creek Watershed
The Tohickon Creek Watershed, located in southeastern Pennsylvania, spans 112 square miles and encompasses portions of Bedminster, East Rockhill, Haycock, Hilltown, Milford, Nockamixon, Plumstead, Richland, Springfield, Tinicum, and West Rockhill Townships in Bucks County, Pennsylvania. Included within its borders are the Boroughs of Dublin, Perkasie, Richlandtown, Trumbauersville, and Quakertown. Named by the Lene Lenape Indians to mean "Deer-Bone-Creek," the Tohickon Creek runs from the Nockamixon Dam to its confluence with the Delaware River some eight miles downstream. Historically, the Creek is known for providing shelter to the Doan Gang, who were famous for a string of Bucks County robberies in the 1780s and hid in a small house made of logs along the Tohickon Creek on the Plumstead side while fearing their capture (New Hope, PA, http://www.newhopepa.com/DelawareRiver/tohickon_index.htm, and DEP, http://www.dep.state.pa.us/hosting/efp2/reports/SERO/team14/14%20Draft%202D%20Delaware%20River%20Tohickon%20Creek%20061101.pdf).

Neshaminy Creek Watershed
The Neshaminy Creek Watershed occupies an area of 233 square miles, 86% of which is located in central and lower Bucks County, with the remaining 14% in Montgomery County, both of which are located in Pennsylvania. The northern portion of the watershed lies in the uplands of the Piedmont Province, while the southern portion lies in the lowlands of the Coastal Plain. These two geologic regions are separated by the dramatic Fall Line, which sharply rises to a height of 200 feet. The Neshaminy Creek is 50 creek miles in length and flows approximately 50 miles in a southeasterly direction to its confluence with the Delaware River. The headwaters of the Neshaminy Creek flow from its West Branch (in the Lansdale/Hatfield Area) to its North Branch (Northeast of Doylestown). Topographically, the watershed is predominantly rolling hills and steep-sided stream valleys. Ten impoundments lining the Neshaminy and its tributaries provide public water, recreation, and flood protection for the region.

In terms of land use, some portions of the upper watershed are still rural or semi-rural in nature. Very few, small and scattered, forested areas still exist. The headwaters of the West Branch, the Little Neshaminy, and the southern portion of the watershed are highly developed, which contributes to an increase in the amount of development in the watershed. The municipalities encompassed within the watershed region are Bensalem Township, Bristol Township, Buckingham Township, Chalfont, Doylestown, Doylestown Township, Hatfield, Hulmeville, Ivyland, Langhorne, Langhorne Manor, Lansdale, Lower Southampton Township, Middletown Township, New Britain, New Britain Township, Newtown, Newtown Township, Northampton, Penndel, Plumstead Township, Upper Southampton Township, Warminster Township, Warwick Township, and Wrightstown Township (The Delaware Riverkeeper Network, http://delawareriverkeeper.org/factsheets/neshaminy.html).

Tidal PA Bucks Watershed
The smallest of all the Delaware River Subwatersheds is the Tidal PA Bucks Watershed. Located in the southeast corner of Bucks County, Pennsylvania, it drains 57 square miles of land. The watershed contains only three, second-order tributaries, the longest being Mill Creek.

Tidal PA Philadelphia Watershed
The Tidal PA Philadelphia Watershed drains 152 square miles of land in parts of Philadelphia, Montgomery, and Bucks Counties in Pennsylvania. The area splits the geologic border of the Piedmont Region and the Atlantic Coastal Plain Region. These two distinct regions are separated by a jagged boundary where Coastal Plain sediments have lapped onto the Piedmont crystalline rocks. Located with in this watershed are three second order tributaries that drain directly into the Delaware River, namely, the Poquessing, Pennypack, and Tacony Creeks.

NJ Mercer Direct
The NJ Mercer Direct Watershed is directly across the Delaware River from the PA Bucks Direct Watershed entirely located in New Jersey. Starting in Lower Hunterdon County, New Jersey, the watershed then stretches across Mercer County and into Monmouth County. The total drainage area of this watershed is 155 square miles. The watershed contains 10 short (1.5 – 13.5 miles in length) second-order tributaries that drain directly into the Delaware River.

PA Bucks Direct Watershed
The PA Bucks Direct Watershed is contained entirely within Bucks County and contains the many small tributaries that drain directly into the Delaware River. The 83 square mile drainage area holds 14 Major Tributaries, the four longest being the Paunnacussing, Pidock, Jericho, and Houghs Creeks. The watershed is located in the Gettysburg-Newark Lowland section of the Piedmont Province. This section is characterized by red sedimentary rocks such as sandstone, siltstone, shales, and conglomerates, and average elevations between 450 – 550 feet.

Crosswicks Creek Watershed
The headwaters of the Crosswicks Creek flow from the Fort Dix and McGuire Air Force Military Reserves in New Jersey in a northwesterly direction and then turn sharply south. It is at this point, in the City of Bordentown, New Jersey, that the creek meets the Delaware River. The Crosswicks Creek Watershed encompasses portions of Burlington, Mercer, Monmouth, and Ocean Counties. The length of this watershed measures 25 miles while its total area extends 146 square miles. Some of the creek's significant tributaries include Buck Brook, Buckhole Creek, Culvert Pond Run, Doctors Creek, Edges Brook, Ivanhoe Brook, Jumping Brook, Lahaway Creek, Long Bog Run, Mile Hollow Brook, Negro Run, North Run, South Run, and Thornton Creek. Major municipalities within the Crosswicks Creek Watershed region include Allentown, Bordentown Township, Chesterfield, City of Bordentown, Fort Dix Military Reservation, Hamilton, New Hanover, North Hanover, Upper Freehold, and Springfield.

Land use patterns prevalent in this region are agricultural/undeveloped, forested, urban/suburban residential, commercial, and military (Delaware Riverkeeper Network, http://www.delawareriverkeeper.org/factsheets/crosswicks_creek.html)

Tidal New Jersey Upper Watershed
The Tidal New Jersey Upper Watershed is comprised of seven second-order tributaries that drain directly into the Delaware River. The total drainage area of these tributaries, and thus the entire watershed, is 109 square miles. The area is located within Burlington County, New Jersey.

Rancocas Creek Watershed
The Rancocas Creek Watershed spans an area of 360 square miles, which is the largest in south central New Jersey. Of this area, 167 square miles are drained by the North Branch and 144 square miles are drained by the South Branch. The 31 mile long North Branch is fed by the Greenwood Branch, McDonalds Branch, and Mount Misery Brook. The major tributaries to the South Branch include the Southwest Branch of the Rancocas Creek, Stop the Jade Run, Haynes Creek, and Friendship Creek. The main stem of the South Branch flows approximately eight miles and drains an area of nearly 49 square miles before converging with the Delaware River at Delanco and Riverside. The eastern portion of this watershed drains the Pinelands Protection Area.

Some of the major impoundments located within this region include Medford Lake, Pine Lake, Browns Mills Lake, and Crystal Lake. In terms of land use patterns, approximately one-half of this drainage basin is forested, with the remaining area divided between agricultural use and urban/suburban uses. Significant development is currently taking place in many former agricultural areas (New Jersey Waters.com, http://www.njwaters.com/wma/19.htm).

Tidal NJ Lower Watershed
The Tidal NJ Lower Watershed is the southern most watershed of the Delaware River, draining an area of 185 square miles. It occupies all of northern Camden County, New Jersey and small parts of both Burlington and Gloucester Counties to its north and south respectively.

Figure 1.2.3-2 Major Subwatersheds of the Delaware River Watershed

1.2.3.3 Geology, Groundwater, and Soils

Geology

Figure 1.2.3-3 shows the major rock types within the Delaware River Watershed. The headwaters of the Delaware River are located in the *Appalachian Plateau Province*, the northernmost province in the watershed with an altitude range between 659 and 2,953 feet (210 and 900 m.). This area is characterized by high, flat rock formations comprised of horizontal layers of Carboniferous and Devonian sandstone as well as shale and conglomerates, which serve as aquifers in the Catskill Mountains, a source of high quality water. Glacial lakes and swamps dot the region, interspersed among numerous steep valleys and 80-foot deep sediment plains of sand and gravel laid by melting glaciers during the formation of the plateau. Groundwater in the province is found in bedding planes and fractures in the land. Wells, which average a depth of 35 feet (11 m.), yield about 90 gallons of water per minute (gpm), except in the Catskills, where the average well yield is about 40 gpm. The water table is near the surface in this area, and quality water can also be found in the glacial deposits from approximately 12,000 years ago (Majumdar, Miller, and Sage, 1988).

The 40,000-foot (12,192-meter) thick folded sedimentary mountains of the *Valley and Ridge Province*, located in the center of the watershed just below the Appalachian Province, are the distinguishing features of this region, which is split into two sections: the Ridge and Valley Section (note the difference in word order from its parent province) to the north and the Great Valley Section to the south. These two areas are divided by Kittatinny Mountain, which is also known as "Blue", "North", and "First" Mountain. The province as a whole ranges from 167-1,969 feet (51-600 m.) in elevation. The mountainous Ridge and Valley section was formed as a result of the repeated upward movement of the earth's plates at the closing of the Paleozoic Era and concurrent stream erosion over time, which were responsible for the notable features of this province: parallel ridges and valleys, the great length of the ridges, and the uniform ridge crest lines (Thornbury, 1965 as cited in Majumdar, Miller, and Sage, 1988). Sandstone and shale make up the eastern side of the mountains, while the western side is comprised of shale and limestone, as are the valleys, where numerous marine fossils can be found. The streams of the province follow the lowland and flow into the valleys at right angles. Of the numerous rock formations that yield water in this region, average yields are roughly 23 gpm from 37 to 40-foot (11-12 m.) wells in the Mahantango Formation (PA), 22 gpm from 41-76-foot (12-23 m.) deep wells in the Catskills (NY), and 30 gpm from various other formations (Majumdar, Miller, and Sage, 1988).

Easily eroded Cambrian and Ordovician limestone and shale comprise the rock of the Great Valley Section, a rolling landscape of folded and fractured rock within the Ridge and Valley Province and below the Valley and Ridge section. Only about 60 miles (97 km) of the 1,000 miles (1,609 km) of the Great Valley are located in the Delaware Basin. This area, called the Lehigh Valley, ranges in elevation from 160 to 800 feet (49-244 km). The rest of the Great Valley extends southeast all the way into Alabama. The shale of the Great Valley is mostly concentrated on the north side. The limestone found on the southern side serves as an aquifer for the hard, turbid water of the region, which has necessitated the abandonment of some wells. The wells with the highest capacity are found in the valleys, and those with the least capacity are on hilltops. Those of the Martinsburg Shale Group on the north side yield an average of 250 gpm, and the wells of the Beekmantown Group vary, with an average hovering around 1,000 gpm. Porous 80-150-foot (24-46 m.) thick dolomite clay and sand characterize the Leithsville Formation near the Reading Prong, and serve as storage for groundwater of an amount equivalent to that of the Beekmantown Group. The limestone aquifers of the Allentown Formation have a limited yield, and only 25 gpm are yielded by the carbonate Jacksonburg "cement rock" aquifer, used mainly for residential purposes. Groundwater in the Great Valley Section is located in bedding planes and fractures, with most of it located above the 400-foot (122 m.) level. Although there are only a few slow streams in the thick limestone lowland, many faster flowing streams can be found in the narrow valleys of the slate bench in the northern section of the Lehigh Valley, which rises 50-100 feet (15-30 m.) higher than the limestone.

The oldest igneous and metamorphic rocks in the watershed are found in the *New England Province*, which ranges from 167-1,312 feet (51-400 m.) and includes the Reading Prong geological region. A great deal of metamorphism in this province has yielded gneiss, schist, and quartzite rocks, particularly in the Reading Prong section, located between Reading, Pennsylvania and Sussex and Morris counties in New Jersey. The Reading Prong is a narrow belt of folded and faulted Precambrian crystalline rocks and metamorphosed Paleozoic igneous and sedimentary rock, similar to that which comprises many New England mountains. In New Jersey, long, parallel crystalline rock ridges with limestone valleys make up the Reading Prong; whereas in Pennsylvania, the uplands of the Prong are interspersed with limestone lowland.

The Reading Prong, which ranges from 600 to 1,100 feet (183-335 m.) in elevation, is also known as "Durham Hills" in northern Bucks County, "Reading Hills" in Berks County, and "South Mountain" in Lehigh and Northampton counties. The headwaters of many streams can be found in this region. Groundwater is located in narrow openings along vertical joints and in bedding planes. The granite-gneiss sections, whose wells vary from 8-100 gpm and average 25 gpm, supply water for residential purposes. The Hardyston Formation, which has a high concentration of iron, has an average well yield of 75 gpm, and what little water the Hornblende Gneiss formation yields is harder and contains more nitrates than other rock groups in the province. There is concern today that the groundwater in the northern New Jersey section of this region is contaminated with radon as a result of high uranium concentrations found in certain formations there (some wells measured 150% times the expected Federal standard), particularly hornblende granite. Because uranium tends to accumulate in areas of high temperature, such as faults (which is where the groundwater in this geographic section is located), the wells in this area of the Reading Prong may be at risk. However, no municipalities currently require radon analysis for well water and so there is no monitoring for radon (Hydrotechnology Consultants, Inc., http://www.hydrotechno.com/docs/doc8.html).

The diverse geology of the *Piedmont Province* (below the Reading Prong) includes Precambrian and Paleozoic igneous, metamorphic, and sedimentary rock. The two distinct regions that make up this province, the Triassic Lowland and the Uplands (including the Trenton Prong), range from 36-984 feet (11-300 m.) in elevation and are composed of different rock types. The Triassic Lowland is a gently rising plain of sandstone and shale located between the Reading Prong to the north and the Trenton Prong to the south, at the base of the Uplands section in this province. The rolling hills that are characteristic of the Triassic Lowland have their limits within the Delaware River Basin in Bucks, Montgomery, and Chester counties, although the Lowland actually extends as far west as Adams County, PA. The hills, which rise from 150 to 500 feet (46-152 m.) above sea level, are broken up at various points by diabase dikes and sheets between 400 and 700 feet (122 and 213 m.) above sea level. Igneous rocks make up the higher ridges of the Lowland, whereas below the ridges and valleys, 16,000-20,000 feet (4,877-6,096 m.) of freshwater sediments can be found, especially sandstone (Majumdar, Miller, & Sage, 1988). It is believed that the Lowland basins that traverse the Delaware were cracks created when Africa and North America were separated (River Places, http://www.riverplaces.com/drguide/DRGuideGeology.html).

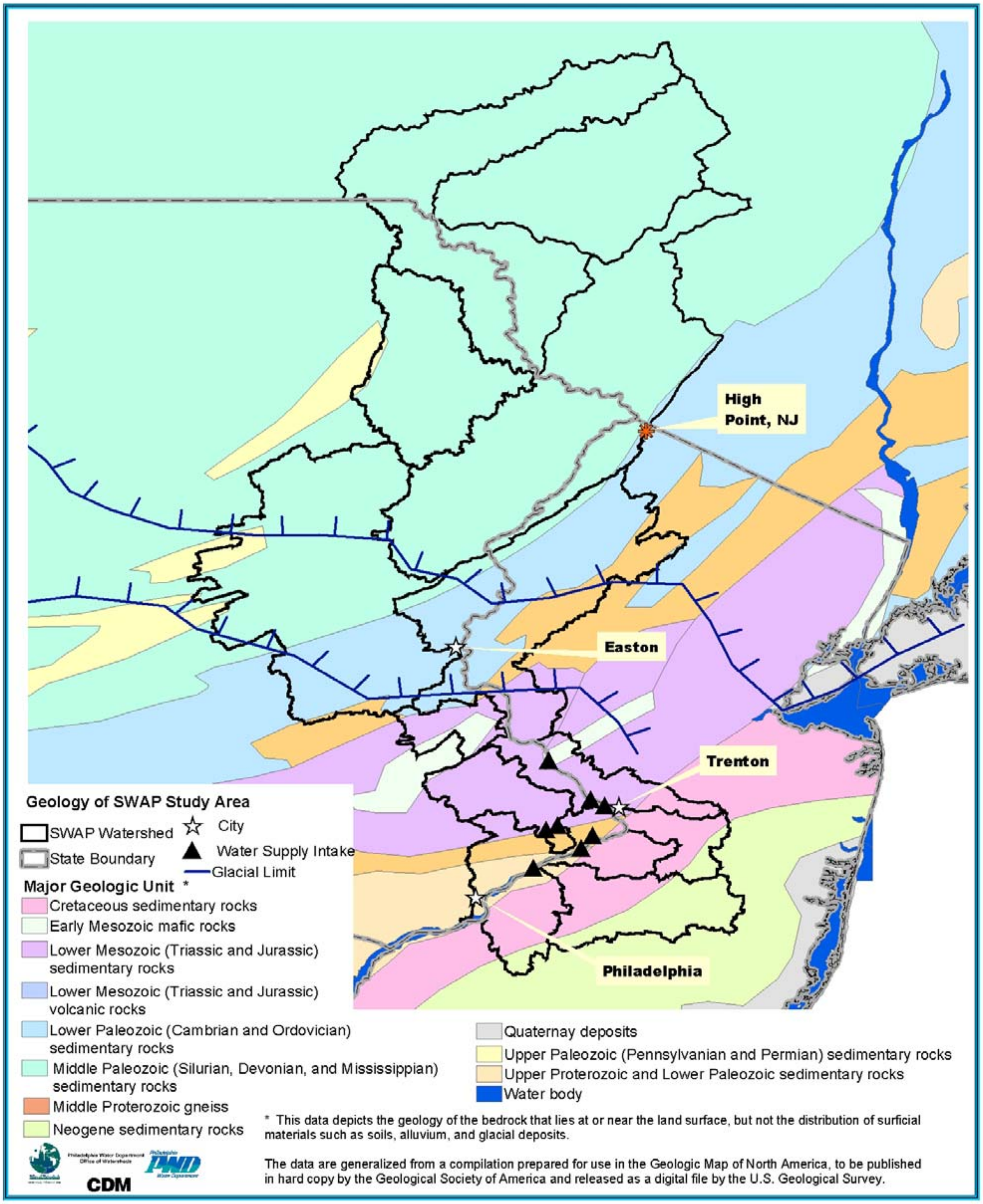
Folds and faults of igneous and metamorphic rock comprise the other section in this province: the Uplands, a low plateau that extends from southern New York to Alabama, and includes large amounts of Paleozoic gneiss and patches of marble. The elevation of the region varies from 300-400 feet (91-122 m.) on the Delaware River to roughly 800 feet (244 m.) at Parksburg. The Trenton Prong is a triangular area in the lower part of this section in southeastern Pennsylvania that encompasses land from Trenton west to northern Chester County. This area is characterized by flat-topped hills and shallow valleys, and consists of a variety of rock types that have been extensively folded and faulted: igneous and metamorphic crystalline rocks, such as granites and gneisses; metamorphosed sedimentary schist, phyllite, and quartzite; and partially metamorphosed limestone and dolomites (Majumdar, Miller, and Sage, 1988). This prong was most likely formed from an eroded mountain range. Most water in the crystalline rocks is located at the surface, with wells yielding only small quantities. Yields in the Piedmont Province vary from 2 to 100 gpm due to the complex geographical layout of this region.

Within the Trenton Prong, about 200-300 feet (61-91 m.) below the harder crystalline uplands, lies the limestone Chester Valley, a structurally-significant area 1-3 miles (1.6-4.8 km.) in width that extends for 55-miles (89 km.) from the Delaware River area to Lancaster County's limestone lowlands. The meeting point of the limestone of the Chester Valley and the igneous-metamorphic rocks of the areas north of the valley is called the Marter Line. Separating the Piedmont Province from the Atlantic Coastal Plain below it is the Fall Line--a physical barrier of falls and rapids that flows over relatively erosion-resistant crystalline rock stretching from New Jersey to Texas, and serves as a natural boundary that marks the extent of navigable waters. Baltimore, New York, Philadelphia, Trenton, and Wilmington are major cities in the Delaware Basin that are located on the Fall Line. Once water power was harnessed, these cities grew into major industrial centers that relied heavily on the Delaware River for their burgeoning success.

The *Coastal Plain Province* ,(just below the Fall Line), was formed when Triassic Era deposits were eroded and redeposited to the southeast by water and glaciers. The plain, which slopes southeast to the Continental Shelf, has a maximum elevation of only about 328 feet (100 m.). The province is divided into two sections: the Outer Coastal Plain, which is comprised of southern New Jersey and eastern Delaware, and the Inner Coastal Plain, which consists of a narrow belt in Pennsylvania, northern Delaware, and an area in New Jersey located roughly 20 miles (32 km.) to the east of the Delaware River. Both sections, which are divided by a line of hills, contain clays, gravels, sands, and silts, but were formed in different geological time periods: the Inner Coastal Plain in the Cretaceous and Pleistocene Eras, and the Outer Coastal Plain in the Tertiary Era.

The Raritan, Magothy, Pennsauken, and Cape May formations are major sources of groundwater in the region between Philadelphia and Wilmington, with wells yielding between 400 and 800 gpm. The sandstone and gravel of the Raritan Formation yield the most water, but the 30-40-foot (6-9-m.) thick sand, gravel, and clay of the Pennsauken and Cape May formations also contribute a significant amount of water. However, much of the water in this province must be treated for quality (Majumdar, Miller, and Sage, 1988.)

Figure 1.2.3–3 Geology of SWAP Study Area



Groundwater

Water from both surface and ground sources is affected by a number of factors, pollution being the foremost concern among them. As such, efforts have been made by the Delaware River Basin Commission, local municipalities, and industrial users to control both point and non-point sources of contamination in watershed rivers and streams. Of particular concern throughout the four basin states are excesses of naturally-occurring substances that result from the geologic makeup of the land, anthropogenic sources resulting from urban and industrial development, acid mine drainage from past and present mining operations, faulty waste storage and disposal, and agricultural runoff of pesticides, fertilizers, and animal waste. Drought and flooding are also important agents that influence water flow and quality by affecting pollution levels in water supplies.

More than 20,000 bodies of water, including more than 300,000 river and shoreline miles and 5 million acres of lakes throughout America, have been identified as polluted (EPA, http://gwpc.site.net/news/nws-epa_impaired_waters_rule.htm). In addition, the EPA estimates that 40 % of our surveyed rivers, lakes, and estuaries do not support basic uses such as fishing or swimming because of non-point source pollution of surface and ground water sources, which means that the majority of Americans—over 218 million out of 275,562,673 (July 2000 est., Yahoo Reference, http://education.yahoo.com/reference/factbook/us/popula.html) —live within ten miles of a polluted body of water (EPA, http://www.epa.gov/owow/tmdl/atlas/intro.html). (EPA, http://www.epa.gov/owow/tmdl/atlas/cover.html).

In the Delaware River Basin, groundwater supplies within the New York portion of the watershed are considered to be excellent. However, there are both natural and anthropogenic causes for concern. Naturally high levels of total dissolved solids, sulfates, iron, chlorides, methane, and radon are present in the bedrock in some areas. More imminent concerns to public water supply users, however, is the contamination closer to the surface: septic tank leaks, spills, and agricultural runoff and subsequent recharge of pesticides and fertilizer (Ground Water Protection Council, http://gwpc.site.net/gwreport/states.htm).

Groundwater in Pennsylvania is classified as good for the most part, but the quality of groundwater is worsening due to anthropogenic causes, such as acid mine drainage from coal mining, leaking underground storage tanks, leachates from landfills and hazardous waste sites, agricultural runoff and recharge, and increasing development. Non point sources of pollution associated with sprawl and development are the suspected causes of recently noted increases in levels of TDS, chloride, calcium, potassium, hardness, and sodium (Ground Water Protection Council, http://gwpc.site.net/gwreport/states.htm)

New Jersey's groundwater is considered to be good overall. Naturally occurring excesses of iron, total dissolved solids, sulfate, hardness, manganese, and pH result from the chemical makeup of rockbeds in certain areas, as do high levels of radionuclides such as radium (in the Piedmont and Coastal Plain provinces of the state), uranium

(Piedmont Province), and arsenic (Piedmont Province). Leaking underground storage tanks, spills, and improper disposal of hazardous materials are problems in highly populated urban areas of the state. Agricultural runoff and contamination by mercury (Coastal Plain) and salt (coastal regions) are also known pollution concerns. (Ground Water Protection Council, http://gwpc.site.net/gwreport/states.htm)

Groundwater in Delaware is classified as good on the whole, with the exception of local problems in some areas, such as excesses of naturally occurring iron, manganese, and chloride, as well as anthropogenic causes resulting from leaking underground storage and septic tanks, hazardous waste sites, urban and industrial activities occurring mainly in the northern part of the state, and agricultural runoff and rechargecausing concerns for nitrate pollution. Petroleum compounds (benzene, toluene, ethylbenze, xylenes), volatile organics (tichloroethylene), nitrates, bacteria, and salinity are the main groundwater contaminants (Ground Water Protection Council, http://gwpc.site.net/gwreport/states.htm).

While sufficient and of good quality for the most part, the Delaware River Basin's source water supplies, both surface and groundwater, are still in need of protection, particularly in known vulnerable sites and highly populated, industrialized urban areas. Various local, state, and federal agencies have been working to improve the quality of the water supplies for the last few decades. Their efforts continue to pay dividends for the health of the rivers and streams, as is evidenced by the noticeable improvements that have been made since the 1940s, when the Delaware River was in the worst condition in its history. At present, the river has shown remarkable recovery, and continues to improve, as new legislation is better able to protect this crucial resource.

Soils

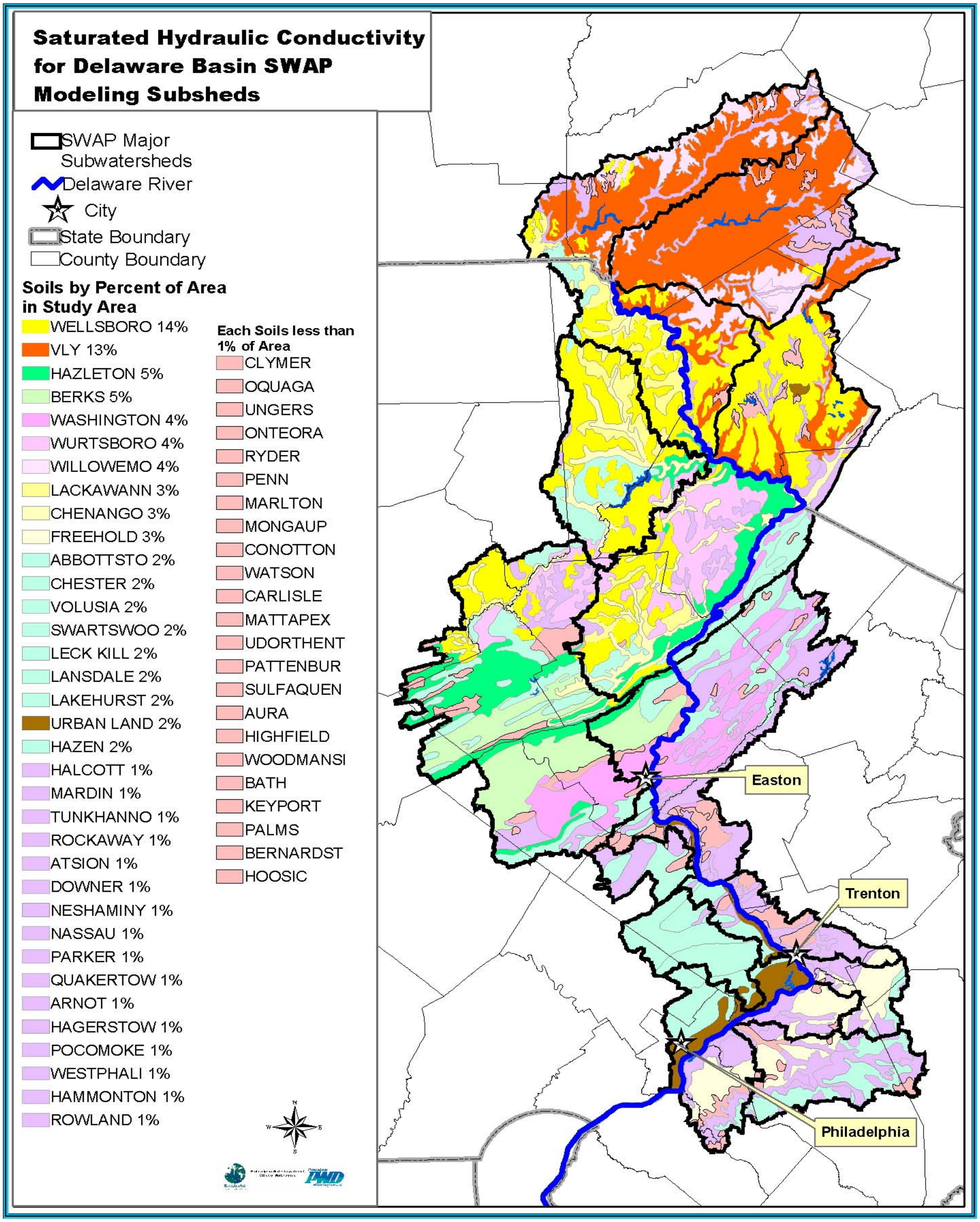
The Delaware River Watershed is comprised of a variety of soils, which determine the landscape of the watershed and the transport properties of the river and its tributaries. Within the major hydrological classifications and groups of soils, there are 58 specific subtypes in the SWAP study area. As shown in Figure 1.2.3-4, these soil subtypes vary with location in the watershed, but in some cases, large portions of the watershed are one soil type. The Wellsboro, Vly, Hagerstown, Hazelton, Berks, Washington, Wurtsboro, and Willowemoc soil classifications define approximately 50 percent of the watershed soils. As shown in Table 1.2.3-1, these soils are generally well drained, experience moderate runoff during rain events, and are typically located on significant slopes. The two poorly-drained soils, the Wellsboro and Wurtsboro soils, are located in the northern and central portions of the study area. The Wellsboro soil is the most predominant soil type within the study area.

Table 1.2.3-1 Prevalence of Various Soil Types in the Study Area

Soil Type	Percentage of Study Area	Slopes %	Permeability	Runoff	Drainage	Found on
Wellsboro	14	0-50	Very slow to slow	Slow to rapid	Moderately well to poorly drained	Level to steep glaciated uplands
Vly	13	0-55	Moderate	Medium to rapid	Well drained to excessively drained	Bedrock controlled glacial till uplands, most soils are forested
Hazleton	5	0-80	Moderately rapid to rapid	Medium	Well drained	Ridges, hilltops, and upper sideslopes
Berks	5	0-80	Moderate to moderately rapid	Slow to rapid	Well drained	Summits, shoulders, and backslopes of dissected uplands
Washington	4	1-15	Moderate	Medium to rapid	Well drained	Level to gently rolling uplands
Wurtsboro	4	0-25	Slow	Slow to rapid	Moderately well to poorly drained	Level to sloping soils of glaciated uplands, almost entirely in woodlands
Willowemoc	4	0-35	Very slow to moderate	Slow to rapid	Moderately well drained	Level to moderately steep uplands, many areas are forested

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

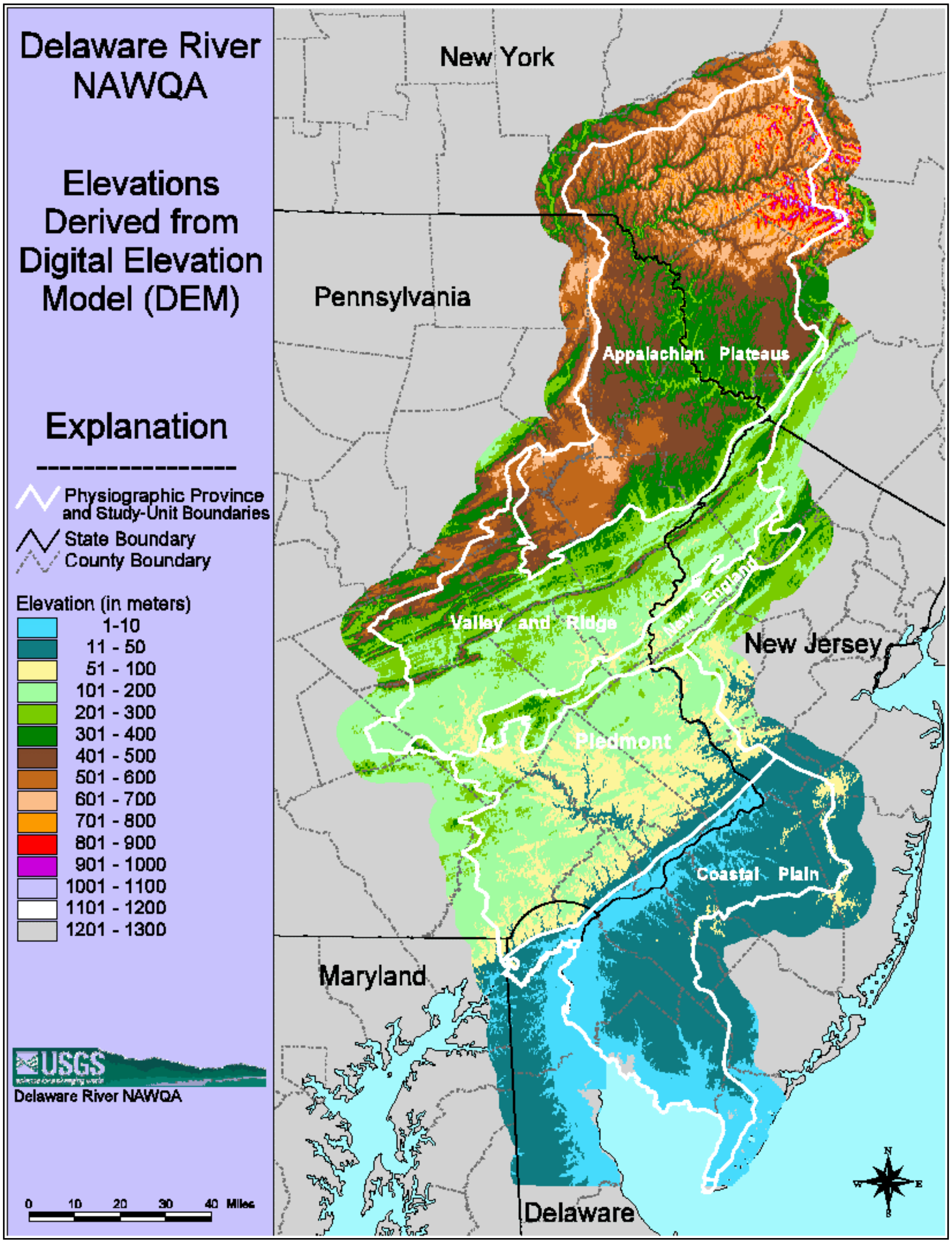
Figure 1.2.3-4 General Distribution of Soils in the SWAP Study Area



The soil characteristics of high runoff and steep slopes make runoff of persistent and conservative contaminants into the rivers and streams very possible if no management practices are in place. These attributes also affect the quantity of the runoff that may erode streambanks.

The general topography of the watershed can indicate where runoff issues may be important. Development on steeply sloping areas can create more of an impact on river water quality than development on gently sloped areas due to the potential to transport polluted runoff farther and faster. As shown in Figure 1.2.3-5 a digital elevation model demonstrates the elevations of the various areas of the study area. The steep valley areas are where the color gradation changes quickly and dramatically. These would be considered sensitive areas where runoff from particular sources or activities could have a potentially significant impact on river or stream water quality. These are also areas that would be ideal for preservation and protection against development pressure to minimize future runoff issues.

Figure 1.2.3-5 Digital Elevation Model of the Lower Schuylkill River Watershed



1.2.4 Hydrology

Key Points

- **The Humid Continental climate pattern that characterizes the Delaware River Basin is responsible for the relatively normal variations in weather that occur within the region.**
- **Cities within the basin are served by surface water from the Delaware, its tributaries, and reservoirs; whereas the less populated areas rely more on groundwater sources.**
- **The Schuylkill and Lehigh Rivers are the largest of the Delaware's tributaries that provide surface water. Flow at the gauge in Trenton averages about 9,149 cubic feet per second.**
- **Due to the persistence of heavy flooding within the Delaware River Basin, two agencies were created, the Pennsylvania State Water Plan and the Delaware River Basin Commission, which have been making great strides in flood prevention.**
- **In 1988, two and a half million people, or 1/3 of the Delaware River Basin, obtained their drinking water from groundwater sources.**
- **The integrity of the basin's groundwater supplies needs to be protected from pollution and development so that watershed residents continue to have a reliable source of drinking water**.

The Delaware River Basin experiences the Humid Continental climate pattern. This pattern encompasses relatively normal variations in weather, which are predominantly the results 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^{o}F in the northern basin to 105^{o}F in the southern basin, whereas minimum temperatures vary from approximately –34^{o}F in the north to -11^{o}F in the south. Therefore, the maximum temperature range across the basin is 140^{o}F. With respect to seasonal climate, winter temperatures fluctuate between approximately 23^{o}F in the upper basin and 35^{o}F in the lower basin. Conversely, summer temperatures normally average between 65^{o}F in the upper basin and 77^{o}F in the lower basin. Annually, the average temperature varies from about 48^{o}F in the upper basin to about 54^{o}F in the lower basin (Climate and Man, 1941, Climates of the States – Pennsylvania, Annual in Majumdar, Millar, and Sage, 1988).

Annual average precipitation rarely fluctuates within the Delaware River Basin; the area normally receives 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).

Long-term historical data in Philadelphia was initially assessed in order to gauge recent decade scale trends against the backdrop of natural regional variation in climate and hydrology. Monthly climate data based on a regional composite index developed by the National Climatic Data Center (NCDC) are available from 1895 through the present day. Historical climate data has been further summarized here by calculating annual totals for precipitation and averages for temperature based on monthly figures.

Annual precipitation in the Philadelphia area has shown a steady increase through the 1900s, with an extended period of drought in the 1960s. Precipitation was high in the 1970s and has most recently varied around the long-term mean for annual precipitation. Annual temperatures in the region have not shown such a strong trend over the entire century, although temperatures appear to have increased over the first half of the century, while decreasing since then, as shown by Figure 1.2.4-1.

Figure 1.2.4-1 Long-Term Average Annual Temperature at Philadelphia

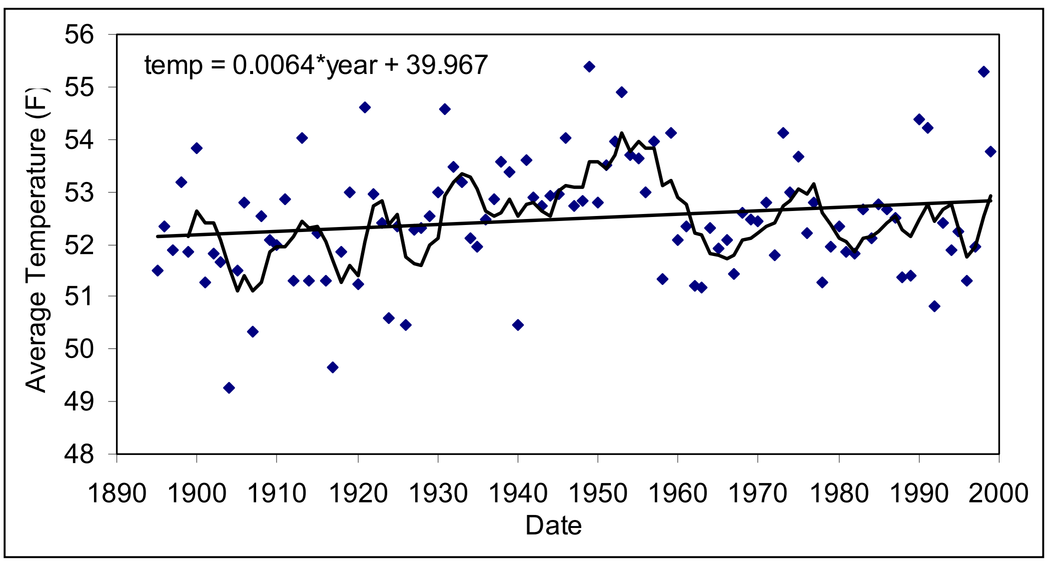
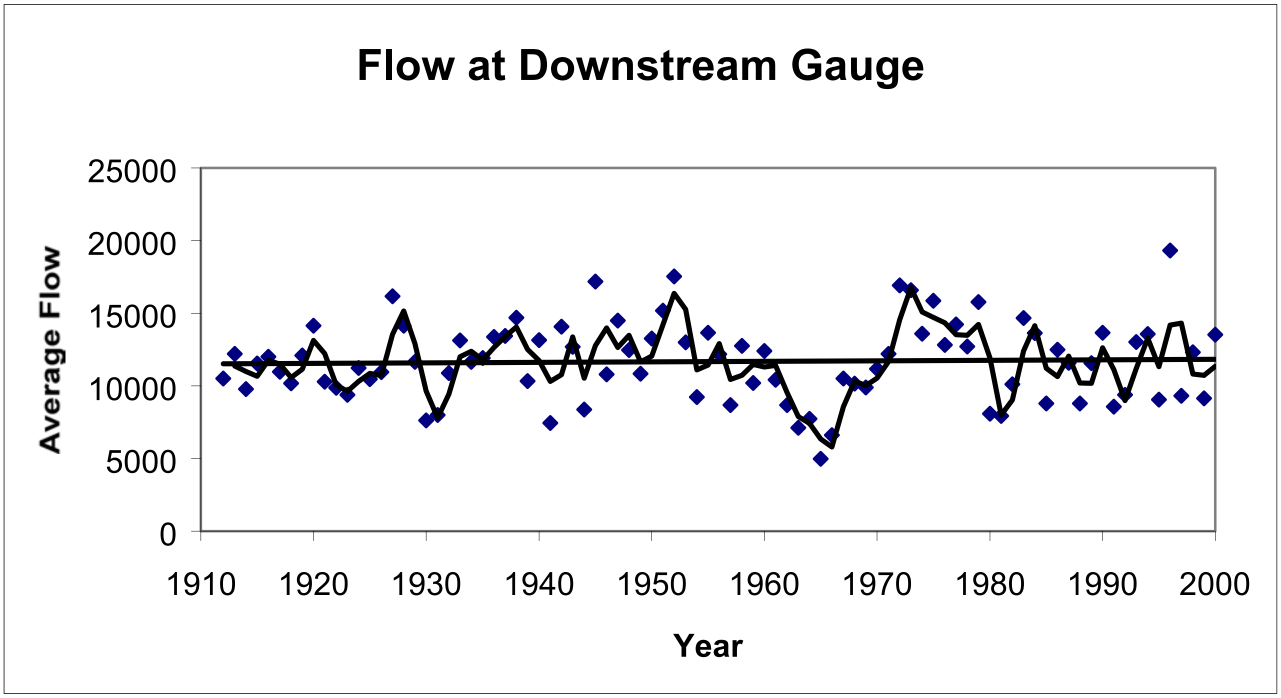


Figure 1.2.4-2 Annual Average Flow at Trenton Gauge of Delaware River

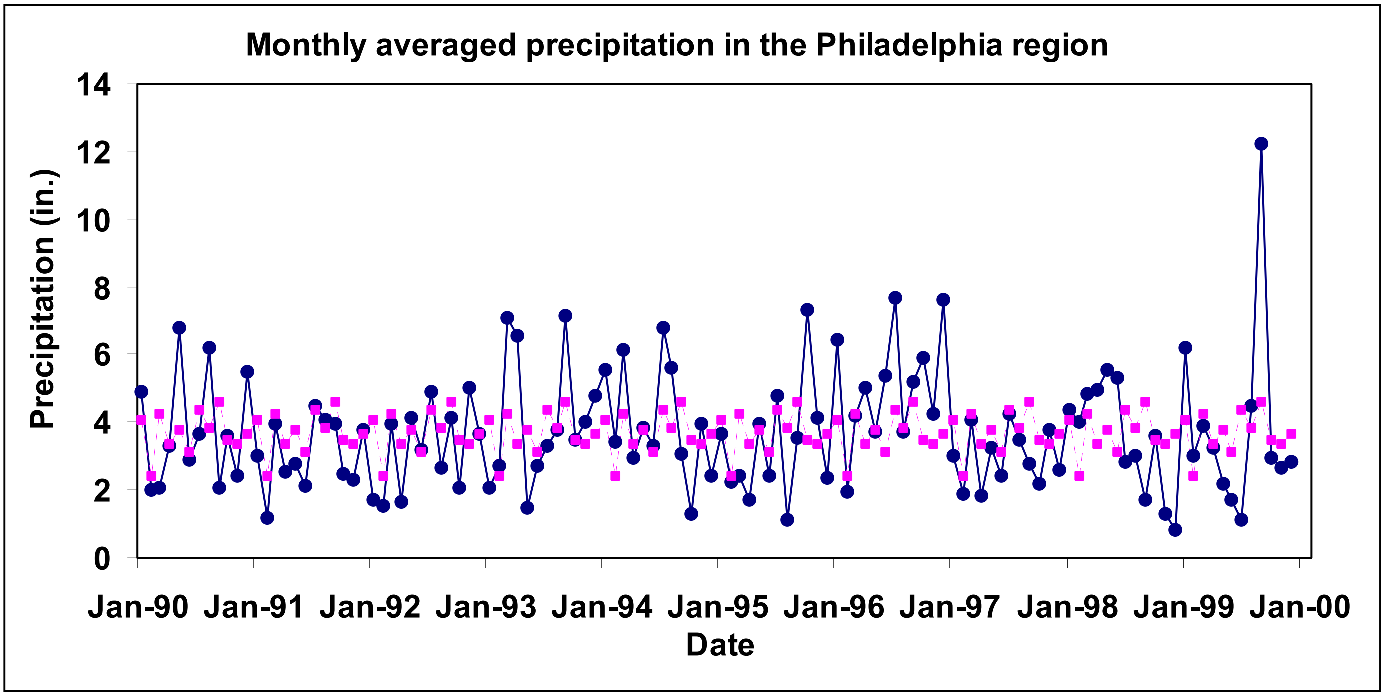


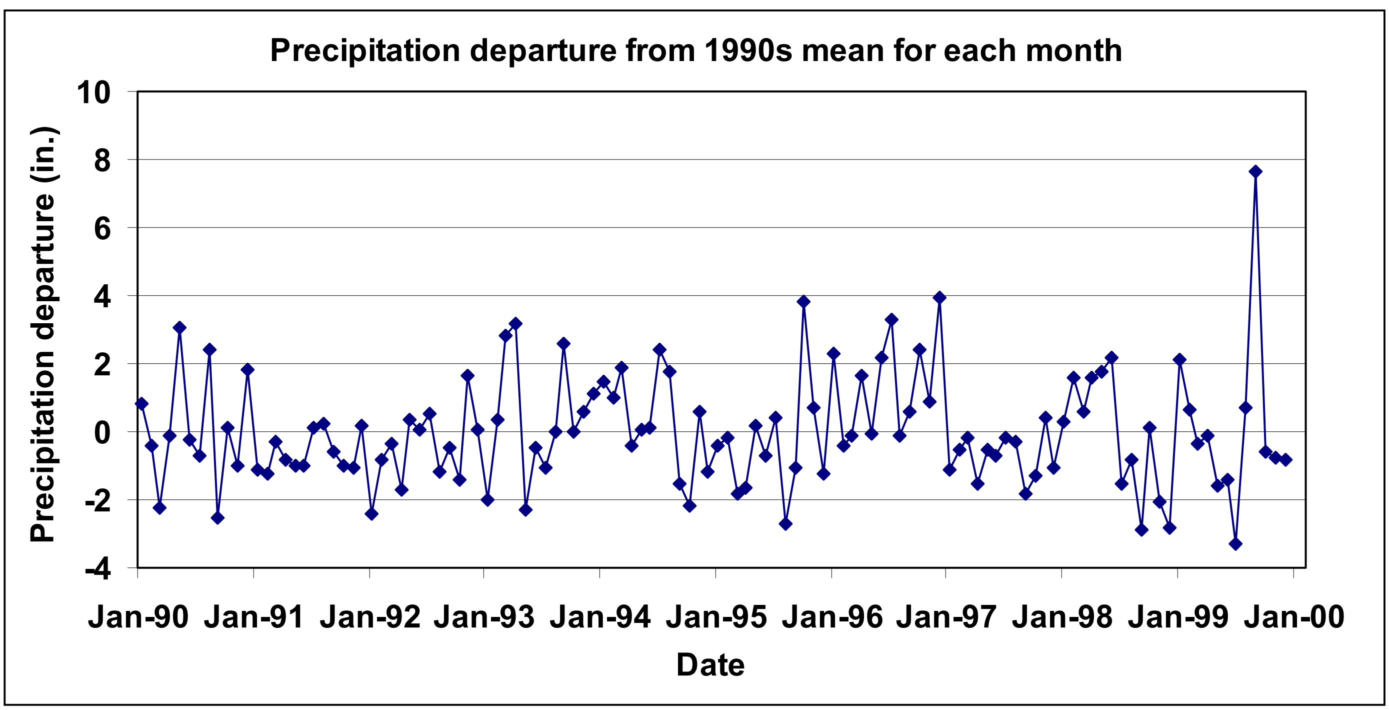
Historical flow in the Delaware River, measured as daily averaged flow at the Trenton gauge from 1910 through the present, is shown in Figure 1.2.4-2. Average annual flow dropped below 5000 cubic feet per second (CFS) only once over the period of record, during the drought of the 1960s.

Recent decade scale patterns in climate and river flow for the region were also assessed to ascertain direct connections between these parameters and Philadelphia Water Department (PWD) intake water quality data. Monthly data for precipitation through the 1990s indicates extended dry periods through 1991 and 1997, along with a severe short-term drought from May through July 1999, as illustrated by Figure 1.2.4-3. February has been particularly dry through the period, while the August average precipitation has been unusually high for summer months. Departures from monthly averages indicate variation from mean precipitation levels and are often a better indicator of climatic condition than are absolute values of precipitation.

Figure 1.2.4-3 Precipitation trends in Southeastern Pennsylvania through the 1990's

Small squares in top panel indicate 1990's monthly flow averages. Deviation from monthly averages indicates interannual trends toward particularly wet or dry weather. Averages are calculated by calendar month, so deviation in January, for instance, is the difference between the 1990's average January precipitation, and that occurring in a given year.





The Delaware River Basin generally averages approximately 18 to 28 inches of runoff each year (Page and Shaw, 1977 in Majumdar, Millar, and Sage, 1988). Runoff from the Upper Delaware Basin is impeded by several ponds, lakes, and swamps that are the legacies of Pleistocene glaciation. Within the central section of the basin, the stream flow of the Lehigh River is partly regulated by the Beltzville Lake and Wild Creek, Penn Forest, and Francis E. Walter reservoirs. The influence of this type of flow is apparent in Table 1.2.4-1, which illustrates the difference in the rate of flow during flood stages at various places along the Lehigh River. Due to the reservoir flood storage on the Lehigh, the mean annual flood runoff at Bethlehem is 21.4 cubic feet per second per square mile; whereas, at Stoddartsville, upstream from the reservoirs, it is 37.5 csm. In addition to reservoir control, other factors that play a role in the amount of runoff within a given area include geology, topography, land use, natural vegetation cover, and basin size.

Stream flow within the Delaware River Basin fluctuates immensely, as evidenced by Table 1.2.4-2. The maximum discharge occurs after the periods of heaviest precipitation with the passage of a tropical storm. The seasonal variation in terms of the amount of runoff recorded is driven by the melting of snow and the thawing of the ground in the late winter and early spring (maximum flows), as well as the time when evaporation of surface waters is highest (low flows), which occurs in late summer and early autumn. (Page, 1977 in Majumdar, Millar, and Sage, 1988).

Table 1.2.4-1 Streamflow Statistics for Selected Gauging Stations

	Years of Record	Drainage Area (sq.mile)	Average Annual Runoff (CSM)*	Mean Annual Flood (CSM)*	Ratio of 100-year to Mean Annual Flood	7-Day 10-Year Low Flow (CSM)*
Upper Delaware Basin						
Delaware River at Belvidere, NJ	1922-72 50	4,530	1.7	16.2**	4.2**	0.20
Lackawaxen River at Hawley, PA	1908-17 1938-72 43	290	1.6	41.7	5.4	0.06
Brodhead Creek at Minisink Hills, PA	1950-72 22	259	2.0	42.6	7.9	0.16
Central Delaware River						
Lehigh River at Stoddartsville	1943-72 29	91.7	2.0	37.5	7.5	0.15
Lehigh River at Bethlehem	1902-04 1909-12 65	1,279	1.8	21.4**	3.7**	0.27
Tohickon Creek near Pipersville	1935-72 37	97.4	1.4	75.6	2.7	0.01
Neshaminy Creek near Langhorne	1934-72 38	210	1.3	60.6	3.4	0.04
Lower Delaware River						
Tuplehocken Creek near Reading	1950-72 22	211	1.4	27.8	3.3	0.21
Schuylkill River at Pottstown	1926-72 46	1,147	1.6	20.7	3.2	0.23
Perkiomen Creek at Graterford	1914-72 58	279	1.3	56.4**	2.9**	0.05
Brandywine Creek at Chadds Ford	1911-53 1962-71 52	287	1.3	27.4	3.0	0.31

** Cubic feet per second per square mile*
*** Flood data for period 1957-72, 15 years*
Source: *State Water Plan, Upper Delaware Basin, Central Delaware Basin, Lower Delaware Basin, 1983. Department of Environmental Resources, Office of Resources Management, Bureau of Water Resources Management, Harrisburg, PA. SWP2, SWP3, SWP4 in Sutton, O'Herron, and Zappalorti, 1996.*

Table 1.2.4-2 Duration Table of Daily Flow

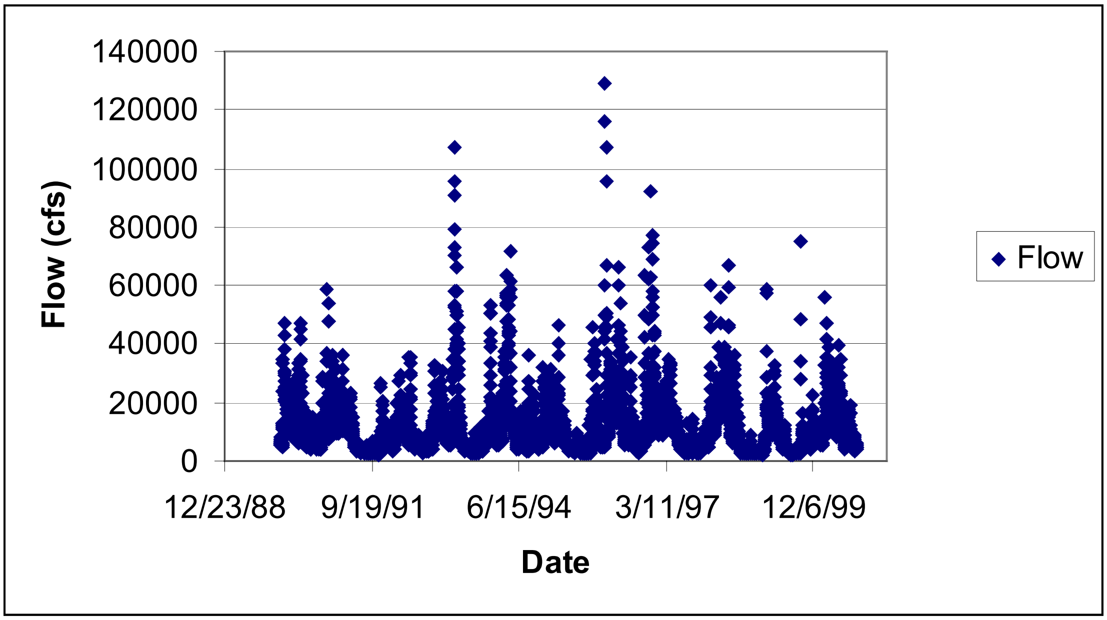
	Delaware River												
Percent	**2**	**5**	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**95**	**98**
Port Jervis, NY	26,000	18,000	12,000	7,800	5,700	4,300	3,400	2,600	2,000	1,500	1,100	750	530
Montague, NJ	28,500	19,000	13,400	9,300	6,800	5,200	4,000	3,150	2,420	1,880	1,400	1,020	750
Belvidere, NJ	35,000	23,600	17,400	12,000	9,000	7,000	5,500	4,300	3,300	2,420	1,720	1,360	1,120
Riegelsville, NJ	42,500	32,000	23,800	16,400	12,400	9,700	7,600	6,000	4,650	3,500	2,500	1,960	1,600
Trenton, NJ	47,500	33,500	24,800	17,400	13,200	10,400	8,300	6,600	5,100	3,850	2,750	2,180	1,780
	Schuylkill River												
Reading, PA	7,100	4,800	3,300	2,100	1,500	1,200	960	710	550	420	300	230	180
Norristown, PA	11,000	6,800	4,400	2,900	2,200	1,800	1,400	1,100	830	570	380	310	250
Philadelphia, PA	13,000	8,300	6,000	3,900	2,900	2,200	1,600	1,200	880	600	360	240	160

Discharge, in cubic feet per second, that was equaled or exceeded for indicated percentage of time.
Source: Busch, W.F. and L.C. Shaw, 1966. Pennsylvania Streamflow Characteristics, Low-Flow Frequency and Flow Duration. Pennsylvania Department of Forest and Waters. Harrisburg, PA, Water Resources Bulletin No. 1 in Sutton, O'Herron, and Zappalorti, 1996.

Average annual Delaware flow at Trenton is 9,149 CFS for the period 1912 through 1999 (USGS gauge data). Daily average Delaware River flow at Trenton through the 1990s is summarized in Figure 1.2.4-4 and indicates extremely low flow conditions in summer 1999, with less-pronounced low flow occurring in 1991. Lowest flows through the decade were not always associated with extended low levels of summer precipitation, suggesting that evaporation, groundwater storage, and surface water removal are important components in the water budget of the region.

Seasonal variation is driven primarily by precipitation, which is highest in spring, and evaporation, which is highest in summer months.

Figure 1.2.4-4 Daily Average Delaware River Flow at Trenton through the 1990's



1.2.4.1 Surface Water

Philadelphia and numerous other upstream cities and communities make extensive use of the Delaware River Watershed's surface water, which includes the Delaware River, some of its 216 connecting tributaries, and water stored in reservoirs throughout the basin, for water supply. Among the more significant tributaries that supply surface water in the basin are: the Schuylkill River, the Lehigh River, and the Lackawaxen River in Pennsylvania; the Neversink and Mongaup Rivers in New York; and the Paulins Kill, Pequest, Musconetcong, and Maurice Rivers in New Jersey (Majumdar, Miller, and Sage, 1988).

With an average annual flow of 2,620 cfs at Fairmont Dam in Philadelphia (USGS data as of 1999, http://water.usgs.gov/pa/nwis/annual/?site_no=01474500&agency_cd=USGS), the 128-mile Schuylkill River is the Delaware's largest tributary, contributing one third of the Delaware's flow (Schuylkill River Greenway, http://www.montcopa.org/schuylkill/). Originating in the Blue Mountains in Pottsville (Schuylkill County) and emptying into the Delaware River at Philadelphia, the Schuylkill River drains 1,893 square miles in southeast Pennsylvania with the help of 12 smaller creeks within its watershed, namely, Tulpehocken Creek, Alleghany Creek, Hay Creek, French Creek, Pickering Creek, Valley Creek, Little Schuylkill River, Maiden Creek, Monocacy Creek, Manatawny Creek, Perkiomen Creek, and Wissahickon Creek.

The Schuylkill River, whose name derives from the Dutch word meaning "hidden river" (because seven islands concealed its mouth when European colonists first encountered it), has historically been very important to the City of Philadelphia and the surrounding areas through which it flows, particularly as a source of drinking water (Schuylkill River Greenway, http://www.montcopa.org/schuylkill/ and Toffey, 1982). The city began using the Schuylkill for drinking water in 1801 and wisely tried to protect the integrity of this resource at that time by purchasing the land surrounding it in order to prevent contamination of the water supply from pollution due to the rapid spread of industry along the banks of the river. However, the existing industry upstream combined with a lack of knowledge regarding sewage and wastewater disposal, as well as the extensive coal mining being carried out at its headwaters at that time (anthracite coal was discovered in Pottstown in 1770) eventually led to severe pollution problems for the river, which jeopardized Philadelphia's water supply. A series of legislative acts in 1945 called for pollution abatement and the de-silting of the river in order to restore it to health. Unfortunately, pollution is still a problem in the Schuylkill today, particularly due to acid mine drainage (AMD) from old abandoned mines near the headwaters, agricultural runoff, and industrial discharges throughout the watershed. Yet the river continues to play a crucial role in the lives of those within its watershed. As of 1990, there were 902.56 MGD of water withdrawn from within the Schuylkill Watershed. Of that, 683.3 MGD were from surface water intakes and 219.26 MGD from groundwater sources to serve 1.6 million people (USGS, http://water.usgs.gov/cgi-bin/wuhuc?huc=02040203).

The Delaware's second largest tributary, the Lehigh River, which drains 1,359 square miles, has an annual flow of 2,293 cfs **(**1999 USGS data, measured 2 miles southwest of Easton, PA at Glendon). Of the 280.56 MGD that were taken from this watershed daily in 1990, 203.4 MGD were from surface water sources, and 77.16 MGD came from groundwater sources (USGS, http://water.usgs.gov/cgi-bin/wuhuc?huc=02040106) to serve roughly 556,000 people. The majority of water bodies within the Lehigh Watershed are of good quality, with the exception of some smaller creeks that are considered impaired waters, mostly due to AMD from abandoned mines, and agricultural runoff (EPA, http://www.epa.gov/iwi/303d/02040106_303d.html).

The main stem of the Delaware River has an annual mean flow of 9,149 cfs at Trenton (USGS data as of 1999, http://water.usgs.gov/pa/nwis/annual/?site_no=01463500&agency_cd=USGS), which is maintained by releases from three large reservoirs on its tributaries in upstate New York (USGS NAWQA 1994). The Cannonsville, Pepacton, and Neversink Reservoirs are all owned by New York City, the single biggest user of Delaware River surface water. Seventy-five percent of the Delaware River Basin's total surface water storage is contained within these three reservoirs with a total combined capacity of 271 billion gallons (Pepacton Reservoir at 140.1 billion gallons, Neversink at 34.9 BG, and Cannonsville at 95.7 BG) (Roberts and The Catskill Center, NYC Watershed Timeline, http://www.catskillcenter.org/programs/csp/H20/Lesson4/nyctime2.htm**).**

Conditional periodic releases from the Cannonsville, Pepacton, and Neversink Reservoirs in the Upper Delaware have a significant effect on water quality in the rest of the river by helping to maintain both water flow and quality downstream. Releases from the NYC reservoirs help to meet the federal flow standard of 1,750 cfs for

Montague, NJ. During low flow in the summer, more than 70% of the flow in the Upper Delaware River and 40+ % of the flow at Trenton is a result of releases from the three reservoirs, which have the combined ability to divert up to 800 MGD. Consequently, reservoir releases influence many water quality factors, such as flow, temperature, pollution, salinity, and fish migration below the release sites (USGS NAWQA, 1999). As a result, the operation of these reservoirs has created controversy regarding the ownership and use of reservoir water over the years. Most notable was court action in the 1950s, which helped settle water withdrawal/diversion disputes between the four basin states and New York City (which is outside the basin) so that all parties would be assured an adequate water supply in times of drought.

Other significant reservoirs in the watershed are all in Pennsylvania.

Francis E. Walter Reservoir
The Francis E. Walter Reservoir, formerly known as the Bear Creek Reservoir, is situated on the Lehigh River in the Lehigh River Basin approximately 77 miles above the confluence with the Delaware River in Carbon and Luzerne Counties, Pennsylvania. This reservoir is an integral piece of a Lehigh River flood control program and is currently authorized to provide whitewater recreational opportunities. The Francis E. Walter Dam was completed in December of 1960. It measures 3,000 feet in length and is 234 feet high. Its drainage area spans 288 square miles, and its flood control storage measures 107,815 acre-feet (U.S. Army Corps of Engineers, http://www.nap-wc.usace.army.mil/waltr.html)

Beltzville Lake
The Beltzville Lake Reservoir is located in Carbon and Monroe Counties in the Lehigh River Basin in Pennsylvania, more specifically, at approximately 5.2 miles above the confluence with the Lehigh River. This reservoir is an important part of the Lehigh River Flood Control Program, which aids in flood control along the banks of the Pohopco Creek and the Lehigh River as well as operates for water supply, water quality control, and low flow augmentation in the Lehigh River. It also helps provide control of saline water intrusion in the Delaware Estuary. The Beltzville Lake Dam was completed in December of 1971 and is categorized as an earthfill embankment type of structure, also composed of an impervious core with random fill. The dam measures 4,560 feet in length and is 170 feet high. Its drainage area covers 96 square miles, while its flood control storage volume is 27,030 acre-feet (U.S. Army Corps of Engineers, http://www.nap-wc.usace.army.mil/beltz.html)

General Edgar Jadwin Dam
The General Edgar Jadwin Dam, located in the Lackawaxen River Basin on Dyberry Creek, is 30.1 miles above the confluence of the Lackawaxen River with the Delaware River at Lackawaxen, Pennsylvania. This dam is an important part of an integrated reservoir flood control system. In combination with the Prompton Reservoir, the Jadwin Dam provides flood control protection, in varying degrees, to the Boroughs of Prompton, Honesdale, and Hawley, all of which are located within the State of Pennsylvania. In addition, this dam also provides flood control protection to a number

of smaller communities lining the Lackawaxen River. The dam was completed in September of 1959 and is an earth and rockfill embankment structure. It has a length of 1,255 feet and a height of 109 feet. The Jadwin Dam's drainage area encompasses 64.5 square miles, and its flood control storage volume measures 24,500 acre-feet (U.S. Army Corps of Engineers, http://www.nap-wc.usace.army.mil/jadrs.html)

Prompton Lake Reservoir

The Prompton Lake Reservoir is located on the West Branch of the Lackawaxen River in the Lackawaxen River Basin, approximately 4.7 miles upstream of Honesdale, Pennsylvania and a half-mile upstream of the village of Prompton, Pennsylvania. This reservoir is an estimated 31 miles above the confluence of the Lackawaxen River with the Delaware River at Lackawaxen, Pennsylvania. The Prompton Lake Reservoir is a part of an integrated reservoir flood control network, in which it, in combination with the General Edgar Jadwin Dam, provides flood control protection, in varying degrees, to the Boroughs of Prompton, Honesdale, and Hawley, all of which are located in Pennsylvania. In addition, the reservoir aids in the flood control protection of smaller communities along the Lackawaxen River. The Prompton Lake Dam was completed in July of 1960 and is categorized as a zoned earthfill embankment type of structure. Measuring 1,200 feet in length and 140 feet in height, the Prompton Lake Dam spans a drainage area of 59.6 miles, with a flood control storage volume of 48,500 acre-feet (U.S. Army Corps of Engineers, http://www.nap-wc.usace.army.mil/prmpr.html)

Neversink Reservoir

Construction on the Neversink Reservoir, located in Sullivan County, New York, began in 1941, but was suspended throughout the World War II period. It resumed in 1946. Although the reservoir was deemed functional and was in operation by 1950, construction was complete three years later in 1953. Fed by the Neversink River, the Neversink Reservoir is considered to be one of the major water sources for New York City as well as the finest of the City's reservoir system, with a storage capacity of 35.5 billion gallons of water, which serves a watershed area of 95 square miles (The Catskill Center,
http://www.catskillcenter.org/programs/csp/H20/Lessons4/nyctime2.htm,
Tri-Valley Central School, http://www.mhric.org/tri-valley/Neversink.html, and the Catskill Watershed Corporation,
http://www.cwconline.org/about/ab_hist.htm).

Cannonsville Reservoir

Located in the village of Cannonsville in southwestern Delaware County, the Cannonsville Reservoir is an estimated 15 miles in length and averages one-half mile in width. In 1967, a dam was constructed across the West Branch of the Delaware River, and the reservoir was created in order to supply water to New York City, where water is diverted via the West Delaware Tunnel. Cold water is also released into the West Branch of the Delaware River via valves, located at the base of the dam. These cold water releases from the bottom of the reservoir have fostered an excellent trout fishery, located in the river below the dam. With a storage capacity of 95.7 billion gallons, the reservoir, when full, comprises 4,800 surface acres and lies approximately 1,150 feet above sea level (Bear Systems, http://www.bearsystems.com/cannonsville/cannonsville.html, The Catskill Center, http://www.catskillcenter.org/programs/csp/H20/Lessons4/nyctime2.htm).

Pepacton Reservoir
The Pepacton Reservoir, on the East Branch of the Delaware River in Delaware County, New York, was created in 1955 by impounding the East Branch of the Delaware River near the village of Downsville, New York with a 2,400 foot-long dam. With a storage capacity of 140.2 billion gallons, and measuring 18 miles in length, the Pepacton is New York City's largest reservoir. When full, the reservoir comprises 5,700 surface acres and is an estimated 1,280 feet above sea level. Water usage results in seasonal fluctuations of reservoir water levels. Although typically full between the months of March and June, water withdrawals normally result in the gradual drawdown of water during the summer and the fall (Bear Systems, http://www.bearsystems.com/Reservoirs/reservoirs4.htm, the Catskill Watershed Corporation, http://www.cwconline.org/about/ab_hist.htm, and The Catskill Center, http://www.catskillcenter.org/programs/csp/H20/Lessons4/nyctime2.htm)

Lake Wallenpaupack Dam
Lake Wallenpaupack, located in the Pocono Mountains of Northeastern Pennsylvania, partially in both Wayne and Pike Counties, measures 13 miles in length and 2 miles at its widest point. The lake spans a surface area of 5,700 acres and is comprised of 52 miles of shoreline. A dam across the Wallenpaupack Creek was constructed by the Pennsylvania Power and Light Company (PP&L) for the purpose of generating hydroelectric power. Construction began in 1924 and was completed by 1926. Two thousand seven hundred men worked on the dike at Tafton, Pennsylvania, as well as the concrete dam at Wilsonville that measures 1,280 feet in length and 70 feet in height. A power plant, located along the Lackawaxen River, receives water for power generation from the Lake Wallenpaupack Dam via a pipeline that measures 14 feet in diameter and 3.5 miles in length. This power plant, in conjunction with the hydroelectric power generated by the dam, is capable of producing 44,000 kW of electricity. Although the Wallenpaupack Dam was specifically constructed as a power dam, it has also served the purpose of providing flood protection along the Lackawaxen River in past years (Pocono Powerboaters Association of Lake Wallenpaupack, http://www.enter.net/~prodoor/lake.htm).

Flows in the Delaware River Basin are due partially to groundwater discharges (baseflow) and partially due to runoff from rain events. Runoff has a distinct seasonal variation. The most runoff occurs during winter or early spring, and the lowest amount of runoff occurs during the late summer or early fall. Runoff is chiefly dependent on the amount of rainfall that a specific area receives; after the winter months, the accumulated snow melts in the early spring create additional runoff and high water tables. The flow in the rivers are generally higher during this time. During the dry late summer months, there is very little runoff and the water table is lower. As a result, streamflow is generally at its lowest at the end of the summer.

In the Delaware River Basin, Precipitation is normally between 40 and 50 inches per year. As a result of loss of precipitation by evaporation and transpiration, only about half of the precipitation falling within the watershed reaches surface waters.

Pollution has been a serious problem in the lower Delaware River Basin for many years. Mine drainage in the headwaters of some of the tributaries has exacerbated the water quality problems caused by domestic waste discharge, because the resulting toxic environment inhibits stream self-purification. The microorganisms that would normally oxidize the organic wastes are either destroyed or hindered by the acidic environment produced by mine drainage. Thus, the organic waste is preserved until the stream environment becomes favorable for microbiological activity. In recent decades, the water quality in the River has seen substantial improvement, as point source discharges of wastewater have been addressed.

Table 1.2.4-3 summarizes the locations, drainage areas, annual mean flows, and annual runoff at 20 gauging stations along the Delaware River. The first gauging station listed is the northernmost one within the study area located along the Delaware River at Port Jervis, New York. The last gauging station on the chart that is located along the lower portion of the Delaware River is the one near Trenton. Below Trenton, the Delaware River is influenced by the tides, and flows vary within the tidal cycle.

Table 1.2.4-3 Stream Gauging Data in the Delaware River Basin

Station ID	Location	Drainage Area (mi2)	Period of Record *	Annual Mean Flow (cfs)	Annual Runoff (Inches)	10% Exceeds (cfs)	50% Exceeds (cfs)	90% Exceeds (cfs)
1434000	Delaware River at Port Jervis NY	3070	1964-2000	4762	N/A	10300	2850	1500
1438500	Delaware River at Montague NJ	3480	1940-2000	5702	N/A	12100	3440	1600
1440200	Delaware River at Delaware	3850	1909-1996					
1442500	Brodhead Creek at Minisink Hills PA	259	1951-2000	560	2.16	1200	350	93
1443500	Paulins Kill at Blai	126	1921-2000	191.78 **	N/A			
1445500	Pequest River at Pequest	106	1921-2000	157.29 **	N/A			
1446500	Delaware River at Belvidere NJ	4535	1923-2000	7838	N/A	16600	5020	1950
1447800	Lehigh River below Francis E. Walter Res. Near White Haven PA	290	1961-2000	625	N/A	1330	415	108
1449000	Lehigh River at Lehighton PA	591	1983-2000	1302	2.2	2660	899	280
1449800	Pohopoco Creek below Beltzville Dam near Parryville PA	96.4	1968-2000	167	N/A	371	105	36
1451000	Lehigh River at Walnutport PA	889	1947-2000	1862	2.09	3860	1300	410
1451500	Little Lehigh Creek near Allentown PA	80.8	1946-2000	100	1.24	171	79	40
1453000	Lehigh River at Bethlehem PA	1279	1941-2000	2462	1.92	4850	1780	685
1454700	Lehigh River at Glendon PA	1359	1967-2000	2856	N/A	5360	2090	870
1457790	Cooks Creek at Durham Furnace PA	29.4	1990-1993	41.1 **	N/A			
1463500	Delaware River at Trenton NJ	6780	1913-2000	11670	N/A	24600	7940	3000
1464000	Assunpink Creek at Trenton	90.6	1923-2000	133.64 **	N/A			
1465500	Neshaminy Creek near Langhorne PA	210	1935-2000	299	N/A	580	140	32
1465798	Poquessing Creek at Grant Ave. at Philadelphia PA	21.4	1965-2000	32.7	N/A	61	12	4.4
1467048	Pennypack Creek at Lower Rhawn St. Bridge Philadelphia PA	49.8	1965-2000	90.9	1.83	169	49	21

** Information from report for AMF, AR, 10%, 50%, 90% were reported between these dates in water years*
*** Calculated Value from yearly data*
http://pa.water.usgs.gov/ar/wy00/pdfs/v1all-00.pdf

Table 1.2.4-4 and Figure 1.2.1-1 describe the size and location of the various tributaries and drainage areas within the Delaware River Basin. As shown, the Lehigh Creek is the largest tributary discharging to the Delaware River north of Trenton. As noted above, the reservoir releases from the New York City reservoirs provide the most water, and can have significant impacts on water quality of the Delaware River.

Table 1.2.4-4 Characteristics of Tributaries in the Delaware River Watershed (in alphabetical order)

Major Tributary	Drainage Area (mi2)	River Mile Location	Length (mi)
Adams Creek	8.1	240	5.536
Alexauken Creek	15.1	150	6.797
Allegheny Creek	9.1	200	4.642
Alloway Creek	52.8	55	21.513
Aquetong Creek	8.0	149	3.732
Assiscunk Creek	45.9	119	16.310
Beaverdam Creek	10.6	299	10.951
Big Timber Creek	55.2	96	16.004
Buck Creek	7.0	138	3.806
Buckhorn Creek	11.8	193	7.569
Bush Kill (Lower)	123.8	227	34.523
Bush Kill (Upper)	6.6	259	5.480
Bustleton Creek	2.6	121	2.907
Byberry Creek	18.7	112	10.595
Cherry Creek	2.1	213	13.587
Chester Creek	66.4	83	19.271
Conashaugh Creek	2.1	243	2.526
Cooks Creek	29.5	174	13.904
Cooley Creek	3.3	312	3.336
Cooper River	40.2	102	15.807
Copper Creek	3.3	163	3.336
Crafts Creek	13.8	125	11.382
Crawford Branch	1.3	249	2.886
Crosswicks Creek	138.5	129	26.458
Crum Creek	38.3	85	22.110
Cummins Creek	5.3	250	5.231
Darby Creek	77.2	86	24.710
Dark Hollow Run	0.70	148	1.687
Delawanna Creek	4.5	205	5.393
Delaware River, WFK	51.0	331	7.658
Dingmans Creek	16.5	239	9.096
Dry Brook	1.2	241	1.499
Dunnfield Creek	3.6	212	4.069
Dyers Creek	1.2	140	1.832
Equinunk Creek	57.6	323	14.899
Factory Creek	4.3	323	5.512

Major Tributary	Drainage Area (mi2)	River Mile Location	Length (mi)
Fiddlers Creek	2.0	143	2.485
Flat Brook	66.2	225	26.095
Frya Run	6.1	177	3.770
Gallows Run	8.7	172	5.238
Hakihokake Creek	16.7	168	7.904
Harihokake Creek	9.9	166	7.221
Hessian Run	12.0	92	2.941
Hollister Creek	9.5	305	4.986
Hornbecks Creek	9.5	236	1.140
Houghs Creek	0.5	141	5.558
Jacoby Creek	6.4	208	4.178
Jericho Creek	9.6	144	6.384
Kittatinny Creek	1.5	239	2.374
Lackawaxen River	487.6	278	27.074
Lackawaxen River, S	2.0	278	2.178
Lehigh River	1360.4	184	107.467
Little Equinunk Creek	25.2	313	10.813
Little Nishisakawick Creek	3.5	164	3.678
Lockatong Creek	23.2	154	14.797
Lopatcong Creek	14.7	182	10.478
Mantua Creek	49.9	90	18.994
Marcus Hook Creek	5.2	80	7.329
Martins Creek (Lower)	11.5	123	5.057
Martins Creek (Upper)	44.6	191	14.544
Masthope Creek	23.8	284	8.439
McMichael Creek	276.6	213	34.884
Mill Creek	19.8	119	39.958
Mill Run	37.0	105	14.814
Moores Creek	10.2	145	4.686
Mud Run	6.0	189	19.795
Musconetcong River	158.1	175	54.771
Neshaminy River	232.4	116	51.376
Newton Creek	10.6	97	10.580
Nishisakawick Creek	11.0	164	9.137
North Branch Calkins Creek	44.2	296	11.713
Oldmans Creek	45.8	77	20.619
Oughoughton Creek	11.9	194	6.839
Panther Creek	4.2	275	3.722
Paulins Kill	176.9	208	39.469

Major Tributary	Drainage Area (mi2)	River Mile Location	Length (mi)
Paunnacussing Creek	7.9	156	5.270
Peggy Run	2.2	290	1.482
Pennsauken Creek	36.1	106	13.066
Pequest River	157.1	198	32.440
Pidcock Creek	12.7	146	7.064
Plum Brook	26.6	153	19.063
Pohatcong River	55.4	178	28.094
Pompeston Creek	7.7	109	5.375
Pond Eddy Creek	6.9	267	3.974
Pond Run	91.3	134	12.709
Pophandusing Brook	5.5	198	4.819
Rabbit Run	0.4	150	1.116
Rancocas Creek	347.7	111	33.657
Raymondskill Creek	25.2	244	11.655
Repaupo Creek (Lower)	45.5	80	18.800
Repaupo Creek (Upper)	14.4	84	9.716
Ridley Creek	37.9	84	23.237
Rockledge Branch	55.1	110	15.572
Salem River	114.9	59	38.227
Sawkill Creek	23.5	247	7.537
Schoolhouse Creek	2.3	299	3.006
Shoeneck Creek	79.9	184	14.037
Shohola Creek	85.2	274	28.958
Slateford Creek	3.0	210	3.732
Stoney Creek	0.8	81	2.245
Stony Brook	4.1	209	7.598
Swan Creek	3.3	149	1.468
Tinicum Creek	24.0	162	10.927
Tohickon Creek	103.9	157	29.254
Toms Creek	9.4	230	7.228
Twin Lakes Creek	11.5	270	5.425
Vancampens Brook	8.9	220	8.090
Vandermark Creek	5.2	248	4.257
Warford Creek	1.4	161	2.416
Westcolang Creek	4.5	281	1.983
Weston Brook	2.5	320	2.345
White Brook	2.1	246	1.935

Table 1.2.4-5 provides information about the characteristics of the reservoirs in the watershed. As shown, the detention time in these reservoirs is significant, which impacts both water quality and zone delineation boundaries.

Table 1.2.4-5 Reservoir Characteristics in the Delaware River Watershed

RES #	STATE	RESERVOIR NAME	DAM NAME	RIVER NAME	DRAINAGE AREA (mi2)	PERCENT OF BASIN AREA	WATER TOT (DAYS)	DISCHARGE (gal/s)	NORMAL CAPACITY (billions of gallons	SURFACE AREA (mi2)
2011	PA	Francis E. Walter Lake	Francis E. Walter	Lehigh River	674.90	8.9	0.71	10629.07	0.65	0.14
1769	NY	Cannonsville Reservoir	Cannonsville Dam	West Branch Delaware River	496.52	6.6	215.3	5272.27	98.08	7.50
1693	NY	Pepacton Reservoir	Downsville Dam	East Branch Delaware River	364.48	4.8	419.47	4135.97	149.89	10.00
1713	NY	Rio Reservoir	Rio Dam	Mongaup River	258.68	3.4	17.48	2828.38	4.27	0.90
2026	PA	Lake Galena	Peace Valley Dam	Neshaminy Creek	188.80	2.5	8.77	2810.43	2.13	0.59
2035	PA	Beltzville Lake	Beltzville	Pohopoco Creek	179.15	2.4	75.11	2069.85	13.43	1.47
1714	NY	Swinging Bridge Reservoir	Swinging Bridge Dam	Mongaup River	169.49	2.2	59.1	1745.20	8.91	1.56
2056	PA	Lake Wallenpaupack	Wallenpaupack Dam	Wallenpaupack Creek	141.69	1.9	290.39	2787.98	69.95	9.68
2052	PA	Pocono Lake	Pocono Lake Dam	Tobyhanna Creek	124.32	1.6	17.87	1140.03	1.76	1.17
2053	PA	Lake Nockamixon	Nockamixon State Park Dam	Tohickon Creek	97.68	1.3	97.49	1546.97	13.03	2.26
2043	PA	Shohola Marsh Reservoir	Shohola Marsh Dam	Shohola Creek	91.12	1.2	33.81	1406.33	4.10	1.75
2010	PA	Prompton Lake	Prompton	Lackawaxen River	83.01	1.1	11.78	1088.41	1.10	0.43
1718	NY	Neversink Reservoir	Neversink Reservoir Dam	Neversink River	77.22	1	251.89	1677.13	36.49	2.34
1683	NY	Toronto Reservoir	Toronto Lake Reservoir Dam	Black Lake Creek	51.35	0.7	155.45	530.36	7.11	1.25
	PA	Churchville Reservoir	N/A	Ironworks Creek	1.63	N/A	30*	N/A	N/A	0.26
	PA	Silver Lake	N/A	Mill Creek	1.45	N/A	30*	N/A	N/A	0.09
	PA	Core Creek	N/A	Core Creek	3.28	N/A	30*	N/A	N/A	0.27

1.2.4.2 Flooding

The Delaware River Basin has seen a number of major floods during the last century. Often, the flooding does not impact the basin as a whole, but rather, only a portion of it. For instance, within the upper basin, major floods occurred in 1942, 1945, 1955, 1967, 1972, and 1981. In the lower basin, major floods occurred in 1931, 1933, 1942, 1950, 1954, 1955, 1960, 1964, 1967, 1972, and 1975. The most significant amount of flood damage was recorded in the Delaware Basin after the flood of 1955, which was caused by two tropical storms passing over the area within only one week of each other. Tropical Storm Connie saturated the basin's soil and caused minor flooding, only to be followed by Tropical Storm Diane, whose heavy precipitation acted as a catalyst for unusually high surface runoff, which in turn caused severe flooding throughout the basin. More damage was done to the region in 1972, as Tropical Storm Agnes caused major flooding, with particularly heavy damage to the Schuylkill River drainage area. As was the case with previous floods, the area's soil was saturated and subsequent heavy rainfall caused rapid runoff.

Due to the persistence of heavy flooding within the Delaware River Basin, flood control was tackled on two fronts: through the Pennsylvania State Water Plan, and by the Delaware River Basin Commission. Efforts on both fronts have resulted in great strides in flood prevention. A number of flood damage centers and reaches have been identified in the attempt to alleviate the worst flooding. A damage reach may be defined as a place where a single flood causes damage of $25,000 or more, a center is identified as a region where the average annual flood damages per mile of stream length totals $500 or more.[1] With each flood, more centers and reaches have been added. This point is illustrated by the 1972 flood, which resulted in the creation of 58 new damage centers in Pennsylvania within the Lower Delaware Basin alone.

Measures to control flooding can be either structural or nonstructural. Structural measures, including reservoirs, levees, floodwalls, and channel modifications have been used in the past to reduce flood damage. An example of this type of structural measure is a completed earthen levee and a concrete wall developed by the Army Corps of Engineers for the purpose of protecting the City of Chester. In the Lehigh Valley, the Corps of Engineers has also constructed the Francis E. Walter Dam, which aids in reducing flood damage in 29 damage centers. Adding to their list of accomplishments, the Corps has also completed the Blue Marsh Lake Project in an attempt to lessen flood damages in 20 centers, which are located downstream of the reservoir. The Pennsylvania Department of Environmental Resources has completed five projects to reduce damages within Morrisville, Warrington, Weissport, and Allentown. In addition, the Soil Conservation Service is presently carrying out flood damage reduction work.

Since structural measures are not total solutions to the flooding problem, flood protection projects will protect a community against only a particular type or size of flood. If the quantity of water exceeds the design criteria, flood damage will occur. As a consequence, nonstructural measures must also be developed in order to fully mitigate

[1] These dollar amounts are equivalent to 1969 dollars.

flood damage. Of these nonstructural measures, floodplain regulations for land use are among the most effective controls. Because floodplains were major areas of economic development in the past, there must be a relocation of activities in flood-prone areas and land acquisition must assure flood-compatible developments. Other nonstructural measures include flood forecasting, warning systems, and flood insurance. Flooding has been a problem in the Delaware Basin and attempts have been made to diminish the damage, however, permanent solutions to flooding have yet to be found. (Majumdar, Millar, and Sage, 1988).

1.2.4.3 Groundwater

In 1988, two and a half million people, or 1/3 of the Delaware River Basin, obtained their drinking water from groundwater sources (Majumdar, Miller, and Sage, 1988). The reliability of groundwater supplies depends on the geology and soil type. In most areas of the Delaware River Basin, the aquifers are composed of fractured bedrock, and usually yield limited quantities of water suitable mainly for domestic wells.

There are four principal types of aquifers in the Delaware River Basin: unconsolidated deposits, crystalline rocks, carbonate rocks, and clastic rocks. The best areas for large supplies of groundwater are the areas underlain by carbonate rocks in the southern part of the basin (Great Valley). Other high yielding aquifers can be found in Philadelphia and south within the unconsolidated deposits in the Coastal Plain.

Most of the aquifers in the Delaware River Basin are composed of consolidated rocks, with the exception of the Coastal Plain deposits in Philadelphia and the thick, weathered mantle in a few isolated areas. Groundwater can occur under water table or artesian conditions. Water table conditions are generally the rule within the Delaware River Basin. Below the water table, the spaces between the soil particles can store or transmit water. These areas have high permeability if the soil is primarily sand and gravel, and low permeability if the soil has a large fraction of silt or clay. The consolidated rocks have very little primary porosity, except for a few of the coarse sandstone beds, and their ability to store and transmit water is small. In most aquifers throughout the basin, water moves through and is stored in openings developed along joints, fractures, faults, and cleavage and bedding planes in the rock (called secondary porosity). These conditions were formed when rocks were stressed by movements in the earth's crust, and they may be enlarged by solution, earthquakes, and earth tides.

Groundwater flows with very low velocity when compared with surface water. Water that reaches the water table has been in contact with the rocks of the aquifer for a much longer time than it has been in contact with the atmosphere or soil. Therefore, much of the dissolved solids in groundwater are derived from aquifers. As contact time between the water and the rock increases, the mineral content of the water also increases to the saturation point. Groundwater in some areas may be contaminated locally by on-site disposal of domestic waste.

1.2.4.3.1 Stressed Groundwater Areas

In 1999, the Delaware River Basin Commission (DRBC) adopted regulations that establish groundwater withdrawal limits for 76 watersheds that fall either entirely or partly within the Groundwater Protected Area of Southeastern Pennsylvania.

The Protected Area (see Figure 1.2.4-5), where more stringent regulations apply to groundwater withdrawals within the Delaware River Basin, was established by the commission in 1980 at the request of the Commonwealth of Pennsylvania after it became evident that development was negatively impacting groundwater levels. The goal is to prevent depletion of groundwater and to protect the interests and rights of lawful users of the same water source, as well as balance and reconcile alternative and conflicting uses of limited water resources in the region.

Declining water tables in the Protected Area have reduced flows in some streams that are groundwater fed, resulting in some stream beds that are totally dry. This reduction in baseflow affects downstream water uses, negatively impacts aquatic life, and can reduce the capacity of waterways in the region to assimilate pollutants.

The Protected Area uses a two-tiered system of water withdrawal limits. The first tier serves as a warning that a subbasin is "potentially stressed". The second tier establishes a maximum groundwater withdrawal limit. In potentially stressed subbasins, applicants for new or expanded groundwater withdrawals are required to implement one or more programs to mitigate adverse impacts of additional groundwater withdrawals. Acceptable programs include conjunctive use of groundwater and surface water, expanded water conservation programs, programs to control groundwater infiltration, and artificial recharge and spray irrigation.

The Groundwater Protected Area Regulations for Southeastern Pennsylvania also:

- Provide incentives for holders of existing DRBC dockets and Protected Area permits to implement one or more of the above programs to reduce the adverse impacts of their groundwater withdrawals. If docket or permit holders successfully implement one or more programs, the commission will extend the docket or permit duration for up to ten years.

- Specify criteria for the issuance and review of dockets and permits as well as procedures for revising withdrawal limits to correspond with integrated water resource plans adopted by municipalities for subbasins.

- Establish protocol for updating and revising withdrawal limits to provide additional protection for streams designated by the Commonwealth of Pennsylvania as "high quality," or "wild, scenic, or pastoral," as defined by the state's Scenic Rivers Program.

The Groundwater Protected Area includes 1,200 square miles and 127 municipalities. In addition to the Neshaminy Creek Watershed, other large drainage areas include the Brandywine Creek, Perkiomen Creek, and Wissahickon Creek subbasins.

In addition to all of **Montgomery County**, the following areas in surrounding counties fall within the Protected Area:

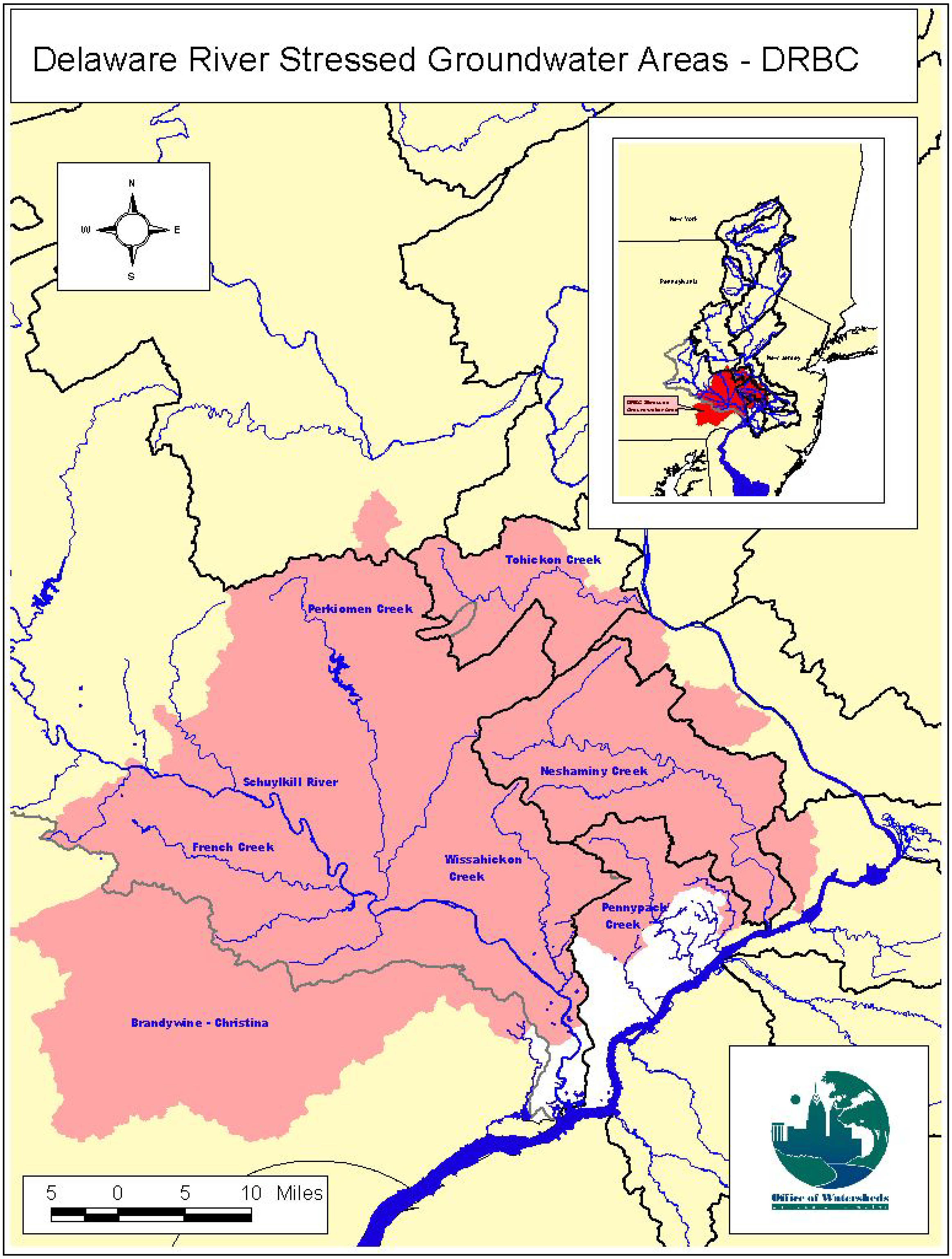
Berks: the Townships of Douglass, Hereford, and Union.

Bucks: the Townships of Bedminster, Buckingham, Doylestown, East Rockhill, Hilltown, Lower Southampton, Middletown, Milford, New Britain, Newtown, Northampton, Plumstead, Richland, Upper Southampton, Warminster, Warrington, Warwick, West Rockhill, and Wrightstown; the Boroughs of Chalfont, Doylestown, Dublin, Hulmeville, Ivyland, Langhorne, Langhorne Manor, New Britain, Newtown, Penndel, Perkasie, Quakertown, Richlandtown, Sellersville, Silverdale, Telford, and Trumbauersville.

Chester: the Townships of Birmingham, Charlestown, East Bradford, East Coventry, East Goshen, East Pikeland, Easttown, East Vincent, East Whiteland, North Coventry, Schuylkill, South Coventry, Thornbury, Tredyffrin, Warwick, West Bradford, West Goshen, Westtown, Willistown, and West Whiteland; the Boroughs of Elverson, Malvern, Phoenixville, Spring City and West Chester.

Lehigh: Lower Milford Township.

Figure 1.2.4-5 Delaware River Stressed Groundwater Areas - DRBC



1.2.5 Land Use in the Delaware River Watershed

Key Points

- **The Delaware River Watershed encompasses 40 counties within Pennsylvania, New Jersey, New York, and Delaware. The SWAP study area includes 30 of these counties.**
- **Philadelphia has the highest population density of any county within the watershed.**
- **The most immense population gains are forecasted to occur within the suburban and rural communities located on the fringe of urbanized areas.**
- **The majority of developed land is located within the southern portion of the SWAP study area, between Lehigh County and Philadelphia County.**
- **The majority of the land within the study area remains forested, although a pattern of suburban sprawl has emerged.**
- **The development of agricultural and rural lands is a cause for concern because it may lead to a loss of habitat for wildlife and an increase in erosion and pollution, which may adversely affect drinking water supplies.**

In order to characterize the Delaware River Watershed and SWAP study area, the National Land Cover Dataset (NLCD) was obtained from the USGS website, http://landcover.usgs.gov/natllandcover.html. The NLCD is a 21-class land cover classification and is based on the USGS' early-mid 1990s 30-meter Landsat Thematic Mapper ™ supplemented with additional data analysis and interpretation of the Landsat data.

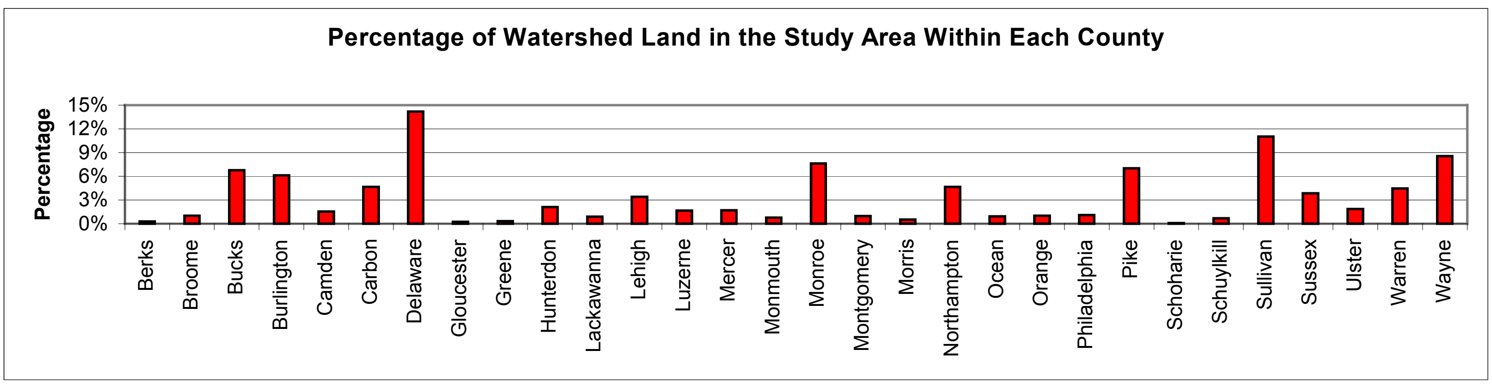
Identifying and characterizing potential contaminant sources within the SWAP study area is just one focus of the Source Water Assessment Program. Reliable characterization of the land use within the study area is important for the source water assessment process, as it is the basis for estimating non-point source loadings. The USGS data set was used as the basis for the land use characterization in the study area because it is believed to the most accurate characterization available.

Table 1.2.5-1 Forty Counties in the Delaware River Watershed by State

Delaware	New Jersey		New York	Pennsylvania	
Kent	Atlantic	*Monmouth*	*Broome*	*Berks*	*Luzerne*
New Castle	*Burlington*	*Morris*	*Delaware*	*Bucks*	*Monroe*
Sussex	*Camden*	*Ocean*	*Greene*	*Carbon*	*Montgomery*
	Cape May	Salem	*Orange*	Chester	*Northampton*
	Cumberland	*Sussex*	*Schoharie*	Delaware	*Pike*
	Gloucester	*Warren*	*Sullivan*	*Lackawanna*	*Philadelphia*
	Hunterdon		*Ulster*	*Lebanon*	*Schuylkill*
	Mercer			*Lehigh*	*Wayne*

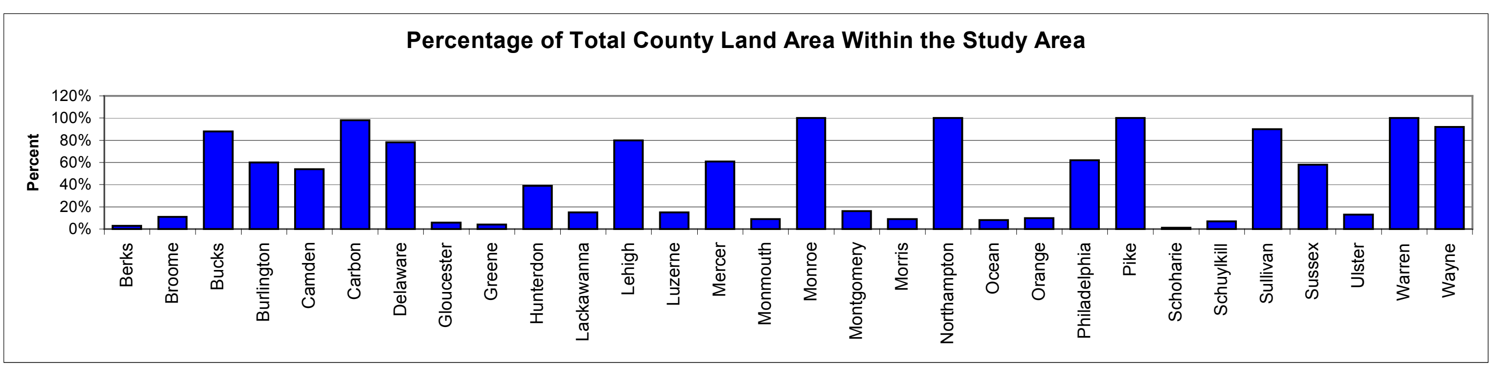
A total of 40 counties have land located within the Delaware River Watershed. Table 1.2.5-1 outlines all 40 of these counties, broken down by state. The counties shown in blue are also located within the SWAP study area. The study area is comprised of 30 counties located within Pennsylvania, New Jersey, and New York. Of these 30 counties, four (Warren County in New Jersey, Monroe, Northampton, and Pike Counties in Pennsylvania) are located entirely within the boundaries of the Delaware River Watershed. (Figure 1.2.5-2) However, since the SWAP study area consists of so many different counties and is 8,106 square miles in size, none of the individual counties make up a majority of the total land area within the study area. Delaware County in New York has the highest percentage of land within the study area at approximately 14%. Warren, Monroe, Northampton, and Pike Counties combined contain about 24%. Philadelphia County, which is the smallest county within the study area but has the largest population, makes up only 1% of the total land within the study area. Sixty percent of Philadelphia County is located within the Delaware River Watershed. The land area totals for each of the counties is shown in Figure 1.2.5-1.

Figure 1.2.5-1 Percentage of Watershed Land in the Study Area Within Each County



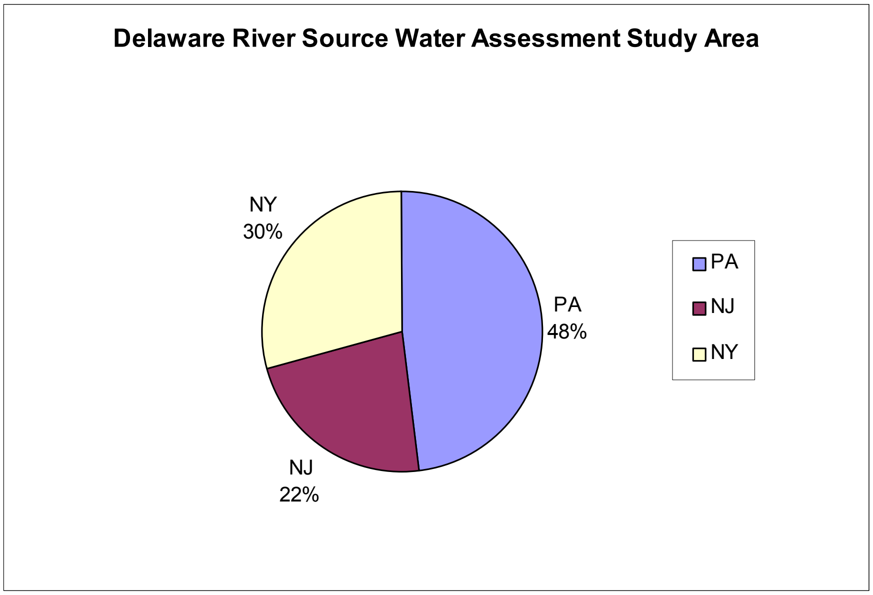
Source: USGS National Land Cover Data 1992

Figure 1.2.5-2 Percentage of Total County Land Area Within the Study Area



Source: USGS National Land Cover Data 1992

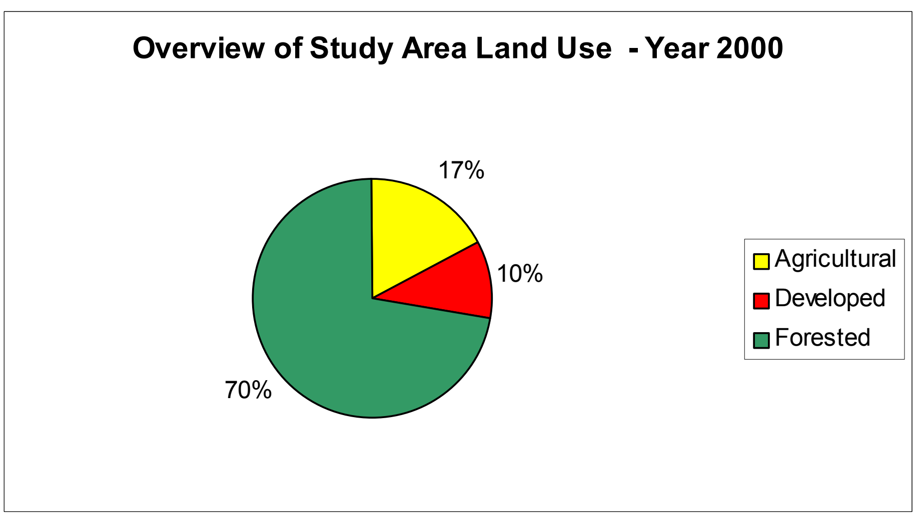
Figure 1.2.5-3 Percentages of Watershed Land by State for the Study Area



Source: USGS National Land Cover Data 1992

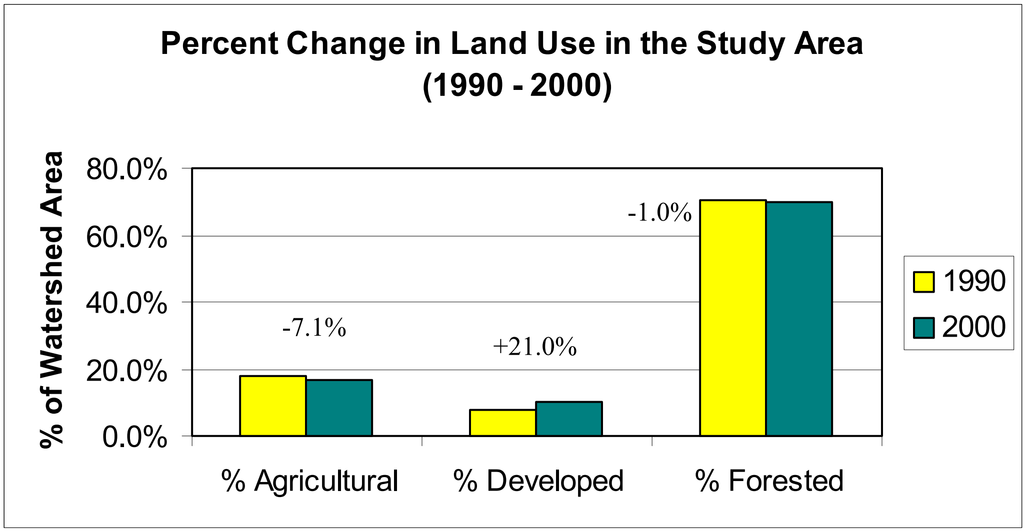
According to the NLCD estimated land use for 2000, 70% of the SWAP study area is comprised of forested lands. Seventeen percent of the area is used for agricultural purposes and 10% is developed. (Figure 1.2.5-4) Decreases in agricultural and forested areas result from increases in development (i.e., residential, commercial, industrial, transportation). Since 1990, there has been a 21% increase in development, and a 7% and 1% decrease in agricultural and forested lands, as shown in Table 1.2.5-2 and Figure 1.2.5-5.

Figure 1.2.5-4 Overview of Study Area Land Use – Year 2000 (Estimated)



Source: USGS National Land Cover Data 1992

Figure 1.2.5-5 Percent Change in Land Use in the Study Area (1990-2000)



Source: USGS National Land Cover Data 1992

Table 1.2.5-2 Land Use Changes in the Study Area: 1990 – 2000

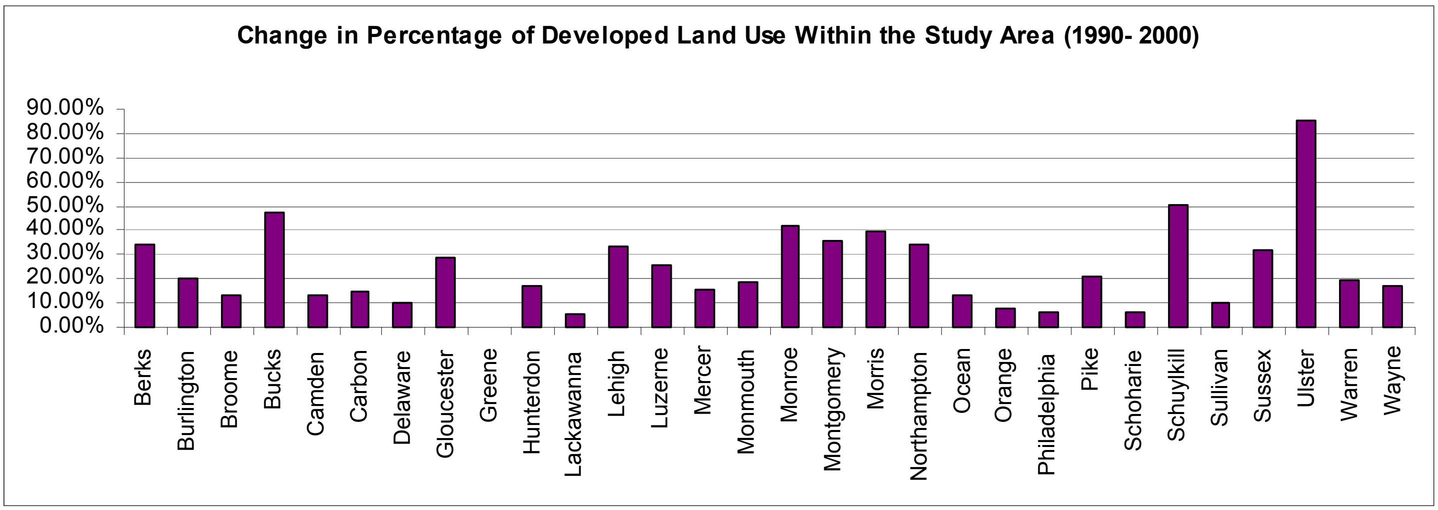
	1990	2000	% Change
% Agricultural	18.2%	17.0%	-7.1%
% Developed	7.9%	10.0%	21.0%
% Forested	70.7%	70.0%	-1.0%

Source: USGS National Land Cover Data 1992
*Note: To calculate % change in agriculture land from 1990 to 2000: [(17.0-18.2)/18.2]*100=-7.1%*

Ulster County in New York had the highest change in percentage of developed land from 1990 to 2000 with an 85.5% increase, although Ulster County still remains one of the least developed counties overall within the study area. Schuylkill County in Pennsylvania experienced a 51% change in developed land during this time, but also remains one of the least developed counties. Philadelphia County is the most developed county within the study area with a developed area rate of about 83%. However, since Philadelphia is already so developed, there was little change from 1990 to 2000. Bucks County in Pennsylvania experienced the greatest actual development increase with 27,645 acres developed. This increase reflects a 32% change in developed land within the Bucks County portion of the study area. This overall percentage is lower when compared to the other counties, but the amount of development is equal to approximately 43 square miles and is all located within a single county. (Figure 1.2.5-6 and Table 1.2.5-3)

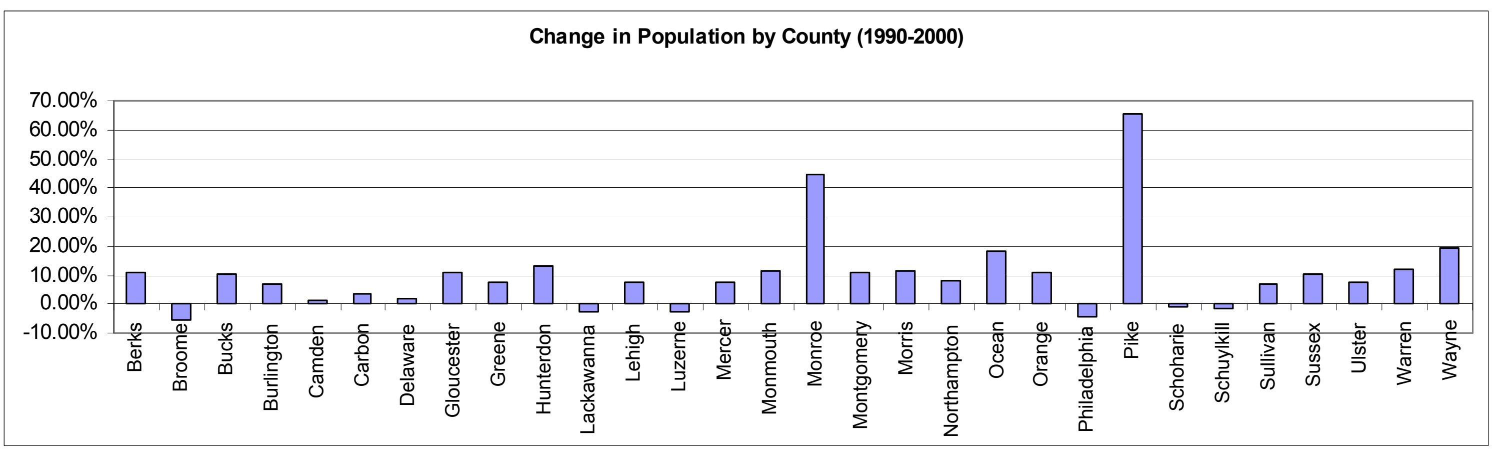
County populations between 1990 and 2000 had the greatest increase in Pike, Monroe, and Warren Counties, all of which are located at the northern end of the study area near the New York and north New Jersey State borders. Pike County alone experienced a 66% change in population from 27,966 to 46,302 persons. Increases in population generally occurred in the suburban Philadelphia counties, which follow a pattern of suburban sprawl within this area. This increase in population is a direct indicator of the increase in development activities that have occurred in these counties as well. Philadelphia, Lackawanna, and Luzerne Counties in Pennsylvania and Broome County in New York, each experienced a loss of population from 1990 to 2000, but still lost acreage to development. (Figure 1.2.5-7)

Figure 1.2.5-6 Change in Percentage of Developed Land Use Within the Study Area by County



Source: USGS National Land Cover Data 1992

Figure 1.2.5-7 Change in Population by County (1990-2000)



Source: 2000 U.S. Census

Table 1.2.5-3 Change in Percentage of Developed Land Use Within the Study Area by County

	1990	2000	Change in Percentage
Berks	3.24%	4.35%	34.27%
Burlington	19.51%	23.38%	19.82%
Broome	0.58%	0.66%	12.88%
Bucks	16.70%	24.59%	47.21%
Camden	65.72%	74.55%	13.35%
Carbon	2.86%	3.28%	14.79%
Delaware	0.58%	0.64%	10.28%
Gloucester	43.96%	56.54%	28.62%
Greene	0.00%	0.00%	0.00%
Hunterdon	2.35%	2.74%	16.78%
Lackawanna	2.32%	2.44%	5.06%
Lehigh	16.39%	21.92%	33.75%
Luzerne	2.57%	3.23%	25.46%
Mercer	33.55%	38.84%	15.78%
Monmouth	2.58%	3.06%	18.85%
Monroe	3.44%	4.88%	41.69%
Montgomery	47.69%	64.75%	35.78%
Morris	10.33%	14.41%	39.52%
Northampton	10.38%	13.95%	34.40%
Ocean	3.70%	4.18%	12.92%
Orange	4.48%	4.82%	7.69%
Philadelphia	77.92%	82.54%	5.92%
Pike	1.39%	1.69%	21.13%
Schoharie	0.43%	0.45%	6.26%
Schuylkill	0.66%	0.99%	50.81%
Sullivan	2.23%	2.46%	10.40%
Sussex	4.53%	5.99%	32.12%
Ulster	0.01%	0.02%	85.50%
Warren	4.53%	5.42%	19.57%
Wayne	0.90%	1.05%	16.81%

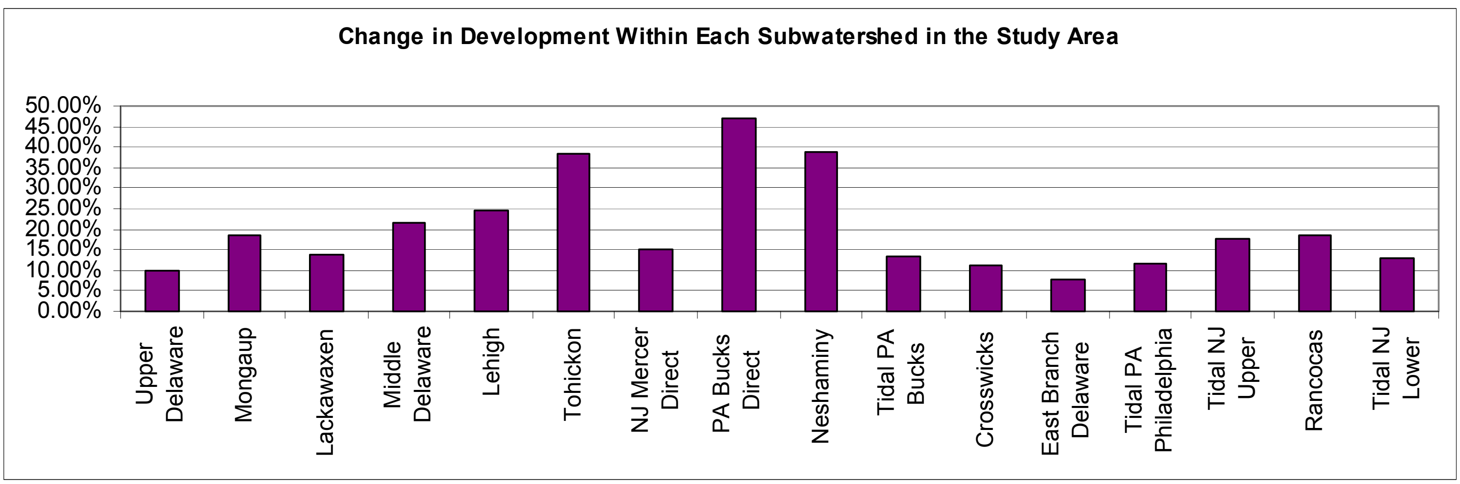
Source: 2000 U.S. Census

Subwatersheds

In general, the subwatersheds within the southern portion of the study area are much more developed than the subwatersheds in the northern portion up through New York. The land surrounding the Delaware River within the Middle Delaware Subwatershed is part of the National Scenic River Corridor and contains the Delaware Water Gap National Recreation Area, which remains protected from development under Federal regulation. The Tidal NJ Lower, Lehigh, and Tidal PA Philadelphia Subwatersheds contain the largest amount of developed land within the study area as illustrated in Figure 1.2.5-8. The Lehigh Subwatershed is also continuing to develop rapidly and experienced a 24% change in development from 1990 to 2000. During this time, 30 square miles of agricultural and forested land was developed within this area. However, developed land still only makes up about 9% of the entire Lehigh Subwatershed. The PA Bucks Direct Subwatershed experienced the largest change in percentage of developed land at approximately 47% from 3,593 to 6,750 acres developed from 1990 to 2000. The Tidal PA Philadelphia Subwatershed remains the most populated and densely developed subwatershed of the entire study area at 79% developed despite the rapid development activities occurring in the other subwatersheds.

The Tidal NJ Lower Subwatershed contains the most total acres of developed area within the study area and experienced a 13% change in development between 1990 and 2000. This change in development is equal to an additional 16.4 square miles. South Jersey currently depends upon groundwater for its water supply. If suburban sprawl continues at this rate, the supply will be quickly depleted and New Jersey may ultimately need to use the Delaware River to obtain drinking water. Table 1.2.5-4 includes the total acres developed for each of the subwatersheds and the change in the percentage of total land developed from 1990 to 2000.

Figure 1.2.5-8 Change in Development Within Subwatersheds of Study Area



Source: USGS National Land Cover Data 1992

Table 1.2.5-4 Change in Development Within Subwatersheds of Study Area

	Acres of Development 1990	Acres of Development 2000	% Change in Developed Land
Upper Delaware	4551.41	5046.65	9.81%
Mongaup	27001.52	33093.84	18.41%
Lackawaxen	4725.27	5483.82	13.83%
Middle Delaware	33860.95	43275.75	21.76%
Lehigh	59690.28	78932.32	24.38%
Tohickon	2487.94	4049.22	38.56%
NJ Mercer Direct	24595.54	28970.82	15.10%
PA Bucks Direct	3593.11	6750.28	46.77%
Neshaminy	35448.08	57821.79	38.69%
Tidal PA Bucks	17050.59	19661.84	13.28%
Crosswicks	12893.44	14491.35	11.03%
East Branch Delaware	2777.72	3016.52	7.92%
Tidal PA Philadelphia	67614.56	76694.49	11.84%
Tidal NJ Upper	9983.61	12095.74	17.46%
Rancocas	33171.31	40632.08	18.36%
Tidal NJ Lower	71663.61	82198.52	12.82%

Source: USGS National Land Cover Data 1992

Actual land use within the SWAP study area is extremely variegated. The forested and rural upper Delaware River Watershed paves the road for suburban development. South of Trenton, the urban complex fosters a suburban/agricultural mix. In the State of Pennsylvania, Bucks, Chester, and Montgomery Counties are furnished with considerable open space and agricultural lands. At the southern portion of the study area, heavy urbanization has run its course within the Philadelphia/Camden area. Table 1.2.5-5 summarizes the land use characterization for the study area. More than 88% of the study area is characterized as agriculture, forests, and wetlands. Developed and urbanized areas account for about 8% of the entire area.

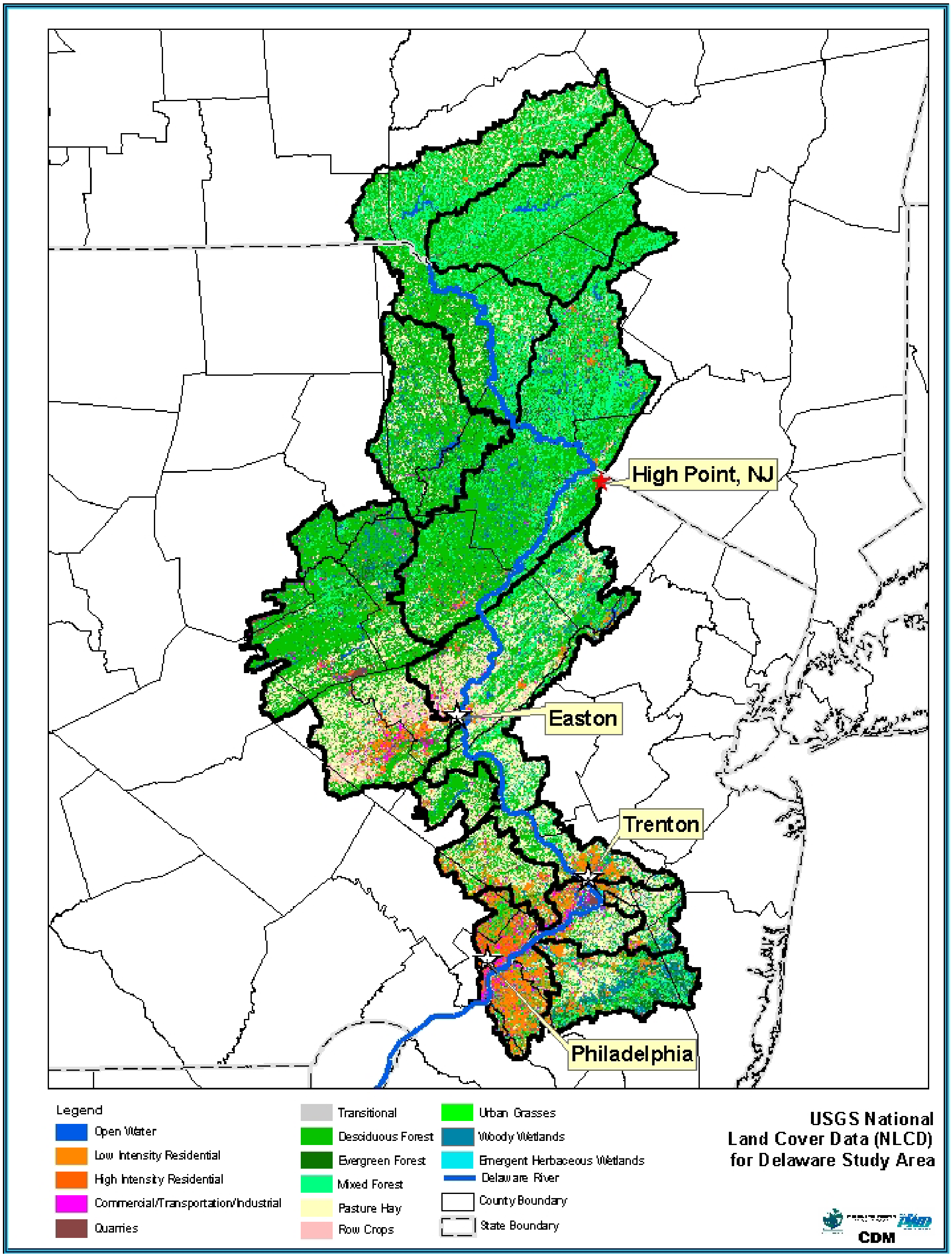
Table 1.2.5-5 Updated Land Use Categories

Land Use Category	Subcategory	Area (acres)	Percentage of Schuylkill Watershed Area
Agricultural	Pasture/Hay	709,269.97	13.65%
	Row Crops	208,963.35	4.02%
Commercial/Industrial/Transportation		87,203.64	1.68%
Forested	Deciduous Forest	2,260,850.70	43.50%
	Evergreen Forest	256,769.73	4.94%
	Mixed Forest	986,204.68	18.97%
Open Water		126,210.27	2.43%
Quarries/Strip Mines/Gravel Pits		20,411.81	0.39%
Residential	High Intensity Residential	61,355.96	1.18%
	Low Intensity Residential	262,549.57	5.05%
Transitional		7,090.90	0.14%
Urban/Recreational Grasses		25,641.07	0.49%
Wetlands	Emergent Herbaceous Wetlands	23,655.40	0.46%
	Woody Wetlands	148,503.83	2.86%

Source: USGS National Land Cover Data 1992

This land use characterization is believed to provide the most accurate and up-to-date coverage of land use for the SWAP study area, and the characterization demonstrates a consistent trend in increased development within the study area and Delaware River Watershed. One final trend that is evident within the study area is the protection of open space along the Delaware River, especially in Pennsylvania. The land surrounding the Delaware River within the Middle Delaware Subwatershed is part of the National Scenic River Corridor and contains the Delaware River National Recreation Area, which remains protected from development under Federal regulation. Further south, along the Neshaminy Subwatershed is the Delaware Canal State Park, which is also protected from development. Figure 1.2.5-9 shows the updated land use for the SWAP study area.

Figure 1.2.5-9 Updated Land Use in the SWAP Study Area



1.3 Summary of Past Reports and Studies

1.3.1 Introduction

Key Points
- **There have been several large studies conducted on the Delaware River by a large number of agencies including DRBC, USGS, USEPA, NJDEP, PADEP, NYDEC, NYDEP, and water suppliers.**

Recently, numerous governmental agencies, watershed organizations, educational institutions, and citizen groups have focused their efforts on improving the ecology of the Delaware River and its tributaries. A listing of reports and studies completed by these groups is given below as a resource reference. Due to the size and complexity of the Delaware River Watershed, it should be noted that this list is not exhaustive.

1.3.2 Delaware River Studies

William E. Toffey's technical paper, **Philadelphia's River Resources,** published in June 1982, is a summary of the conditions of both the Delaware and Schuylkill Rivers' ecosystems. The paper focuses on the challenges that face organizations working towards improving these ecosystems in order to restore them to their former aesthetic and environmental vitality. Industrial development and pollution from sewage treatment plants, specifically in Philadelphia, are mentioned as the main causes of the deterioration of these ecosystems, which is evident in the poor water quality and the lack of an abundant, diverse, and productive fish population. The author makes recommendations for the renewal and maintenance of the rivers with the primary objective of creating a sustainable recreational fishery, a sign of a healthy river system, through the reduction and management of pollution and the cultivation of a fishery.

The Economic Impacts of the Delaware Estuary by William R. Latham, III and John E. Stapleford (1987) discusses how the Delaware Estuary economically affects surrounding areas of the state of Delaware. The report critiques common economic impact models for determining the estuary's total effects and then proposes a seemingly more precise approach to estimating those effects. After describing their alternate methodology, the authors note how they determine the limits of the estuary and define estuary-related activities (versus non estuary-related activities) which are necessary measures before proceeding to tally the estuary's economic contribution to surrounding regions.

Flowing Toward the Future: 21st Century Visions and Directions for the Delaware River and its Watersheds (Governors 21st Century for Environment Commission, *1999)* summarizes the results of ten workshops held in April and May of 1999 to discuss the future of the Delaware River and it watersheds. Five idealistic visions for these areas are outlined: The Ecological Vision, The Water Supply Vision, The Livable, Pleasing Places Vision, The Vibrant Economy Vision, and The Stewardship Vision. The report also lists challenges facing the attainment of those goals and includes six directions for eventually achieving them: The Good Science Direction, The Watershed Education Direction, The Watershed Image and Marketing Direction, The Land Resources Direction, The Water Management Direction, and The Working Better Together Direction. In addition, a list of recommended actions is included for both government and non-government organizations, as well as citizens, in order to bring about the visions for the economic improvement and beautification of the river.

Water Snapshot '96, a report prepared by the Delaware River Basin Commission, contains simple listings of information pertaining to the water quality of the Delaware River and its many streams. The data was compiled over nine-day period of water quality monitoring throughout the Delaware River Basin in a large-scale 1996 Earth Day awareness program focused on clean water. Data collected by government and non-government agencies, environmental, industrial, and concerned citizen groups, and school children includes measurements of air and water temperatures, pH, and levels of dissolved oxygen, nitrate, and phosphate. While the testing area was extensive (samples were taken from a total of 335 locations in 174 waterways in Pennsylvania, New Jersey, New York, and Delaware), it is important to keep in mind that the pooled data was collected by people of widely varying levels of expertise, from elementary-age school children to professionally-trained Water Department employees, and only during a short period of time in the Spring of 1996.

The Delaware Estuary Monitoring Report, August 1998, is the first annual report completed by Delaware River Basin Monitoring Coordinator, Edward D. Santoro, in conjunction with the Monitoring Implementation Team of the Delaware Estuary Program. This report contains a wealth of information regarding the current biological, chemical, and economic status of the Delaware Estuary, and discusses the results of former monitoring efforts, as well as what needs to be done in the immediate future with regard to further improving the vitality of this resource. Also mentioned are issues relevant to the condition of the estuary such as water quality, toxics, living resources, and habitat/land cover/land use. Qualitative and quantitative data on the nutrient/algal relationship, fish populations, and levels of chloride, dissolved oxygen, nitrate, phosphorus, bacteria, pollutants, and metals, etc. are among the many important factors affecting the estuary's health that are discussed.

The Report of the River Master of the Delaware River for the Period of Dec. 1, 1997-Nov. 30, 1998 by Krejmas, Harkness, and Carswell, Jr. is a thorough discussion of the condition of the Delaware River and its monitoring and management by surrounding states during this time period. The report includes both qualitative and a great deal of quantitative data on the year's precipitation, and hydrologic conditions, water quality, flow, controlled releases, discharges, diversions, and storage for the river and its reservoirs, as well as measured levels of chloride, dissolved oxygen, pH, and water temperature.

The Delaware River Basin Commission's **Annual Report 1998,** compiled by Christopher M. Roberts, provides general qualitative data on the river's water supply and water quality and an overview of the DRBC's present and future objectives with regard to the protection, use, and maintenance of this important resource, particularly to increasing monitoring of the river and abating the pollution problem. A "who's who" list of DRBC staff and a financial summary of the commission's operations for the year are also included.

The Delaware River and Bay Water Quality Assessment 1992-1993 305(b) Report, published by the Delaware River Basin Commission in May of 1994, describes the quality and uses of the river between 1992 and 1993. The report contains both quantitative and qualitative data on surface water assessment (including water quality data for the six zones of the river, as well as biological data regarding fish populations, wetlands, and concerns over public health and aquatic life), groundwater assessment, and the DRBC water pollution control program. The appendix contains quantitative data on the following water quality factors for the various river zones: overall use, swimmable, aquatic life support, drinking water safety, fish consumption, aesthetics, and non-degradation.

The Delaware River and Bay Water Quality Assessment 1996-1997 305(b) Report, published by the Delaware River Basin Commission in August 1998, describes the quality and uses of the river between 1996 and 1997. The support of uses such as agricultural, secondary contact, swimming, drinking water, shellfish, aquatic life, and fish consumption are rated as "full", "full but threatened", "partial", or "none" for the various zones of the river and are compared to the ratings of the previous year. Pollution, pH, bacteria levels and fish populations are assessed as well. Also discussed in the report is the DRBC's plan to implement a biological monitoring program for the entire river basin in order to gain a fuller understanding of the relationship between water quality and surrounding flora and fauna.

Delaware Estuary Environmental Indicators, published by the Delaware Estuary Program in January 2001, discusses nine environmental indicators that the program uses to monitor the health of the estuary and the balance between nature and industry that make use of this resource. Agriculture, American shad population, developed land vs. population, water use efficiency (potable water withdrawals), acres of public parkland, dissolved oxygen, contaminated sediments, shellfish resource populations, and suitability of estuary waters for swimming are the nine factors used to analyze the health of the estuary. Brief sections discussing the trends, importance, and the economic, environmental, and social impacts of each indicator demonstrate the program's commitment to preserving and enhancing the estuary ecosystem.

The **Watershed Assessment** for Allentown, Pennsylvania (September 30, 1998), prepared for the Environmental Protection Agency by The Cadmus Group, Inc., provides a wealth of information on the Lehigh River Watershed including geology, lithology, topology, hydrology, land use, population, water quality, pollution, and nutrients, among others. The report also includes the Cadmus Group's recommendations for controlling and combatting watershed problems, such as reducing soil erosion and sedimentation in streams (Allentown's two biggest difficulties). Instituting a source water protection plan for the Allentown Water System based on the establishment of a watershed coalition is another strategy for helping the city share and manage the decision-making, problem solving, and funding involved in water quality control.

The **Lower Delaware River Conservation Plan** prepared by the Heritage Conservancy in September of 1999 proposes a long-term course of action for the management and conservation of the Lower Delaware River Watershed in the face of commercial and residential expansion. With input from the general public and representatives from agencies in the 23 participating municipalities (in New Jersey and Pennsylvania combined), as well as an advisory task group, a list of goals for the maintenance and/or improvement in six areas of the Lower Delaware was formed. Water quality, natural resources, historic resources, recreation, economic development, and open spaces are the foci of the LDRCP's efforts. The conservation plan also includes each municipality's recommendations for meeting these goals.

The **New Jersey Source Water Assessment Program Plan**, submitted to the EPA in October 1999 by the New Jersey Department of Environmental Protection, gives an overview of the Source Water Assessment Program, lists current standards which drinking water must meet, and details New Jersey's strategies for achieving and/or maintaining compliance with those conditions. Ground water, surface water, and pollution issues are addressed in the plan, as well as a variety of oral and written public responses, concerns, and questions regarding the program, which can be found in the appendices.

The **Delaware Estuary Monitoring Report** (July 2000), prepared by Edward D. Santoro in cooperation with the Monitoring Implementation Team of the Delaware Estuary Program, covers continuing estuary monitoring efforts and data from 1998. Qualitative and quantitative data are provided for main issues such as water quality, toxics, and living resources, as well as nutrients, fish populations, and levels of dissolved oxygen, nitrate, phosphorus, bacteria, pollutants, and metals, etc. A variety of charts, graphs, and maps clarify data and facilitate comparisons with previous years.

M.B. McPherson's report for Commissioner S.S. Baxter of the Philadelphia Water Department, **Integration of Instantaneous Dye Release Tests to Simulate Continuous Releases in the Delaware Estuary Model** (April 1963), describes fourteen model tests performed using the Delaware River estuary model at the Waterways Experiment Station in Mississippi in order to recreate the flow of continuous dye releases by incorporating characteristics of instantaneous dye releases. Both qualitative and quantitative data provide experimental details and results of the tests.

Determination of Travel Time in the Delaware River, Hancock, New York, to the Delaware Water Gap by Use of a Conservative Dye Tracer is a U.S. Geological Survey by Kirk E. White and Todd W. Kratzer that was prepared in cooperation with the Delaware River Basin Commission in 1994. This highly quantitative report presents the results of dye experiments carried out on the Delaware River to determine the travel time of a soluble substance over the aforementioned 120-mile span of the river. This information is useful to river authorities for planning a course of action in the event of a possible toxic spill in the study area, as well as for constructing accurate water quality models.

The Delaware Estuary: Discover its Secrets, written by the Delaware Estuary Program in September of 1996, is an environmental management plan for the Delaware Estuary, which takes a global approach to watershed management. This plan addresses the environmental and economic issues that are specific to the Delaware Estuary, while also providing a framework for the effective integration of ongoing management activities. Four focal points are outlined in the plan: land management, water use management, habitat and living resources, and education and involvement. In addition, the plan discusses seventy-six recommended actions that will foster improved environmental quality within the Delaware Estuary.

The Scientific Characterization of the Delaware Estuary (April 1996)**,** a publication of the Delaware Estuary Program, provides a broad description of the state of the Delaware Estuary in 1996. This report primarily focuses on eight characteristics of the estuary: status and trends, physical characteristics, historic use, land use, water quality, toxic substances, living resources and their habitat, and fish and fisheries. Additionally, this report outlines the goals and objectives set forth by the Delaware Estuary Program in its effort to preserve the water and resources of the Delaware Estuary.

Water Quality Monitoring at F. E. Walter Reservoir During 1999, is a report prepared in January of 2000 for the U.S. Army Corps of Engineers by Frederick S. Kelley and Erin Klingebiel of Versar, Inc. This report summarizes the results of water quality monitoring at the F.E. Walter Reservoir from May to September 1999, while also discussing the relevance of water quality measures to the ecology of the Reservoir and making recommendations for future water quality monitoring. Furthermore, this summarization identifies and describes the three types of monitoring performed in the study of the F.E. Walter Reservoir: monthly water quality and bacteria monitoring, drinking water monitoring, and sediment priority pollutant monitoring.

Living Resources of the Delaware Estuary was prepared by the Habitat Task Force of the Delaware Estuary Program (DELEP) in July of 1995. This document provides information regarding the key species and groups of plants and animals residing within the Delaware Estuary. It is designed to familiarize the reader with the living resources of the estuary, with the intent to promote support in caring for these resources. Additionally, this document focuses primarily on four topics relevant to the Estuary: Status and Trends, Habitat Requirements, Special Problems, and Management Considerations and Recommendations. These topics are meant to provide essential information to those interested in undertaking projects within the Delaware Estuary.

William J. Marrazzo and Susan Panzitta's report, Progress on the Delaware River Cleanup Program (August 1984) briefly discusses water quality of the Delaware River over the approximate 40 years since cleanup efforts began. The strategies of the Interstate Commission on the Delaware River (INCODEL) and the Delaware River Basin Commission (DRBC), are the foci of the paper, which highlights some of the most significant periods of pollution and cleanup in the history of the river's use since colonial times. Comparisons are drawn between past and current water quality in the river's six regions.

1.4 Identification of Universal Water Quality Issues

1.4.1 Introduction to Water Quality

Key Points

- **Delaware River water quality has significantly improved over the past 20 years.**
- **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.**
- **While conductivity, nitrate, and iron levels have slightly increased over the past few decades, levels of dissolved oxygen, ammonia, phosphorus, and fecal coliforms have significantly improved, due to reductions in agricultural runoff and improved wastewater treatment.**

The Delaware River is a much healthier river now than it was over the past century, when it was branded as "too thin to cultivate, too thick to drink". The periods of the river smelling of raw sewage, covered in sheens of oils, or foaming with detergent bubbles are now gone, resulting in tremendous improvements in fish, wildlife, and water quality over the past 20 years. These improvements can be directly related to the following major events:

- The decline of the coal industry;
- The decline in the presence and size of the manufacturing industry (steel, paper mills, textiles, glass, etc) throughout the watershed;
- The increased cost of oil;
- The construction of sewers and sewage treatment plants;
- The improvements in sewage and industrial waste treatment plants;
- The Clean Water Act;
- Regulations limiting the presence of phosphates in detergents; and
- Regulations phasing out the use of certain toxic chemicals.

While some of these improvements were related to regulatory initiatives, most changes in water quality were caused by the activities that occurred in the watershed. These recent improvements in water quality have allowed us to see that in a growing number of areas, the main challenges to water quality now come from polluted runoff and not point source discharges. Therefore, the focus of activities that impact water quality are now becoming as much land use related as they are specific point source or facility related.

The process of examining changes in water quality over time is very difficult. The data usually are not available to characterize long periods of record for most chemical parameters. If data are available, changes in analytical methods over time can skew results. It is important to note that based on these factors, the following sections attempt to examine general trends in water quality based only on readily available data. Just because a change is noticed at one location does not mean that it is occurring at all locations. In addition, just because data are not available to characterize an area of the watershed does not imply that the water quality is good, bad, or not meeting water quality standards.

General temporal analysis focused on long-term and past decade trends in water quality in the Delaware River at Philadelphia and data trends provided by the Delaware River Basin Commission. This site was chosen because it is at the downstream end of the Delaware River Watershed, had the most significant and extensive monitoring data available, and because it provides evidence of the dominant changes in long term water quality in the watershed as a whole. Ultimately, it is believed that impacts observed at Philadelphia are possibly occurring at a number of locations along the river and throughout its tributaries to some extent. However, this does not mean that every trend observed at Philadelphia may be happening to the same extent, or at all, in other parts of the watershed. It is hoped that as coordination of watershed monitoring is improved to provide appropriate data to describe long-term trends, evaluations at other key locations throughout the watershed can be performed.

The analytical techniques used involved developing mean annual concentrations and also developing linear regressions of the individual data points to predict long term and future trends. The linear regressions may not be appropriate for accurate predictions or fits for most chemicals since as a concentration of chemical increases or decreases it tends to reach a natural or analytical limit resulting in more of an exponential or logarithmic function.

Analysis of the data yielded the following observations:

- Philadelphia Water Department (PWD) intake data indicate significant decreases in dissolved solute concentrations through the 1990s, including elevated levels of alkalinity, dissolved solids, total phosphorous, ammonia, and fecal coliforms. These trends appear to extend back through the early 1970s. Only nitrate, chloride, and conductivity concentrations appear to be increasing over time. If they continue, they have the potential to adversely affect drinking water treatment processes for the City of Philadelphia in the future.

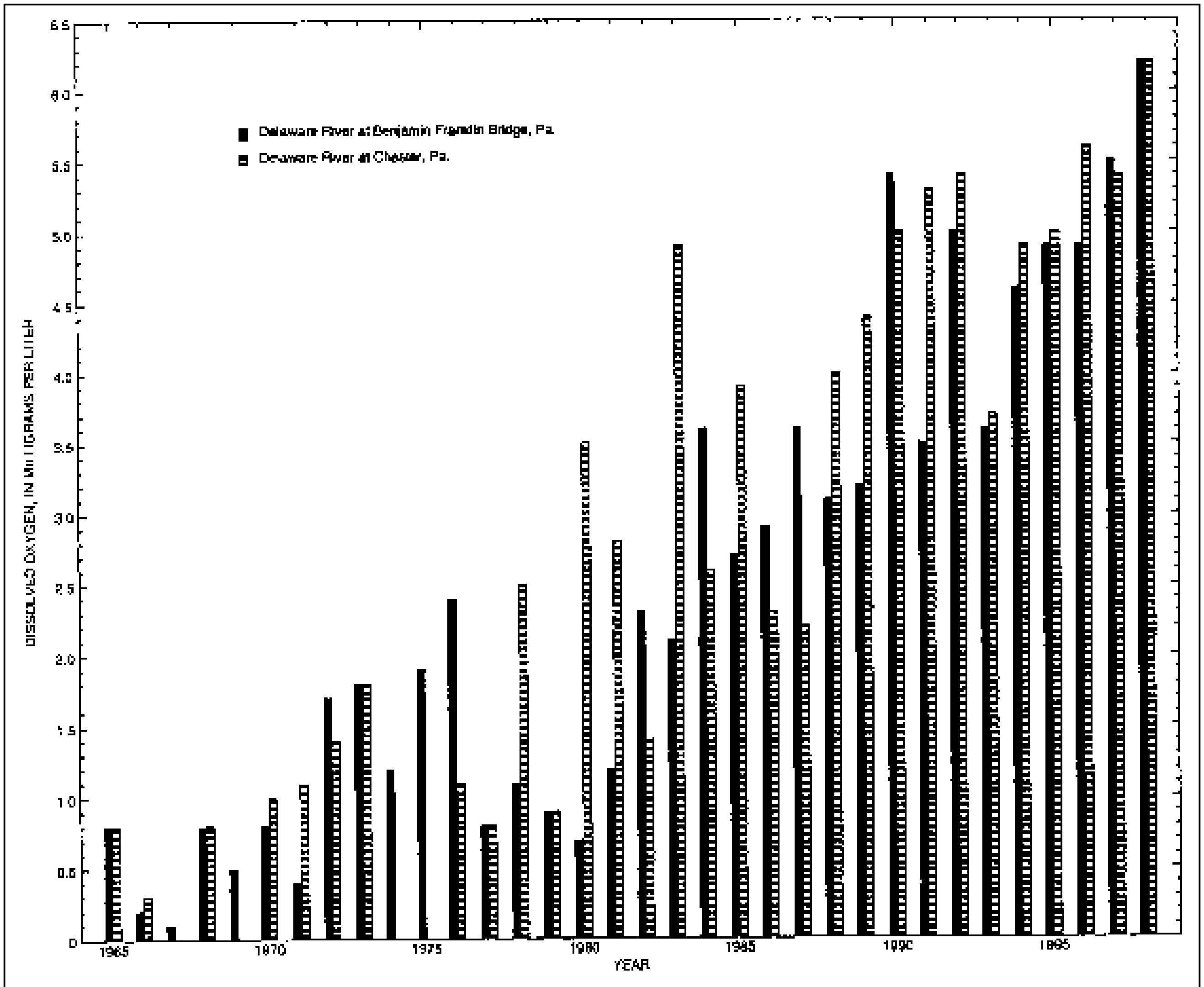
- Spatial analysis of water quality data throughout the watershed indicates that there are no common trends throughout the watershed.

- Increased mass transport levels of sodium and chloride, particularly in winter months through the 1990s, suggest that increased deposition of road salts are significantly impacting water quality at Philadelphia's Delaware River drinking water intakes.

- Though this study focused on adverse changes in river water quality parameters, the Delaware River has seen significant improvements in important water quality parameters such as dissolved oxygen, ammonia, nitrate, total phosphorous, and bacteria since the 1970s. Delaware River nutrient levels (nitrogen and phosphorus) have remained stable or decreased over the past decade due to decreased agricultural runoff within the watershed, along with improved wastewater treatment practices.

- Analysis completed in the 1998 Delaware Estuary Monitoring Report shows dissolved oxygen values have been steadily increasing over the past several decades as seen in Figure 1.4.1-1. The report substantiates improvement in DO from late 1960 through 1990. Since 1990, dissolved oxygen is typically at saturation. Along the main stem of the estuary, from the Pennsylvania/Delaware border, through Philadelphia, and up to Fieldsboro, minimum dissolved oxygen values are 3.5 to 4 mg/L. This meets the DRBC 24 hour criteria for the estuary (Santoro, 1998).

Figure 1.4.1-1 Dissolved Oxygen Levels in July from 1965-1998



***Source**: U.S. Department of the Interior and United States Geological Survey, Report of the River Master of the Delaware River for the Period of December1, 1997 - November 30, 1998, p. 78.*

1.4.2 Long-Term Water Quality, Historical Trends, and Comparison to Other Rivers

Key Points

- **Levels of fecal coliforms (bacteria), ammonia, and phosphorous have decreased over the past thirty years. These improvements have led to increased levels of dissolved oxygen which is beneficial to aquatic life.**
- **Levels of nitrates, chlorides and total residue in the Delaware River have increased over the years.**

Previous assessments of century-long water quality trends in the Delaware River and other northeastern watersheds have demonstrated long term increases in salt concentrations through the 1900s. For instance, nitrate, chloride and total residuals all increased steadily in the Delaware River from 1900 through 1970. These indicators of water quality appeared to level off and remain relatively stable from 1970 through 1990, most likely as a result of improved wastewater treatment and slowing rates of development in the northeastern region (Jaworski and Hetling 1996). Increased national prosperity following the recession of the late 1980s spurred a strong increase in development in suburban regions, including parts of Bucks, Lehigh, Montgomery, Chester, Gloucester, and Burlington counties within the Delaware Watershed. This recent development appears to be causing increases in solute concentrations, driven by increasing wastewater discharge and increased solids transport directly related to land use change.

Recent water quality assessments have indicated long-term temporal increases in nutrient fluxes in major waterways (e.g. Bollinger et al. 1999) in the United States, which may have adverse impacts on water supplies for both drinking water and irrigation systems. These recent trends are apparently driven by major increases in diffuse loading of solutes from both agricultural and urban sources (Novotny and Olem 1994, Reimold 1998). While agricultural sources typically result in increases in nutrient and herbicide concentrations, urban sources of solutes, particularly from highway runoff, can result in increased loading rates of a more diverse suite of solutes. This analysis addresses many of the potential solutes derived from both sources. Urbanization in the Delaware River Watershed has resulted in decreases in land used for agricultural purposes, so long-term decreases in nutrient loading along with long-term increases in other dissolved solutes, including metals and other inorganic constituents, might be expected. Effects of increased loading of solutes to the Delaware River can be complicated by changes in specific ion activities which are directly related to ionic strength, organic content and other bulk water chemistry characteristics that are dynamic as well (Buckler and Granato 1999, Bricker 1999).

As seen in Table 1.4.2-1, increasing levels of nitrate in the Delaware River are particularly significant because the Delaware has the third highest level of nitrate compared to the other eleven major northeastern rivers assessed by Jaworski and Hetling (1996). The rate of increase of nitrate from 1906 to 1993 is also the third highest. Chloride and total residue (total solids – TS) levels and rates of increase place the Delaware in the middle of the other rivers. Levels of these constituents are close or better than the average values across all the rivers. Overall, these trends, particularly the levels and change in nitrate and chlorides, are a concern for the Delaware River, a major river water supply. Figures 1.4.2-1 and Figures 1.4.2-2 depict the long-term historical trends in nitrates, chlorides, and total residue in the Delaware River since the turn of the century.

Over the past thirty years, a number of significant regulatory and environmental initiatives have occurred nationwide. A supplementary analysis was conducted of existing data to examine the trends in water quality since 1970 and determine if the river water quality has been improving. Figures 1.4.2-3 through 1.4.2-7 are trends observed by the Delaware River Basin Commission for dissolved oxygen, nitrate, ammonia, total phosphorus, and fecal coliforms. Figure 1.4.2-8 provides a summary of three decades of changes in levels of water quality indicators, such as ammonia, nitrate, dissolved orthophosphate, conductivity, alkalinity, TSS, turbidity, fecal coliform, total coliform, total iron and total manganese. As shown, there have been significant reductions in the concentrations of ammonia, total phosphorus, and fecal coliforms. In addition, these improvements in water quality have caused significant increases in dissolved oxygen. Of all the different parameters examined, only nitrate appeared to have a strong increasing trend, while conductivity and chlorides appeared to increase at slower rates. The increased nitrate concentrations are the direct result of the installation of secondary wastewater treatment, which converts ammonia to nitrate. The nitrate trend from the 1970 to 1990 does show significant increases related to this event. However, when examined after 1990, the rate of increase appears to slow or stop.

Table 1.4.2-1 Summary of Historical and Current Water Quality Concentrations and Rates of Change For Northeastern Watersheds

Watershed	USGS Station No.	Timeframe	NO_3(1) (mg/l)	NO_3(2) (mg/l)	NO_3 Change (mg/l/yr)	Cl(1) (mg/l)	Cl(2) (mg/l)	Cl Change (mg/l/yr)	T Res(1) (mg/l)	T Res(2) (mg/l)	T Res Change (mg/l/yr)
Delaware	1474500	1913-1993	0.27	2.9	0.0329	6	30	0.3	122	229	1.3375
Potomac	1646580	1921-1993	0.6	1.76	0.0161	3.3	13	0.1347	103	203	1.3689
Delaware	1463500	1906-1993	0.25	1.01	0.0087	2.9	13	0.1161	70	104	0.3908
Blackstone	1111230	1890-1993	0.21	0.97	0.0074	5	44	0.3766	60	154	0.9126
WB Susquehanna	1553500	1906-1993	0.16	0.7	0.0062	4	8	0.046	74	137	0.7241
Rappahannock	1668000	1929-1993	0.15	0.55	0.0063	1.1	5	0.0619	43	53	0.1587
Hudson	1385000	1906-1993	0.18	0.52	0.0039	4	17	0.1494	108	119	0.1264
Connecticut	1184000	1888-1993	0.08	0.35	0.0026	1.5	11	0.0905	53	67	0.1333
Merrimack	1100000	1888-1993	0.07	0.32	0.0024	1.8	19	0.1638	43	68	0.2381
James	2035000	1906-1993	0.06	0.3	0.0028	2.3	9	0.077	89	100	0.1264
Androscoggin	1059010	1906-1993	0.02	0.18	0.0019	2.3	12.5	0.1229	42	66	0.2892
St. John	1015000	1921-1993	0.02	0.15	0.0018	0.7	2.9	0.0306	45	65	0.2778
Average			0.17	0.81	0.0078	2.9	15.4	0.1393	71	114	0.5087

Note: (1) = Earliest historical year
(2) = Four year average for the period 1990-1993
Source: Jaworski et al. 1996

Figure 1.4.2-1 Historical Nitrate, Chloride and Total Residue in Delaware River

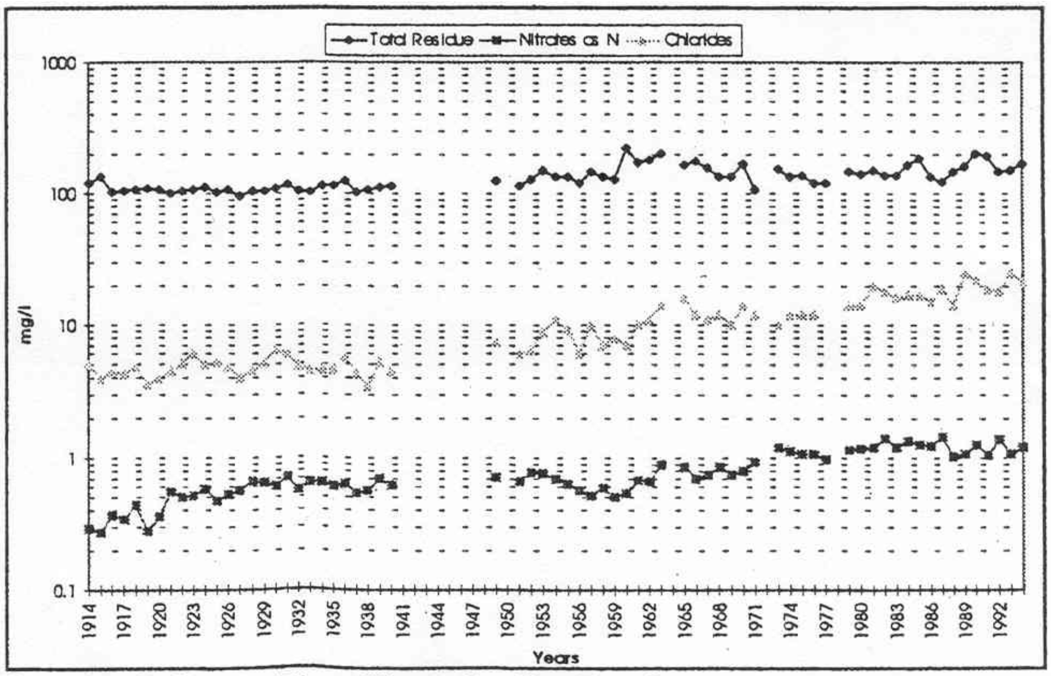
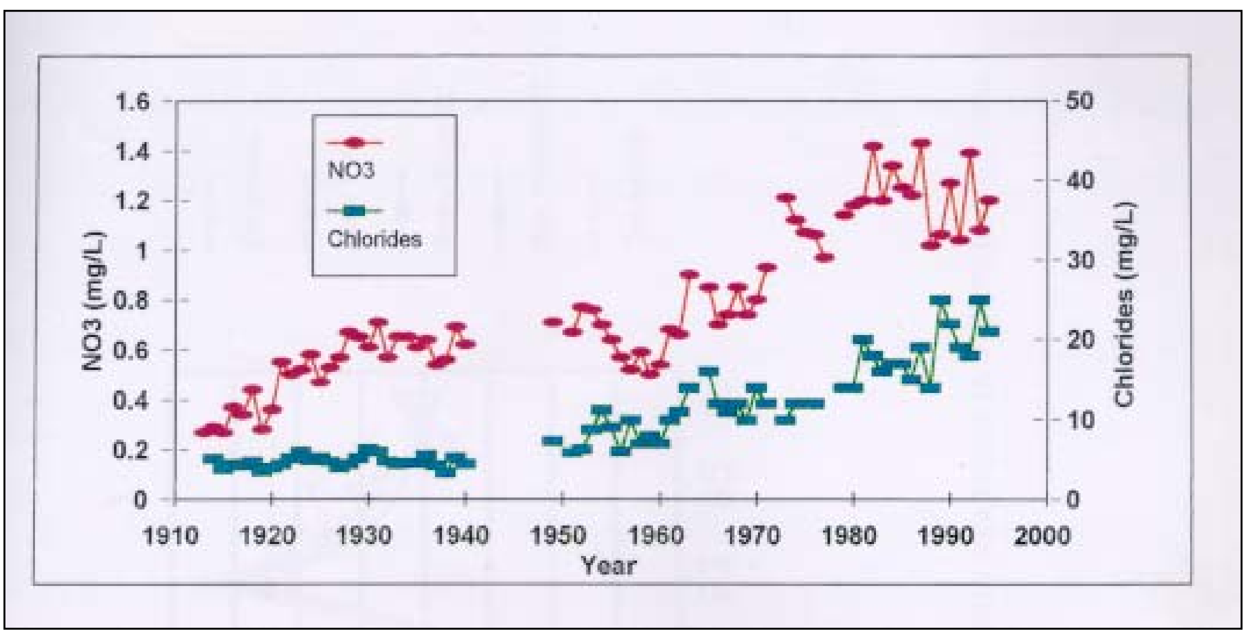


Figure 1. Delaware River Water Quality Trends.

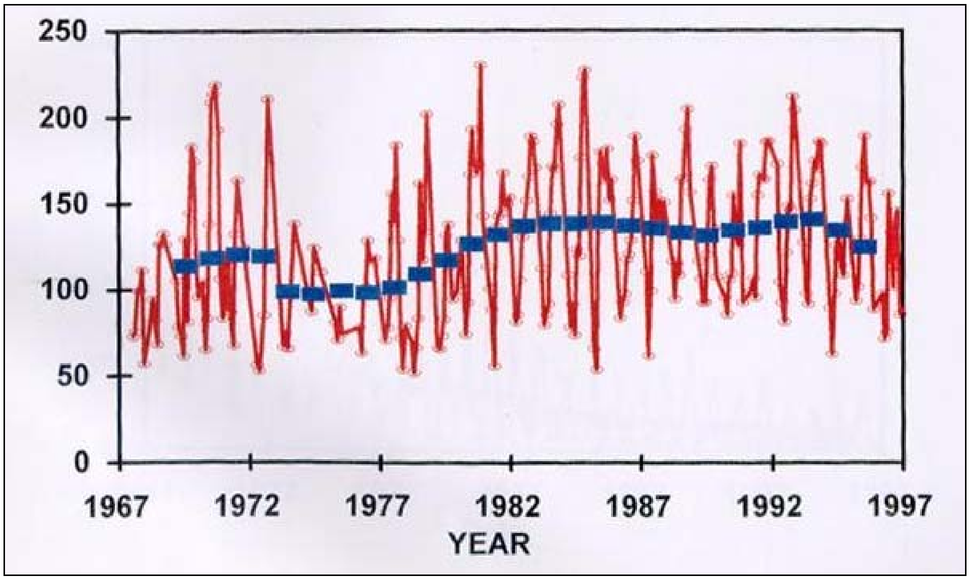
Source: JJaworski et al., Watershed 1996

Figure 1.4.2–2 Long Term Nitrate Trends at Marcus Hook



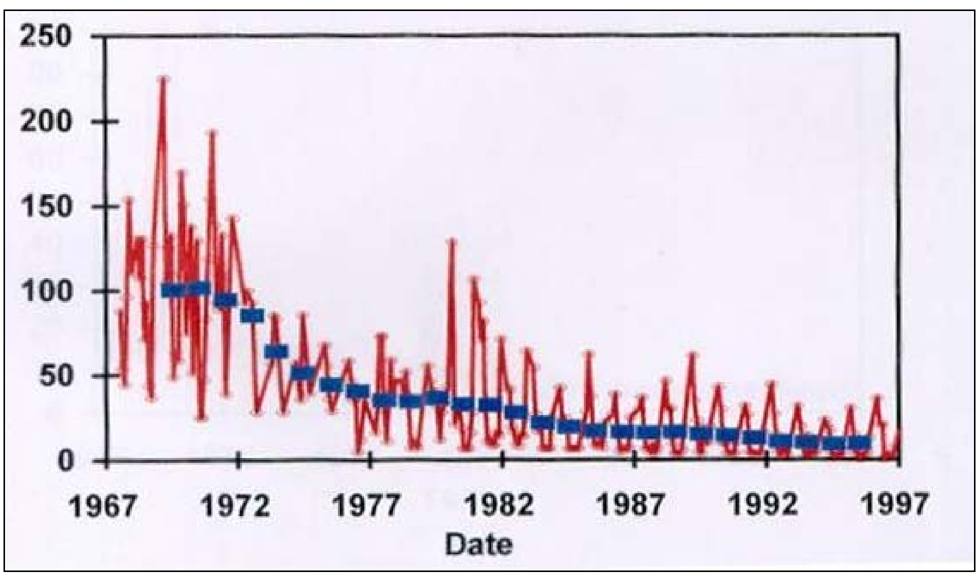
Source: Santoro, 1998

Figure 1.4.2–3 Monthly Average Nitrate-Nitrogen Trend at Marcus Hook, Delaware River: 1967–1997



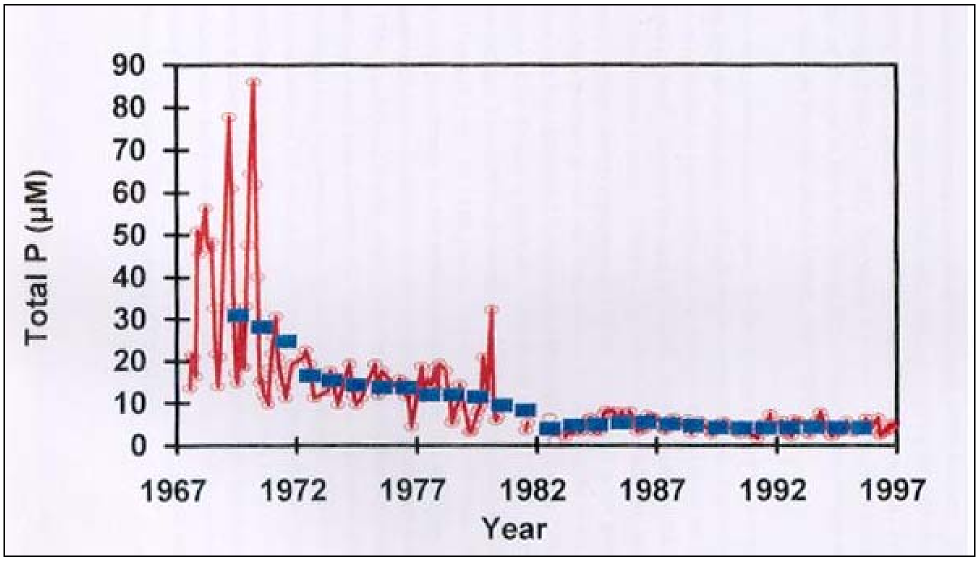
Source: Santoro, 1998

Figure 1.4.2-4 Monthly Average Ammonium Nitrogen Trends at Marcus Hook, Delaware River: 1967 – 1997



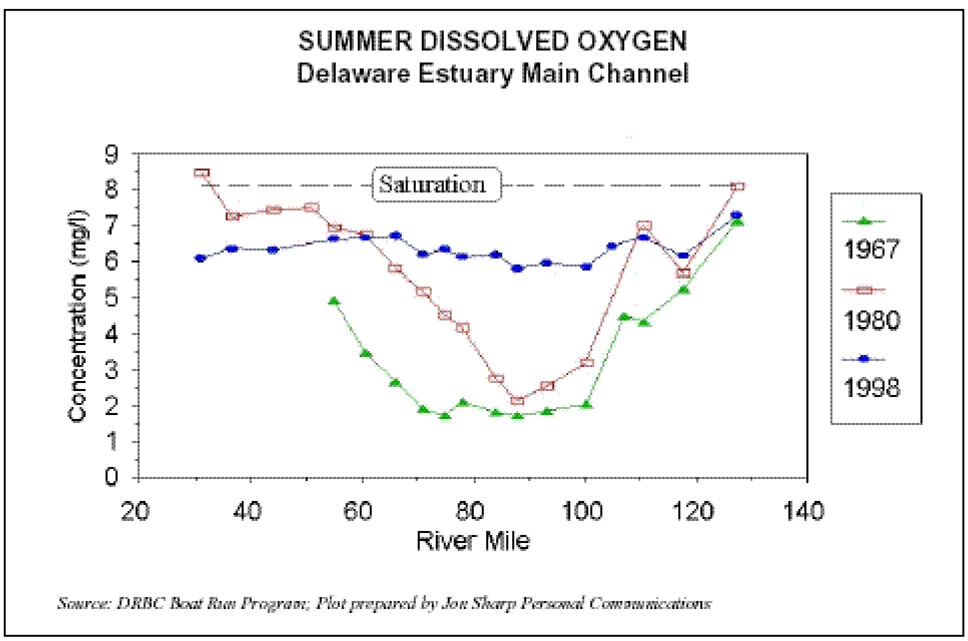
Source: Santoro, 1998

Figure 1.4.2-5 Monthly Average Total Phosphorus Trends at Marcus Hook, Delaware River: 1967 – 1997



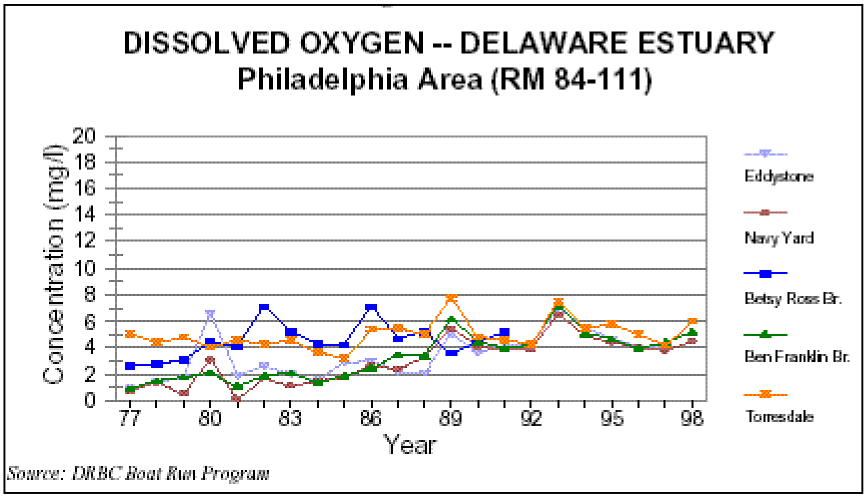
Source: Santoro, 1998

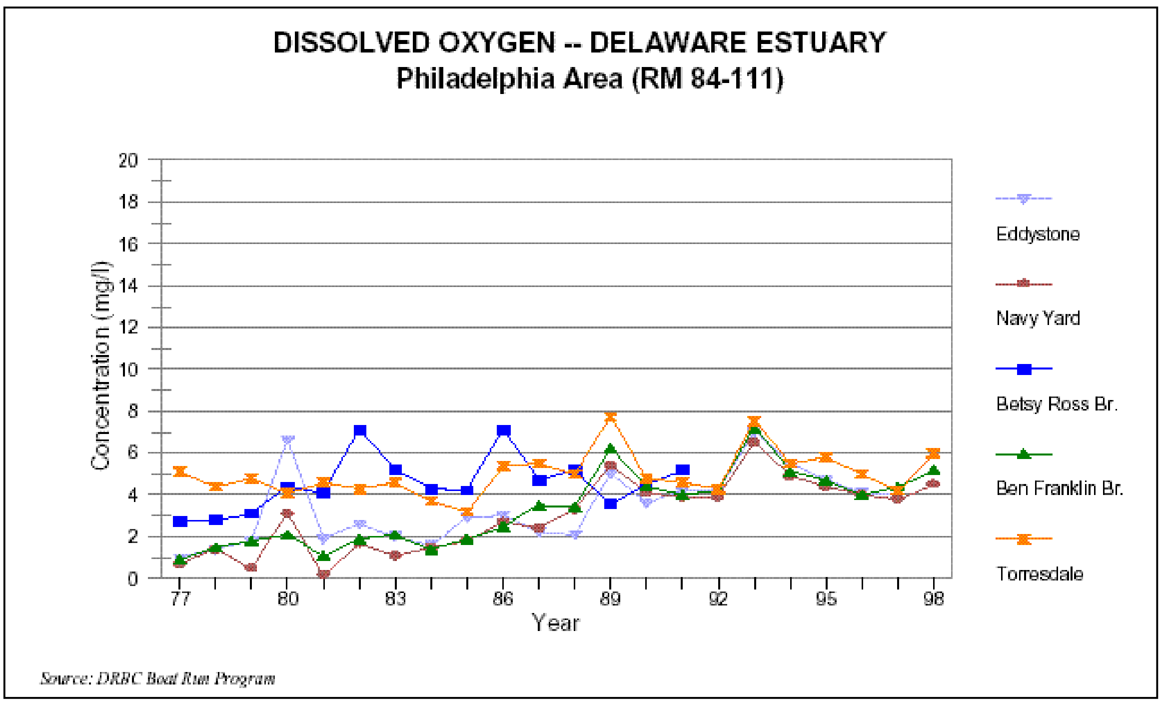
Figure 1.4.2-6 Annual Average Dissolved Oxygen Trends Along The Delaware River During Summer Periods: 1967 – 1998



Source: Santoro, 2000

Figure 1.4.2-7 Annual Average Dissolved Oxygen Trends Along The Delaware River Near Philadelphia: 1977–1998





Source: Santoro, 2000

Figure 1.4.2-8 Changes in Water Quality Indicators in the Delaware River at Philadelphia

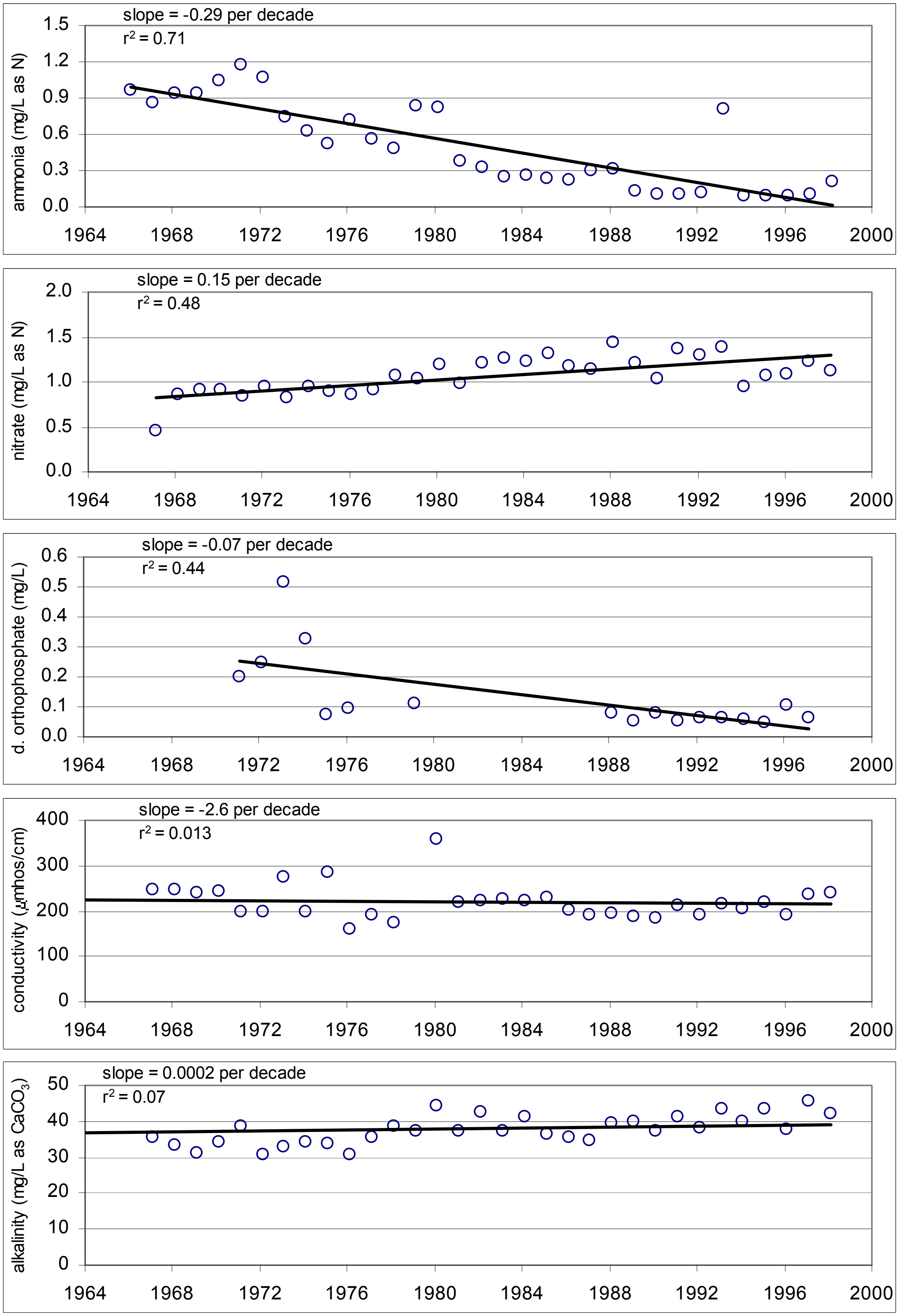
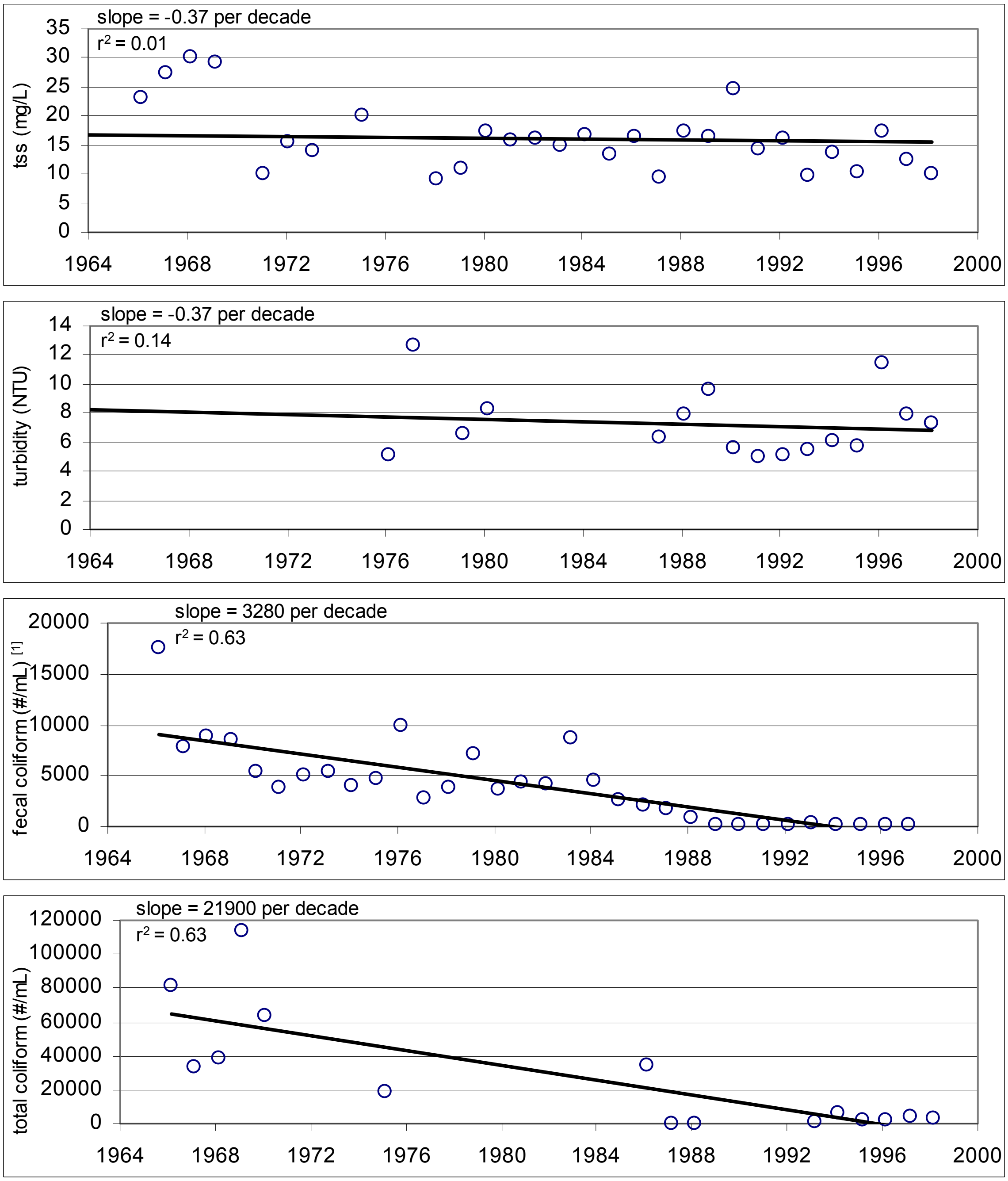
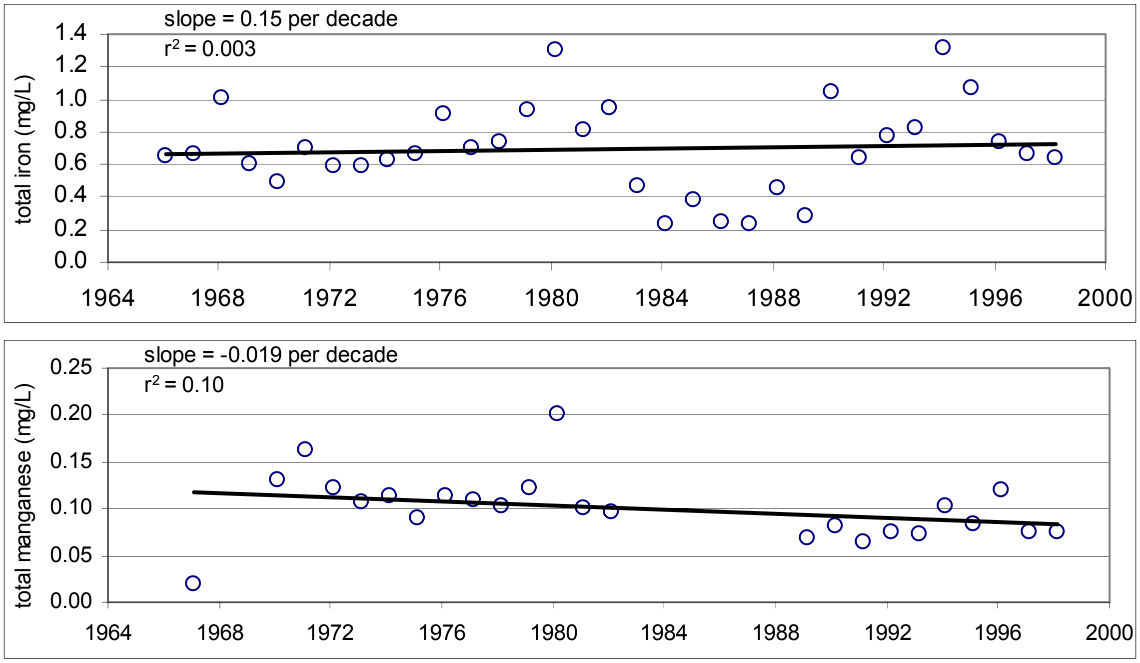


Figure 1.4.2-8 Changes in Water Quality Indicators in the Delaware River at Philadelphia



[1] data prior to 1987 measured under EPAID=31616 and after 1987 by EPAID=31611

Figure 1.4.2-8 Changes in Water Quality Indicators in the Delaware River at Philadelphia



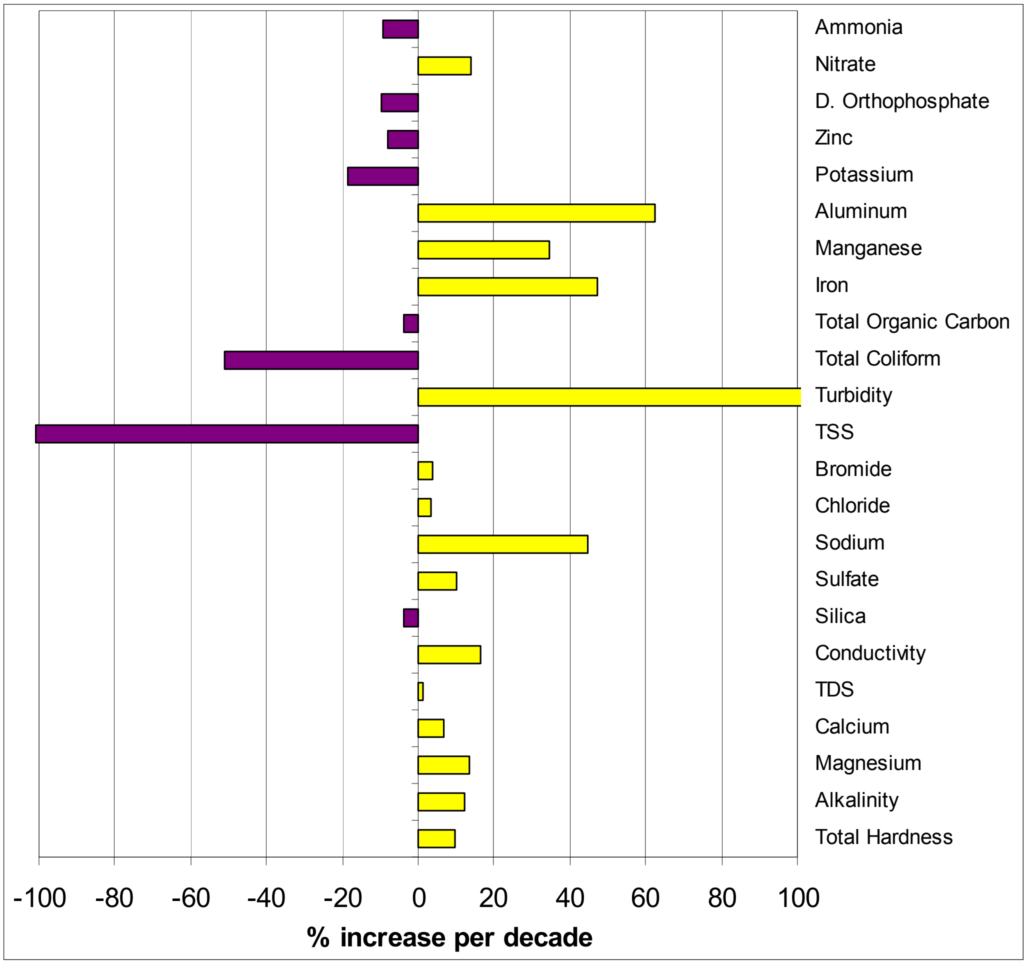
1.4.3 Changes in River Water Quality over the Past Decade

Key Points
- **Over the past decade, levels of alkalinity, conductivity, sodium, chloride, bromide, iron, manganese, nitrate, and turbidity in the Delaware River have increased.**
- **Increases in levels of salts and iron are believed to result from contaminated runoff due to increased development, increased use of de-icing chemicals, and from acid mine drainage.**
- **As point sources throughout the watershed have been abated and wastewater treatment improved, levels of coliforms, total organic carbon, total suspended solids, phosphate, and ammonia have decreased.**

Trends in river water quality over the past decade were examined in order to identify sources of contamination, and to predict future water quality concerns. This process involved the examination of data from 135 different water quality parameters measured at the Philadelphia Water Department river intakes between 1990 and 1999 and data from STORET for the Delaware River Watershed between 1990 and 2000. Of that data set, 22 parameters had sufficient numbers of measurements or detectable results to conduct a proper analysis that included comparisons between parameters and regional climate and development patterns.

Analysis of the data identified the following trends in water quality changes as shown in Figure 1.4.3-1 and Tables 1.4.3-1 and 1.4.3-2. Overall, 14 water quality parameters increased in concentration over the past decade, while levels of eight parameters were observed to decrease, and one parameter changed very little (total dissolved solid). Of the 14 water quality parameters exhibiting increasing trends, most were salts and metals. Future increases in alkalinity, conductivity, sodium, chloride, bromide, iron, manganese, and turbidity in the river water could potentially impact water treatment process operation and finished water quality, and therefore require further investigation.

Figure 1.4.3-1 Percent Change per Decade in Delaware River Quality Parameters at the Baxter Intake, Philadelphia, PA between 1990 and 1999



The observed trends led to efforts to determine the origins and types of sources and activities that would significantly impact river water quality. These observed trends suggested that although significant improvements to protect river water quality have been made for point sources, the sources of the changes in these parameters were most likely due to polluted runoff. If all of the affected parameters were regulated for point source discharges during this period without changes, then it suggests other sources may be impacting these changes. Salts, such as sodium and chloride, that appear to be increasing at significant rates in the river can be the result of increased application of de-icing chemicals in the watershed due to increased road, sidewalk, and parking lot areas in the watershed (see Table 1.4.3-3). Other parameters exhibiting increases, such as aluminum, iron, and turbidity, can be the result of increased erosion of land surfaces and streambanks due to new construction or increased flows in streams from development. The increases in salts and metals also impact conductivity, which has increased throughout portions of the watershed.

Table 1.4.3-1 Parameters That May Have Water Treatment Operation, Distribution System, or Finished Water Quality Impacts over the Past Decade or by 2020 Given Current Trends

Parameter	Decade Mean	Decade Max	Decade Min	Predicted Mean Concentration in 2020
Nitrate	1.2	2.5	0.9	1.6
Aluminum, total	0.7	3.6	0.03	1.4
Iron, total	0.9	8.3	0.05	1.7
Manganese, total	0.08	0.63	0.01	0.15
Turbidity	7.8	65	0.3	21
TOC	2.7	5.4	0.7	2.5
Bromide	0.03	0.136	0.015	0.04
Conductivity, μmhos/cm	204	607	95	279
TDS	125	240	70	179
Calcium	16	30	6	19
Magnesium	6	11	2	7
Alkalinity, mg/L as $CaCO_3$	41	86	18	53
Total Hardness, mg/L as $CaCO_3$	63	121	0.8	78

Units are mg/l unless otherwise specified.
Predicted concentrations are based on linear trends from 1990-2000.

Table 1.4.3-2 Summary of Water Quality Changes in the Delaware River at Philadelphia During the 1990's that May Impact Water Treatment and Possible Sources

Parameter	Group	Change	Possible Sources/Activities
Alkalinity	Physical	Increasing	Acid Mine Drainage and Acid Rain
Conductivity, TDS	Physical	Increasing	Polluted Runoff from Impervious Surfaces
Bromide	Salts	Increasing	Groundwater and Wastewater
Phosphorous	Nutrients	Decreasing	Improved Wastewater Treatment, Less Agricultural Activity in Watershed
Nitrate	Nutrients	Increasing	Wastewater Discharge
Ammonia	Nutrients	Decreasing	Improved Wastewater Treatment, Less Agricultural Activity in Watershed
Total Organic Carbon	Organics	Decreasing	Improved Wastewater Treatment and Reduced Agriculture
Turbidity	Particulates	Increasing	Erosion, Construction, Farming/Tilling
Total Suspended Solids	Particulates	Decreasing	Improved Wastewater Treatment and Reduced Agriculture
Manganese, Aluminum, & Iron	Metals	Increasing	Acid Mine Drainage, Construction, and Erosion from Due To Impervious Surfaces

Table 1.4.3-3 Reference Pollutant Concentrations (mg/l) in Roadway Runoff

Pollutant	Normal Highway Runoff (FHWA)	Highway Snow Wash-Off (FHWA)	Urban Runoff (NURP)
Chloride	13	400 - 5600	
Total Suspended Solids	93	204	100
Nitrate	0.660	0.680	0.680
Total Phosphorus	0.293	0.570	0.330
Copper	39	91	34
Lead	234	549	144
Zinc	217	420	160

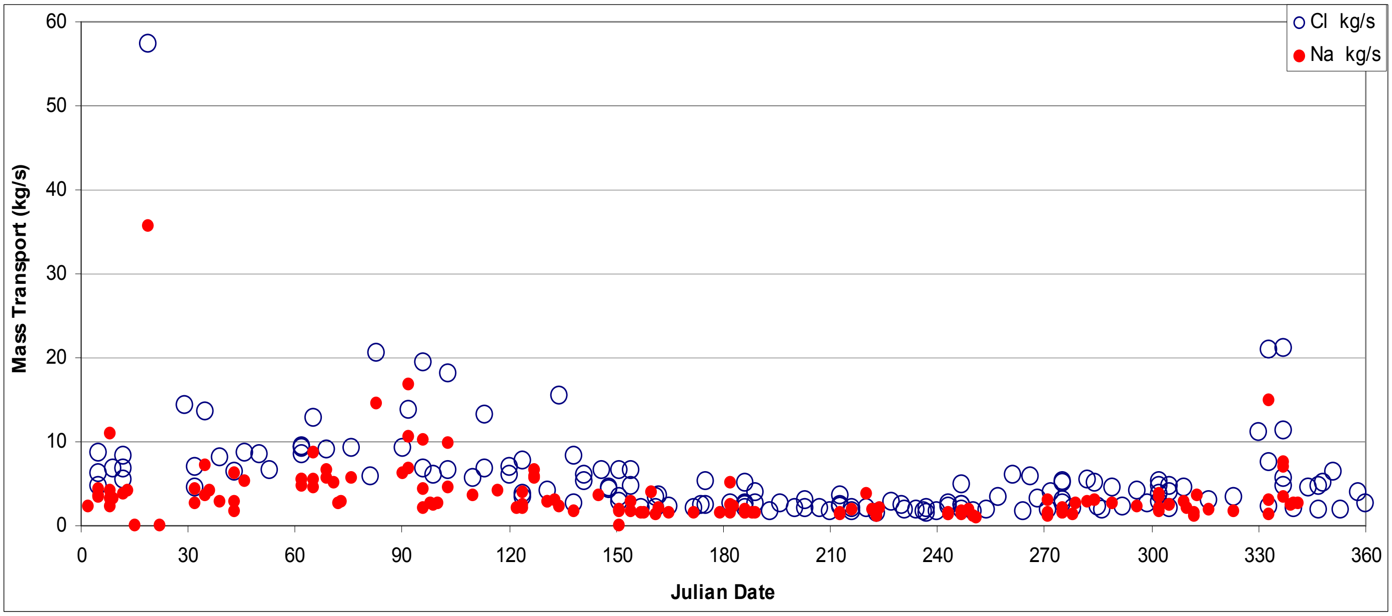
Table data excerpted from Reimhold (1998), FHWA - Federal Highway Administration Study Data (Reimhold, 1998), NURP - National Urban Runoff Pollutants Study (Reimhold, 1998).

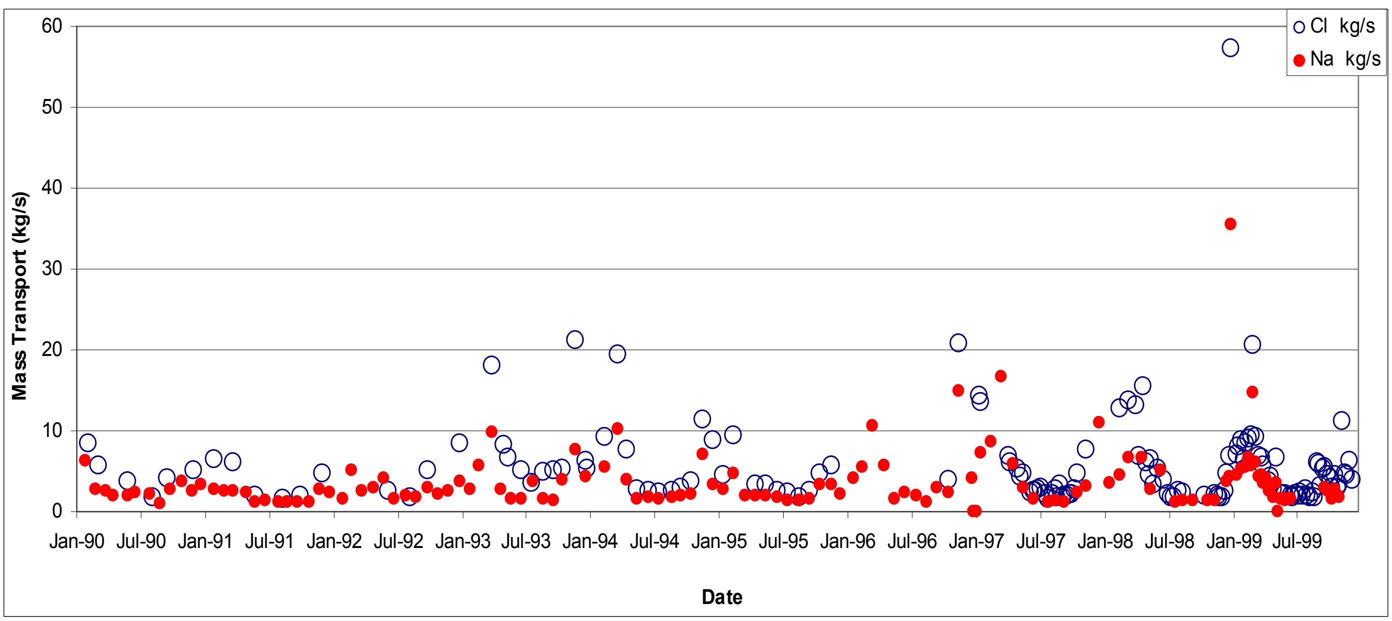
Solute mass transport rates also increased over the course of the 1990s, providing further evidence for adverse impacts of regional development on water quality. Rates of mass transport were calculated for individual samples from PWD Baxter Intake, which were based on the daily averaged flow rate data from the Trenton sampling location for the specific sample dates. Since the Delaware River is tidal downstream of Trenton, the daily average flow data from Trenton was used. Trends in Na and Cl fluxes indicate seasonal variation in mass transport, with highest rates of flux occurring during winter months when salt applications for road deicing can contribute dissolved solids to river water. Increases in flux rates for both ions are evident on a decade scale, with the most striking trends occurring in maximum measured flux rates through the period.

While relatively low discrete flux rates can be measured at any given time, maximum measured discrete fluxes within a given year are dramatically increasing, suggesting that major storm related discharge is driving increased solute transport in the watershed (Figure 1.4.3-2). Increased flux rates (which are calculated by multiplying an individual concentration measure by the average flow for that day) are direct evidence for increased loading rates and transport through the system.

Figure 1.4.3-2 Bulk Mass Transport of Sodium and Chloride in the Delaware River in the 1990's

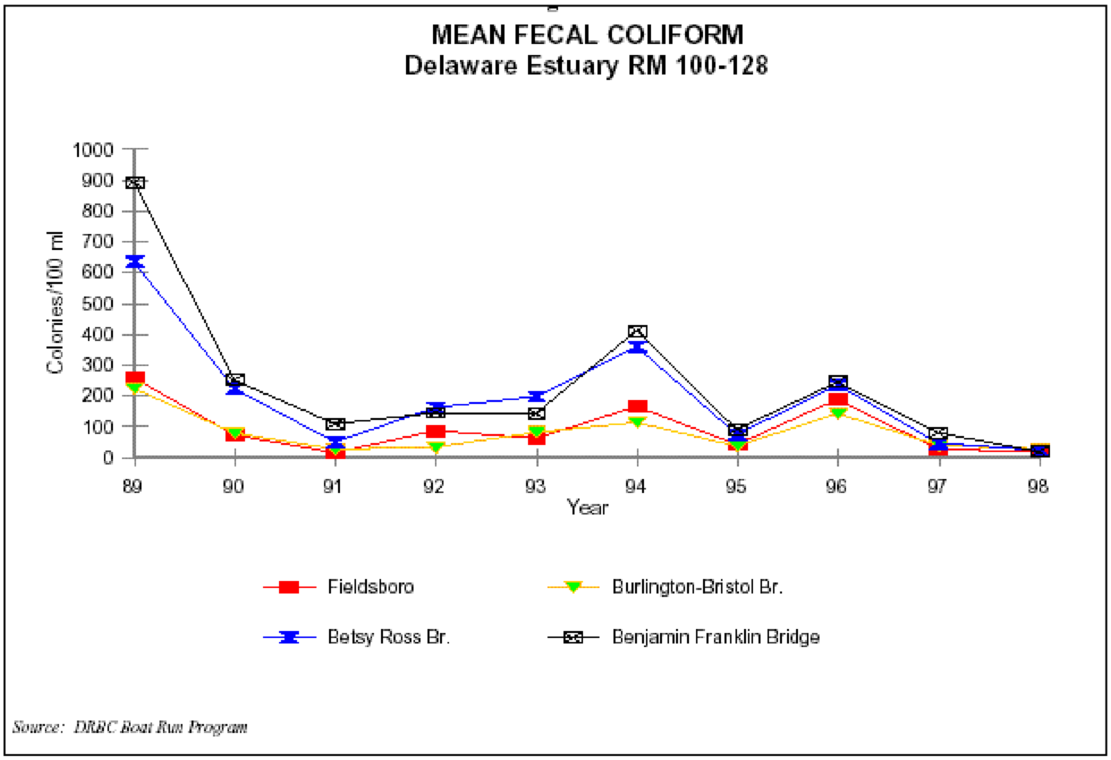
The top panel illustrates elevated concentrations in winter months associated with stormwater discharge and deposition of road salts for de-icing. The bottom panel illustrates increases through the decade possibly driven by the fast rate of development in suburban areas within the watershed.





Though the concentrations of some parameters have increased the past decade, others are improving. As shown in Figure 1.4.3–3, fecal coliform bacteria concentrations have been decreasing significantly over the past decade. Mean annual concentrations are actually lower than the fishable/swimmable standard set by the USEPA. This is largely due to the improvements in wastewater treatment and reductions of discharges from overflowing sanitary sewer systems.

Figure 1.4.3-3 Mean Fecal Coliform Concentrations in the Tidal Delaware River Near Philadelphia : 1990–1998



Source: Santoro, 2000

The plausibility that changes in water quality at Philadelphia were representative of other watershed locations was analyzed by comparing trends at Philadelphia with water quality data throughout the watershed. Figure 1.4.3-4 shows the changes in various water quality parameters in the mainstem of the Delaware River from Port Jervis down to Philadelphia over the past decade. The data indicates that there are few watershed wide trends in water quality. Only fecal coliforms, total dissolved solids, and dissolved oxygen observed similar and improving trends at all three locations along the mainstem Delaware River over the past decade. Other parameters differed in trend by location due to the localized influences that various land uses, industries, and activities have on water quality. Another confounding factor is the number of data points or samples collected at the locations to determine trends. The most upstream location, Port Jervis, usually had less than 12 observations for the decade (See Table 1.4.3-4). The number of samples analyzed at Trenton was greater reaching 63 samples with a minimum of 13 collected for the decade. The Philadelphia location (Baxter) had over 100 samples collected for the decade. The quantity of samples collected suggests that only the trends for dissolved oxygen, alkalinity, turbidity, and fecal coliform can be properly compared at Trenton and Philadelphia. Only the trends in fecal coliform and dissolved oxygen concentrations over the decade appeared to match for Trenton and Philadelphia. Trends in alkalinity and turbidity at the two locations did not match over the past decade suggesting that either more data are needed at the Trenton location or that there are local influences impacting water quality between the two locations.

Figure 1.4.3-4 Watershed-wide Trends in Percent Increase per Decade in Various Water Quality Parameters in the Mainstem of the Delaware River from 1990-1999

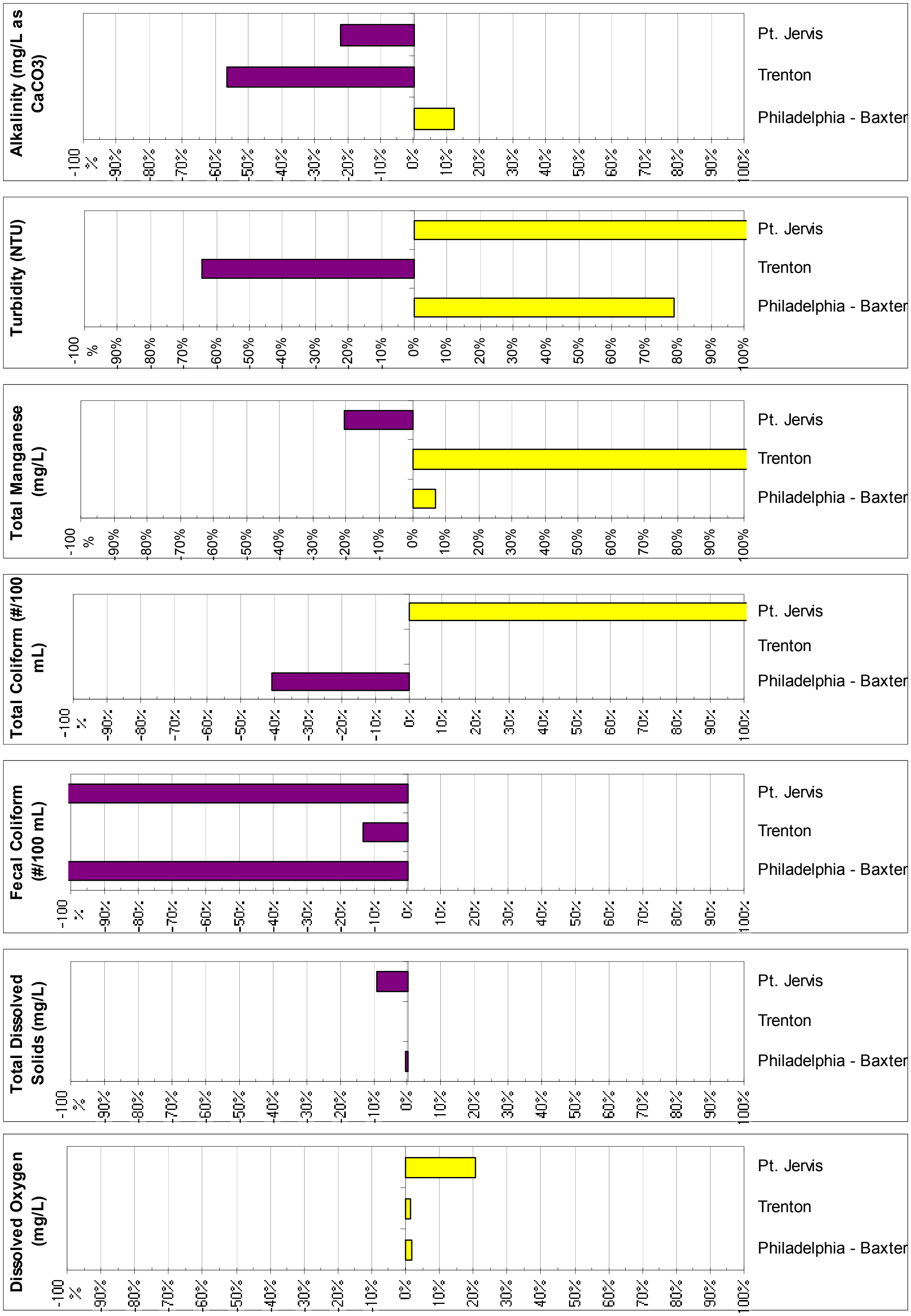


Table 1.4.3-4 Summary of Spatial Changes in Mainstem Delaware from 1990-1999

	Philadelphia - Baxter	Trenton	Pt. Jervis
Alkalinity (mg/L as $CaCO_3$)			
% increase over 1990 - 1999	12%	-56%	-22%
2020 prediction	53	-31	5
Decade Min	17	0.6	6
Decade Max	86	72	19
Decade Median	41	30	13.5
Count	649	63	20
Turbidity (NTU)			
% increase over 1990 - 1999	79%	-64%	268%
2020 prediction	19	0	6
Decade Min	0.28	0.6	0.2
Decade Max	65	62	14
Decade Median	5	2.9	1
Count	692	63	18
Total Mn (mg/L)			
% increase over 1990 - 1999	7%	146%	-21%
2020 prediction	0.45	0.13	0.02
Decade Min	0.01	0.01	0.01
Decade Max	0.63	0.16	0.06
Decade Median	0.07	0.03	0.04
Count	332	16	10
Total Coliform			
% increase over 1990 - 1999	-41%		13757%
2020 prediction	0		9562
Decade Min	0		32
Decade Max	45000		1000
Decade Median	890		245
Count	231		9
Fecal Coliform			
% increase over 1990 - 1999	-368%	-13%	-190%
2020 prediction	0	134	0
Decade Min	0	2	2
Decade Max	2333	2400	110
Decade Median	83	20	44
Count	155	43	8
Total Dissolved Solids			
% increase over 1990 - 1999	-1%		-9%
2020 prediction	122		38
Decade Min	70		31
Decade Max	240		60
Decade Median	121		48
Count	65		19
Dissolved Oxygen			
% increase over 1990 - 1999	2%	1%	21%
2020 prediction	9.82	10.91	14.32
Decade Min	4.80	7.20	7.20
Decade Max	15.50	14.80	13.70
Decade Median	8.98	10.70	10.22
Count	100	109	23

Given the potential for spatial differences in water quality trends, a spatial-temporal comparison was conducted for approximately 12 watershed locations. As shown in Table 1.4.3-5, the Little Lehigh Creek observed some of the highest concentrations of nutrients, conductivity, and total dissolved solids due to influences by heavy agricultural activities in that watershed. The Neshaminy, Poquessing, Rancocas and Pennypack Creeks observed greater concentrations of chlorides and iron due to runoff from impervious surfaces in these highly developed watersheds. The Lehigh River observed the greatest manganese concentrations due to the influence from acid mine drainage.

Table 1.4.3-5 Spatial Comparison of Water Quality Parameters in the Delaware River Watershed

Source Water	Location	Conductivity (umhos/cm)	Total Dissolved Solids (mg/L)	Total Phosphorus (mg/L as P)	Ammonia (mg/L as N)	Nitrate (mg/L as N)	Chloride (mg/L)	Total Organic Carbon (mg/L)	Fecal Coliform (col/100 mL)	Iron (mg/L)	Manganese (mg/L)
Delaware River	Port Jervis, NY	81	48	0.013	0.010		8.6			0.14	0.040
Little Lehigh Creek	Robin Hood Bridge	359	261	0.060	0.040	3.85		2.35		0.18	0.021
Lehigh River	PA State Road 115 Bridge, Stoddartsville	74	60	0.028	0.020	0.26		2.70		0.18	0.068
Lehigh River	State Road 4022 Bridge, Walnutport	105	78	0.050	0.090	0.57		2.20		0.16	0.101
Delaware River	Trenton, NJ	171		0.070	0.030		15.0		20	0.11	0.034
Neshaminy Creek	Route 13, Bristol, PA	367	236	0.190	0.040	1.87	45.0		190	0.78	
Delaware River	PSWC -Bristol Plant Intake				0.040	1.80	37.5	3.00		0.32	0.064
Poquessing Creek	State Road, Philadelphia		248	0.060	0.035	1.47	57.5			0.47	
Rancocas Creek	Browns Mills, NJ			0.030	0.050		4.9	7.80	11	2.40	0.040
Rancocas Creek	Mount Holly, NJ			0.098	0.270		12.8		490		
Delaware River	PWD - Baxter Intake	201	121		0.080	1.17	21.0	2.65	0	0.61	0.070
Pennypack Creek	State Road, Philadelphia		268	0.455	0.060	3.51	50.0			0.30	
Delaware River	Ben Franklin Bridge	219		0.103	0.090	1.20	21.0			0.18	

Given these varying water quality profiles, watershed wide trends in water quality were examined. Figure 1.4.3-5 compares the changes in various water quality parameters in the tributaries to the Delaware River over the past decade. As shown, several watersheds have observed significant changes in conductivity over the past decade. The median increase per decade for all locations combined was 15%, but ranged from 3 to 70%, depending upon the location. Figures 1.4.3-5 and 1.4.3-6 provide an in-depth view of the conductivity trends in the Little Lehigh Creek (Robin Hood Bridge) and Lehigh River (Stoddartsville, PA) Watersheds.

Figure 1.4.3-5 Watershed-wide Trends in Percent Increase per Decade in Water Quality Parameters in the Tributaries of the Delaware River from 1990-1999

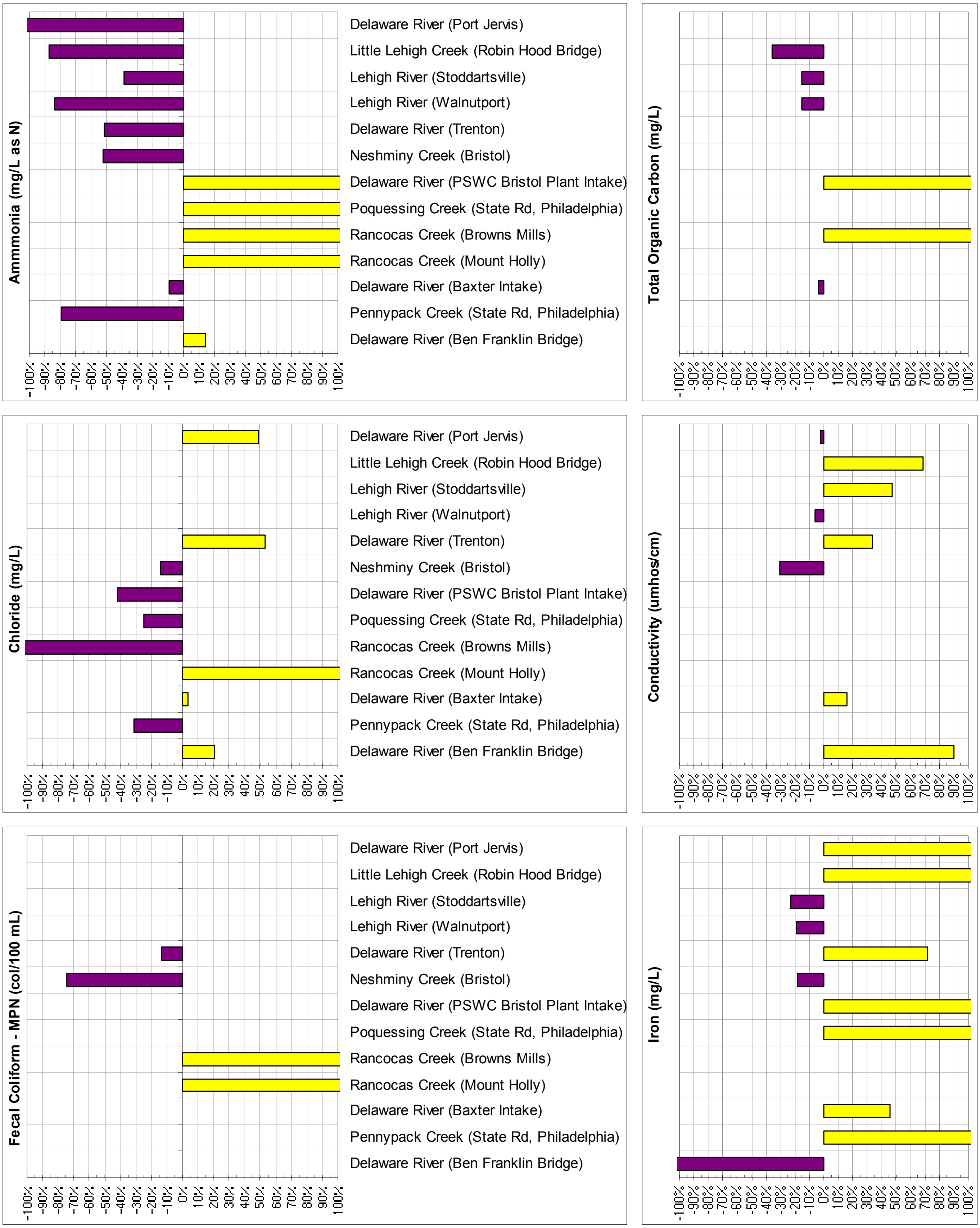
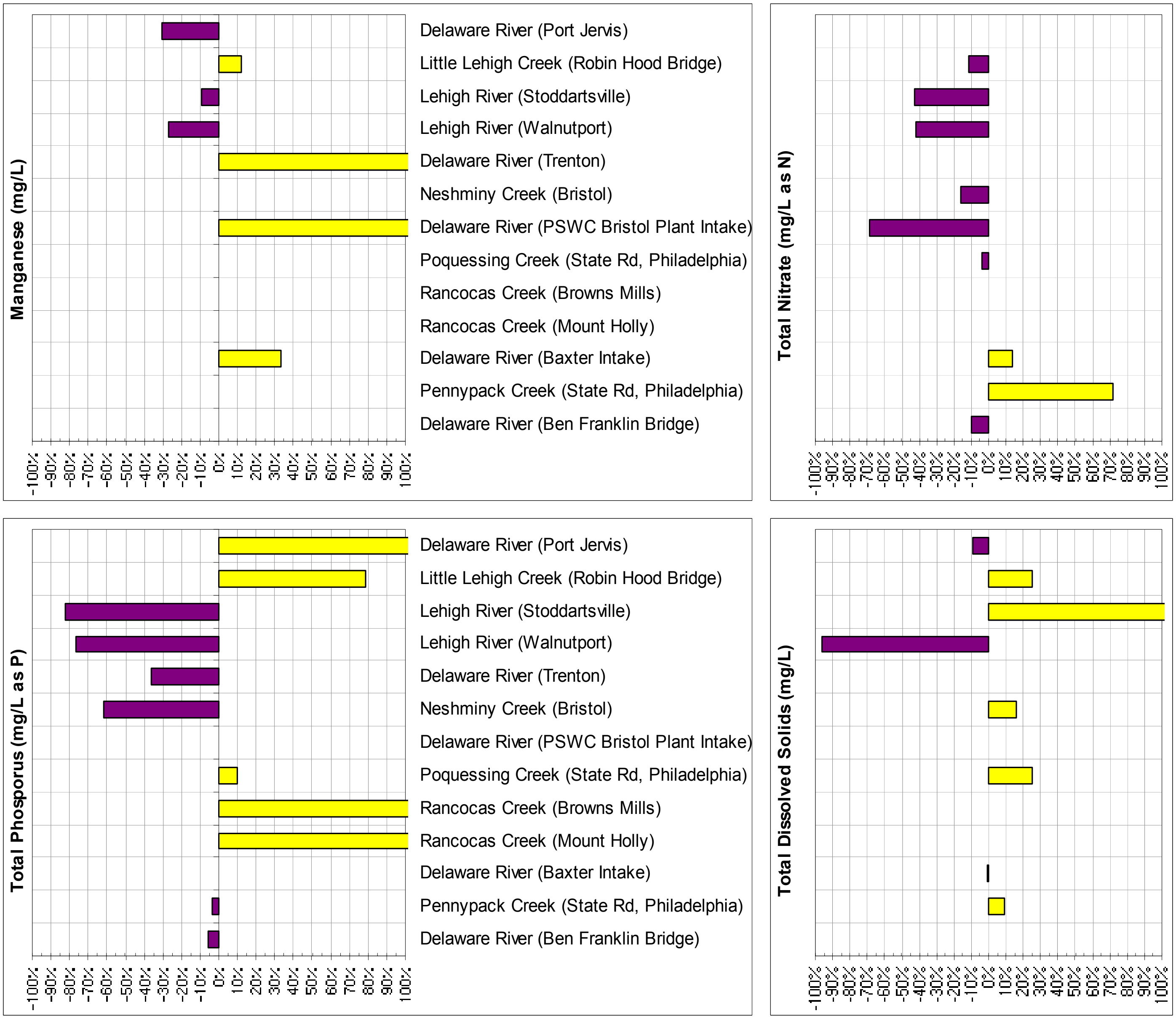


Figure 1.4.3-5 Watershed-wide Trends in Percent Increase per Decade in Water Quality Parameters in the Tributaries of the Delaware River from 1990-1999



A brief summary of the observations for watershed wide trends based on the observations from Figure 1.4.3-5 is provided in Table 1.4.3-6. The upward and downward trends for each location and parameter were compared in Table 1.4.3-6. Only upward or downward trends of greater than 10% were considered great enough for a directional assignment, otherwise they were considered unchanged for the decade.

As shown, there is no obvious parameter that is increasing throughout the entire watershed over the decade. However, there are geographical trends that are discernable. The sites in the mainstem Lehigh River are seeing the most improved overall water quality including reduced metals and nutrients. It is believed that these improvements are due to acid mine drainage mitigation and improvements in wastewater treatment in the Lehigh Valley.

The Neshaminy Creek, which has a number of mixed uses and activities including intense agriculture and development appeared to have improvements in almost all categories except total dissolved solids suggesting some influences by runoff from impervious cover.

The Rancocas Creek, Poquessing Creek, and Little Lehigh Creek appeared to have the most number of increasing parameters observed. The Rancocas and Poquessing Creeks are highly developed with little riparian buffers and are influenced by urban and residential runoff. The Little Lehigh Creek is located in an area near Allentown that has intense agriculture and is seeing increased development as well.

The mainstem Delaware River at all locations appears to have an equal amount of increasing and decreasing parameters at any given location, but they are not identical. This is most likely due to changes in land use and activities in any geographical region of the watershed.

On a parameter basis, ammonia, total organic carbon, and nitrate appeared to be increasing in the area draining into the tidal section of the watershed while it decreased in the non-tidal section of the watershed. Conductivity and total dissolved solids appeared to be the only two factors increasing watershed wide and that correspond to one another. Total phosphorus, iron, and manganese appeared to have no discernable geographical trend.

Figures 1.4.3-6 and 1.4.3-7 provide specific examples from the Lehigh River Watershed of the increasing trends of conductivity occurring throughout most of the watershed. The Lehigh River is facing increased development pressure from the New York City, Philadelphia, and Harrisburg areas. As shown, the smaller streams and creeks tend to show more steep increases in conductivity due to their sensitivity, but even in the mainstem Lehigh River these impacts are noticed.

Table 1.4.3-6 Spatial Comparison of Water Quality Trends in the Delaware River Watershed: 1990-1999

Location	NH3	TOC	Cl	Cond.	Fecal Coliform	Fe	Mn	Nitrate	TP	TDS
Delaware River – Port Jervis	↓	----	↑	NC	↓	↑	↓	----	↑	
Little Lehigh Creek (Robin Hood Br.)	↓	↓	----	↑	----	↑	↑	↓	↑	↑
Lehigh R. (Stoddartsville)	↓	↓	----	↑	----	↓	↓	↓	↓	↑
Lehigh R. (Walnutport)	↓	↓	----	↓	----	↓	↓	↓	↓	↓
Delaware River – Trenton	↓	----	↑	↑	↓	↑	↑	----	↓	----
Neshaminy Cr. (Bristol)	↓	----	↓	↓	↓	↓	----	↓	↓	↑
Delaware River – Bristol	↑	↑	↓	----	----	↑	↑	↓	----	----
Poquessing Cr. (State Rd.)	↑	----	↓	----	----	↑	----	NC	↑	↑
Rancocas Cr. (Browns Mills)	↑	↑	↓	----	↑	---	----	----	↑	----
Rancocas Cr. (Mt. Holly)	↑	----	↑	----	↑	---	----	----	↑	----
Delaware River – Baxter	↓	NC	NC	↑	↓	↑	↑	↑	----	NC
Pennypack Cr. (State Rd.)	↓	----	↓	----	----	↑	----	↑	NC	↑
Delaware River - Ben Fr. Br.	↑	----	↑	↑	----	↓	----	↓	NC	----

Figure 1.4.3-6 Increased Conductivity Trends in the Little Lehigh Creek Watershed at Robin Hood Bridge during 1990-1995

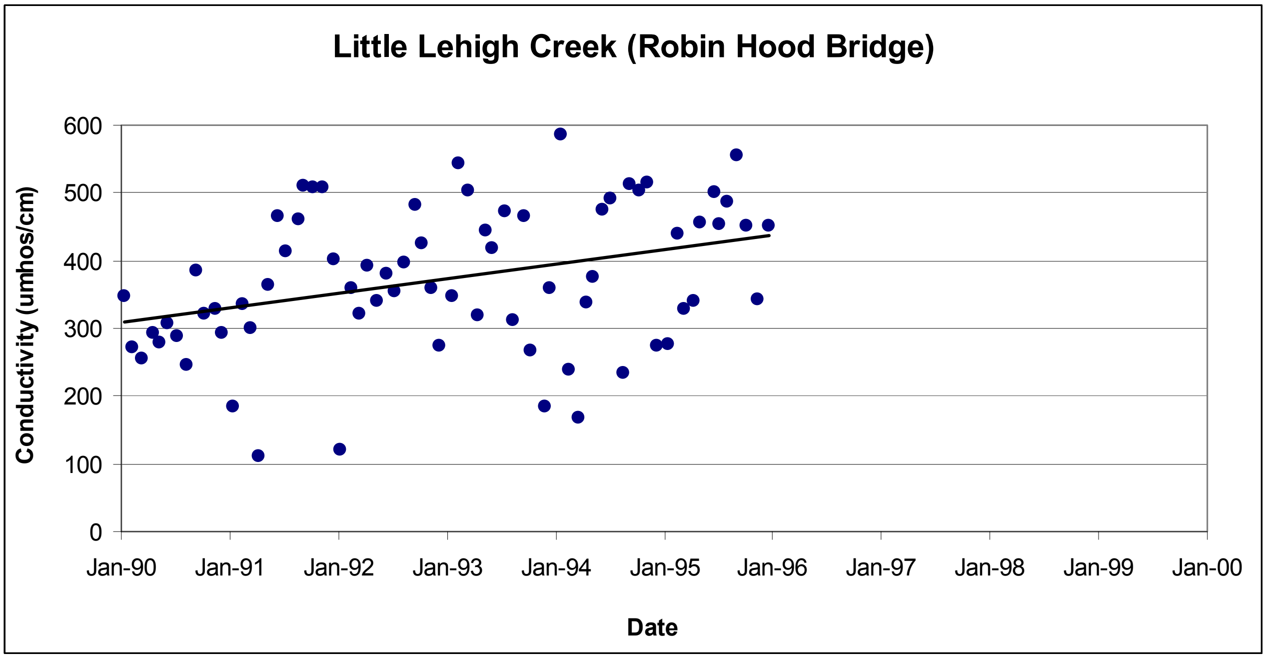
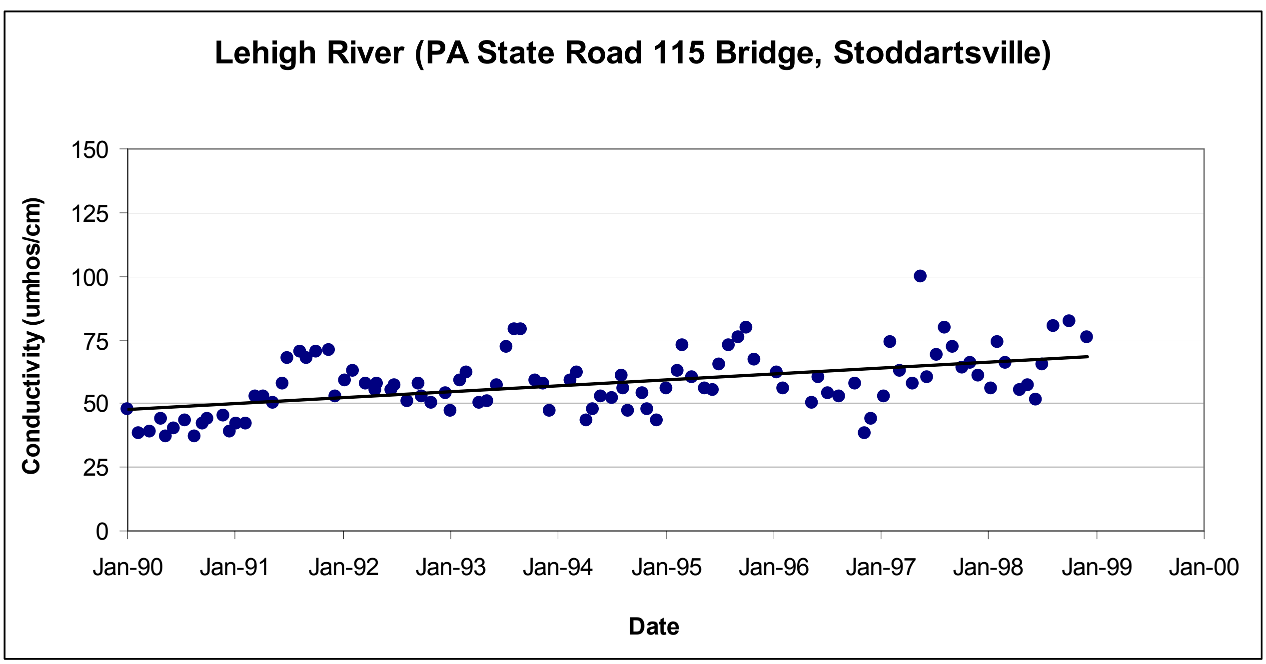


Figure 1.4.3-7 Increased Conductivity Trends in the Lehigh River Watershed at Stoddartsville, PA during 1990-1999



1.4.4 Differences in Water Quality Throughout the Watershed

Key Points
- **Subwatersheds with high levels of conductivity tend to have higher levels of phosphorus, chloride, nitrate, iron, and total dissolved solids.**
- **Conductivity measurements may serve as an indicator of areas within the watershed that are being impacted by non-point sources.**

Spatial analyses were performed to determine if there were relationships between the mean conductivity in a watershed and other water quality parameters (see Table 1.4.3-4). Though water quality data throughout the watershed were limited, correlations between the mean conductivity and total phosphorous, chloride, nitrate, ammonia, total dissolved solids, iron, manganese and total organic carbon were discovered. As shown in the tables below, watersheds with higher conductivity tended to have higher concentrations of other water quality parameters. Mean watershed conductivity also correlated with mean values of total phosphorous, chloride, nitrate, iron, and total dissolved solids (see Table 1.4.4-1). These correlations suggest that the abundant and frequently measured conductivity data may provide a useful screening tool to identify watershed areas with water quality challenges. In addition, these correlations also suggest that trends in conductivity may be useful for indicating changes in certain water quality parameters (most inorganic or ionic water quality parameters) and serve as an indicator parameter for tracking watershed health.

Table 1.4.4-1 Spearman Rank Order Correlations of Mean Conductivity and Mean Water Quality Parameters in the Delaware River Watershed

Mean Conducitivity vs.	Number of Watersheds	R - value	p-value
Total Dissolved Solids	6	0.885714	0.018845
Total Phosphorus	7	0.857143	0.013697
Ammonia	8	0.457865	0.253941
Nitrate	6	0.942857	0.004805
Chloride	5	0.974679	0.004818
Total Organic Carbon	4	-0.4	0.6
Fecal Coliforms	4	0.8	0.2
Iron	8	0.706599	0.050063
Manganese	6	-0.37143	0.468478

Table 1.4.4-2 Universal Water Quality Issues for the Delaware River Watershed

Analysis of water quality data, impaired stream information, and observations from watershed surveys led to the conclusions that were made regarding the universal water quality issues which are presented in Table 1.4.4-2.

Source Type	Activity	Contaminant Source	Tidal Watershed	Middle Watershed	Upper Watershed
Nonpoint Source	Mining/Acid Mining Drainage (AMD)	AMD and Metals		X	
	Agricultural runoff	Nutrients, herbi-cides/pesticides, pathogens		X	X
	Urban/Suburban Runoff	Salts, nutrients, metals	X	X	
	Erosion	Sediment	X	X	
	Construction	Sediment	X	X	
Point Source	Sewage Discharge	Pathogens, Nutrients	X	X	X
	Abandoned Industrial Facilities	Metals, Organics	X	X	
	Industrial Discharges	Organics, Metals	X	X	
Special/Spills	Oil Pipelines	Organics	X	X	
	Truck/Railroads	Organics	X	X	
	Tire Piles/ Junkyards	Special	X	X	X
	Reservoir Releases	algae / metals	X	X	X
	AST / USTS	Organics	X	X	

1.4.5 Analysis of Stream Impairments and Sources in the Delaware River

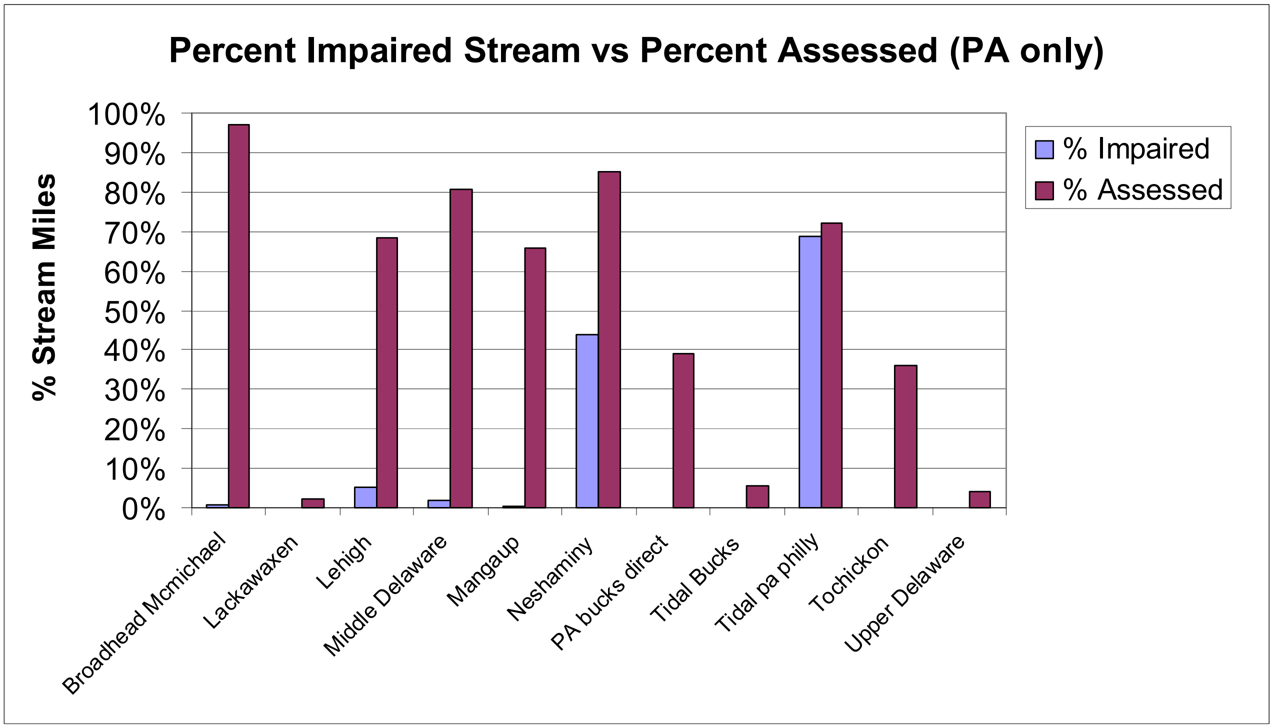
Key Points

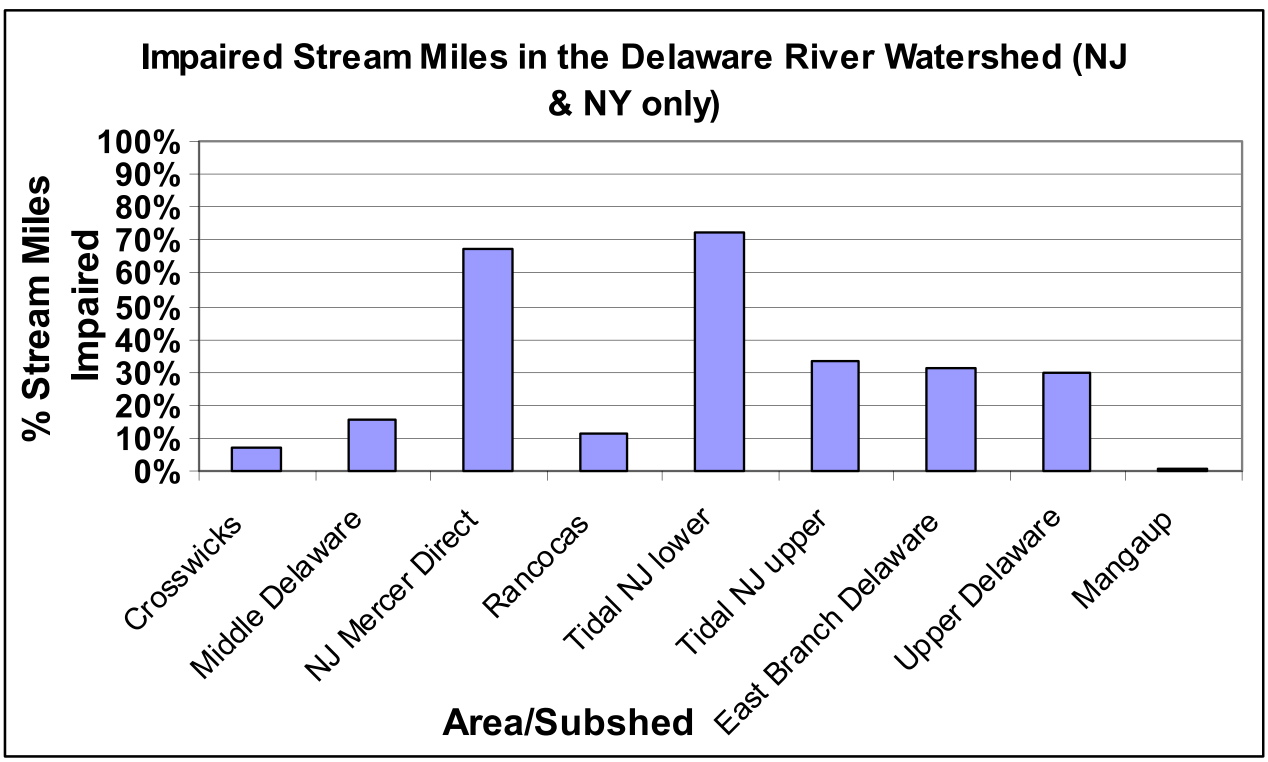
- **Of the 14,299 miles of streams and creeks within the Delaware River Watershed 35% (5,056 miles) have been assessed to determine their compliance with applicable water quality standards.**
- **Nearly 65% of the assessed stream miles have attained applicable water quality standards.**
- **Flow alterations, phosphorus (nutrients), and toxic chemicals in fish tissue and sediment were identified as the most significant causes of impairment within the watershed.**
- **Stormwater runoff from urban and suburban areas was identified as the cause of almost half of the impaired stream lengths within the watershed in Pennsylvania.**
- **Although water quality data suggests that pathogens are a concern throughout the entire watershed, very few segments are listed as having pathogens as the primary cause of impairment.**

In accordance with Section 305 (b) of the Federal Clean Water Act, the Pennsylvania Department of Environmental Protection (PADEP) prepared a 305 (b) Water Quality Assessment Report in 2000. The Report summarizes water quality management programs, water quality standards, and point and non-point source controls. The Delaware River Watershed includes 14,299 miles of streams and creeks. Of these streams, 6,916 miles are located in Pennsylvania. New York contains 4,457 miles of streams within the Delaware River Watershed. The remaining 2,926 miles of streams of the total 14,229 are located in New Jersey. Thirty five percent, or 5,056 miles, within the watershed have been assessed in order to determine compliance with applicable water quality standards. Almost 65% of the stream miles that have been assessed – 3,270 miles - have attained the applicable water quality standards. Streams that are impacted by contaminant sources (point sources, or non-point sources such as stormwater runoff or acid mine drainage) causing water quality standards to not be met, are designated as impaired. Thirty five percent of the stream miles (1,786 miles) that have been assessed do not meet applicable water quality standards and are designated as impaired. To date, 9,243 miles of streams within the watershed have not been assessed. Most of the unassessed stream miles within the watershed, 65% of the total unassessed streams, are located in New Jersey and New York. 47% of Pennsylvania's total stream miles within the Delaware River Watershed have not been assessed.

Figure 1.4.5-1 shows the percentage of assessed miles within each watershed that do not meet water quality standards and have been designated as impaired.

Figure 1.4.5-1 Impaired Miles vs. Miles Assessed in Each Subwatershed of the Delaware River Study Area by State





The areas of the tidal Delaware River in Pennsylvania and New Jersey as well as the Neshaminy Creek and streams in Mercer County have the greatest percentages of impaired stream miles. Impairments were also identified in other subwatershed areas as well, but to a lesser extent.

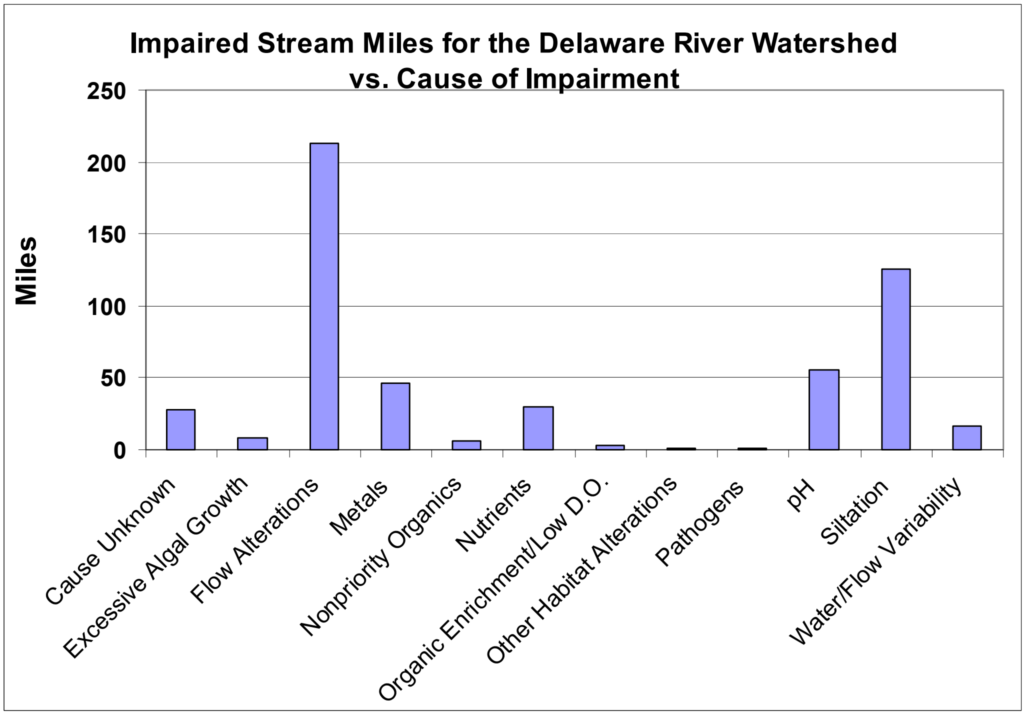
Excessive algal growth, flow alterations, pH, mercury, PCBs, nutrients, siltation, and water/flow have all been identified as causes of impairment within the Delaware River Watershed. Figure 1.4.5-2 summarizes the miles of impairment and their primary causes throughout the Delaware River Watershed.

In Pennsylvania, the leading cause of impairment has been identified as water/flow variability. Siltation is the second leading cause of impairment, while pH, metals, and nutrients make up the largest remaining impairments. In New York and New Jersey, the leading cause of impairment was phosphorus (a nutrient). Toxic chemicals such as mercury, lead, and PCB's in sediments and fish tissues were the second leading cause of impairment. Metals such as chromium, arsenic, and beryllium made up the remaining major impairments. Comparison of the observed causes of impairment between the three states indicates some common issues with nutrients and metals. However, there are very unique and special geographical divisions in the types of impairments and their significance depending upon the region or state. These could be related to development, geology, or industrial factors that cannot be easily discerned at the level of gross comparison conducted in this analysis.

Point and non-point sources, such as agriculture, municipal point sources, urban stormwater runoff, small residential runoff, land development, and acid mine drainage, are the leading sources of impairment in the Pennsylvania portion of the Delaware River Watershed, as shown below by Figure 1.4.5-3. The sources of impairment for New York and New Jersey were not reported. It is assumed that these sources may generally be similar given the common causes of impairment in the three states. However, toxic chemical related impairments in New York and New Jersey may suggest sources of impairment from industrial discharges and manufacturing.

Figure 1.4.5-4 displays the status of stream assessment within the Delaware River Watershed. Green lines represent streams where applicable water quality standards are being met. The red lines represent impaired streams where water quality standards are not being attained. The blue lines represent the streams that have not been assessed yet. Impaired stream reaches are most common in the southern sections of the watershed. The central portion of the watershed has the greatest amount of unassessed streams, compared to the rest of the watershed. More efforts should be made to assess the middle portions of the Delaware River Watershed.

Figure 1.4.5–2 Causes of Impairment Within the Delaware River Watershed



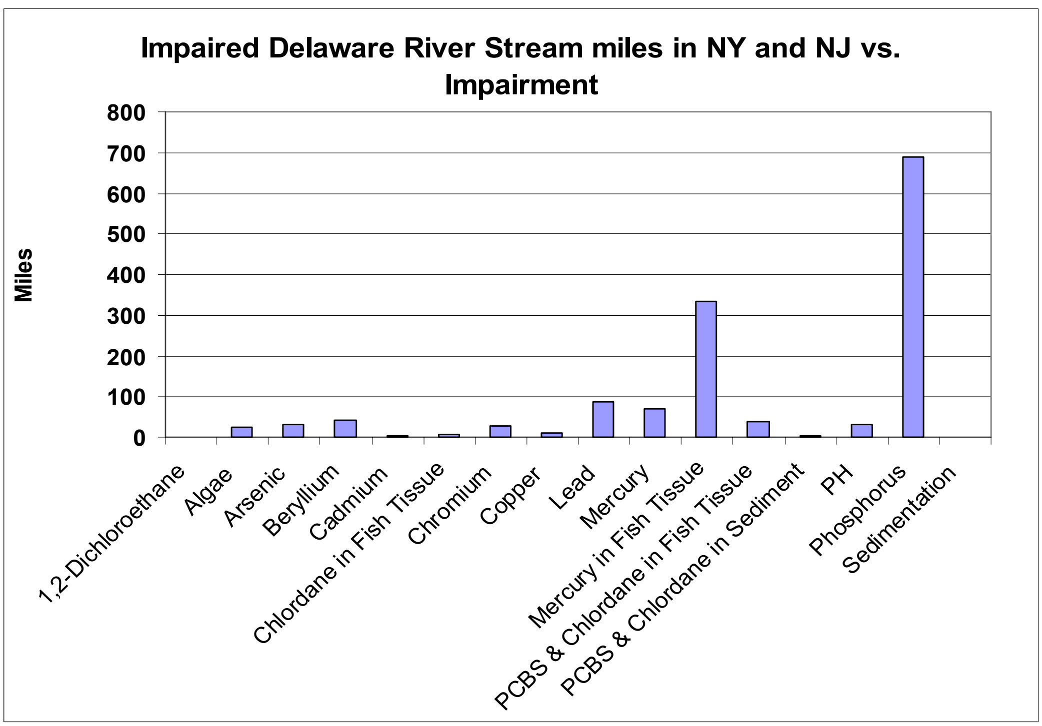


Figure 1.4.5-3 Miles of Impairment within the Delaware River Watershed vs. Their Primary Sources of Impairment

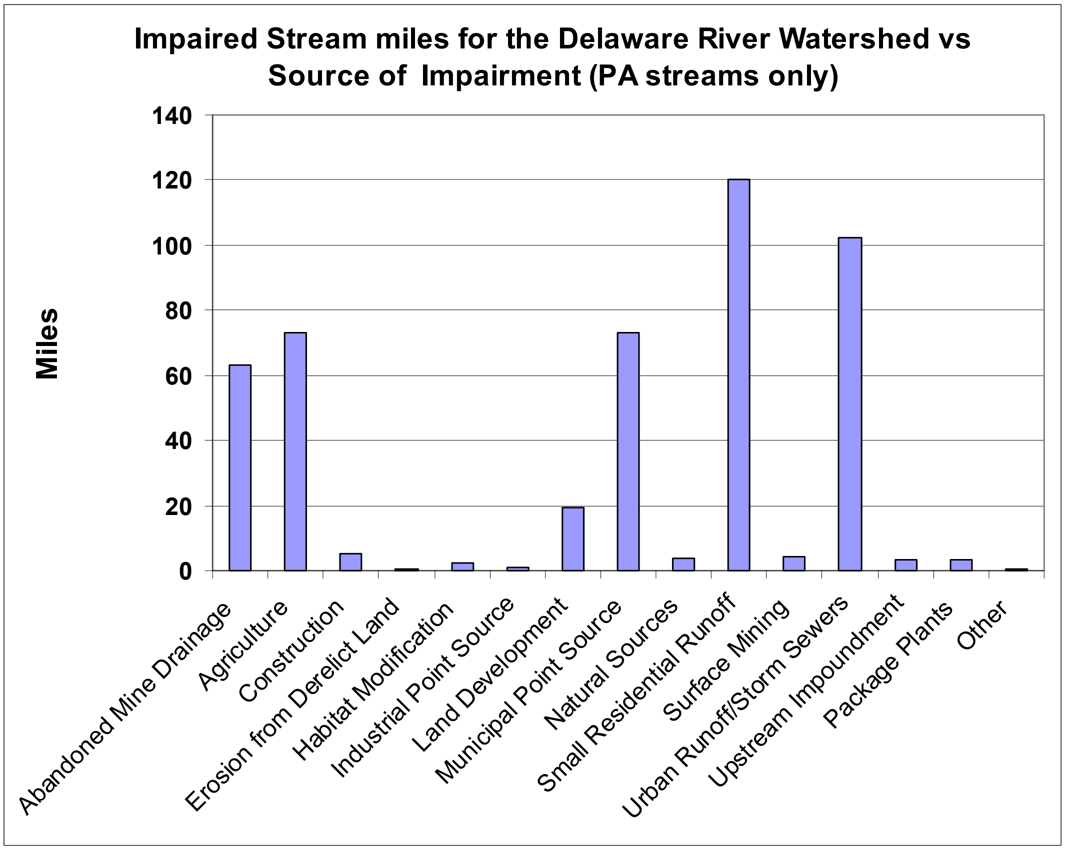
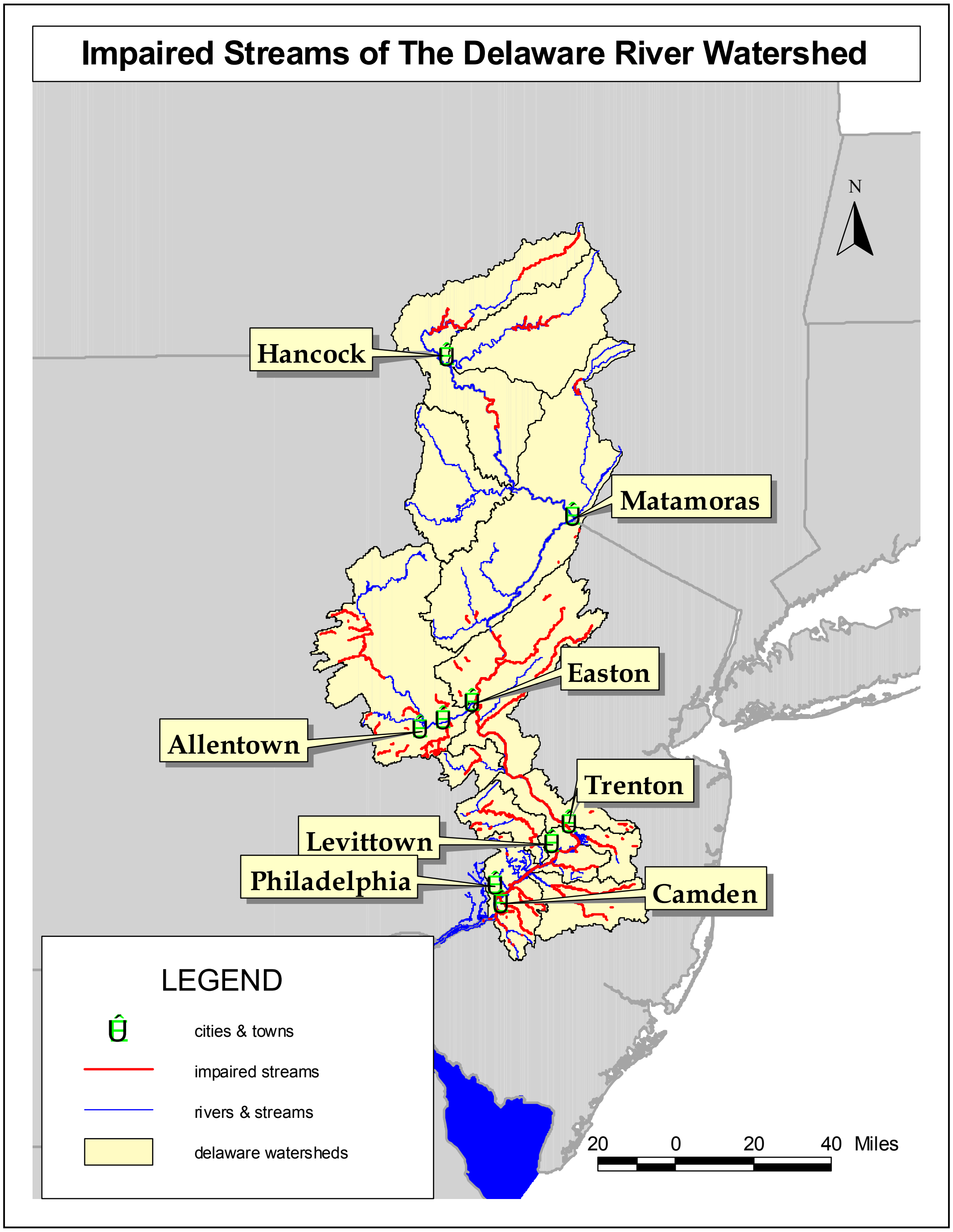


Figure 1.4.5-4 Impaired Streams Within the Delaware River Watershed



1.4.6 Universal Water Quality Issues

Key Points

- **Potential sources of contaminants affecting Delaware River water quality include acid mine drainage, sanitary wastewater, abandoned industrial sites, agricultural and construction runoff, reservoir operation, catastrophic accidents, road runoff, and wildlife.**
- **Untreated or inadequately treated sanitary wastes can contribute significant bacterial loads to the river.**
- **Abandoned industrial sites and dumpsites located within the river's floodplain could significantly impact downstream water users.**
- **Erosion resulting from agricultural activities and pathogens from livestock wastes introduce sediment and microbial pathogens into the river.**
- **Erosion from construction sites without well-maintained sediment controls can significantly increase sediment loads to the river. To date, impacts from catastrophic accidents and spills have been insignificant, due to skillful, well-prepared responses.**
- **Storm runoff containing deicing salts and herbicides from right-of-way application cause increased levels of chlorides, sodium, SOCs, and urea in the river.**
- **Algal blooms resulting from excessive nutrients can significantly affect water treatment requirements.**
- **Increasing populations of Canada geese in the watershed have resulted in impacts on various localized stretches of the river.**

Based on the analysis of the water quality data, stream impairment data, stakeholder input, and several watershed inspections, a number of specific issues were identified that have impacts throughout the watershed. These issues are:

- Acid mine drainage
- Discharges from septic systems, sewerage systems, and wastewater treatment plants
- Dumping, tire piles, salvage yards, and abandoned industry in or near the floodplain
- Agricultural runoff of herbicides, pesticides, fertilizer, sediment, and phosphorus
- Erosion and construction runoff
- Dam removal and sediment releases
- Catastrophic accidents and spills, particularly oil delivery spills, from roads, trains, and fires
- Road runoff
- Wildlife management

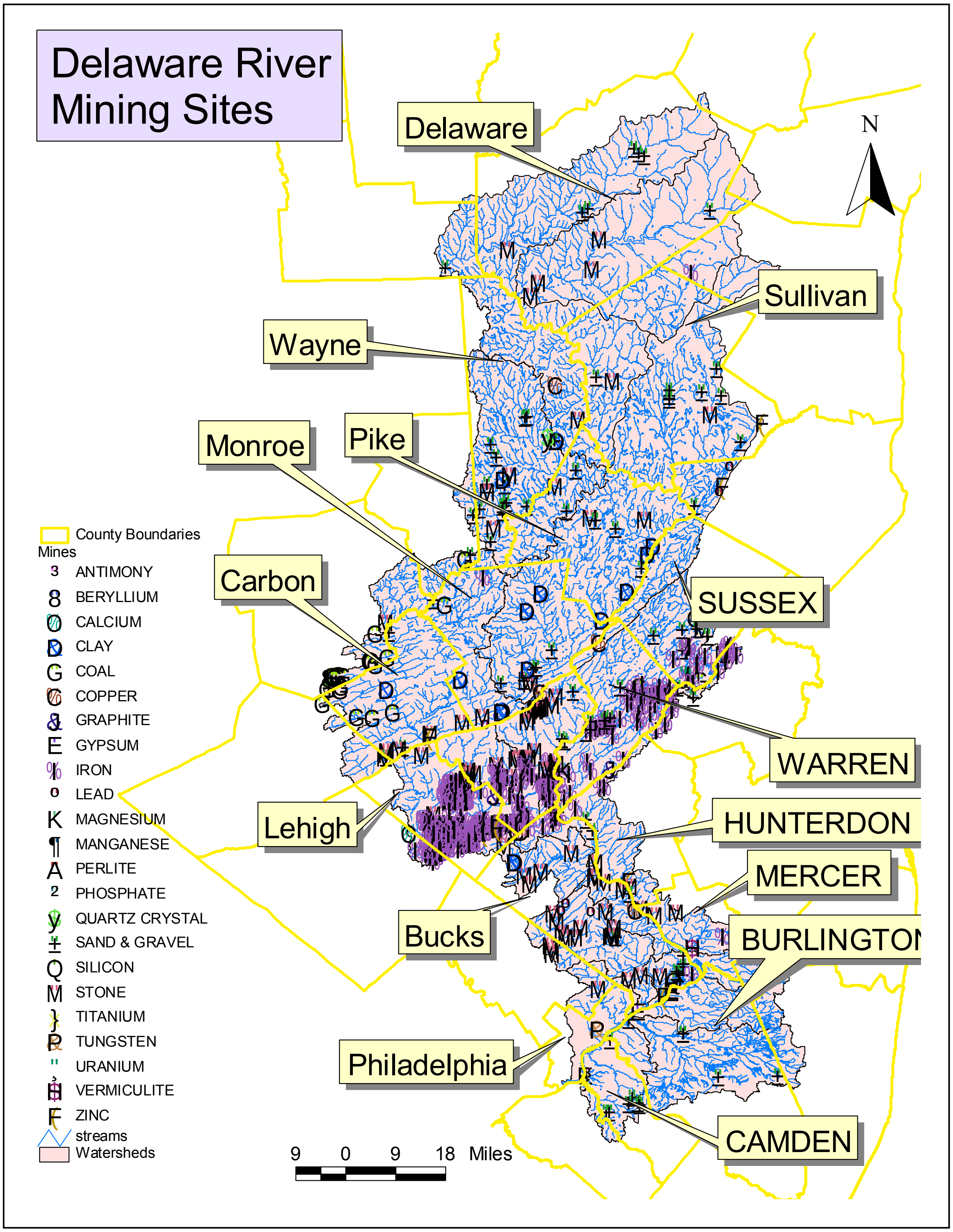
These topics will be discussed in detail throughout this section.

1.4.6.1 Acid Mine Drainage

There are 659 known surface and underground mining facilities in the Delaware River Watershed. Mining of sand and gravel, iron, and stone make up 86 % of those operations. Although coal mining has historically been the most predominant, iron mining is now just as common. Approximately 4% (25) of the mines currently operating in the watershed are coal mines located in the Upper Lehigh River Watershed within Carbon and Monroe Counties (See Figure 1.4.6-1).

Acid Mine Drainage (AMD) is generated when the iron sulfide-bearing materials created by the interaction of the sulfate in coal beds and sulfate-reducing bacteria are exposed to oxygen in air or water during mining. The iron sulfides react with the oxygen to produce hydrogen sulfide, which makes the water more acidic. As the water becomes more acidic, its ability to leach metals from the existing rock layers increases. Therefore, the water from mines is not only acidic, but often contains increased concentrations of aluminum, iron, manganese, calcium, magnesium, and sulfate. Acid mine discharges can come from shafts, tunnels, boreholes, drifts, and seeps. AMD can also come from culm piles or spoil piles that run off into nearby streams.

Figure 1.4.6-1 Mining Locations in the Delaware River Watershed



1.4.6.2 Discharges from Septic Systems, Sewerage Systems, and Wastewater Treatment Plants

Improper wastewater collection and treatment causes pathogens and nutrients to impact the quality of source water supplies, recreational water quality, and aquatic life. Improper wastewater collection and treatment may result in the following:

- Wet weather overflows of raw sewage by the sewer system (manholes and pump stations) due to treatment plant capacity limitations
- Wet weather overflows of raw sewage by the sewer system (manholes and pump stations) due to lack of collection system capacity and infiltration/inflow sanitary sewer overflows (SSOs)
- Wet weather overflows of raw sewage by the sewer system due to combined sewer overflow systems (CSOs)
- Wet weather overflows of raw or partially treated wastewater by the treatment plant due to treatment plant capacity limitations or lack of treatment upgrades.
- Dry weather overflows caused by blockages (tree roots, grease, etc.) sometimes due to poor collection system maintenance.
- Dry weather discharges of raw sewage due to defective sewer lateral connections and improperly operated CSOs
- Routine discharges of raw sewage due to lack of adequate septic systems, sewerage systems, and enforcement
- Routine discharges of raw sewage due to failing septic systems
- Periodic discharges of partially treated sewage due to treatment plant performance limitations

Most of these issues can be observed throughout the Delaware River Watershed. Though not as prevalent as in the original watershed inspections conducted in the 1880’s, 120 years of progress still have not resulted in the use of adequate and proper sewerage systems within the entire watershed, and discharges of raw sewage still occur to this day. These discharges come from “wildcat” sewers (illegal sewers discharging directly to the river), and the numerous cabins and cottages throughout the watershed that are suspected of making illicit discharges into the river and local streams and lakes. Some are discharging raw sewage, while others are operating with septic systems that have failed, or septic systems that are not located on properly draining soils or which drain to areas of fractured rock and limestone. In addition, there are several communities with CSO discharges upstream of drinking water intakes. These include Bethlehem, Allentown, Easton, Gloucester, and Camden.

The impacts of wet weather issues extend beyond wastewater treatment plant performance. Sometimes the lack of treatment capacity by the wastewater treatment plant causes a "back up" in the sewer system entering the wastewater plant and results in overflows at manholes and pump stations (Figure 1.4.6-2). Other times, the infiltration and inflow of rainwater and groundwater into the sewer pipes themselves, either due to age or disrepair of the sewer system, will also cause manholes and pump stations to overflow. The communities most affected by these issues are older communities with decaying infrastructure and new communities without enough sewer and treatment capacity to handle the increased residential populations as people move further out from urban areas. Overall, sewer system capacity and integrity as well as treatment plant capacity during wet weather periods represent the greatest and most difficult sewage related issues in the watershed.

Figure 1.4.6-2 Overflowing Manhole Near a Stream

Though some communities are facing consent orders and enforcement action against them due to stormwater runoff problems, other communities are working hard to address stormwater issues. For example, Bucks County has been working hard to address inflow and infiltration issues and has become a model for other communities to emulate. The City of Philadelphia has also made strides to identify and mitigate defective laterals as well as piloting innovative stormwater reduction techniques.

1.4.6.3 Dumping, Tire Piles, Salvage Yards, and Abandoned Industry Near the Floodplain

The Delaware River Watershed was one of the first areas in the United States to feel the effects of industrialization. However, as metal manufacturing and other manufacturing industries have declined, the sites of these industrial activities were abandoned, leaving valuable riparian area damaged and unrestored. Some of these abandoned sites have old spoil piles, or lagoons that still leach remnants of contaminated materials. These sites are also neglected, and therefore, no one organization is responsible for the monitoring or mitigation of the old lagoons and spoil piles. These abandoned and somewhat isolated areas also encourage dumping and general neglect by the nearby communities since they are considered to be hazardous eyesores.

In addition to abandoned industrial sites, there are numerous salvage yards and several trash transfer stations located along the river and stream banks. These sites appear to be in or near areas prone to flooding, and seem to have limited environmental practices in place to prevent contaminated runoff or debris from entering the river. Old oil tanks and chemical containers in or near areas prone to flooding have been observed at some of these facilities and warrant special concern. Other areas include tire piles, as shown by Figure 1.4.6-3, which if ignited by vandalism or accident, will result in significant damage to the entire Delaware River below them.

Figure 1.4.6-3 Dumping and Abandoned Industry Along The Delaware River

1.4.6.4 Agricultural Runoff

Agricultural activities without proper controls can release pathogens, nutrients, herbicides, pesticides, and sediment into streams, which impacts source water quality, recreational water quality, and aquatic life. More than 17% of the Delaware River Watershed is agricultural land.

Over the past several decades, the amount of agricultural land has been decreasing in the Delaware River Watershed, but this does not mean that the level of agricultural activity is decreasing proportionally. It is suspected that residential development of agricultural land is concentrating agricultural activity into smaller areas that can lead to greater local impacts on water quality.

Erosion and runoff of soils during tillage and farming release significant amounts of sediment and nutrients into the streams and rivers if there are no proper riparian buffer strips in place. In addition, cattle access to streams causes significant damage to the streambank and makes it more susceptible to erosion. Runoff of livestock wastes also releases pathogens into water supplies. Figure 1.4.6-4 illustrates agricultural uses of land within the watershed.

Figure 1.4.6-4 Cows in the Stream and Farming Tillage Impacts on Sediment and Nutrients

Despite the potential for significant negative impacts by agricultural activities, agricultural lands also represent the simplest and cheapest areas for potential restoration and protection. In fact, many farmers are actively pursuing a variety of techniques to help protect and restore local streams. As shown in Figure 1.4.6-5, a number of farmers are installing specially designed cattle crossings and streambank fencing to reduce the impacts of cattle on streams. Other farmers are even establishing riparian buffers to protect the streambank and to filter out harmful nutrients.

Figure 1.4.6-5 Techniques to Prevent the Impacts of Agricultural Activities
Farmers installing cattle crossings (left) and streambank fencing with riparian buffers (right) to limit the impacts of livestock on streambanks and filter runoff from pastures along the Pennypack Creek

1.4.6.5 Development, Construction, and Erosion Runoff

The Delaware River Watershed is developing at a significant rate. With this development comes the construction of homes, highways, and businesses to support that growth. This construction usually entails significant disturbance and moving of earth. The impacts of runoff from construction sites can range from negligible to significant, depending on the characteristics of the construction site, the types of erosion controls that are implemented, and the maintenance of those control structures. There are many types of controls that include the placement of sediment barriers or fences, or bags, which trap sediment in storm drains. Erosion and sediment control plans must be submitted for review to the township and/or county Soil Conservation District. However, the amount of time and personnel available from both the township and county conservation district are limited, compared to the amount of submittals by the numerous developers and developed sites. In addition, the amount of time and staff available to inspect sites in order to observe if the proposed erosion controls are in place are also severely limited, and frequently, priorities are driven by complaints from citizens.

As shown in Figure 1.4.6-6, the impacts of runoff from construction can be severe, releasing significant amounts of sediment into local waterways. The combined impact from the sediment releases at these locations in certain areas can lead to increased dredging and reduced storage capacity in water supply reservoirs. In addition, sediments carry phosphorus into lakes and streams, causing algal blooms. The excess nutrients cause our reservoirs to become eutrophic.

Figure 1.4.6-6 Photographs of the Impacts of Runoff from Construction
Left: Erosion and runoff construction and construction runoff. Right: the impacts of construction runoff that includes increase dredging of reservoirs or decreased water supply storage.

1.4.6.6 Reservoir Operations and Water Releases

There are over a dozen reservoirs in the Delaware River of varying sizes that are used to maintain adequate flow and water supply for all users throughout the watershed. However, these reservoirs can also concentrate contaminants, especially algae. The reservoir can have impacts on water quality in a number of ways. First, it can release concentrated or elevated concentrations of contaminants that will react with the ambient water in the receiving streams and change its characteristics. For example, algae that are growing in a reservoir are released by its operation, that upon entering different water quality conditions can die off releasing chemicals that impact the taste and odor of the water. Also, large releases of nutrients or metals re-suspended in soluble forms by anoxic conditions at lakes into local streams can also cause water quality issues. The second way a discharge from a reservoir can impact water quality is through releases of small quantities of algae that, upon entering the rivers, are now in conditions that are favorable to their overproduction or blooming. Algae once released from a low nutrient reservoir into a nutrient laden stream combined with a long travel time in the river to water intakes downstream could cause an algae bloom that impacts water quality and taste and odor for weeks downstream.

Overall, it is recommended that the operation of these reservoirs, including the levels and quality of releases (bottom/anoxic water vs. top water), be communicated in a real time format to water suppliers. Studies should be conducted to determine how these releases can impact water quality through changing algal populations in their receiving streams.

Figure 1.4.6-7 Reservoirs in the Delaware River Basin - Beltzville Lake

1.4.6.7 Catastrophic Accidents and Spills

At any given time throughout the watershed, an accident that releases contaminants that can directly impact the quality of a water supply can occur. These catastrophic events can require public water supply withdrawals to stop for periods of time ranging from a few hours to several days, limiting available water to affected communities. Water suppliers and communities are prepared to deal with such accidents, because their emergency response planning included preparation for just such occasions. Therefore, the impacts on the public in general are limited. However, when an accident of significant nature does occur under conditions that cannot be anticipated, the impact can be quite dramatic. For example, in the Delaware River Watershed alone during the past several years, there were a number fuel oil spills or discharges into waterways, a railroad tanker car derailment, several major fires along the river at large industrial facilities or abandoned facilities, underground storage tank spills, and various spills of gasoline and oil onto roads and bridges, which leaked into local streams.

One tanker car can contain up to 14,000 gallons of hazardous chemicals. In this area, most railroad lines run along the Schuylkill and Delaware Rivers and pass through Philadelphia. Therefore, given the significant amount of shipping through this corridor, the risk and possibility of a tanker car derailment and release of hazardous material into the Delaware River, though fairly low, is real.

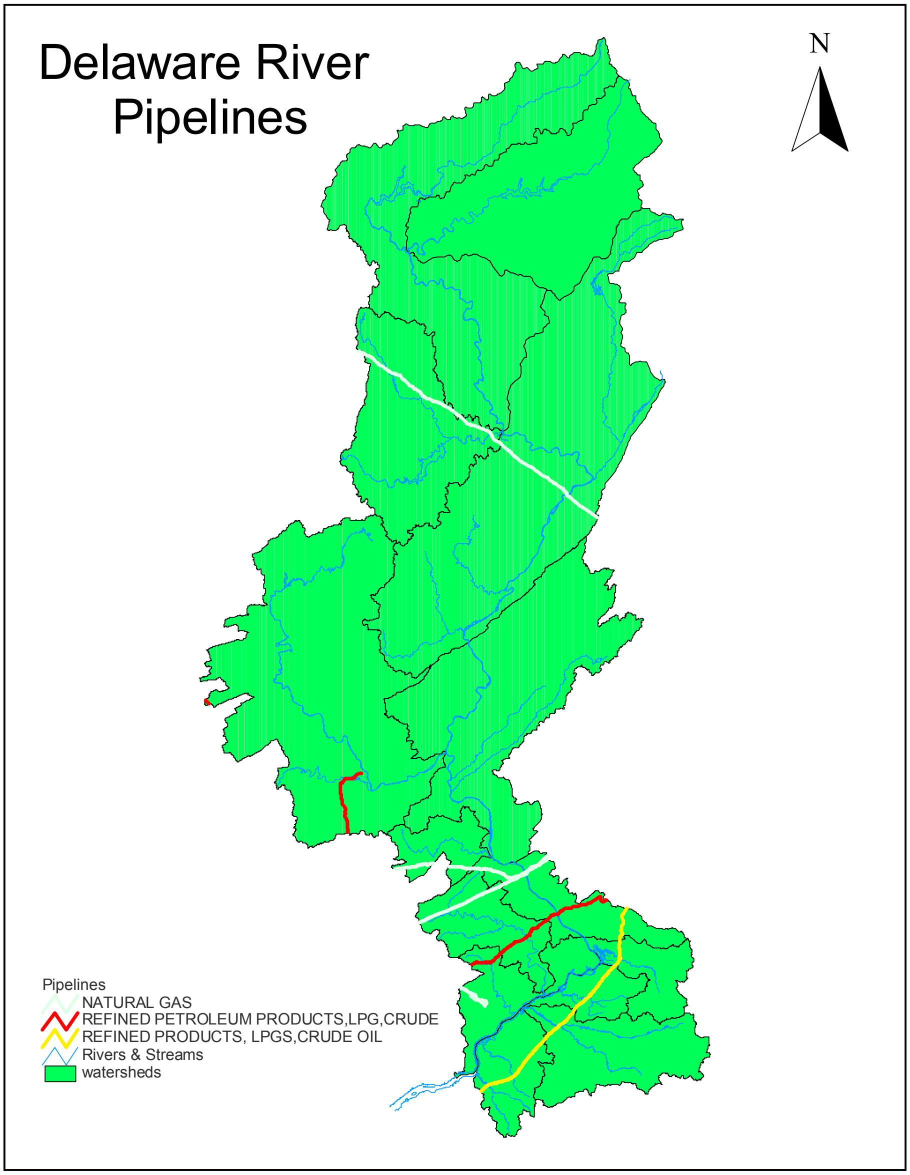
In addition to railroads and other transportation, barge and commercial shipping traffic is quite significant in the tidal Delaware River. An accident from an oil tanker or tanker containing other hazardous materials could have catastrophic impacts on water supplies.

Figure 1.4.6-8 Tanker Car Derailment in Philadelphia
Tanker cars can carry up to 14,000 gallons of hazardous materials.

Beyond the known incidents of this year alone, there are past incidents that continue to concern water suppliers. For example, petroleum pipelines have broken, releasing thousands of gallons of petroleum into local groundwater supplies, streams, and water supplies. The river has many major petroleum pipeline crossings, unknown to the general public. The age and location of these pipelines are largely unknown and the petroleum suppliers are just now voluntarily supplying partial information to local and federal governments. It is believed that these pipelines are of significant age and nearing their service life expectancy. Locations of known pipelines are shown on Figure 1.4.6-9.

The highways and bridges that cross the Delaware River and its tributaries also represent significant opportunities for impacts on water supplies. In the event of an accident, tanker trucks carrying gasoline or fuel oil can spill thousands of gallons of their cargo into storm drains on roads and bridges that discharge directly into the stream or river. In some cases, since many roads follow along the banks of the river and streams, entire trucks can run off the road and into the stream or river, releasing their cargo. In addition to the possibility of impacts due to direct spills from trucks and cars, bridge maintenance activities have been known to release chemicals into the river itself. The painting of bridges can result in the release of paints and solvents if not handled properly and applied with the appropriate controls.

Figure 1.4.6-9 Petroleum and Natural Gas Pipelines in the Delaware River Watershed



Petroleum pipelines cross the Delaware River and its tributaries in many places and may be reaching the end of their service life. Due to voluntary mapping requirements, only a portion of the pipelines in the watershed may be identified on GIS.

1.4.6.8 Road Runoff

In addition to the numerous types of spills and catastrophic impacts from accidents on highways and bridges, maintenance of roadways and parks can also impact water quality. The maintenance of highway shoulders includes spraying of herbicides such as glyphosate to kill weeds growing beside the highway. The evidence of spraying can be observed in summer and fall, when it may be possible to notice a brown swath of dead plant material including portions of nearby trees within 20-50 feet of the highway shoulder. Though the application of these materials is important for the maintenance and protection of the highway, they are sometimes sprayed into storm drains or nearby waterways where they can persist and impact water quality. This effect could be significant given the large number of miles of highway in southeastern Pennsylvania and numerous miles of roadway adjacent to streams and rivers.

Another concern from road runoff is the release of road salts during winter application periods, as illustrated by Figure 1.4.6-10. Concentrations of salts, such as sodium and chloride, have increased significantly over the past several decades at some locations in the watershed. These increasing trends seem to be linked to the increased development and impervious cover in the watershed as more highways, driveways, walkways, and parking lots are built in the watershed. The application of salts to these surfaces to make them safe for travel is important. However, at some time in the future, these practices may need to be addressed in order to reduce impacts on waterways before they significantly impact water supplies or aquatic life. Several water supplies in the Northeastern U.S. have similar issues with the impacts of salt application on water quality and have developed programs to reduce application and mitigate impacts in sensitive areas. Salt mist spraying before storms using special trucks is an example of a new technology that can be used in the Lower Delaware River Watershed to reduce salt application and mitigate salt runoff impacts.

Another example of the negative impacts of runoff can be found in the situation that occurred in the winter of 1994 when some communities ran out of salt and began using fertilizer as a de-icer on sidewalks and driveways. The urea in the fertilizer reacted with the chlorine at a treatment plant and caused major taste and odor problems. This occurrence highlights the need to educate community members about the preventable negative impacts of runoff.

Figure 1.4.6-10 Road Salt Application During the Winter

1.4.6.9 Algae Impacts

The growth and die-off of various types of algae can have significant impacts on water treatment. Diatoms can bloom and clog the filtration process requiring increased filter backwashing. When blue-green filamentous algae die, they release very minute concentrations of chemicals that are not harmful to human health, but which make the water taste and smell unpleasant. The removal of these chemicals requires additional and costly treatment. Algal blooms are caused by excess nutrients in the aquatic system, as well as the loss of shade cover from trees along the stream and river. The reduction of nutrients from agricultural runoff, sewage discharge, and lawn fertilizer application are important components in preventing these situations. Preventing the loss of riparian buffer and shade trees along the stream and river would also keep this problem from worsening. The frequent impacts on taste and odor have involved understanding the sources of these algae blooms. Figure 1.4.6-11 shows one of the instances when the sources were tracked to the Lehigh River.

Figure 1.4.6-11 Picture of Algae on the Lehigh River
The low flows and slow flows behind dams and in reservoirs, large amounts of sunlight, and excessive concentrations of nutrients in the Delaware River provide the proper conditions for algae blooms.

1.4.6.10 Wildlife Management

The Delaware River Watershed provides refuge to many wonderful birds and animals. However, there are certain conditions in which any animal can damage the land and water resources in a given area (see Figure 1.4.6-12). Damage can be caused by a significant and unnatural proliferation of a species, the inhibition of migratory activities, destruction of predatory species, or other factors. The impacts of large and ever-increasing populations of geese in this watershed and nationwide are well known. Figure 1.4.6-12 depicts a local goose population. In the Philadelphia area, geese have been found to impact areas for most major water supplies, which has resulted in the closing of several areas to swimming. Studies by the Philadelphia Suburban Water Company identified that geese were responsible for 70% of the *E. coli* bacteria in one of the regions lakes.

There are a number of techniques that are being employed in order to protect land and water resources from the geese. Some of these involve educating people not to feed the geese in sensitive areas, while others include scaring the geese with noises or dogs. The last resort used in most cases usually involves the active hunting of geese or egg addling to control skyrocketing resident populations in various areas.

Deer have also been identified in various suburban and urban areas as the cause of negative impacts on local land and water resources. Park and land areas that provide habitat for deer, but prevent hunting due to nearby homes, have experienced increasing deer populations. In some cases, the herd becomes unnaturally large and starts to damage the trees and undergrowth through heavy feeding. The loss of undergrowth in old canopy forest areas is significant and leads to increased erosion. In addition, deer can be vectors for many pathogens.

Overall, it is recommended that water suppliers, park managers, golf course managers, state and federal wildlife officials, and wildlife experts should meet in order to develop a deer and geese management plan for impacted areas of the Delaware River Watershed. This would help to combine the resources of various individual efforts into a comprehensive and more effective form of action.

Figure 1.4.6-12 Geese Damaging Land Near a Water Supply Intake
The skyrocketing population of resident non-migratory geese throughout Pennsylvania and the entire United States is damaging land and water resources.

1.4.7 Watershed Monitoring: Current and Future Needs

Key Points

- **Most of the monitoring within the Delaware River Watershed is conducted by over ten water suppliers, government agencies, academic institutions, and community and environmental groups.**
- **Water quality monitoring efforts still need to be better coordinated, and the data should be compiled, organized and shared in a timely fashion.**
- **There are over 2,500 known monitoring locations in the Delaware River Watershed. It is estimated that less than half of these sites have routine or regular monitoring.**
- **Water quality monitoring sites appear to be well distributed within the watershed, with the Middle Delaware River Watershed observing the largest concentration of monitoring locations.**

Understanding the current and future water quality challenges facing water suppliers and the Delaware River Watershed requires analysis of data collected over time at different locations in the watershed. However, the current approach to monitoring has not been coordinated or planned. At any given time, there are five public agencies conducting professional routine monitoring of the Delaware River Watershed. Each of the many water suppliers and businesses in the watershed conducts some form of monitoring at their intakes. In addition, community groups conducting routine monitoring of nearby streams share their data with the Delaware Riverkeeper. Other community organizations conduct monitoring, but do not share it with other organizations due to lack of time, technical capabilities, and resources. Overall, the Delaware River Basin Commission has been the only organization to attempt to track water quality trends, provide limited coordinated of monitoring, and conduct spatial comparisons.

Most of the energy and effort that goes into routine monitoring is focused upon specific issues and projects in particular subwatersheds or areas of the Delaware River. For example, monitoring by the U.S. Army Corps of Engineers is focused on the recreational quality of their various lakes (Beltzville, Francis E. Walter). The Delaware River Basin Commission monitors the tidal Delaware River more heavily for recreational quality considerations. Water suppliers and businesses tend to monitor their intake water quality for process adjustment considerations. Table 1.4.7-1 and Figure 1.4.7-1 provides a description of the organizations that conduct routine monitoring in the Delaware River Watershed and the level of monitoring that is conducted. As shown, almost all of the known monitoring sites in the watershed are conducted by state or federal organizations.

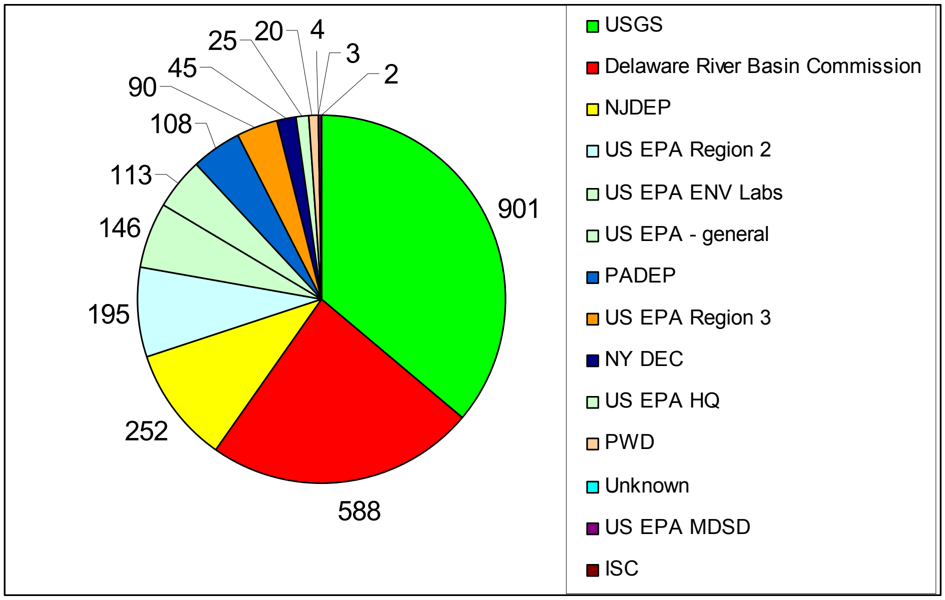
There are almost 2,500 known locations where routine monitoring is occurring in the Delaware River Watershed. Figure 1.4.7-2 provides a breakdown of the number of locations within the various subwatersheds of the Delaware River. This would suggest that there is a routine monitoring location to characterize every 6 to 8 square miles of the approximately 13,000 square-mile watershed. However, this is not the always the case.

As shown in Figures 1.4.7-2 and 1.4.7-3, over 75% of the monitoring sites are located in the Lower/Tidal and Middle Delaware River Watershed, which represent 50% of the total watershed area.

Table 1.4.7-1 Summary of Routine Watershed Monitoring

Organization	Focus Area (s)	Level of Monitoring	Parameter Groups	# of monitoring locations
PADEP	Pennsylvania	Professional	Physical, inorganics, and metals. Limited microbiological	108
USEPA	Watershed wide	Professional	Physical, inorganics, and metals	572
USGS	Watershed wide	Professional	Physical, inorganics, organics, SOCs, and metals parameters	901
US Army Corps of Engineers	Beltzville Lake, Francis E. Walters	Professional	Physical, inorganics, organics, SOCs, microbiological and metals parameters	Unknown
NJDEP	New Jersey	Professional	Physical, inorganics, organics, SOCs, microbiological and metals parameters	252
Delaware River Basin Commission	Watershed Wide	Professional	Physical, inorganics, organics, SOCs, microbiological and metals parameters	588
NYDEC	New York	Professional	Physical, inorganics, organics, SOCs, microbiological and metals parameters	45
Delaware Riverkeeper	watershed wide	Volunteers	Simple physical parameters, limited inorganics and metals	unknown
Water Suppliers	All	Professional	Varies, but mostly inorganics, metals, microbiological Limited organics	< 20 with almost weekly or daily data for many parameters

Figure 1.4.7-1 Breakdown of Organizational Monitoring in The Delaware River Watershed



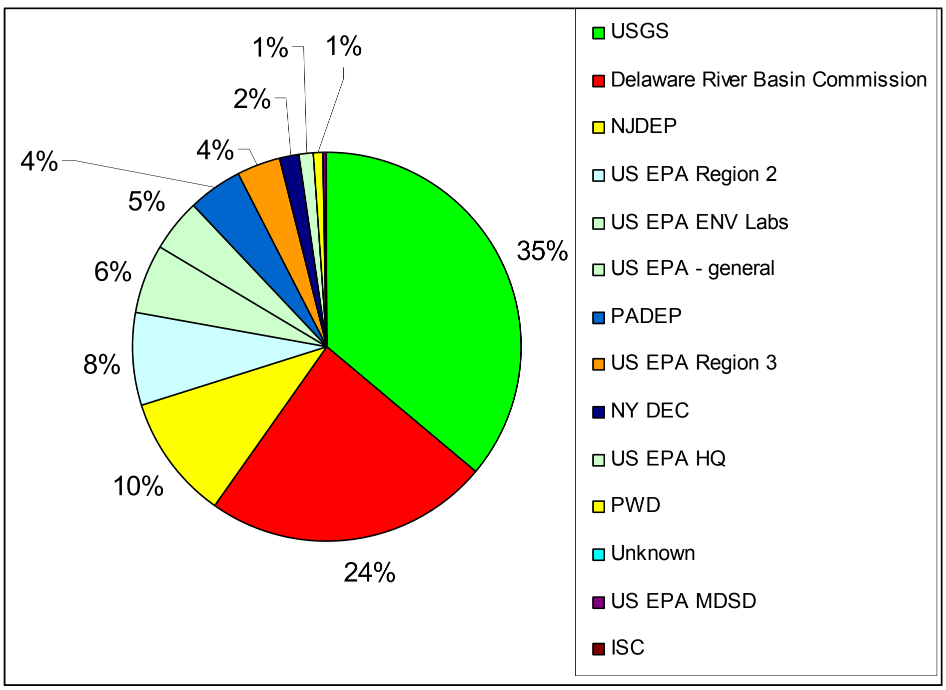
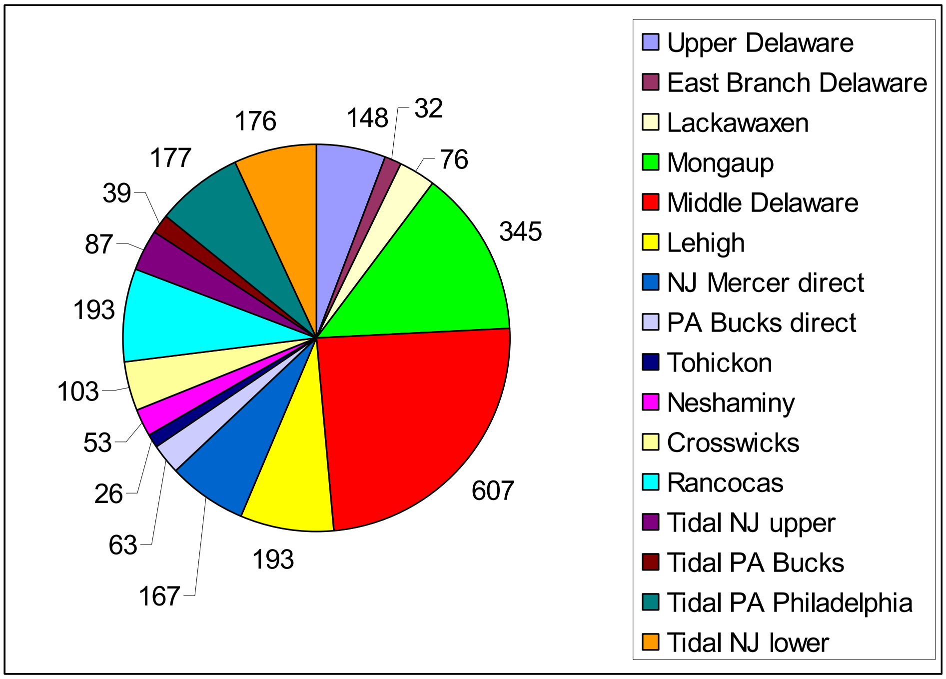


Figure 1.4.7-2 Number of Monitoring Sites in Delaware River Subwatersheds



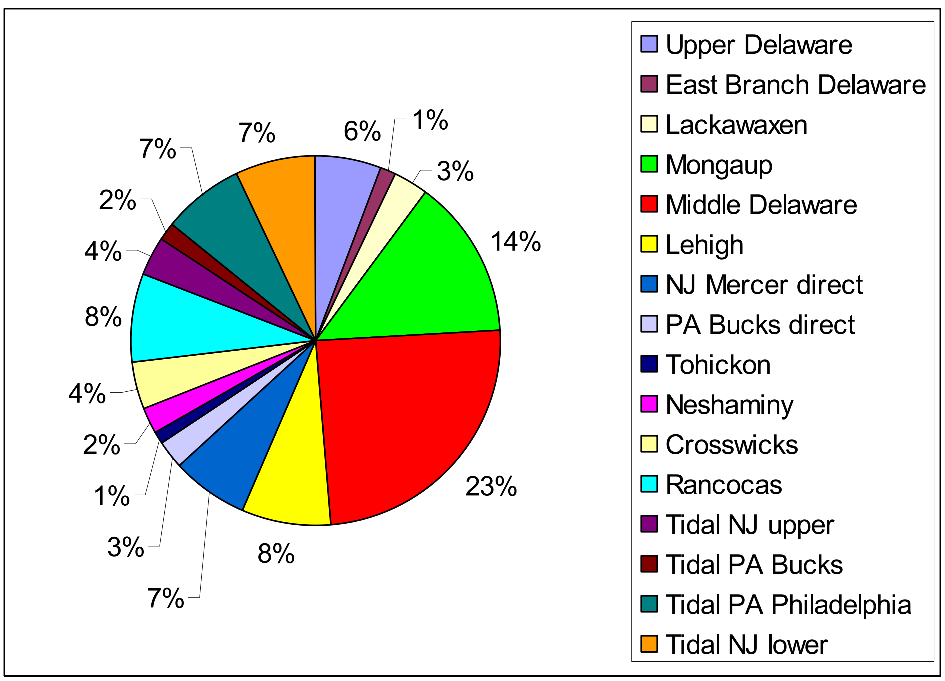
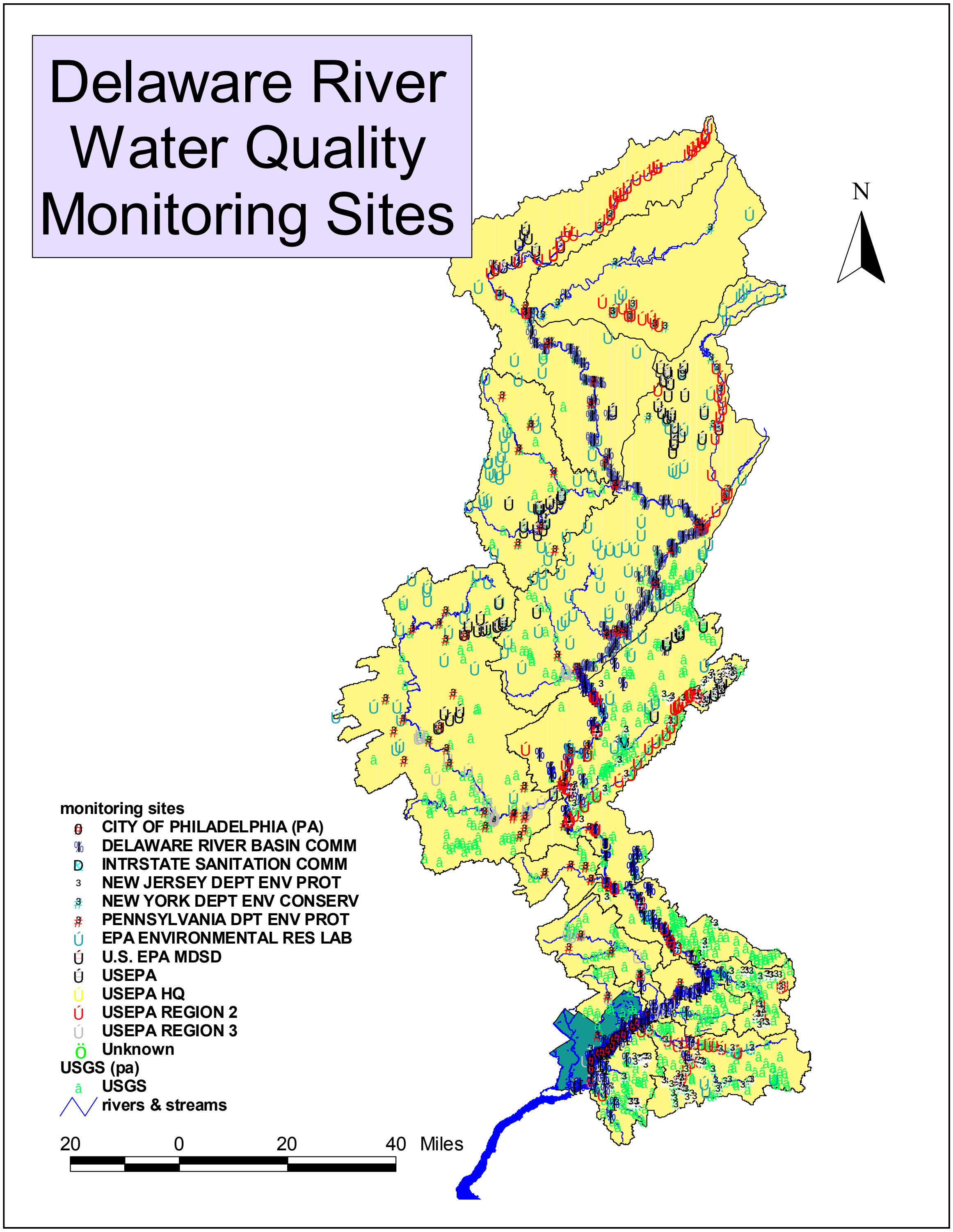


Figure 1.4.7-3 Routine Monitoring Locations by Organizations in the Delaware River Watershed



The quantity and type of monitoring is also important, in addition to the issue of where routine water quality monitoring is occurring. For example, though STORET indicated that a number of sites were monitored by NPS, USGS, and PADEP, that does not always mean that these sites were active for the same periods. For example, the USGS may monitor a number of locations, but it has only collected data from different time periods (70's, 80's, and 90's) for those locations. In addition, as project goals and water quality studies change, so do the selection of parameters. Therefore, monitoring may appear to be continuous at a location, but not for every desired parameter. In order to conduct any meaningful analysis of the water quality for a given watershed, sometimes data from multiple locations has to be pooled together into one data set for analysis.

In addition to the 2,500 potential sites for water quality data, there are numerous special studies conducted by water suppliers, community organizations, universities, county health departments, dischargers, and public agencies with little or no knowledge of one another, or of methods of coordination or data sharing. For example, although Beltzville Lake is extensively monitored by the U.S. Army Corps of Engineers during the spring and summer, it is also studied by other universities, schools, and community organizations. The different monitoring locations and parameters, as well as different seasons and sampling frequencies (USACE tends to conduct most of its monitoring during the summer) lead to various conclusions about the quality of the lake.

Pennypack, Poquessing, and Neshaminy Creeks are another example of locations where a variety of water quality monitoring programs have been conducted in recent years by water suppliers and watershed organizations. At times, dischargers, community groups, and consultants were conducting various levels of monitoring for their own special studies as well. None of this data has been combined to date.

Another important observation is that most of the mainstem river monitoring is conducted by the Delaware River Basin Commission, while tributaries are monitored by either the state environmental protection agencies, USGS, or the USEPA. Though this is a good way to focus resources, it also can prevent organizations from the ability to look at the whole watershed and see connections between water quality in the tributaries and the mainstem river. Therefore, sharing of water quality amongst these agencies is important to increase understanding of watershed issues and connectivity.

Overall, based on the information available from an analysis of the amount, types, and locations of monitoring in the watershed, the following monitoring requirements were identified:

- A data clearinghouse for water quality data needs to be created and made available to all organizations. A format for data reporting should be sent to all organizations that want to participate.

- An organization in the watershed needs to be properly funded in order to be responsible for compiling, organizing, and monitoring the water quality data from the numerous stakeholders in the watershed.

- Organizations that conduct monitoring should form a consortium for the purpose of frequent discussion of monitoring efforts and plans in order to promote better coordination and sharing of data.

- More monitoring locations are needed in locations in the upper watershed or at least monitoring in the upper watershed needs to be conducted more routinely and with more parameters.

- All monitoring organizations should agree on selecting standard monitoring stations for various parameters. It is recommended that the standard locations be placed close to the mouths of the major tributaries to the watershed. The long-term DRBC sites and certain water supply intakes may be the best places to start when selecting these sites. Routine monitoring would be conducted at these stations over long periods of time in order to examine changes and trends in water quality over the years, seasons, or decades. This information will be used as part of a report card system for water quality improvement.

Long term monitoring should be conducted for manganese, aluminum, iron, sodium, chloride, turbidity, total suspended solids, dissolved oxygen, temperature, ammonia, total phosphorus, orthophosphate, nitrate, *E. coli*, and fecal coliforms. Currently, most monitoring does not include coliform measurements except along the mainstem and tidal sections of the river. Efforts should be made to transfer data from hardcopy format in special studies into electronic format. Long term monitoring of the mainstem river at a number of locations is significant, however the same level of effort and quality is not available for many of the Delaware River's tributaries. This prevents the ability to discern the cause and source of water quality issues along the mainstem river. Increased tributary monitoring at special locations linked to long term mainstem monitoring locations can enhance understanding of current and future water quality issues.

1.5 Inventory of Potential Point Sources of Contamination

Key Points

- **Potential point and non-point sources of contamination throughout the watershed were compiled from a variety of databases.**

Based on PADEP guidelines for the statewide Source Water Assessment Program (SWAP), a contaminant inventory of point and non-point sources was developed. The inventory is an essential part of assessing the source water for a drinking water supply intake, because it compiles potential contaminant sources within the 5-hour, 25-hour, and beyond 25-hour time of travel delineation zones. A study area inventory was developed because the zones for the eight water intakes encompass a large portion of the Delaware River Watershed. The study area inventory provides insight into the clustering of sources by major subwatersheds within the Delaware River Watershed.

The focus of this discussion is the study area point source contaminant inventory. Non-point sources are discussed in the land use (section 1.2.5) section of this document and within intake-specific section 2.2.3.

Point source data was compiled from various federal and state databases available on the Internet, as well as from self-assessment data provided by water suppliers. Sources were checked by stakeholders, and verified for correct active status and location. An ACCESS® database was developed to efficiently store and manage information describing the point sources:

The following federal databases were reviewed to identify point sources in the Schuylkill River Watershed:

- Permit Compliance System (PCS)
- Resource Conservation and Recovery Act Information System (RCRIS)
- Comprehensive Environmental Response, Compensation, and Liability Act Information System (CERCLIS)
- Toxic Release Inventory (TRI)

Regulated aboveground storage tanks (ASTs) were also compiled from the PADEP Storage Tank Program. Combined with the information provided by the aforementioned federal databases, the database compilation was complete

The databases were queried for facility, process, and violation information. Facility information included name, facility identification numbers, owner, and location (street address and/or latitude, longitude). Process information included data quantifying on-site contaminants and quantities and/or loading rates. Violation information was related to type (administrative, operation or effluent violation) and frequency.

1.5.1 Point Source Contaminant Inventory

Key Points

- **Over 5,000 potential point sources were identified within the 8,000 square-mile Delaware River Study Area.**

Once the database compilation and population were completed, a study area inventory of potential contaminants was developed for the Delaware River SWAP Study Area. The land area covered by the inventory extends over 8,000 square miles, 500 subwatersheds, and 5,000 point sources. The inventory is sorted by major sub-watershed and will be posted on the Delaware Source Water Assessment project website www.phillywater.org/delaware. The full inventory or an inventory for a subwatershed of particular interest will be available for download from the website or by contacting PADEP.

An example of the inventory for the study area of the Delaware River Watershed is provided in Figure 1.5.1-1. The example shows some of the pertinent attributes associated with the various source types. If a field is blank, then the information was not available. The number of blank fields gives an idea of the incompleteness of much of the downloaded data, especially for SIC codes, contaminants, and quantities.

For PCS facilities, the name, address, NPDES ID, SIC code description, minor/major designation, flow rate, contaminant groups, and violation remark are indicated. A major facility has a flow rate of 1 MGD or greater.

Attributes shown for RCRA facilities are generally the same as for PCS. Instead of minor/major designation, RCRA facilities are differentiated on size as large quantity generators (LQG) or small quantity generators (SMG). A LQG generates more than 2,200 pounds of hazardous waste per calendar month. Flow rates do not apply to most RCRA sites, which are mostly industrial facilities with aboveground or underground storage tanks. An AST download from PADEP is used to supplement the scarce quantity information for RCRA sites. AST data attributes include fairly complete capacity and contaminant information for each site.

TRI attributes include similar fields as the PCS and RCRA facilities. Quantity information is available as ranges, such as 1,000 to 9,999 kg per year. The quantity shown is an average over all available years. If the facility had a release, then the maximum range value is used in the average, otherwise the minimum is used. TRI quantity refers to the amount used or generated on-site. Releases in TRI may be to air, water or land.

Attributes for CERCLA facilities include basic information such as name and EPA ID. In addition, a flag is shown to indicate whether the facility is on the National Priority List (NPL) or not. Quantity and capacity data for CERCLA facilities is limited to two facilities watershed wide. The number of enforced violations is also provided.

Figure 1.5.1-1 Example of Point Source Contaminant Inventory for the Delaware River SWAP Study Area

AST Summary

Name: 1 SVC CTR
Address: 1637 W TILGHMAN ST ALLENTOWN 18102 **Facility ID:** 39-06273
Total Tankage (gal): 19,000 **Releases:** No **Contaminants:** VOC,PH

Name: 181 WHEELER COURT
Address: 181 WHEELER CT LANGHORNE 19047 **Facility ID:** 09-44904
Total Tankage (gal): 7,000 **Releases:** No **Contaminants:** PH

Name: 24 HOUR STORE
Address: 10 STELLA ST MATAMORAS 18336 **Facility ID:** 52-00672
Total Tankage (gal): 30,000 **Releases:** No **Contaminants:** VOC

CERCLA Summary

Name: 200 WOLVERTON STREET **Facility ID:** NJD986648129
Address: 200 WOLVERTON STREET TRENTON 8625 **NPL Status:** NOT ON NPL
# of Units: 1 **# of Enforcements:** 0

Name: 2314 N. AMERICAN STREET **Facility ID:** PAD048613368
Address: 2314 N. AMERICAN STREET PHILADELPHIA 19123 **NPL Status:** Not on the NPL
# of Units: **# of Enforcements:**

Name: 2514 ORTHODOX STREET SITE **Facility ID:** PAN000305658
Address: 2514 ORTHODOX STREET PHILADELPHIA 19124 **NPL Status:** Not on the NPL
# of Units: **# of Enforcements:**

Name: 3200 N. 22ND STREET **Facility ID:** PA0000569202
Address: 3200 N. 22ND STREET PHILADELPHIA 19145 **NPL Status:** Not on the NPL
# of Units: **# of Enforcements:**

Name: 3M CO-TAPE DIV **Facility ID:** PAD981034002
Address: GREEN LN BRISTOL 19007 **NPL Status:** NOT ON NPL
# of Units: 1 **# of Enforcements:** 0

Name: A & E MFG CO INC **Facility ID:** PAD042266171
Address: 2110 HARTEL ST LEVITTOWN 19057 **NPL Status:** NOT ON NPL
# of Units: 1 **# of Enforcements:** 0

1.5.2 Inventory Characterization

Key Points
- **Over 5,000 potential point sources were identified within the watershed.**
  - **The highest concentrations of potential point sources were located in the most highly developed subwatersheds such as the Neshaminy Subwatershed.**
- **Sewer systems, dry cleaners, and chemical manufacturers were among the most frequently identified potential point sources.**
  - **The Tidal PA Philadelphia, NJ Tidal Lower and Tidal PA Bucks had the greatest number of dischargers per acre of drainage area.**

1.5.2.1 Entire Watershed Inventory Summary

The inventory has been compiled for the entire Delaware Watershed SWAP study area and its major subwatersheds. With 5000 point sources throughout the area, this characterization highlights the types of sources (PCS, RCRA, etc.) that exist and where those sources are concentrated. Table 1.5.2-1 presents the number of facilities for a particular source type for each major subwatershed.

Table 1.5.2-1 Summary of Point Source Types by Major Watershed

Major Watershed	# of PCS Facilities	# of RCRA Facilities	# of ASTs	# of TRI Facilities	# of CERCLA Facilities
Outside Study Area	58	236	0	7	0
Crosswicks	27	1	2	2	8
Lackawaxen	13	26	59	1	1
Lehigh	81	400	610	91	58
Middle Delaware	134	160	134	56	45
Mongaup	38	78	120	16	22
Neshaminy	43	300	218	42	70
NJ Mercer Direct	54	27	22	40	28
PA Bucks Direct	11	6	18	0	5
Rancocas	47	8	5	17	40
Tidal NJ Lower	113	108	11	51	58
Tidal NJ Upper	32	31	25	8	40
Tidal PA Bucks	32	160	150	39	58
Tidal PA Philadelphia	56	135	111	131	201
Tohickon	24	41	39	5	21
Upper Delaware	11	3	2	1	0
Totals	**774**	**1720**	**1526**	**507**	**655**

Table 1.5.2-1 indicates that for two of the six potential source types – RCRA and ASTs, the Lehigh Subwatershed has the greatest number of sites. This is consistent with the fact that the Lehigh River Watershed encompasses a greater land area than any of the other subwatersheds. The PCS data indicates that the Middle Delaware has the largest amount of facilities while the Tidal PA Philadelphia has the largest number of TRI and CERCLA facilities. These tallies do not necessarily mean that the sources are significant with respect to contamination of the drinking water supplies. The ranking analysis for

each intake determines significance by accounting for other source characteristics, such as time of travel to the intake, water quality impact, or number of violations.

The data from Table 1.5.2-1 is further analyzed based on watersheds with the three highest occurrences of each source type. This compilation is summarized in Table 1.5.2-2. This table clearly shows that the Lehigh, the Tidal PA Philadelphia, and the Neshaminy have high concentrations of sources. Across all source types, with the exception of PCS, the Neshaminy has one of the three highest clusters. This is consistent with the significant industrial land use within the area in which it lies. Both the Neshaminy and the Lehigh have seen a large increase in development during the past decade. Therefore, they also have a significantly large number of facilities.

Table 1.5.2-2 Major Subwatershed Source Type Occurrence

Source Type		Major Watershed	Number of Facilities	Source Type		Major Watershed	Number of Facilities
PCS	1st	Middle Delaware	134	TRI	1st	Tidal PA Philadelphia	131
	2nd	NJ Tidal Lower	113		2nd	Lehigh	91
	3rd	Lehigh	81		3rd	Middle Delaware	56
RCRA	1st	Lehigh	400	CERCLA	1st	Tidal PA Philadelphia	201
	2nd	Neshaminy	300		2nd	Neshaminy	70
	3rd	Outside Study Area	236		3rd	Lehigh/Tidal PA Bucks	58
ASTs	1st	Lehigh	610				
	2nd	Neshaminy	218				
	3rd	Tidal PA Bucks	150				

Table 1.5.2-3 summarizes the most frequently reported types of industrial facilities, based upon SIC codes. The most frequently occurring potential point sources are sewerage systems and gasoline service stations. Using the PADEP land use-based activities defined in the SWAP document, drycleaning plants, water suppliers and industrial inorganic chemicals that are not elsewhere classified are most prevalent in the watershed.

Table 1.5.2-3 Schuylkill Watershed Top Point Sources by Industrial Classification

SIC Code/Description	Number	PADEP Land Use/Activity	Number
4952 - Sewerage Systems	237	Misc. - NPDES Locations	240
5541 - Gasoline Service Stations	53	Industrial - Chemical Manufacturer	227
7216 - Drycleaning Plants, Except Rug Cleaning	37	Industrial – Machine/Metalworking Shops	164
4941 – Water Supply	29	Plastics Manufacturing	110
2819 - Industrial Inorganic Chemicals, Not Elsewhere Classified	27	Electronics Manufacture	99

Although Tables 1.5.2-1 through 1.5.2-3 identify the watersheds in which the groups of source types are located, as well as the most common industries, the drainage areas of the subwatersheds were not considered. By normalizing the number of potential sources in a subwatershed by drainage area, a better representation of clustering and cumulative impacts may be ascertained. Because existing dischargers are more of a concern for cumulative impacts than other potential sources (such as ASTs, RCRA sites or TRI facilities), the data for PCS dischargers was normalized, as described below.

1.5.2.2 PCS Dischargers

Table 1.5.2-4 lists the number of PCS dischargers within each major subwatershed, normalized by drainage area. Although the greatest number of dischargers was located within the Middle Delaware and the NJ Tidal Lower, the normalized data identifies other subwatersheds of concern. A large density of PCS facilities is found within the NJ Tidal Lower, Tidal PA Bucks, and Tidal PA Philadelphia Subwatersheds.

Table 1.5.2-4 Watershed Clustering of Dischargers on a Drainage Area Basis

Major Subwatershed	# of PCS Facilities	Drainage Area (acres)	#/DA (#/acre)
Outside Study Area	58	N/A	
Crosswicks	27	94,455.31	2860E-07
Lackawaxen	13	381,418.14	341E-07
Lehigh	81	871,465.37	929E-07
Middle Delaware	134	633,512.17	2120E-07
Mongaup	38	980,340.74	388E-07
Neshaminy	43	149,395.58	2880E-07
NJ Mercer Direct	54	99,111.98	5450E-07
PA Bucks Direct	11	52,830.14	2080E-07
Rancocas	47	222,547.22	2110E-07
Tidal NJ Lower	113	118,237.15	9560E-07
Tidal NJ Upper	32	69,511.52	4600E-07
Tidal PA Bucks	32	36,160.97	8850E-07
Tidal PA Philadelphia	56	97,317.99	5750E-07
Tohickon	24	83,899.16	2860E-07
Upper Delaware	11	761,835.50	144E-07
Totals	774		

Discharger data is further normalized by median flow in Table 1.5.2-5. Median flow from the period of record at USGS at the nearest gauge to the major subwatershed was used. If more than one gauge was associated with the subwatershed, then a drainage area weighted average value was used. When normalized by flow, as well as by drainage area, clusters of PCS sites are found in the Middle Delaware and NJ Tidal Lower.

Table 1.5.2-5 Watershed Clustering of Dischargers on a DA/Flow Basis

Major Subwatershed	# of PCS Facilities	#/DA (#/acre)	Median Flow (cfs)	#/DA/Flow (#/acre/cfs)
Crosswicks	27	3.E-04	N/A	
Lackawaxen	13	3.E-05	250	1.E-07
Lehigh	81	9.E-05	2090	4.E-08
Middle Delaware	134	2.E-04	N/A	
Mongaup	38	4.E-05	120	3.E-07
Neshaminy	43	3.E-04	140	2.E-06
NJ Mercer direct	54	5.E-04	N/A	
Rancocas	47	2.E-04	N/A	
Tidal NJ lower	113	1.E-03	N/A	
Tidal PA Philadelphia	56	6.E-04	49	1.E-05
Tohickon	24	3.E-04	47	6.E-06
Totals	630			

The inventory of dischargers or PCS facilities throughout the Delaware River SWAP study area is summarized in Table 1.5.2-6. In all, 774 dischargers are found throughout the study area, although only 124 are major dischargers (<1 MGD). Almost of all these are sewerage systems. In fact, sewerage systems comprise the largest component, 326 of 774, for both major and minor dischargers. After sewerage systems, gasoline service stations, water suppliers, elementary and secondary schools, and petroleum bulk stations comprise 122 of the remaining 448 dischargers.

Table 1.5.2-6 PCS Discharger Summary

Total Dischargers	774
Major Dischargers	124
Major Sewerage Systems	81
Top 5 Discharge Types by SIC Code 4952 – Sewerage Systems 5541 – Gasoline Service Stations 4941 – Water Supplier 8211 – Elementary And Secondary Schools 5171 – Petroleum Bulk Stations	 326 53 29 22 18
Dischargers with Available DMR Data	147
Most Common Parameters with DMR Data	Total Suspended Solids pH BOD5 Fecal Coliform Ammonia Nitrogen
Most Common Parameters for Effluent Limits	Total Suspended Solids pH Fecal Coliform Oil and Grease BOD
Discharge Flow Rate Range	0.0 – 40 MGD

Because so many of the dischargers are minor, Discharge Monitoring Report (DMR) data was only available for 147 sites. The most common parameters found in the DMRs and effluent limits are indicated in Table 1.5.2-6. The common DMR parameters – TSS and BOD5 - correlate with turbidity and TOC (DBP precursor), which are of concern from a source water perspective. Metals such as copper, as well as oil and grease, also pose a concern for drinking water supplies.

Discharge Monitoring Report (DMR) data is further summarized in Table 1.5.2-7 based on maximum reported quantities and parameter groups. The parameter groups generally follow those identified in the PADEP SWAP guidance document. These groupings are used to rank potential contaminant sources in the intake-specific report sections. Since the ranking analysis was based on DMR maximum quantity data, the data was compiled in Table 1.5.2-7 to provide a frame of reference. The data also gives an idea, on a pounds-per-day basis, as to the "worst case" order of magnitude of a discharge. This data was available for only 147 of the 774 dischargers in the Delaware River study area and is generally linked to major dischargers. With that in mind, the data truly represents a worst-case estimate of individual loads being discharged into the Delaware River.

Table 1.5.2-7 Summary of Available DMR Data

Parameter Name	Range of Max Quantity Reported			Mean Max Quantity	Count Of Max Quantities
CARBONACEOUS BOD5	0.001	-	11759	383.7751041	1450
CHEMICAL OXYGEN DEMAND, COD	0.090000004	-	1547.102051	189.4572866	136
CHLORINE, TOTAL RESIDUAL	0	-	3191.800049	94.76029557	34
CYANIDE, TOTAL	0	-	795.7670288	157.3065284	25
pH	0.029999999	-	0.029999999	0.029999999	1
SOLIDS, DISSOLVED TOTAL, TDS	85	-	57304	17873.77984	124
SULFATE as SO4	10499	-	30113	14105.88	50
SULFIDE as S	-0.331999987	-	0.583000004	0.014263291	79
TKN (TOT. KIELDAHL NITROGEN)	0.07	-	131	24.03246572	73
BOD, CARBONACEOUS 5 DAY,5 C	28	-	51	39.6	5
BOD5, BIOLOGICAL OXYGEN DEMAND	-4.881000042	-	185656	1509.49896	3275
OXYGEN DEMAND, ULTIMATE	0.800000012	-	486	87.88842852	70
FLOW RATE	7E-05	-	27984	70.44311617	2856
TEMPERATURE	0	-	0	0	1
ALUMINUM, TOTAL	0.289999992	-	66	5.692051282	39
ALUMINUM, TOTAL RECOVERABLE	0.266460001	-	988	104.0015283	13
ANTIMONY TOTAL RECOVERABLE	0.002	-	0.233999997	0.093906976	43
ANTIMONY, TOTAL	0.0038	-	139.1999969	17.51409974	31
ARSENIC, TOTAL	0.002	-	58	11.15967137	7
ARSENIC, TOTAL RECOVERABLE	0	-	58.59999847	9.14406254	32
BARIUM, TOTAL	0.00162	-	151.3000031	17.11456004	27
BERYLLIUM, TOTAL	0.00333	-	11.69999981	3.808360883	12
CADMIUM TOTAL RECOVERABLE	0	-	47.29999924	6.51294108	34
CADMIUM, TOTAL	0.0019	-	5.699999809	0.48664193	31
CHROMIUM TOTAL RECOVERABLE	0.090839997	-	69.59999847	26.22453079	19
CHROMIUM, TOTAL	-0.123000003	-	68.09999847	1.09930143	138
CHROMIUM; HEXAVALENT	0.100000001	-	0.188999996	0.131333331	3
COPPER TOTAL RECOVERABLE	0.0004	-	2387	81.53983143	200
COPPER, TOTAL	-0.363000005	-	340	4.323660717	251
IRON TOTAL RECOVERABLE	9.600000381	-	2999	923.1400002	5
IRON, TOTAL	0.090000004	-	0.326000005	0.143	30

Parameter Name	Range of Max Quantity Reported			Mean Max Quantity	Count Of Max Quantities
LEAD TOTAL RECOVERABLE	0	-	141.8999939	6.986599123	55
LEAD, TOTAL	0.02	-	22.70000076	1.926857597	33
MANGANESE, TOTAL	0.207000002	-	2396.971924	1300.752856	13
MERCURY TOTAL RECOVERABLE	0.002	-	208	21.813348	10
MERCURY, TOTAL	0.0004	-	1.799999952	0.550325001	8
NICKEL TOTAL RECOVERABLE	0	-	561	56.73148915	23
NICKEL, TOTAL	0.001	-	1248	19.20851764	79
SELENIUM, TOTAL	0.002	-	3.599999905	1.626	4
SELENIUM, TOTAL RECOVERABLE	0.025	-	34.79999924	18.4964282	7
SILVER TOTAL RECOVERABLE	0	-	58.59999847	9.936652097	23
SILVER, TOTAL	0	-	69	3.063370561	34
THALLIUM, TOTAL	0.002	-	58.59999847	19.3259994	9
ZINC TOTAL RECOVERABLE	-0.080300003	-	991	59.14021157	256
ZINC, TOTAL	-0.023	-	681	16.76426172	185
AMMONIA (AS N) + UNIONIZED AMMONIA	0.002	-	60	16.42626311	38
AMMONIA-NITROGEN	0	-	1599	53.89651911	1362
NITRATE NITROGEN, TOTAL AS NO3	3.700000048	-	37.40000153	14.36707324	82
NITRATE-NITRITE, NITROGEN	15	-	505	210.25	20
NITRATE-NITROGEN as N	0.159999996	-	0.360000014	0.258888892	9
PHOSPHORUS, TOTAL as P	-2.835999966	-	217	7.037953976	639
DISSOLVED OXYGEN	0.017000001	-	0.017000001	0.017000001	2
HYDROCARBONS,IN H2O,IR,CC14 EXT. CHROMAT	0	-	42.5	4.091238115	21
OIL AND GREASE	0	-	3549	174.3518653	118
PETROL HYDROCARBONS TOTAL RECOVERABLE	0	-	6.730000019	0.541140841	71
PETROLEUM HYDROCARBONS, TOTAL	0	-	42.5	4.091238115	21
(DIOXIN) 2,3,7,8-TCDD	0	-	0.034600001	0.01154	3
1,2,4-TRICHLOROBENZENE	0	-	37.79999924	7.006199885	13
1,2-DICHLOROBENZENE	0	-	37.79999924	7.432576805	13
1,2-DIPHENYLHYDRAZINE	0.0007	-	37.79999924	10.45344429	9
1,3-DICHLOROBENZENE	0	-	29.29999924	5.997884545	13
1,4-DICHLOROBENZENE	0	-	29.29999924	5.658178497	14
2,4,6-TRICHLORO- PHENOL	0.001	-	75.69999695	34.43043878	5
2,4-DICHLOROPHENOL	0	-	37.79999924	9.558022061	9

Parameter Name	Range of Max Quantity Reported			Mean Max Quantity	Count Of Max Quantities
2,4-DIMETHYLPHENOL	0	-	75.69999695	19.12802154	9
2,4-DINITROPHENOL	0	-	37.79999924	9.558422061	9
2,4-DINITROTOLUENE	0	-	37.79999924	7.063964153	14
2,6-DINITROTOLUENE	0	-	37.79999924	9.558022061	9
2-CHLORONAPHTHALENE	0.001	-	37.79999924	17.20443971	5
2-CHLOROPHENOL	0	-	75.69999695	19.12822154	9
2-NITROPHENOL	0	-	37.79999924	9.558066506	9
3,3'-DICHLORO- BENZIDINE	0.001	-	37.79999924	10.83372207	9
4,4'-DDD	5E-05	-	1.169999957	0.287934994	6
4,4'-DDE (P,P'-DDE)	1E-05	-	1.169999957	0.286254994	6
4,4'-DDT (P,P'-DDT)	2E-05	-	1.169999957	0.300594995	6
4,6-DINITRO-o-CRESOL	0	-	37.79999924	9.558066506	9
4-CHLORO-3-METHYL PHENOL	0.001	--	75.69999695	34.43043878	5
4-NITROPHENOL	0	-	37.79999924	9.558066506	9
A-BHC-ALPHA	0	-	0.579999983	0.170639997	5
A-ENDOSULFAN-ALPHA	3E-05	-	0.579999983	0.172376664	6
ACENAPHTHENE	0	-	15.10000038	4.296500045	8
ACENAPHTHYLENE	0	-	15.10000038	3.101530802	13
ALDRIN	0	-	0.579999983	0.18188571	7
ANTHRACENE	0	-	15.10000038	3.118069257	13
B-BHC-BETA	0.017999999	-	0.579999983	0.234549994	4
B-ENDOSULFAN-BETA	3E-05	-	1.169999957	0.31492666	6
BENZIDINE	0.002	-	151	41.29227769	9
BENZO (A) ANTHRACENE	0	-	15.10000038	3.169107725	13
BENZO (A) PYRENE	0	-	15.10000038	3.126614285	14
BENZO(B)FLUORANTHENE	0	-	15.10000038	3.761538488	13
BENZO(GHI)PERYLENE	0.0007	-	15.10000038	4.643190055	10
BENZO(K) FLUORANTHENE	0	-	15.10000038	3.58004617	13
BHC-DELTA	0.009	-	0.579999983	0.213299996	4
BIS (2-CHLOROETHOXY) METHANE	0.001	-	75.69999695	34.43043878	5
BIS (2-ETHYLHEXYL) PHTHALATE	0	-	257.2999878	31.42625706	19
BIS(2-CHLOROISOPROPYL)ETHER	0.001	-	37.79999924	9.843860831	10
BUTYLBENZYL PHTHALATE	0.0007	-	37.79999924	10.30688871	9

Parameter Name	Range of Max Quantity Reported			Mean Max Quantity	Count Of Max Quantities
CHLORDANE (TECH MIX. AND METABOLITES)	7E-05	-	5.800000191	1.41120503	6
CHRYSENE	0	-	276	22.40442145	14
DI-N-BUTYLPHTHALATE	0	-	37.79999924	8.572238284	13
DI-N-OCTYL PHTHALATE	0.001	-	75.69999695	34.43043878	5
DIBENZO (A,H) ANTHRACENE	0.001	-	15.10000038	5.184344509	9
DIELDRIN	1E-05	-	1.169999957	0.279921661	6
DIETHYL PHTHALATE	0	-	75.69999695	13.89251491	13
DIMETHYLPHTHALATE	0	-	75.69999695	12.36159293	15
ENDOSULFAN SULFATE	3E-05	-	1.169999957	0.31309666	6
ENDOSULFAN, TOTAL	3E-05	-	1.169999957	0.270546659	6
ENDRIN	2E-05	-	0.579999983	0.156373329	6
ENDRIN ALDEHYDE	2E-05	-	1.169999957	0.35276166	6
FLUORANTHENE	0	-	37.79999924	6.935242732	14
FLUORENE	0	-	15.10000038	3.21043079	13
GAMMA-BHC	0.001	-	1.090000033	0.296025003	8
HEPTACHLOR	0	-	0.579999983	0.170639997	5
HEPTACHLOR EPOXIDE	0	-	1.50999999	0.457639994	5
HEXACHLOROBENZENE	0	-	37.79999924	7.126199903	13
HEXACHLOROBUTADIENE	0	-	37.79999924	7.130899894	13
HEXACHLOROCYCLO-PENTADIENE	0.002	-	37.79999924	10.49747762	9
HEXACHLOROETHANE	0	-	37.79999924	7.220107575	13
ISOPHORONE	0.001	-	37.79999924	10.32773318	9
N-NITROSODI-N-PROPYLAMINE	0.001	-	75.69999695	34.43043878	5
N-NITROSODIMETHYL-AMINE	0.001	-	75.69999695	20.40585485	9
N-NITROSODIPHENYL-AMINE	0.0004	-	75.69999695	18.0851194	10
NAPHTHALENE	0	-	15.10000038	2.67493849	13
NITROBENZENE	0	-	37.79999924	7.646807608	13
PCB-1016 (AROCHLOR 1016)	8E-05	-	5.800000191	1.628546689	6
PCB-1221 (AROCHLOR 1221)	0	-	5.800000191	1.627033357	6
PCB-1232 (AROCHLOR 1232)	0	-	5.800000191	1.627033357	6
PCB-1242 (AROCHLOR 1242)	0	-	5.800000191	1.627033357	6

Parameter Name	Range of Max Quantity Reported			Mean Max Quantity	Count Of Max Quantities
PCB-1248 (AROCHLOR 1248)	0	-	5.800000191	1.627033357	6
PCB-1254 (AROCHLOR 1254)	0	-	5.800000191	1.627033357	6
PCB-1260 (AROCHLOR 1260)	0	-	5.800000191	1.627033357	6
PENTACHLOROPHENOL	0.001	-	37.79999924	17.20443971	5
PHENANTHRENE	0	-	15.10000038	2.578653355	15
PHENOL	0	-	58.59999847	14.42462457	8
PHENOLS	-0.069200002	-	0.875500023	0.088076296	54
PHENOLS, TOTAL	0.07	-	25.94199944	1.449191165	68
PYRENE	0	-	37.79999924	7.361453722	13
TOTAL BASE/NEUTRAL PRIORITY POLLUTANTS	0.013	-	2.400000095	0.620500023	4
TOTAL PCBs	7E-05	-	5.800000191	1.916454027	5
TOTAL TOXIC ORGANICS (TTO) (40CFR433)	0	-	0.354999989	0.11833333	3
TOXAPHENE	0.0002	-	5.800000191	1.91510002	6
SOLIDS,SUSPENDED TOTAL TSS	-40.04000092	-	22666	374.4907629	4817
FECAL COLIFORM	0.090999998	-	0.090999998	0.090999998	1
1,1,1-TRICHLOROETHANE	0	-	5.800000191	1.890657137	14
1,1,2,2-TETRACHLORO-ETHANE	0.001	-	6.639999866	3.29049001	10
1,1,2-TRICHLOROETHANE	0	-	11.69999981	2.864221439	14
1,1-DICHLOROETHANE	0.0004	-	29.29999924	8.295466545	9
1,1-DICHLOROETHYLENE	0	-	11.69999981	2.713942884	14
1,2-DICHLOROETHANE	0	-	253	26.06299998	10
1,2-DICHLOROETHANE, TOTAL WEIGHT	0	-	11.69999981	2.960972743	11
1,2-DICHLOROPROPANE	0	-	5.800000191	1.294185725	14
1,2-TRANS-DICHLOROETHYLENE	0	-	11.69999981	2.794182157	14
1,3-DICHLOROPROPYLENE	0	-	0	0	4

Parameter Name	Range of Max Quantity Reported			Mean Max Quantity	Count Of Max Quantities
2-CHLOROETHYLVINYL ETHER	0.001	-	58.59999847	26.30869943	6
4-BROMOPHENYL PHENYL ETHER	0.002	-	37.79999924	17.20487971	5
4-CHLOROPHENYL PHENYL ETHER	0.002	-	37.79999924	17.20487971	5
ACROLEIN	0.01	-	189.1999969	59.7657264	11
ACRYLONITRILE	0	-	94.62000275	25.42139995	15
BENZENE	0	-	5.800000191	1.607014308	14
BIS (2-CHLOROETHYL) ETHER	0.001	-	45	14.02624983	10
BROMOFORM	0.0003	-	5.800000191	2.860430015	10
BROMOMETHANE	0.0116	-	58.59999847	24.31015973	10
CARBON TETRACHLORIDE	0	-	11.69999981	3.070138479	13
CHLOROBENZENE	0	-	11.69999981	2.549857155	14
CHLOROETHANE, TOTAL WEIGHT	0	-	58.59999847	14.37121962	10
CHLOROFORM	0	-	21.44000053	7.350373399	15
CHLOROFORM, DISSOLVED	0.236000001	-	34.97999954	8.112599951	10
CHLOROMETHANE	0.0137	-	58.59999847	23.20036974	10
CIS-1,3-DICHLORO PROPENE	0.0074	-	29.29999924	7.652539905	10
DIBROMOCHLOROMETHANE	0.0002	-	5.800000191	2.374741667	12
DICHLOROBROMOMETHANE	0.001	-	67.69719696	2.348946114	65
ETHYL BENZENE	0	-	0	0	4
ETHYLBENZENE	0.0003	-	29.29999924	7.90842988	10
METHYL BROMIDE (BROMOMTHANE)	0.0007	-	0.0008	0.00075	2
METHYL CHLORIDE (CHLOROMETHANE)	0	-	0.0023	0.000542857	7
METHYLENE CHLORIDE	0	-	11.69999981	2.444811122	18
TETRACHLOROETHENE	0	-	5.800000191	1.548650014	20
TOLUENE	0	-	18.20000076	3.544285808	7
TOLUENE, DISSOLVED	0.0003	-	29.29999924	9.312724898	8
TOTAL VOLATILE POLLUTANTS	0.003	-	0.034000002	0.012000001	4
TRANS-1,3-DICHLORO PROPENE	0.0003	-	29.29999924	7.8560199	10
TRICHLOROETHENE	0	-	2.900000095	0.657082122	19

Parameter Name	Range of Max Quantity Reported			Mean Max Quantity	Count Of Max Quantities
TRICHLOROETHYLENE, DISSOLVED	0.0003	-	5.800000191	2.262425019	8
VINYL CHLORIDE	0	-	29.29999924	6.676493253	15
VOLATILE COMPOUNDS, (GC/MS)	19	-	77.19999695	45.37499952	4

Table 1.5.2-7 shows that total suspended solids (TSS) loads are the highest of any parameter and have the greatest number of reported quantities. Total suspended solids are related to the turbidity parameter group. Turbidity is another indicator of particulates in the water supply, but it is a more meaningful measure of performance in drinking water treatment. Maximum and average ammonia loads are greater than phosphorus loads. The table also indicates the various volatile organic compounds (VOCs) and synthetic organic compounds (SOCs) discharged into the Delaware River. Vinyl chloride has the single greatest VOC discharge of 6.7 pounds per day (lbs./day). Relative to the other VOC discharges, acrylonitrile and acrolein are also large average quantities. Total phenols are the largest discharged quantity for the SOCs. Otherwise, quantities of SOC discharges are similar. Of the metals, iron is clearly the largest discharged quantity. High maximum quantities are also reported for aluminum, total chromium, total copper, total lead, total nickel, and total zinc. Chromium and lead pose the greatest risk in drinking water.

1.5.2.3 RCRA/AST Facilities

As summarized in Table 1.5.2-8, RCRA facilities comprise many of the point sources in the Delaware River study area. However, only 387 of the 1,685 RCRA facilities are designated as large quantity generators (LQGs). Data describing the industry type or capacity of the facilities is limited. Taking into account the limited number of SIC codes, most RCRA facilities are dry cleaning plants, followed by chemicals and chemical preparations not elsewhere classified, and automotive transmission repair shops, electroplating, plating, polishing, etc., and top, body, and upholstery repair shops and paint shops. Relatively few RCRA sites were cited for violations. Capacity information for use in ranking sites is available for merely 58 sites, and contaminant information was not available. Reported capacities ranged from 2 to 25,000,000 gallons for the RCRA sites with available data.

Table 1.5.2-8 RCRA Facility Summary

Total RCRA Facilities	1685
Large Quantity Generators	387
Facilities with SIC Codes	265
Top 5 RCRA Industry Types by SIC Code 7216 – Dry Cleaning Plants 2899– Chemicals And Chemical Preparations, Not Elsewhere Classified 7537 – Automotive Transmission Repair Shops 3471 – Electroplating, Plating, Polishing, etc. 7532 – Top, Body, And Upholstery Repair Shops And Paint Shops	 37 10 8 7 7
RCRA Facilities with Violations	282
RCRA Facilities with Capacity/Volume Data	58
Range of Capacity	2 – 25,000,000 gallons 1 – 3,456,000 gal/day
Most Common Parameters/Contaminants	Not Applicable – no contaminants linked to RCRA downloads

As mentioned previously, RCRA data was supplemented with AST information from PADEP. PADEP AST data included useful and detailed information relating to tank age, contaminants, and volumes. AST data is summarized in Table 1.5.2-9.

Table 1.5.2-9 AST Facility Summary

Total AST Facilities	1526
AST Facility Overlap with RCRA Facilities	73
Total Number of Tanks	4674 Total/1904 ASTs
Tank Capacity Range	200 gal – 8 MG
Tank Age Range (years)	1 – 75
Number of Different Parameters/Contaminants	138
Most Common Parameters and Quantities by Number of Tanks Misc. Hazardous Substance Diesel Fuel Gasoline	 609 tanks/5.1 MG 235 tanks/6.7 MG 192 tanks/18.1 MG
Most Common Parameters/Contaminants and Quantities by Total Volume Heating Oil Gasoline Diesel	 78 MG 18 MG 7 MG

Table 1.5.2-9 shows that 1,526 facilities throughout the Delaware River SWAP study area have aboveground storage tanks on-site. Of those facilities, only 73 overlap with the RCRA facilities. This may be due to RCRA sites also having underground storage tanks on-site. The AST data is useful for characterizing potential contaminant sources in the watershed. Tanks range in capacity from 200 gallons to 8 million gallons and range in age from 1 to 75 years old. Older tanks may pose a greater risk for spills and leaks. The tanks contain 138 different substances. The most common of these by volume is an unidentified hazardous substance, followed by diesel fuel, and gasoline. The significance of these tanks as contamination sources depends on factors such as the total volume of substance at any one site, tank age, and the time of travel to the drinking water intake. These factors are considered in the intake-specific susceptibility ranking.

1.5.2.4 TRI Facilities

A summary of TRI sources is presented in Table 1.5.2-10. A facility is listed in the TRI if a chemical from the inventory is used or manufactured on site. These sites do not necessarily discharge the listed chemical(s). Data describing on-site chemicals, quantities of chemicals used or manufactured in a given year, and releases to air, water or the ground is available for the TRI sources.

Table 1.5.2-10 indicates that 507 TRI facilities are found in the Delaware River SWAP study area. A SIC code is identified for 504 of these industries. SIC codes are linked to activities that PADEP identified in the state SWAP document. Based on activity, most

TRI facilities are chemical manufacturers, machine/metalworking shops, or plastics manufacturers.

Chemical and quantity data is very complete for the TRI facilities, however quantities are presented as ranges. Ammonia, copper, toluene, phosphoric acid and nitric acid are the most common chemicals listed by the various TRI sites. Release information was available for 312 of the TRI facilities. A company by the name of Horsehead Development Co. Inc. has the greatest number of reported releases. The Zinc Corp. of America and Ashland Chemical Inc. have the next highest numbers of reported releases.

Table 1.5.2–10 TRI Facility Summary

Total TRI Facilities	507
Facilities with SIC Codes	504
Top 3 Industry Types by Activity Chemical Manufacturing Machine/Metalworking Shops Plastics Manufacturing	 115 83 63
Top 3 TRI Industries by SIC Code 2819 2899 2851	 15 15 15
Facilities with Quantity Data	12
Most Common Parameters for Facilities with Quantity Data Ammonia Copper Toluene Phosphoric Acid Nitric Acid	 37 20 17 16 14
Facilities with Release Data	312
Facilities with Greatest Number of Releases Horsehead Development Co. Inc. Zinc Corp. of America Ashland Chemical Inc.	 168 releases to water 168 releases to water 105 releases to water

1.5.2.5 CERCLA Facilities

Although data characterizing CERCLA facilities in the SWAP study area is limited, Table 1.5.2-11 summarizes the available information. While 655 CERCLA facilities are located within the study area, only 34 are on the final National Priority List (NPL). Information for 35 of the CERCLA facilities is available through the RCRA and TRI databases, where those facilities are also listed. Only 63 sites are found in the floodplain. Since information on the Superfund sites is so limited, these sites are screened or ranked subjectively for the intakes. The low number of NPL sites and sites in the floodplain is considered in the subjective screening.

Table 1.5.2–11 CERCLA Facility Summary

Total Number of CERCLA Facilities	655
Number on the NPL List	34
Number also listed as RCRA	29
Number also listed as TRI	6
Number in Flood Plain	63

1.6 Identification of Restoration Efforts

Key Points

- **Federal, State and private grants have provided almost $20 million for environmental projects within the Delaware River SWAP study area over the past several years.**
- **Grants were awarded to 54 recipients, with county and municipal groups receiving the majority of funds.**
- **Almost 60% of the grants awarded were used for protection projects.**

In order to gain an understanding of the current levels of environmental stewardship and awareness within watersheds, a compilation of grants and restoration projects was completed. State, Federal and private grant sources identified the levels of funding that they provided through various programs to respective watersheds within the Delaware River SWAP study area from 1995 to 2001.

These programs include the Pennsylvania Department of Environmental Protection's (PA-DEP) 319 Nonpoint Source Program, the Growing Greener Program, the Pennsylvania Department of Conservation and Natural Resource's (PA-DCNR) Rivers Conservation Plan Program, and Pennsylvania's Coastal Zone Management Program. Also included were Pennsylvania's Natural Resources Conservation Service's (NRCS) Conservation Reserve Program (CRP), Wetlands Reserve Program (WRP), Watershed Protection and Flood Prevention Act (PL-566) Program, and the Environmental Quality Incentives Program (EQIP). In addition, private sources of funding were also compiled, including the William Penn Foundation, the Pew Charitable Trusts and The Pennsylvania League of Women's Voters. Additional sources of funding included New York State DEP, New York City DEP, and New Jersey DEP funds. Federal funds via the Army Corps of Engineers (USACOE), the United States Environmental Protection Agency (EPA), the United States Fish and Wildlife Service (FWS), and the National Science Foundation (NSF) were also investigated.

From the data received, the Delaware River SWAP Study Area had a total of $19,167,802 awarded within its boundaries for the time period of 1995 to 2001, with most of the grant dollars being awarded post-1997.

Figure 1.6-1 Distribution of Grant Dollars Within the Delaware River SWAP Study Area

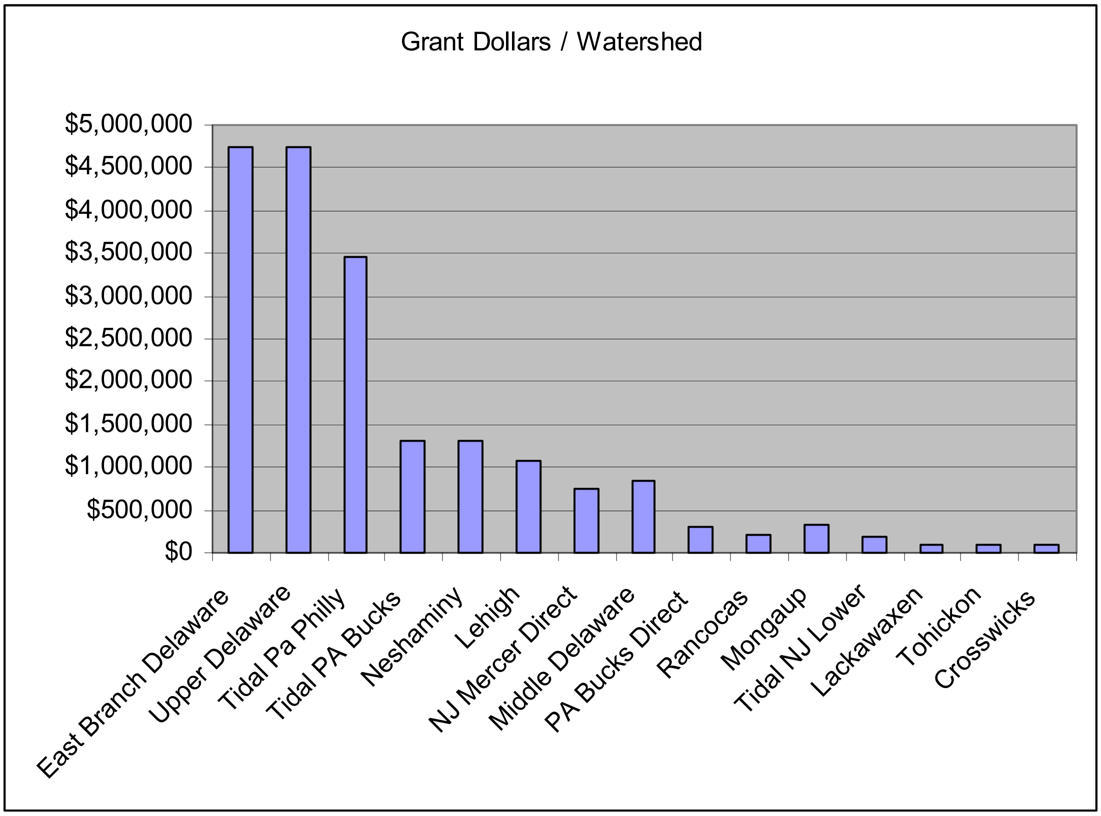


Figure 1.6-2 shows the grant dollars broken up by dollars for each study area subwatershed. The East Branch Delaware and the Upper Delaware Watersheds both ranked first in terms of grant dollars, with a total of $4,751,250 awarded to each. These watersheds are the location for two large reservoirs, Cannonsville and Pepacton, which provide an unfiltered source of drinking water for New York City. In order for New York City to use this supply as an unfiltered source, they must provide an extreme level of watershed protection. This effort is reflected in the amount of restoration and protection money spent in these watersheds.

Figure 1.6-2 Grant Money per Capita Awarded Within Each Delaware River SWAP Study Area

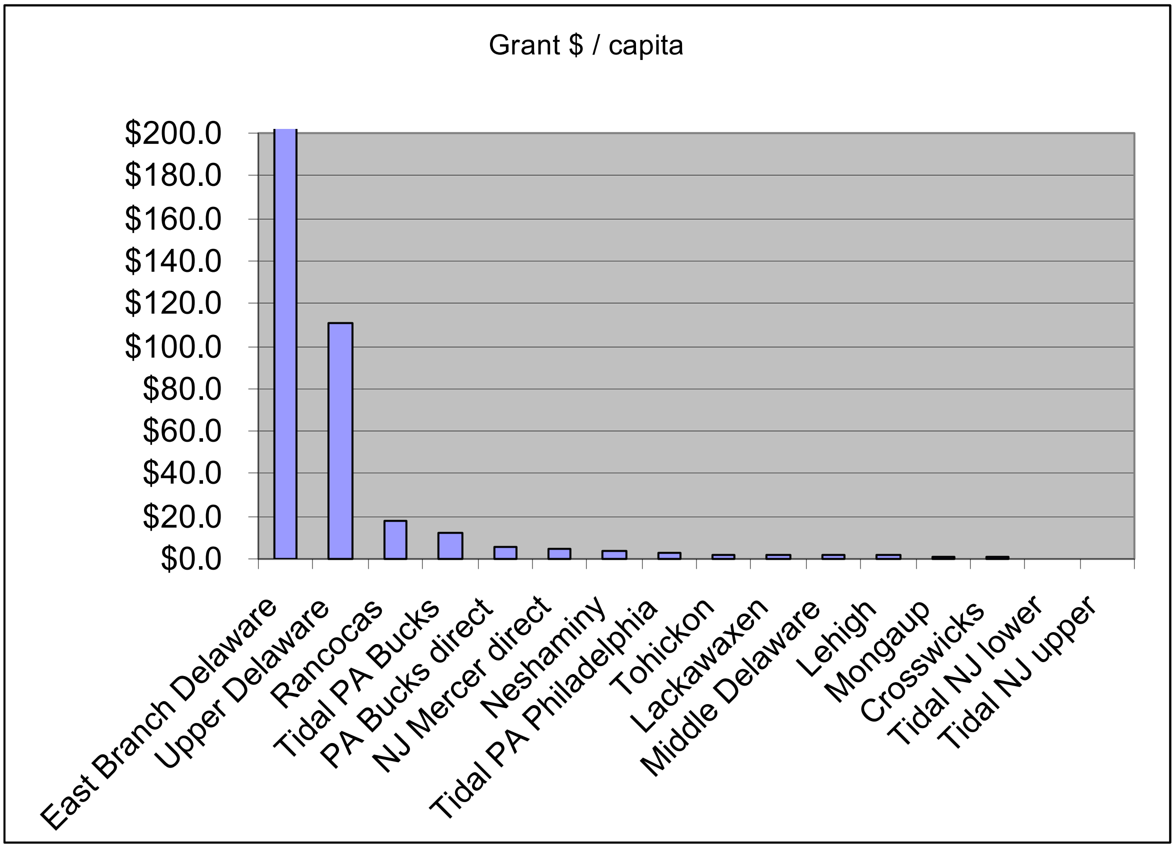
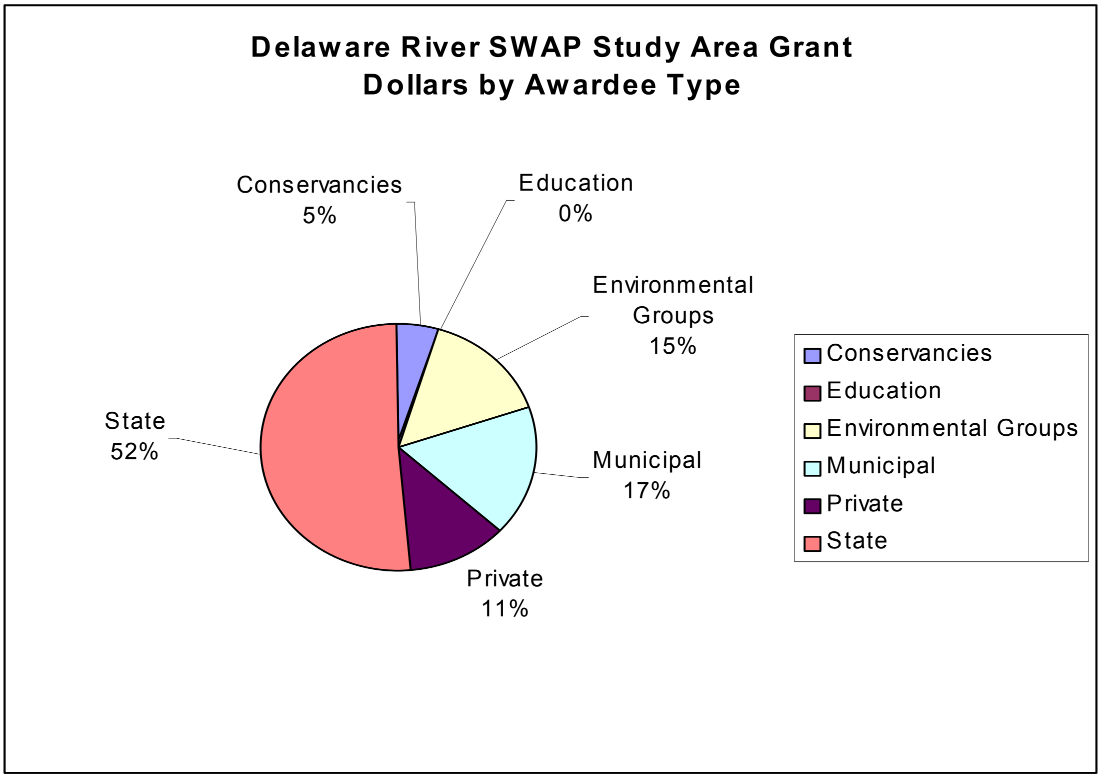


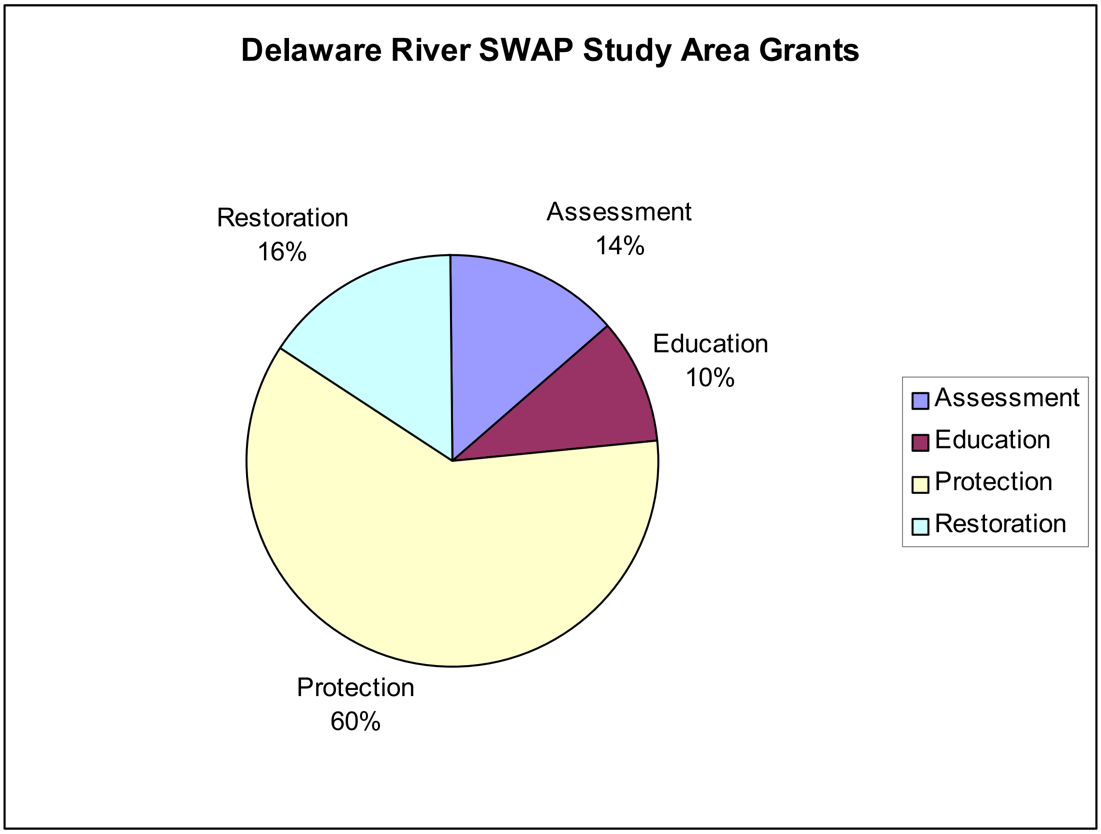
Figure 1.6-2 shows the amount of effort that New York City/State have done in the headwaters of the Delaware River. These areas are not heavily populated, but provide the majority of water for the citizens of New York City. This tends to skew the results, because more people benefit from protection efforts in those areas than depicted because they are located outside of that watershed (New York City).

Figure 1.6-3 Distribution of Delaware River SWAP Study Area Grants by Recipient Type



This figure shows that a majority of funds (52%) were given to state agencies. The vast majority of these funds are related to New York City transferring funds to New York State to provide protection efforts in the headwaters of the Delaware River for Canonsville and Pepacton Reservoirs.

Figure 1.6-4 Distribution of Delaware River SWAP Study Area Grants by Project Type



1.7 Public Participation Process

Key Points

- **Public kick-off meetings, Technical Advisory Group meetings, media articles and a web site are some of the methods used to involve the public in the SWAP.**

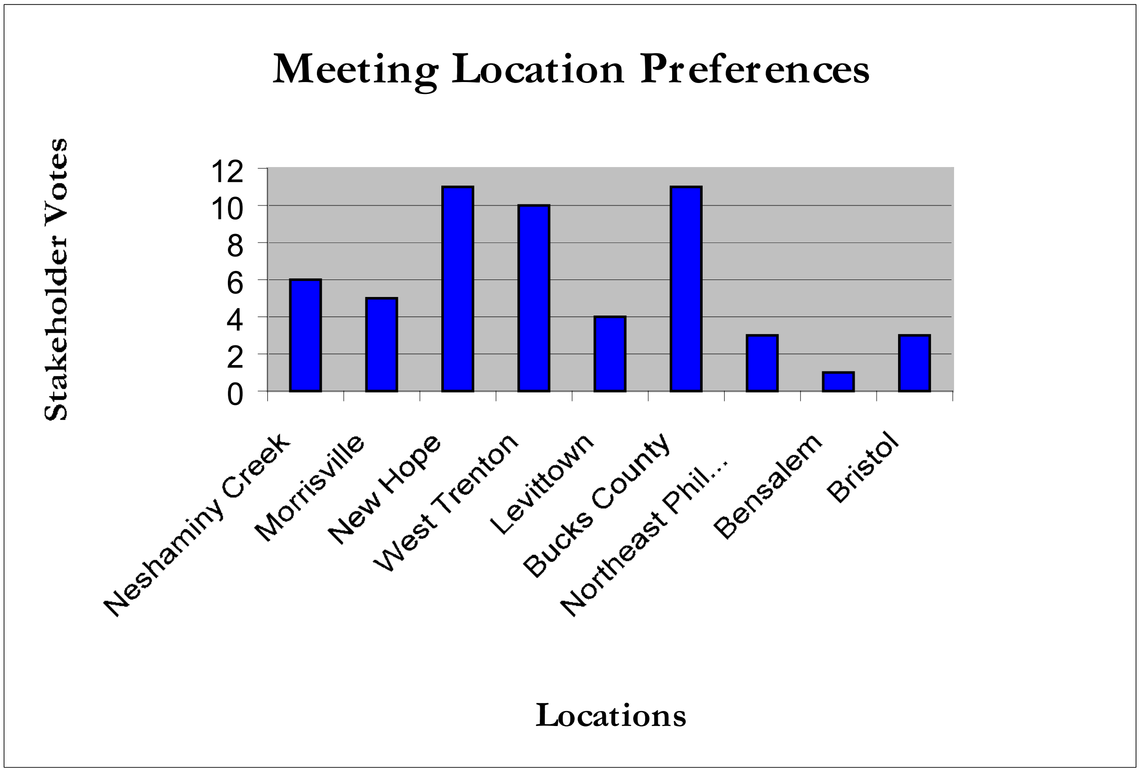
Several avenues will be available for stakeholder and public involvement throughout the Delaware Source Water Assessment Program. These include:

- Public kickoff meetings
- Public wrap-up meetings
- Technical advisory group meetings
- Legal notices
- Newspaper articles
- SWAP web site

This multi-faceted approach provides opportunities for the partnership to introduce the public and stakeholders to the source water assessment program and process, and for the partnership to obtain information and feedback from the public. In the past, these avenues appear to have been moderately successful at reaching interested public and stakeholders. One public meeting has resulted in 34 attendees, two advisory group meetings resulted in 23 attendees, 12 legal notices have been published, two newspaper articles have been published about the project, and the web site has been accessed 146 times to date. More public meetings discussing the ongoing assessment will take place in the near future

One of the important goals of gathering stakeholder input during the initial stages of the public participation process is to develop a framework for the meetings to ensure that they are optimally effective. According to the results of the first round of surveys distributed to gather stakeholder input, the best time for the stakeholders to meet is during the day (either morning or afternoon) and most would prefer to meet in the New Hope, West Trenton, or Bucks County areas. The following figure illustrates the amount of stakeholder votes each location received.

Figure 1.7-1 Meeting Location Preferences



1.7.1 Advisory Groups

Key Points

- **An open Technical Advisory Group (TAG) has been established to facilitate communication among stakeholders and to gather information about the watershed.**
- **The TAG meets quarterly to assist the Source Water Assessment Partnership in the SWAP process.**

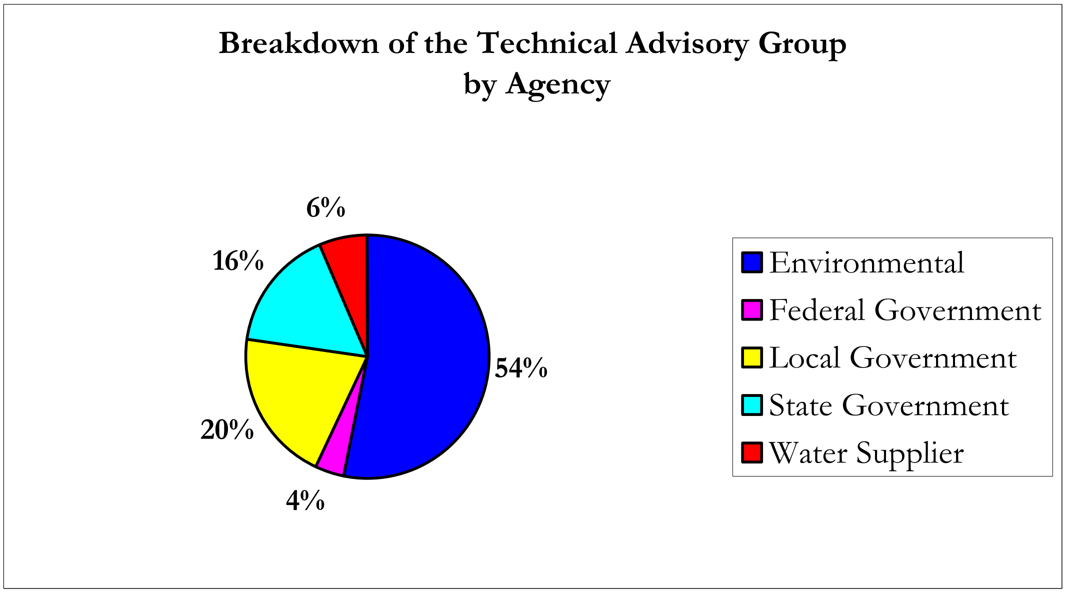
To better facilitate communication among the Source Water Assessment Partnership and the regions of the Delaware River Watershed to be assessed, an open Technical Advisory Group (TAG) has been formed. This TAG was developed by the partnership as a way to closely interact with the stakeholders, and in turn, to gather integral information about each region of the Delaware River Watershed. All of the stakeholders have been invited by the partnership to participate. Meeting quarterly, it is the primary responsibility of the TAG to inject public interest into the SWA process. Other duties of this group include:

- Sharing information with stakeholders
- Verifying the information put forth by the partnership
- Providing input on the assessment techniques and criteria used by the partnership
- Offering general information regarding the areas local to each TAG
- Participating in public outreach and education
- Describing current protection activities
- Identifying "potential" sources of contamination and preservation
- Assisting in the development of summary reports

Technical Advisory Group Participants

Composed of watershed organizations, public interest groups, dischargers, suppliers, and local government agencies, the TAG offers a broad variety of perspectives and visions. The following graph is illustrative of the various types of agencies participating in the Technical Advisory Group (see Figure 1.7.1-1).

Figure 1.7.1-1 Technical Advisory Group Breakdown



The following is a summation of some of the TAG's participants:

It is the mission of the ***Department of Environmental Protection (DEP)*** to protect the air, land, and water of Pennsylvania from pollution, and to provide for the health and safety of its citizens through a cleaner environment. DEP works as a partner with individuals, organizations, governments, and businesses for the prevention of pollution and the restoration of natural resources. It achieves these goals via public service, protection, teamwork, communication, and pollution prevention. DEP is the state agency largely responsible for administering Pennsylvania's environmental laws and regulations. Its responsibilities include: reducing air pollution; making sure that drinking water is safe; protecting water quality in Pennsylvania rivers and streams; making sure waste is handled properly; managing the Commonwealth's recycling programs and helping citizens to prevent pollution and comply with the Commonwealth's environmental regulations. DEP is committed to general environmental education and encouraging effective public involvement in setting environmental policy.

PennFuture is an organization that takes pride in defending the environment. In achieving its mission of defending nature, PennFuture effectively resists those who attack the environment and rallies against those who fail to do their duty to protect it. By combating global warming, smog, acid rain, and illness, and by advocating the increase of desperately needed funding for farmland preservation, among other things, PennFuture is making great strides in assuring that polluters and their allies no longer decide the fate of the environment and the economy. Comments and concerns may be voiced to Brenna Herpmann at (800) 321-7775. PennFuture's mailing address is 212 Locust Street, Suite 410, Harrisburg, PA 17101.

In order to share the responsibility of managing the water resources of the Delaware River Basin, the ***Delaware River Basin Commission (DRBC)*** was formed by the signatory parties of the Delaware River Basin Compact (Delaware, New Jersey, New York, Pennsylvania, and the United States). Since its inception on October 27, 1961, the very day that Compact became law, DRBC has been a pacesetter in environmental protection. As mentioned in its mission statement, DRBC focuses mainly on protecting, enhancing, and developing the water resources of the Delaware River Basin for the benefit of present and future generations. In achieving their mission, DRBC has developed such programs as water pollution abatement, water supply allocation, regulatory review (permitting), water conservation initiatives, regional planning, drought management, and flood control. Questions, comments, and concerns may be forwarded to Jon Zangwill via e-mail, zangwill@drbc.state.nj.us or telephone, (609) 883-9500 x 307. DRBC's mailing address is 25 State Police Drive, West Trenton, NJ 08628.

Clean Water Action (CWA) is a national citizens' organization that works toward the following goals: affordable water, prevention of health-threatening pollution, creation of environmentally safe jobs and businesses, and the empowerment of people to make democracy work. In addition, CWA organizes grassroots groups, coalitions, and campaigns with the common interest of protecting health and quality of life, so that they may better promote environmental well-being within a community. The mailing address of the CWA National Office is 4455 Connecticut Avenue NW – Suite A300, Washington, DC 20008-2328 (Telephone: (202) 895-0420). The mailing address of the CWA Philadelphia Office is 1201 Chestnut Street, #602, Philadelphia, PA 19107. All inquires may be directed to Bob Wendelgass at the Philadelphia Office via e-mail, bwendelgass@cleanwater.org or telephone, (215) 640-8800.

It is the mission of the ***Pennsylvania Environmental Council (PEC)*** to improve the quality of life for all Pennsylvanians. In doing so, PEC enhances the Commonwealth's natural and man-made environments by integrating the advocacy, education, and implementation of both community and regional action programs. Director of Watersheds Programs, Ann Smith, will be accepting questions, concerns, and comments at (215) 563-0250. The mailing address of the PEC is 117 South 17th Street, Suite 2300, Philadelphia, PA 19103-5022.

Founded in 1989, The ***Delaware River Greenway Partnership*** (DRG) promotes awareness and protection of the river and other natural resources by encouraging both public and private stewardship of the Delaware River and the greenway that surrounds it. Among the DRG's current projects are: *Bridging Our Lower Delaware*, *Delaware River Heritage Trail*, and *Annual Education Reform*. The DRG also publishes a quarterly newsletter, the *Delaware River Greenway News*. The DRG can be contacted by telephone at (908) 996-0230.

The ***Bucks County Sierra Club*** is an organization that works to protect the county's land, air, and water resources by encouraging Bucks County residents to take an active role in making elected officials recognize the importance of these resources and prevent further damage to them.

The mission of the ***Bucks County Water and Sewer Authority*** is to provide quality service in an environmentally safe manner at an affordable rate, and to educate their current and future customers on water conservation. The authorities' ongoing goals include: maintenance of their commitment to affordable rates and excellent service levels, meeting or exceeding all environmental and public health standards, continual seeking and identification of cost saving procedures without the sacrifice of quality, and the education of customers, neighbors, and the communities' children in that water is a limited resource and should be treated as one of our most valuable commodities. The *Bucks County Water and Sewer Authority* was founded by the Bucks County Commissioners in 1962 to support local municipalities with the installation of water and sewer service. As a non-profit agency carrying out an enterprise role, no tax money is involved in the operation of this (or any) authority; all income is derived by billing the people who utilize their services. Consequently, those not making use of the service do not pay towards it; also known as "user pays." The good news is, as an "Authority", it only charges its customers the cost to operate the service.

The ***Stroud Research Center*** uses its advanced knowledge of stream and river ecosystems to provide solutions for water resource problems around the world. The center uses extensive education programs, conservation leadership, and its professional services to promote public understanding of freshwater ecology and to develop new ideas and hypotheses to improve the environment. Included in Stroud's mission statement are: the advancement of knowledge of stream and river ecosystems through interdisciplinary research, the development and communication of new ecological ideas, hypotheses or theories, the provision of solutions for water resource problems worldwide, and the promotion of public understanding of freshwater ecology through education programs, conservation leadership and professional service. The Stroud Center can be contacted via telephone at (610) 268-2153 or fax at (610) 268-0490. The mailing address for the center is 970 Spencer Road, Avondale, PA, 19311. Comments and concerns may also be voiced via e-mail at Webmaster@Stroudcenter.org.

Since it's beginning in 1969, the ***Catskill Center for Conservation and Development*** has worked as a non-profit organization to inform the public of issues concerning the conservation of the resources of their area. Public forums are used to encourage the public to get involved with these issues, and to help foster a deep appreciation for the environment in which they live. Centering on environmental protection and sustainable economic development has helped the organization to protect the cultural, historic, and natural resources of the Catskill Mountains. Merging both environmental protection and sustainable economic development, the organization is a campaigner for the region's vital main streets, valuable natural resources, artistic and historic assets, and working landscapes. They achieve this through four main program areas; *Natural Resources and Land Conservation, Education, Community Planning and Development, and Regional Culture and Arts.* The Catskill Center can be reached via telephone at (845) 586-2611. It is located in Arkville, New York.

Funded in 1959, ***Trout Unlimited's*** mission statement is "to conserve, protect and restore North America's trout and salmon fisheries and their watersheds." The organization accomplishes this mission through an extensive volunteer network. With 125, 000 volunteers in 500 chapters nationwide, the organization works directly through professionals who testify before congress and intervene in federal legal proceedings to ensure they are involved in conservation issues. The drive of the organization is to protect our rivers and fisheries for generations to come. Trout Unlimited can be reach by telephone at (703) 522-0200 and by fax at (703) 284-9400. The mailing address is 1500 Wilson Blvd., #310, Arlington, VA, 22209-2404. Questions and comments can also be sent via e-mail at trout@tu.org.

The ***Heritage Conservancy***, formerly known as the Bucks County Park Foundation, was founded in 1958 when concerns about the rapid loss of open space in Bucks County started to arise. Since that time, the conservancy has been dedicating its time and efforts to protecting the counties natural and historic heritage. By partnering with citizens, businesses, and government agencies, the conservancy has become a leader in land conservation and historic preservation. The organization achieves these environmental goals through a process of assessing potential sites, educating the public, and implementing actions to improve our natural habitats. The Heritage Conservancy can be contacted by phone at (215) 345-7020 and by fax at (215) 345-4328. The mailing address is 85 Old Dublin Pike, Doylestown, PA, 18901.

Created as a chapter of the National Audubon Society in 1969, the ***Bucks County Audubon Society*** has set out to create a sense of need for environmental change. Since their start, the BCAS has been protecting the environment, educating the public on ways to better conserve their natural resources, and promoting the wise use of land, water, and air. With over 2300 members, BCAS is one of the chief citizen membership groups representing environmental and ecological interests in Bucks County. The mailing address for the Bucks County Audubon Society is 6234 Upper York Road, New Hope, PA, 18938. BCAS can also be reached by phone at (215) 297-5880 or by fax at (215) 297-0835. All e-mail can be directed to bcas@bcas.org.

The ***New Jersey Audubon Society*** works to instill a sense of environmental conservation in New Jersey's citizens to protect the plants, animals, and natural resources of their state. Though not associated with The National Audubon Society, the NJAS has set forth to conserve the natural environment through education programs and information services, as well as to increase the public's knowledge of New Jersey's flora and fauna through extensive field work. As one of the oldest independent audubon societies, the NJAS has made every effort to protect threatened and endangered species and has also established and maintained wildlife sanctuaries and education centers. The mailing address for the NJAS is: New Jersey Audubon Society Headquarters, 9 Hardscrabble Road, PO Box 126, Bernardsville, NJ 07924. Questions and concerns can also be direct via telephone at (908) 204-8998 and through e-mail at hq@njaudubon.org.

The ***National Audubon Society of New York State*** works on local, state, and national levels to provide protection for birds, forests, wetlands, and wildlife. The statewide council advocates and educates the proper management of wildlife and their habitats to help improve the environment. The National Audubon Society of New York has, since its foundation, significantly increased its financial and staff commitments to centers and education. They are looking at the broadest possible range of opportunities to meet their goals of continued growth in the area, under the principle that realistic center growth must provide results that are fiscally advantageous, operationally practical and educationally sound. The society can be reached via telephone at (518) 869-9731, fax at (518) 869-0737, and by means of e-mail at nasnys@audubon.org. The mailing address is 200 Trillium Lane, Albany, NY 12203.

The ***New Jersey Farm Bureau*** represents the agricultural producers and enterprises of New Jersey. Their goal is to create positive public relations, influence laws and regulations, and to seek out activities and ventures that benefit the welfare of the producer members. In their mission, the New Jersey Farm Bureau states that their mission is to represent the agricultural producers and enterprises of New Jersey at all levels of government – local, county, state, federal, and international. The bureau's mailing address is 168 West State Street, Trenton, New Jersey, 08608. They can also be reached by phone at (609) 393-7163 and by fax at (609) 599-1209.

Pennsylvania-American Water Company is committed to providing quality water, services, and products to their customers while trying to maintain the environment in which we live. The company works hard to focus on personal solutions and to exceed the expectations of their clients in the services they provide. In their mission they state that they will "continually build ever-increasing value for their shareholders and their customers in the business of water resource management." The PAWC can be reached via their toll-free number at (800) 565-7292.

It is the mission of the ***Wildlands Conservancy*** to protect vital open spaces, watersheds, wildlife, and farmlands in Pennsylvania. The organization is dedicated to the preservation of rivers, land, and trails through public education programs. The efforts of this member-supported organization have produced over 31, 000 acres of permanently protected open spaces in eastern Pennsylvania. The Conservancy is also working to protect Pennsylvania's waterways and care for injured or orphaned wildlife. Questions and concerns can be voiced through phone at (610) 965-4397 or fax at (610) 965-7223. The mailing address for the conservancy is 3701 Orchid Place, Emmaus, PA 18049.

Established in 1996, the ***Partnership for the Delaware Estuary*** was created to coordinate the protection and enhancement of the Delaware River Estuary. The partnership has taken a leadership role in promoting the conservation of this natural resource to help contribute to the usefulness of the estuary for environmentally friendly recreational purposes. By increasing the publics awareness and understanding of this important natural resource, the partnership is encouraging enhancement and protection throughout the Delaware Estuary. Comments, questions and concerns can be directed to Kathy Klein via e-mail at partners@udel.edu. The Partnership for the Delaware Estuary may also be reached through its toll-free number at 1-800-445-4935.

New Jersey Futures was formed in 1987 to serve as the watchdog over the state's development and redevelopment plans. This nationally recognized promoter of open space protection has become a leader in the fight for smarter land use. NJF is also working with the state of New Jersey on a plan to become the nations first "sustainable state:" a plan that incorporates the balance of economic, environmental, and social goals of the state. The organization is working hard to develop a strong economy, and a healthy natural environment. The mailing address for NJF is New Jersey Future, 114 West State Street, Trenton, NJ, 08608. Questions and concerns can be voiced via e-mail to njfuture@njfuture.org. The organization can also be reached by telephone at (609) 393-1189 and by fax at (609) 393-1189.

Technical Advisory Group Meetings

Three TAG meetings were held as of April 2001. The following table outlines the date, location, and number of attendees at each meeting.

Table 1.7.1-1 Summary of Technical Advisory Group Meeting Dates and Locations

Meeting	Date	Location	Number of Attendees
1	May 16, 2001	Delaware River Basin Commission Offices West Trenton, NJ	14
2	November 8, 2001	Bucks County Water & Sewer Authority Offices Warrington, PA	9
3	May 14, 2002	Bucks County Water & Sewer Authority Offices Warrington, PA	
			Total Attendees 23

Summarization of Technical Advisory Group Meeting Minutes

These meetings are, in essence, forums for discussion during which local stakeholders are encouraged to voice their concerns and share their opinions of the project. The following is a summation of the minutes from the first two meetings:

MEETING 1

This meeting acted as an introduction to the Delaware River Watershed as well as to the Source Water Assessment Program. The meeting both summarized the Delaware River and its intrinsic values as well as reviewed the operation and challenges of a water treatment plant. The watershed of the Delaware River was said to be a home to over seven million people, composed of 1,450 industrial and municipal dischargers in which wastewater treatment accounts for 98% of the total discharge to the estuary. It was also stated that 17.5 million people rely on the Estuary's surface water intakes for drinking water; most of the water being distributed throughout New York City. The estuary was cited as a source of heritage, history, culture and recreation for the region. In evaluating the operation and challenges of a water treatment plant, the Baxter WTP was broken down and analyzed. The plant was undergoing capitol construction; therefore, a review of its current and future conditions took place.

The specific aspects of the Delaware River Watershed as a source of drinking water supply are as follows:

- It is comprised of eight large surface water intakes.
- Over 600,000 MGD is withdrawn on average from the river and its tributaries (not allocated)
- It serves over 17.5 million people

The Source Water Assessment (SWA) was explained to be an iterative, continuous, and multi-phase process. The process aids in the identification of "potential" and/or existing sources of contamination, evaluates the vulnerability/susceptibility of the water supply to contaminant sources, and determines protection priorities and activities for the water supply. The ultimate goal of the SWA was specified as developing local sources of water protection initiatives involving both water suppliers and the public and educating the public about the source of their drinking water as well as its pertinent challenges.

Utilities and stakeholders were encouraged to become interested in the SWAs because the program was based on federal regulations mandated by Congress. Responding to requests by the public to know more about their water supply and how to protect it, Congress included provisions for a SWA within the Safe Drinking Water Act Reauthorization of 1996. It is the goal of Congress to have 50% of the United States population enveloped under Source Water Protection Plans by 2005.

The SWAs were said to benefit the stakeholders present at the meeting because stakeholders of the TAG would be directly involved by:

- Identifying sources of contamination and areas for protection
- Having their organization highlighted for interested persons to contact/join
- Determining potential linkages between their efforts and protection efforts
- Increasing potential funding opportunities for communities and watershed groups by incorporating projects into approved SWA plans

The point was made that source water advisory group participation is an integral piece in determining the success of the project. This group meets quarterly throughout the length of the project, provides public input into the process, and helps determine public outreach. A number of tasks that the stakeholders can do in order to assist in the source water assessments were also listed. These tasks, such as listing water source issues, providing pictures or tours of areas of concern, and providing input on ranking criteria were summarized. Final products and purposes of the project were also reviewed. The following table illustrates these specific final products.

Table 1.7.1-2 Final Products and Purposes

Product	*Type*	*Audience*
SWA Report	Technical	Water Supplier & Public Agencies
Summary Report	Educational/Motivational	Public
Maps/Coverages	Technical	Water Supplier & Public Agencies Watershed
Source Water Partnership	Educational/Motivational/Technical	All Stakeholders

It was also stated at the meeting that due to an inaccuracy in the federal databases, source issues must be "groundtruthed". In doing so, many things will be looked at including:

- Thousands of point sources and regulated facilities
- Dozens of wastewater plants
- Hundreds of farms
- Non-point source potential
- Numerous other sources typically identified

Another topic of consideration is source water protection issues. The following table outlines various issues as well as their possible sources:

Table 1.7.1-3 Source Water Protection Issues

Issues	*Possible Sources*
Pathogens-*Giardia/Cryptosporidium*	Sewage, livestock, & wildlife
Algal Blooms/Nutrients	Sewage, agriculture, lawncare, golf courses
Metals-Manganese	Acid mine drainage
Chloride & Sodium	Road salts/highways
Pesticides/Herbicides	Lawn care, right of ways, agriculture
MTBE/Bromide/DBP Precursors	Cars & recreational watercraft

Operation and challenges of a water treatment plant were also discussed at the meeting. Specifically, the challenges of optimized water treatment during capitol construction and increased regulatory requirements. The Baxter WTP was broken down in order to assess the challenges it faces. Its current condition and historical treatment were outlined in detail and the areas for improvement were identified. Baxter, scheduled to undergo capitol construction for seven months, finished in June 2001.

The meeting finished with a series of questions and answers in which the stakeholders were able to voice their concerns and comments as well as inquire about the assessment.

A schedule and timeline were presented. The deadlines for the draft reports, which begin in April 2002, are marked for completion by January 2003. The following figure displays the breakdowns of the assessment and the schedule.

Figure 1.7.1-2 Assessment Schedule

Intakes Assessed

Water Supply	Draft Reports
PWD – Baxter	April 2002
PSWC – Bristol	October 2002
Morrisville	October 2002
Lower Bucks JMA	October 2002

Non-tidal/Tributary Intakes

Water Supply	Draft Reports
PSWC – Neshaminy	July 2002
Middletown – Chubb Run	July 2002
PA American – Yardley	January 2003
Bucks County Water	January 2003

MEETING 2

Meeting two was broken up into three main sections. They were:

1. *Delaware River Source Water Assessments*
2. *Contaminant Source Inventory*
3. *Susceptibility Analysis*

Zone Delineation's for tidal and non-tidal areas were covered under the Delaware River SWAs. Determining the zone delineation for the intakes is a difficult task due to their considerably large size. The zone delineation was therefore broken down into several sections for simplification. These sections that compose the breakdown are:

- Intakes (the eight intakes were broken down into tidal and non-tidal influence and by intakes on tributaries)
- Zone definitions (Zones A, B, and C)
- Time of travel for tidal, non-tidal, and tributary intakes
- A further breakdown of tidal intakes
- Additional incorporation of tributaries in tidal zone, non-tidal river intakes, tributary delineation, and water quality data were also present in the analysis

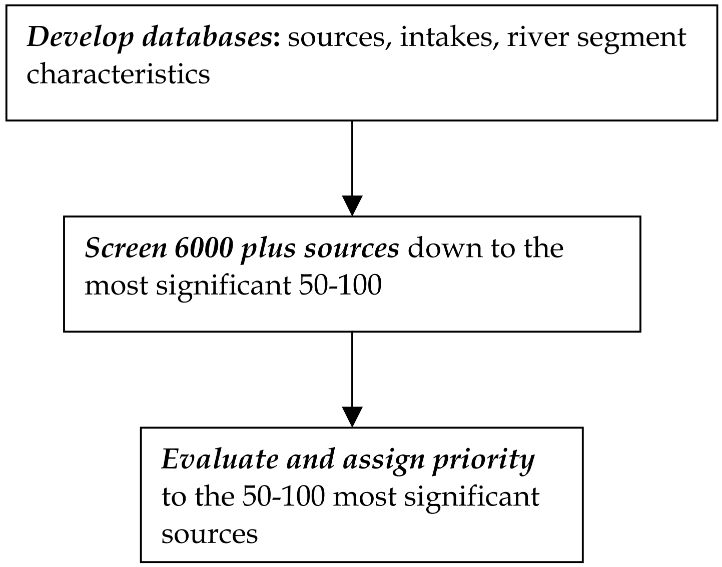
The next steps to take in the delineations were also discussed and include:

- Cleanup and refinement of the zones
- Beginning of data analysis
- Searching for electronic data or water quality studies to "groundtruth" suspected potential sources
- Working on stream impairment GIS and data for NJ

A contaminant inventory database compilation had been completed and was discussed at the meeting. Main web sites such as the "Right To Know Network" (RTK) and "Envirofacts" were utilized in the contaminant source compilation. Federal databases were accessed and data was downloaded. The data was downloaded by county, the data sites were then "clipped" in GIS to eliminate those outside of the watershed boundaries, missing "x-y" coordinates were filled in, facility data was cross-referenced, and quantity/contaminant data was populated.

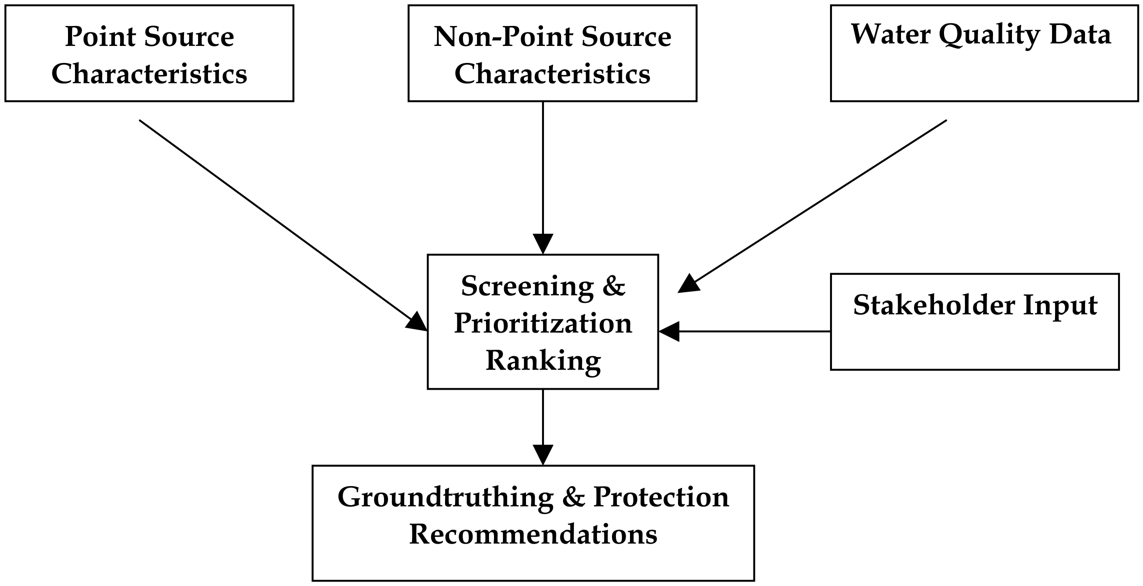
A susceptibility analysis overview was also presented at the meeting. The Delaware River Source Water Assessment proved to be a complex undertaking with the watershed covering 300 miles of river, as well as a 13,000 square mile watershed with more than 6,000 potential sources. The overall goal of the project is to understand which sources are most critical and which are less serious, understand present water quality concerns, focus energy on important sources, and result in a limited number of high priority sites. The general approach is comprised of three main steps, which are illustrated in the following figure (Figure 1.7.1-3):

Figure 1.7.1-3 Main Steps in the General Approach



This approach is based on and includes the approach of the Source Water Assessment and Protection Program of PADEP. It has been modified and formalized into the process that includes point sources, non-point sources, and "special categories" such as acid mine drainage, spills from railroads, and pipeline breaks. A technical approach or state approach was presented at the meeting and includes surface water and zone delineation, water quality analysis, a susceptibility analysis for the state which includes qualitative measures as well as available qualitative data. The Delaware River approach is inclusive of all the elements of the state approach but is more extensive. For example, the Delaware River approach is more quantitative than the state approach and is designed to handle thousands of potential sources. An illustration of the source water assessment simplified approach follows (see Figure 1.7.1-4). In this approach, stakeholder input is included in the "Screening and Prioritization Ranking" along with "Point and Non-Point Source Characteristics" and "Water Quality Data". After all four go through the "Screening and Prioritization Ranking", "Groundtruthing and Protection Recommendations" are then developed.

Figure 1.7.1-4 Source Water Assessment: Simplified Approach



A source priority ranking was completed utilizing the Evamix Evaluation Criteria Groups. The groups are comprised of:

- River Flow Related Criteria (2)
  - Location
  - Time of Travel
- User Related (1)
  - Potential Health Impact (combined ranking only)
- Intake Criteria (3)
  - Relative Impact (both intake and source related)
  - Removal Capacity (combined ranking only)
  - Impact on Treatment Operations (combined ranking only)
- Source Related (3)
  - Potential for Release/Presence of Controls
  - Potential Release Frequency
  - Violation Type/Frequency

Based on these, the stakeholder's criteria weightings are illustrated in the following table (Table 1.7.1-4):

Table 1.7.1-4 Stakeholder Criteria Weightings

Criteria	Min	Max	Average	Agreed
Relative Impact at Intake	5%	25%	13%	12
Time of Travel	2%	15%	7%	5
Existing Removal Capacity	3%	30%	13%	10
Impact on Treatment Operation	2%	30%	10%	10
Potential Health Impacts	10%	30%	20%	20
Potential for Release/Controls	3%	20%	10%	14
Potential Release Frequency	3%	20%	9%	14
Violation Type/Frequency	3%	20%	9%	10
Location	2%	20%	8%	5

The Delaware River approach employed four linked databases. In regards to the intake; location, stream segment, withdrawal data, and a list of contaminants where 50% MCL exceeded were included. In the stream segment were segment ID, position in stream, flow, and velocity. Lastly, the source included ID, location, stream segment, zone, quantity, concentration, contaminants, and likelihood of release.

Within the Delaware River approach it was necessary to assign pollutant categories. These categories are essential because the approach used cannot deal with thousands of sources, 42 intakes, and try to do this for all types of pollutants. The purpose of this approach is to assign one or more 10-pollutant categories to each source. This may be done using data from Federal or State Databases or through the use of SIC code and standard assumptions of pollutants related to SIC codes.

Advantages to the Evamix approach are that it helps to clearly define the alternatives under consideration, it requires a clear set of evaluation criteria, and it does not lose information because it accepts quantitative and qualitative data. Additionally, it organizes objective information into a clear set of scores, it segregates the subjective part of the evaluation into criteria weights, and it is flexible and simple in that it handles new data easily. Finally, the process is clear, defensible, and reproducible.

For this Delaware River approach, the Evamix results will be reviewed and "reality checked." Results for high-ranking sources will be added to other sources outside of the analysis (e.g., highway spills, pipelines, etc.). Furthermore, high-ranking sources will be flagged for follow-up data collection in a later phase to verify results.

The meeting again closed with questions and answers in which the stakeholders were able to present their concerns and provide input on the assessments.

1.7.2 Public Meetings

Key Points

- **Thirty-four people attended the first of several public kick-off meetings being conducted to introduce the SWAP.**

To date, one public kick-off meeting has been conducted to educate the public about the importance of the Delaware River Source Water Assessment Program (SWAP). This, along with each future public kick-off meeting will utilize the following general approach in order to generate public interest:

- Press releases produced by the Philadelphia Water Department and the local stakeholders will be sent to the local media and newspapers
- Legal notices will be sent to the local media and newspapers
- Advertisements will be published in the Pennsylvania Department of Environmental Protection (PADEP)'s *Update*

Hosted by local watershed organizations to promote a sense of credibility as well as to establish a connection with local residents, these meetings are, in essence, informational forums where members of the public are enabled to voice their concerns as well as share their visions for the project. The first public meeting held on November 15, 2001 sponsored by the Friends of the Pennypack Creek at the Holmesberg Baptist Church, yielded 34 attendees.

Standard meeting agendas have been developed and are followed at each meeting. This agenda generally consists of an introduction and an explanation of the purpose of the meeting. Another component of this agenda is an overview of source water assessments, which includes a brief, yet thorough, description of the SWAP as well as the areas to be assessed, i.e., the Delaware River Watershed. In addition, a discussion of contaminant source issues and water quality concerns is a keynote feature of the agenda. Finally, each meeting is concluded with an exercise in identification of potential contaminant sources, in which the attendees are asked to identify local sites that may impact the water supply. Examples of source water assessment issues are presented and photos of these examples are shown to aid the public in identification. Questions, concerns, and comments are addressed as they are raised.

Prior to these kick-off meetings, several avenues are pursued in an attempt to notify the public of their occurrence. Letters produced by the Philadelphia Water Department, local stakeholders, and watershed groups specifying the location and directions, date, time, and nature of the meetings are mailed to numerous stakeholders, including many of the businesses, government agencies, and environmental organizations located within or affected by the Delaware River Watershed. The information contained in these letters is also posted on the SWAP website, www.phillywater.org/delaware. To further generate public interest, various watershed groups and local stakeholders post fliers throughout their respective areas and send press releases to their local newspapers. Many of these local newspapers will feature articles describing the nature of the meetings as well as the outcome, when applicable. Legal notices detailing the location, time, and date of each meeting are printed in the local newspapers in each area with which the SWAP is affiliated, for the purpose of opening the meetings to everyone within the watershed. Table 1.7.2-1 is illustrative of the publications in which the legal notices have appeared thus far, the dates of publication, and the general areas reached.

Table 1.7.2-1 Legal Notices Published for Public Kickoff Meetings

Date of Notice	Publication Name	Area Reached
11/14/01	*Northeast Times Newsweekly*	Philadelphia, PA
11/14/01	*Far Northeast Times*	Philadelphia, PA

The articles featured in each newspaper clearly state the purpose of the meeting as well as the date and location of each meeting. The function of the SWAP is described as well as its derivation. The articles invite the public to share their visions of the project and the opportunity for attendees to contribute what they would like to see develop throughout the duration of the assessment. A contact number is also provided in the event that anyone might want to pursue more information on the source water assessments.

1.7.3 Website

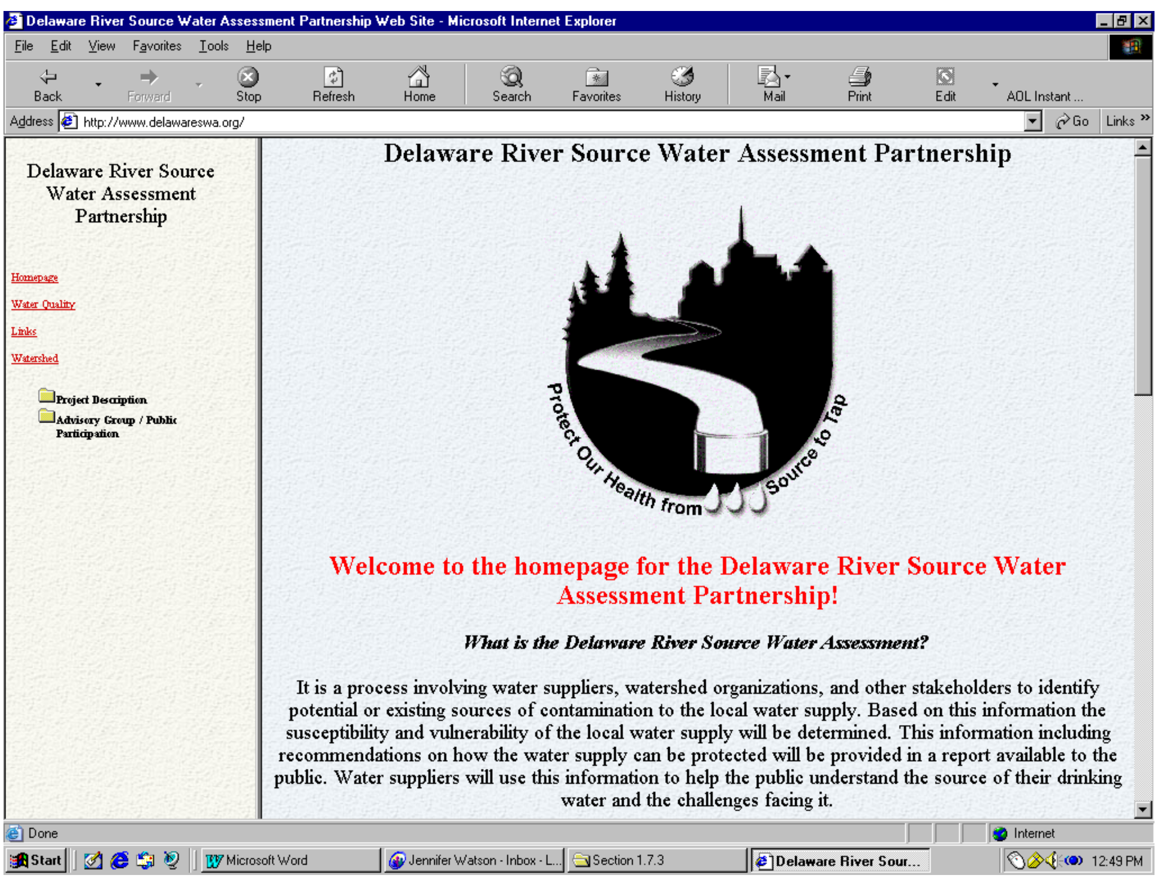
Key Points

- **SWAP project information is available through the project website, www.phillywater.org/delaware.**

A website has been developed for the project (www.phillywater.org/delaware*)* to provide a location where information about the project can be easily accessed by the public and stakeholders (see Figure 1.7.3-1). Although, this is a task beyond the scope of the contract, it is considered a necessary form of information delivery. Most importantly, the website is considered the most efficient way of providing the advisory group meeting information, meeting handouts, and meeting minutes without producing a significant burden of production on staff, given that there are many stakeholders to whom information must be mailed on at least a quarterly basis.

The website has been set up to provide general information about the purpose of the SWAP as well as contact information. It also provides links to information about public meetings, advisory group meetings, meeting materials, general watershed information, limited maps, watershed organizations, and general water quality information. Another special feature is an on-line stakeholder survey that stakeholders can fill out to provide information about their water quality issues.

Figure 1.7.3-1 Delaware River SWAP Website (www.phillywater.org/delaware)



1.8 General Recommendations for the Delaware River Watershed

The compilation of extensive field surveys, interviews with numerous stakeholders, and the examination of water quality, land use, and impaired stream information was compiled into the recommendations listed below for the Delaware River Watershed. These recommendations address 12 different categories, including general watershed protection ideas and specific activities related to watershed issues.

1.8.1 Grant Funding and Watershed Organizations

Based on the protection priority areas, restoration projects, and grant funding information available, it is apparent that there is a need for more restoration projects and watershed organizations for protection of the mainstem of the Delaware River between Trenton and Port Jervis. Efforts should be made via the Delaware Riverkeeper to promote development of local sponsors in these areas more effectively.

- Current grant funding appears to be focused appropriately on restoration with most of the grant money going to state organizations. It is recommended that the states make this money available to local municipalities to implement local protection efforts if these monies are not already available.

1.8.2 Protection and Preservation

- A coordinated regional protection plan needs to be developed and adopted by water suppliers, planning commissions, and municipalities for establishment and protection of sensitive and high priority protection areas to the multiple and overlapping water supply areas between Camden and Easton.

- Conservation easements should be acquired, zoning areas adjusted, or local ordinances enacted in order to reduce stormwater impacts from future development between Camden and Easton.

- The TMDL process and requirements along the Delaware River should include components to address drinking water impacts.

Priority for funding of Growing Greener and DCNR grants for projects in priority water supply protection areas should be given to projects that address sustainable mitigation of stormwater impacts and restoration or preservation of areas. In addition, agricultural land within the protection priority corridor would also be given easier access and higher priority for USDA funding, such as EQUP or CRP, in order to keep sensitive land areas out of production and protect local streams. PADEP and USDA could designate farms within the priority protection area as high priority for development of nutrient management plans. Townships located within a priority protection area should also be required to adopt a uniform ordinance to address stormwater impacts from current and future activities.

1.8.3 Sewage Discharge and Regulatory Enforcement

- Overall, both the sewer system capacity and integrity and the treatment plant capacity during wet weather periods represent the greatest and most difficult sewage-related issues in the watershed. Infrastructure improvements for adequate wastewater collection and treatment systems are needed to address infiltration and inflow or system capacity issues. These improvements will eliminate events such as overflowing manholes of raw sewage into downstream water supplies.

- Raw sewage discharges upstream of water supply intakes by communities through CSOs or SSOs need to be monitored, evaluated, and improved. These discharges can significantly impact pathogen concentrations in downstream water supplies.

- Wastewater dischargers should be encouraged and given incentives to switch to ultraviolet light disinfection and/or filtration of effluents in order to reduce C*ryptosporidium* pathogen levels and viability from discharges. Permits for discharge from new wastewater facilities or plant expansions should include ultraviolet light disinfection requirements.

- It is recommended that the DRBC and the PADEP regions covering the Delaware River Watershed develop a watershed-wide approach to addressing permit requirements. One suggestion would be a uniform fecal coliform discharge limit for any wastewater discharge upstream of a drinking water intake in the watershed.

- Compliance requirements for industries and municipalities discharging wastewater into the protection priority corridor between Camden and Easton should be enforced.

- Encouragement of rigorous and regular revision and implementation of ACT 537 Sewage Facilities Management Plans in Montgomery, Bucks, Mercer, and Lehigh counties. In addition, the sewage facility related issues from the SWAs should be incorporated into the ACT 537 plan with emphasis on monitoring and measuring progress towards addressing identified problems.

1.8.4 Stormwater Runoff Impacts

- Incentives for townships and communities in priority runoff areas are needed to mitigate stormwater impacts on water supplies.

- The Phase II stormwater regulations should be fully implemented and enforced throughout the watershed, with first priority for compliance monitoring and inspections recommended for communities discharging into protection priority areas for drinking water supplies.

- The Delaware River Basin in coordination with the Delaware Riverkeeper, PADEP, and NJDEP should set a goal for achieving a certain number of specific BMPs within the next 10 years. For example, the goal could be to implement 100 BMP projects or build 100 infiltration trenches or wetlands, or mitigate/treat one billion gallons of stormwater runoff in 10 years or by 2010.

1.8.5 Spills and Accidents/Emergency Response

- Interaction and communication with petroleum pipeline owners and operators, as well as railroad, road and bridge construction crews needs to be developed and improved. It is important for these stakeholders to understand water supply issues and impacts from catastrophic accidents and spraying of herbicides on rights-of-way. Therefore, a series of emergency response workshops needs to be coordinated to include the following parties:

    - PEMA
    - PECO
    - CSX/Conrail
    - PennDoT
    - Local Street Department Construction and Maintenance Managers

- Given the potentially catastrophic impacts from spills and accidents, an early warning system similar to that on the Ohio River should be installed along the mainstem of the Delaware River to provide water suppliers warning and accurate real time data when spills and accidents occur. It is recommended that the USGS be involved in the implementation of the early warning system.

- New permits should be banned for new storage tanks and facilities that use or store toxic chemicals including petroleum products within the 100 year floodplain of the river and its tributaries. The PADEP should also develop and implement a long-term plan to relocate, reduce, or eliminate tanks and sources with toxic chemicals that are currently located within the floodplain.

- An accurate time-of-travel study needs to be conducted on the Lower Delaware River to determine the time various spills will take to arrive at various water supply intakes and the amount of dilution under various flow scenarios. This should be incorporated into a computer model for emergency planning simulations using various chemicals and scenarios. This is also an important component necessary to make information from the early warning system more useful. The USGS should be involved in the implementation of this effort.

- In sensitive water supply areas along roadways and bridges, signage should be erected, which would include phone numbers to contact water suppliers during emergencies and spills. The signs should include a unique identification number corresponding to a known location for the water supplier.

- A special workshop with street departments and PennDoT should be held in order to develop a strategy to reduce salt impacts from road salt application. This may include strategies to acquire special funding for salt misting trucks to reduce salt application in sensitive areas.

1.8.6 Agricultural Impacts

- Agricultural land that is preserved should have specific riparian buffer and streambank fencing requirements included in its preservation status.

- Additional incentives and efforts should be allocated to develop nutrient management plans for farms in sensitive water supply areas.

- Active agricultural lands adjacent to streams in sensitive water supply areas should be required to have riparian buffers or streambank fencing to reduce impacts from livestock activity, pasture runoff, and crop runoff. Livestock releasing fecal material directly into a stream represent a direct waste discharge to a water body and therefore, should be subject to the similar regulations and permit requirements as other dischargers.

- The targeting of USDA funding for water quality protection under EQIP and enrollment of CRP lands should give consideration to sensitive water supply areas, and the programs should be made more accessible to farmers. To maximize water supply protection, water suppliers should be consulted in connection with the allocation of EQIP and CRP funds. A goal should be set by the USDA, DRBC, PADEP, and NJDEP to have approximately 25-50% of all agricultural lands in sensitive water supply areas to have streambank fencing or riparian buffers by 2010.

- Areas of intense or concentrated agricultural activity should also be prioritized for protection and mitigation efforts.

1.8.7 Erosion and Sedimentation Issues

- Special erosion controls and ordinances to reduce stormwater impacts from future development and erosion are needed in protection priority areas for water supplies.

- Conservation Districts need more assistance in addressing erosion control and stormwater runoff issues from development.

- The operation and discharge of contaminants and algae from the many reservoirs in the watershed are suspected of having impacts on water supplies. These areas need to be monitored and investigated or communication about these discharges and the timing of their impacts needs to be better understood.

1.8.8 Wildlife Impacts

- The U.S. Fish and Wildlife, state game commissions, park managers, golf course managers, and water suppliers should develop and implement a regional management plan to address the exploding population of non-migratory Canada geese.

1.8.9 Public Education

- Township officials in priority protection areas should be educated about stormwater impacts on water supplies through meetings, workshops, or mailings.

- The results of the local source water assessments need to be presented directly to local township officials. Common issues from multiple water supplies should also be provided to show how everyone lives downstream and feels the impact from pollution.

1.8.10 Data and Informational Needs for Improved Protection and Assessment Efforts

- A combined and coordinated effort to establish data protocols for proper data comparison (GIS or otherwise) between the various states in the Delaware River Basin needs to be established. Currently most data cannot be compared between states.

- An accurate watershed-wide land use GIS coverage is necessary for TMDLs and runoff impact estimates.

- GIS coverages of farms, types of agriculture, farming density, and EQUP/CRP lands, or lands with conservation easements, should be developed for the entire watershed.

- GIS coverages of the sanitary and stormsewer collection systems and outfalls in watershed communities should be developed.

- Updated and accurate locations of the many known point sources, as well as their outfall locations are necessary since many are currently off by far distances in comparisons between GIS and reality.

- Detailed GIS coverages of the age and location of petroleum pipelines in the watershed should be developed.

- Detailed GIS coverages of location, type of activity, and dollar amounts spent on various restoration, education, and protection efforts in the watershed should be compiled.

- A GIS coverage of the land use zoning for various townships and proposed future development corridors should be created to prioritize future protection and preservation efforts.

- Violation information for dischargers on the E-facts and Envirofacts websites for PADEP and EPA are incorrect and outdated. Efforts should be made to make this information more accurate and up-to-date.

- Updated information regarding the status and impacts from CERCLA sites and abandoned industry in the watershed should be compiled.

- A cumulative loading analysis of various discharges and runoff in the watershed should be performed.

- Actual and accurate estimates or reported values of contaminant concentrations from dischargers should be electronically available.

1.8.11 Water Quality Monitoring and Data Recommendations

Overall, based on the information available from an analysis of the amount, types, and locations for monitoring in the watershed, the following is needed:

- More comprehensive routine monitoring locations are needed in the major tributaries of the Delaware River Watershed.

- All monitoring organizations should agree on selecting standard monitoring stations for various parameters. It is recommended that the stations be placed close to the mouths of the major tributaries to the watershed. The long-term DRBC sites and certain water supply intakes may be the best place to start in selecting these sites. These standard stations would have routine monitoring conducted over long periods of time in order to examine changes and trends in water quality over years, seasons, or decades. This information will be used as part of a report card system for water quality improvement.

- Long term monitoring should be conducted for manganese, aluminum, iron, sodium, chloride, turbidity, total suspended solids, dissolved oxygen, temperature, ammonia, total phosphorus, orthophosphate, nitrate, E. coli, and fecal coliform. Currently, most monitoring does not include coliform measurements.

- Efforts should be made to transfer data from hardcopy format in special studies into electronic format.

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Delaware River Source Water Assessment
List of Acronyms

ACCESS	Microsoft Access Database Software
AMD	Acid Mine Drainage
AST	Aboveground Storage Tank
BOD	Biological Oxygen Demand
BG	Billion Gallons
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CERCLIS	Comprehensive Environmental Response, Compensation, and Liability Act Information System
CFS	Cubic Feet per Second
COWAMP	Pennsylvania's Comprehensive Water Quality Management
CRP	Conservation Reserve Program
CSO	Combined Sewer Overflow
CSX	CSX Transportation Rail Company
CWA	Clean Water Act
CWA	Clean Water Action
DBP	Disinfection by-product Precursor
DCNR	Department of Conservation and Natural Resources
DEP	Department of Environmental Protection
DMR	Discharge Monitoring Report
DO	Dissolved Oxygen
DRBC	Delaware River Basin Commission
DVRPC	Delaware Valley Regional Planning Commission
EPA	Environmental Protection Agency
EQIP	Environmental Quality Incentives Program
ESRI	Environmental Systems Research Institute
EVAMIX	Mixed Data Multi-criteria Evaluation Software Program
FBRR	Filter Backwash Recycling Rule
FHWA	Federal Highway Administration
FWS	Fish and Wildlife Service
GIS	Geographic Information System
GPD	Gallons Per Day
INCODEL	Interstate Commission on the Delaware River Basin
LQG	Large Quantity Generators
MCPC	Montgomery County Planning Commission
MGD	Millions of Gallons per Day
MSL	Mean Sea Level
MTBE	Methyl Tertiary Butyl Ether
NAWQA	National Water Quality Assessment
NCDC	National Climatic Data Center
NJDEP	New Jersey Department of Environmental Protection
NLCD	National Land Cover Data Set
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System Permit Program

NPL	National Priority List
NPS	Non-Point Source
NRCS	Natural Resources Conservation Resources
NSF	National Science Foundation
NURP	National Urban Runoff Pollutants Study
NWR	National Wildlife Refuge
NWSRS	National Wild and Scenic River System
PADEP	Pennsylvania Department of Environmental Protection
PAWC	Pennsylvania American Water Company
PCB	Polychlorinated Biphenols
PCS	Permit Compliance System
PEC	Pennsylvania Environmental Council
PECO	Pennsylvania Electric Company
PEMA	Pennsylvania Emergency Management Agency Program
PWD	Philadelphia Water Department
PWS	Public Water Supply
RCRA	Resource Conservation and Recovery Act
RCRIS	Resource Conservation and Recovery Act Information System
RTK	Right To Know
SDWA	Safe Drinking Water Act
SOC	Synthetic Organic Compounds
SQG	Small Quantity Generators
SSO	Sanitary Sewer Overflow
STEPS	Student Technical Experience in Problem Solving
STORET	USEPA's Environmental Data System of STORage and RETrieval
STP	Sewage Treatment Plant
SWA	Source Water Assessment
SWAP	Source Water Assessment Program
TAG	Technical Advisory Group
TDS	Total Dissolved Solids
TM	Thematic Mapper
TMDL	Total Maximum Daily Load
TOC	Total Organic Carbon
TPH	Total Petroleum Hydrocarbons
TRI	Toxic Release Inventory
TS	Total Solids
TSS	Total Suspended Solids
USACE	US Army Corps of Engineers
USACOE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
VOC	Volatile Organic Compounds
WHP	Wellhead Protection Program
WRP	Wetlands Reserve Program
WWTP	Wastewater Treatment Plant

APPENDIX

Figure A:

ZONE 5 — TIMES NEWSPAPERS, WEDNESDAY, NOVEMBER 14, 2001

Drinking water is the hot topic

The Friends of Pennypack Creek will host a public meeting from 7:30 to 9 p.m. tomorrow at the Holmesburg Baptist Church, at Frankford Avenue and Rhawn Street, to discuss potential sources of contamination to the Delaware River.

The Delaware River Source Water Assessment Project (SWAP) is a public-private initiative facilitated by the Philadelphia Water Department.

The SWAP is designed to explore and understand the environmental challenges to the Delaware River watershed as a means to identify its existing and potential pollution sources to drinking water supplies.

In 1986, amendments were passed to the federal Safe Drinking Water Act that required state agencies and water suppliers to survey drinking water sources for contaminants and to make the information available to the public.

This meeting is an opportunity for individuals and organizations to become involved and to add their vision to the project.

For more information, call 215-685-4944. ••

Figure B:

Meeting will discuss study of drinking water supply

The Friends of Pennypack Creek will host a public meeting on Thursday, Nov. 15, from 7:30 to 9 p.m. at the Holmesburg Baptist Church, at Frankford Avenue and Rhawn Street, to discuss potential sources of contamination to the Delaware River.

The Delaware River Source Water Assessment Project (SWAP) is a public-private initiative facilitated by the Philadelphia Water Department.

The SWAP is designed to explore and understand the environmental challenges to the Delaware River watershed as a means to identify its existing and potential pollution sources to drinking water supplies.

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This meeting is an opportunity for individuals and organizations to become involved and to add their vision to the project.

For more information, call 215-685-4944. ••

Cannot identify source of this article. (Possibly News Gleaner)

Figure C:

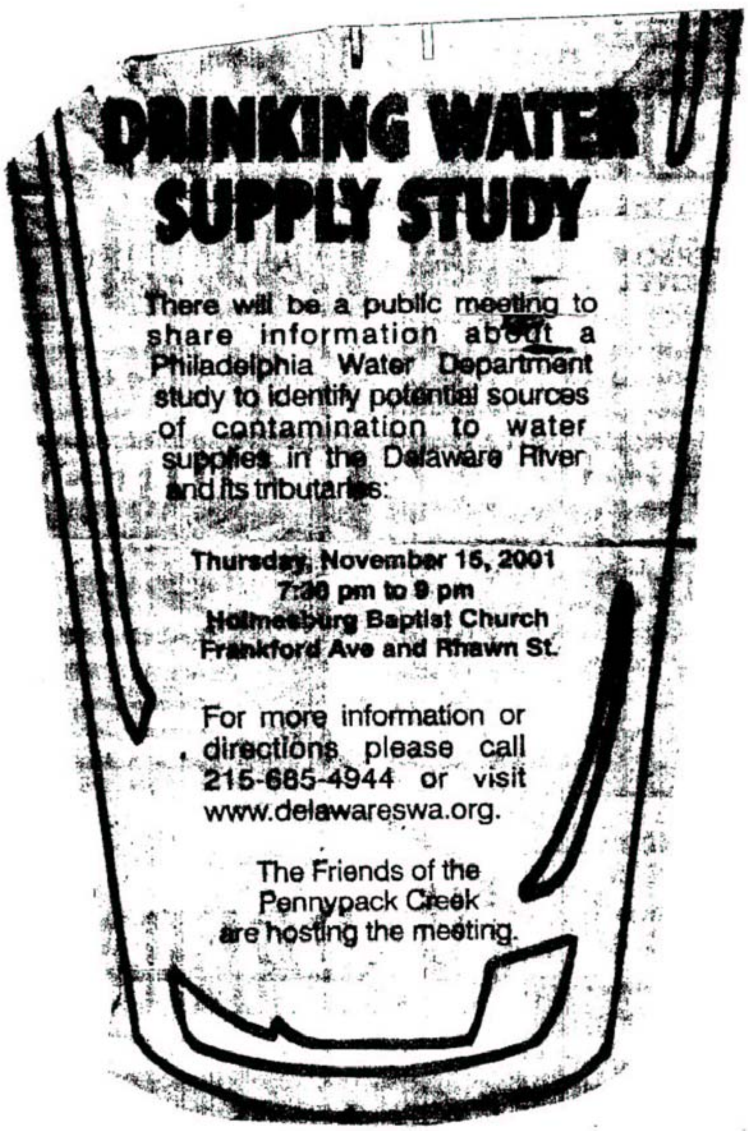

DRINKING WATER SUPPLY STUDY
There will be a public meeting to share information about a Philadelphia Water Department study to identify potential sources of contamination to water supplies in the Delaware River and its tributaries:
Thursday, November 15, 2001
7:30 pm to 9 pm
Holmesburg Baptist Church
Frankford Ave and Rhawn St.
For more information or directions please call 215-685-4944 or visit www.delawareswa.org.
The Friends of the Pennypack Creek are hosting the meeting.

Figure D:

Drinking Water Supply Study

There will be a public meeting to share information about a Philadelphia Water Department study to identify potential sources of contamination to water supplies in the Delaware River and its tributaries:

Thursday, November 15, 2001
7:30 p.m. to 9 p.m.
Holmesburg Baptist Church
Frankford Avenue and Rhawn Street

For more information or directions, please call 215-685-4944 or visit www.delawareswa.org.

The Friends of the Pennypack Creek are hosting the meeting.

Figure E: *The Northeast Breeze*, December 6, 2001

Water Department to test quality of creeks

BY NICOLE CLARK
Staff Writer

Ever wonder what's floating in your drinking water before it's decontaminated?

At a recent meeting of the Friends of Pennypack Park, Christopher Crockett, an engineer and manager of the Philadelphia Water Department Office of Watersheds Source Water Protection Program discussed the Delaware River Source Water Assessment Partnership, also called SWAP, a new plan to identify existing and potential pollutants to drinking water supplies.

Funded through a grant from the Pennsylvania Department of Environmental Protection, the study will survey the Delaware River watershed, a 330-mile stretch of river encompassing 13,500 square miles of area and running through 42 counties. The watershed includes the Tookany, Tacony, Frankford and Pennypack creeks.

Crockett stressed our tap water is already safe. The survey's purpose is to make the water easier and less expensive to treat.

"These are not evaluations or indications of your drinking water quality or safety," Crockett said. "We evaluate it before it goes to the plant. We don't want you to get worried that water goes straight from the river into your glass."

Philadelphia, he said, is home to award-winning treatment plants and is one of the most aggressive cities in the country in ensuring water safety.

A public-private initiative comprised of regulatory agencies, water suppliers, watershed and environmental organizations, the Delaware River SWAP was implemented after 1996 amendments to the federal Safe Drinking Water Act passed in 1974.

In response to the public's desire to know more about water supplies and how to protect them, the amendments required state agencies and water suppliers to survey their drinking water sources for origins of contamination and to make the information public in annual Consumer Confidence Reports. The reports, which currently document the quality of tap water, were first published in 1998. Source water information will be the most recent addition.

Crockett said PWD was hired by the state rather than a private consultant because of its knowledge of the area. But the department still needs citizen input.

"It's simple things like calling in if you see (short) dumpers or oil spills," he said, "broken water mains or developers without fences allowing (pollutants) to fall in." Overflowing sewers and manholes, runoff and eroding streambanks are other targets.

The Pennypack Creek empties into the Delaware River behind the Baxter Water Treatment Plant, 9001 State Road. Baxter provides water to almost 60 percent of the city's population. The Belmont and Queen Lane water treatment plants supply the rest.

A watershed, Crockett said, is an area where rainwater runs off the land and drains into a river or creek. "Unit" watersheds, like the Pennypack, can make up a larger watershed, such as the Delaware River.

The protection plan's first step is to determine which areas drain into the surface water intakes. Those pull water from creeks or streams, not the ground. The Delaware River and its tributaries provide drinking water to about 17 million people, including those in New York

(Continued on page 21)

Figure E (continued): *The Northeast Breeze*, December 6, 2001

December 6, 2001 The Northeast Breeze 21

Water Department to test quality of Tacony and Pennypack creeks

(Continued from page 10)
City, Trenton and Philadelphia.

A water quality data review will pinpoint exactly what lives in the water. "We'll be looking for trends," Crockett said. "Is the stream getting better or worse?"

Potential sources of contamination, such as gas stations, dry cleaners and parking lots, are everywhere. Through surveys, interviews with water suppliers and stakeholders, public meetings and water analysis, PWD will identify each one, then rank them according to hazard level.

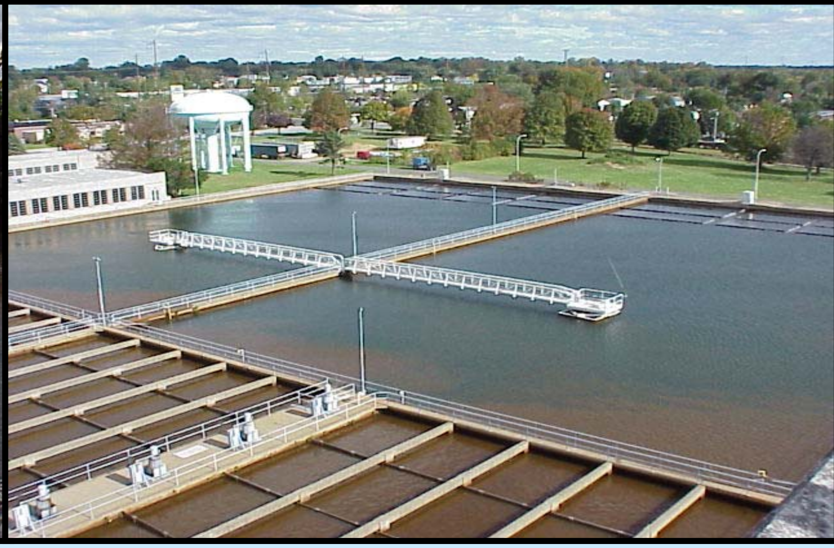
Among the pollutants they'll be searching for are pathogens contained in sewage, livestock and wildlife waste, algal blooms that release non-harmful but fishy-smelling chemicals that must be treated with carbon, and nutrients from lawncare and golf courses.

Others on the list are metals and manganese created by acid mine drainage, chloride and sodium from highways and road salt, pesticides and herbicides used in lawncare products and agriculture methods, MtBE, a gasoline additive leaked from cars and watercraft, and natural elements in the river, such as bromide, that can chemically react with other elements to create potential cancer-causing compounds.

Once those spots are identified, a protection plan will be developed. The hope is that neighborhood organizations will hold meetings and workshops to educate people on issues such as safer alternatives to road salt and how to properly use lawncare products. Crockett said groups could also acquire grants for water protection by incorporating projects approved in SWAP plans.

The state deadline for PWD's draft report on the Baxter plant's supply is April. Crockett said he will probably return to a meeting of the Friends of Pennypack Park in winter to report the plan's progress.

If you would like to provide PWD with information regarding pollution in the Delaware River watershed, call Christopher Crockett at 215-685-6234 or email him at chris.crockett@phila.gov. More information and an opinion survey are available at www.delawareswa.org.

PHILADELPHIA WATER DEPARTMENT
BAXTER WATER TREATMENT PLANT (PWSID# 1510001)
SOURCE WATER ASSESSMENT REPORT
SECTION 2: DELAWARE RIVER INTAKE


This report was produced for the Pennsylvania Department of Environmental Protection in accordance with the Source Water Assessment and Protection Plan.

Philadelphia PWD Water Department

Prepared by The Philadelphia Water Department
June 12, 2002

dep

<u>*With support from:*</u>
Bucks County Water and Sewer
Philadelphia Suburban Water Company
Pennsylvania American Water Company
Pennsylvania Department of Environmental Protection
Camp Dresser & McKee

Delaware River SWA
Protect Our Health from Source to Tap

PADEP Contract: ME350056

Office of Watersheds
philadelphia water

Executive Summary - Baxter WTP Intake Source Water Assessment

The 1996 Safe Drinking Water Act Amendments required the assessment of all source water supplies across the country to identify potential sources of contamination, the vulnerability and susceptibility of water supplies to that contamination, and public availability of the information. In response to this charge, the Delaware River Source Water Assessment Partnership, comprised of the Pennsylvania Department of Environmental Protection, the Philadelphia Water Department, the Philadelphia Suburban Water Company, and the Pennsylvania American Water Company, and the Bucks County Water and Sewer Authority conducted the assessment with stakeholders to identify water supply protection priorities in the Delaware River Watershed. The following summary includes two main sections. One section discusses the various characteristics and observations made through collection of watershed wide information. The remaining section provides a brief listing of the main recommendations based on the results of the analysis.

High Protection Priority Issues and Activities

Overall, the following activities were identified as having high priority for protection efforts to address:

- Sanitary Sewer Overflows of raw sewage from sewer collection systems, sewage lift stations, and manholes from upstream communities
- Urban, residential, and agricultural runoff from various areas of the watershed, mostly located in tributaries such as the Pennypack Creek, Poquessing/Byberry Creek, Neshaminy Creek, Rancocas Creek, Lehigh River, and Musconetcong River.
- Discharges from municipal and industrial sources such as sewage treatment plants and chemical manufacturing facilities between Camden and Trenton.
- Spill and accidents from cars, tanker trucks, railroad cars, pipelines, tire piles, and fires at industrial facilities near the river and its tributaries

Observations & Characterization

- Raw water is gravity fed via tidal elevation changes from the Delaware River at a daily average rate of 175 million gallons per day (MGD) with maximum capacity of 320 MGD.
- The Baxter Water Treatment Plant serves approximately 750,000 customers in Northeastern Philadelphia and Lower Bucks County.
- The water supply intake is located at Delaware River mile 11. It is the farthest downstream public water supply located on the Delaware River in Pennsylvania.
- The drainage area of the basin above the Baxter Intake is approximately 7,500 square miles. Land use of the area just upstream of the intake is primarily residential and light/heavy industrial.

- Water withdrawn from the Delaware River is coagulated, settled, filtered, and disinfected with chlorine to make it safe prior to distribution to customers. Drinking water quality meets or exceeds all state or federal requirements.

- Delaware River water quality is monitored to assess potential health risks, aesthetics, and treatment requirements.

- The Philadelphia Water Department routinely monitors pH, color, alkalinity, hardness, total dissolved solids, conductivity, turbidity, coliform, *Giardia* and *Cryptosporidium,* total organic carbon, UV absorbance, bromide, nitrogen, phosphorus, iron, manganese, sulfate, chloride and sodium at their Baxter Intake. Many other parameters are monitored as part of special studies.

- Turbidity and other suspended contaminants in the river tend to increase as a function of precipitation, runoff and river flow.

- Salt levels in the river appear to fluctuate seasonally, perhaps in response to application of road salts during the winter.

- Over the past decade, 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.

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

- Almost 6,000 potential point sources were identified within the 2,060 square mile Baxter Intake. Most of these potential sources do not – and will never – discharge to Delaware River. They have been identified so that water suppliers can assess their potential impacts upon the water supply, and identify appropriate protective measures.

- Over 1,700 RCRA facilities are located upstream of the Baxter Intake. Most RCRA facilities are not large quantity generators.

- Sewage systems, dry cleaning plants (except rug cleaning), and gasoline service stations are most common.

- Volatile organic chemicals, petroleum hydrocarbons, and SOCs were the most frequently reported contaminants.

- 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 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.

- Unit *cryptosporidium* and turbidity loadings were higher from agricultural areas.

- A series of screenings was used to identify those sources that have the greatest potential to affect water quality at the Baxter Intake.

- Five non-conservative contaminant categories and five conservative contaminant categories were selected to represent all potential contaminants.

- For each category, a threshold value indicative of the significance of the concentrations of contaminants that could result from a potential spill or discharge was defined.

- EVAMIX, a multi-criteria software package was used to prioritize the potential significance of each of the potential point sources within Baxter's Zone A and Zone B, and to evaluate the potential significance of non-point sources estimated by the Delaware River Runoff Loading Model.

- NPDES and nonpoint source discharges within the Baxter Intake's Zone A and Zone B were determined to have the highest protection priorities in the watershed.

- The potential significance of each source of contamination was designated A (potentially significant source of highest protection priority) through F (Potential source of lowest protection priority). Those sources ranked A through C are potentially significant sources of contamination to the Baxter Intake.

- All of the highest ranked sources are either NPDES sites or stormwater loadings from specific sub-watersheds.

- Contaminant sources actually discharging to the river (e.g., NPDES permitted point sources, or stormwater runoff) are estimated to have greater potential significance than those with only the potential to release contaminants to the river (e.g., a spill or leak).

- EVAMIX was also used to rank potential sources for each contaminant category.

Protection Recommendations

- Overall, the primary protection areas to focus PWD's protection efforts to protect and improve PWD's water supply 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, and Neshaminy Creek areas as well as portions of the Muscentong, Pohatcong, Lehigh Rivers. However other parts of the watershed may need limited attention for contaminant specific issues.

Based on the results of the susceptibility analysis, water quality data, and stream impairments, it is clear that the potential impacts from point source discharges need to be addressed from the discharges along the main stem of the Delaware River from Camden to Trenton. Efforts to reduce these impacts would require the following components:

- Enforcement of compliance requirements for industries and municipalities discharging wastewater into the protection priority corridor between Camden and Trenton;

- Facilities Management Plans in Montgomery and Bucks Counties. In addition, the sewage facility related issues from the SWAs should be incorporated into the ACT 537 plan with emphasis on monitoring and measuring progress towards addressing identified problems;

- Development of a coordinated regional protection plan that will be adopted by water suppliers, planning commissions, and municipalities for establishment and protection of sensitive and high priority protection areas to multiple and overlapping water supply areas between Camden and Trenton;

- Development of mechanism or framework to address source water protection and non- point source issues in the Lower Delaware River Basin area. The DRBC has a number of water resources and watershed/TMDL related committees, but they are focused only on source water protection concerns. Finding a way to include the priority areas and issues identified in the SWAPs into the existing DRBC framework for implementation and mitigation is critical;

- Development and support of watershed or local community/environmental organizations to restore and protect various segments of the protection priority corridor between Camden and Trenton and;

- Ensure that TMDL process and requirements along the Delaware River include components to address drinking water impacts;

- Development of special state or federal legislation that provides funding and authority for water supply protection efforts in the protection priority corridor between Camden and Trenton;

- Include C*ryptosporidium* impacts in the permitting process for wastewater dischargers upstream of drinking water intakes;

- Development of incentives for upstream communities to mitigate stormwater runoff;

- Acquisition of conservation easements or adjustment of zoning areas or local ordinances to reduce stormwater impacts due to future development in the protection priority runoff areas;

- Education of township officials along the protection priority corridor about stormwater impacts;

- Preservation of existing greenspace along the Delaware River in the protection area;

- Enforcement of the Phase II stormwater regulations for townships in priority runoff areas;

- Development of conservation easements, riparian buffers, and streambank fencing to mitigate impacts from agricultural activities;

- A corporate environmental stewardship program should be developed to educate, provide incentives, and engage businesses in water supply protection and stormwater mitigation;

- A workshop should be sponsored by PADEP to educate golf courses about the benefits of joining the environmental certification program by the Audobon Society;

- Efforts should be made to encourage PADEP and DRBC to address and prioritize the impacts of CSOs and untreated discharges of raw sewage upstream of drinking water.

In addition to those efforts mentioned above, the following specific actions are recommended for protection efforts in the Poquessing and Pennypack Creek Watersheds:

- Development of regulatory and financial incentives for enhanced wastewater discharge for pathogen removal and inactivation to address *Cryptosporidium* impacts;

- Development of incentives and controls for mitigation of stormwater runoff impacts. This includes requiring that current TMDL efforts in the watershed include specific components to address drinking water issues and concerns. This will provide an example of how the Safe Drinking Water Act and Clean Water Act should be integrated;

- Conduct an examination of current zonings and ordinances with the Bucks County Planning Commission, Bucks County Conservation District, and local townships to determine ways they can be enhanced to address current and future stormwater impacts. Identify areas where innovative techniques and incentives can be used to mitigate stormwater impacts and assist in the development and implementation of these efforts;

- Encourage and support the development of an Act 167 Stormwater Management Plan for the Pennypack and Poquessing Creek;

- Establish riparian buffers and steambank fencing in all agricultural areas of the Pennypack, Poquessing/Byberry and Neshaminy Creek Watersheds.

The Philadelphia Suburban Water Company already works with numerous stakeholders to protect its water supply in the Neshaminy Creek. Therefore, it is recommended that any protection efforts be coordinated with the Philadelphia Suburban Water Company environmental initiatives and programs in the Neshaminy Creek Watershed.

In addition to the previous specific geographic recommendations, the following general efforts are recommended:

- Emergency Response Planning activities should be focused on priority AST, TRI, and RCRA facilities since they have been shown to have the greatest relative impact on water quality. Efforts should also be initiated to collect more detailed data on these sites for reprioritization.

- Long-term protection efforts should focused on improving the quality of wastewater discharges and stormwater runoff. These will have the greatest overall impacts on improving source water quality.

- Sources of pathogens appear to be the sources of greatest priority to PWD when examined in the overall rankings. Therefore, these sources should be addressed accordingly.

- A corporate environmental stewardship program should be developed to educate, provide incentives, and engage businesses in water supply protection and stormwater mitigation.

- Special mechanisms and funding should be developed to allow the distribution of monies to support or initiate specific initiatives outside the City of Philadelphia that will protect or restore the water supply. This may involve development of a quasi-governmental or non-profit organization that can raise funds and distribute them to various organizations conducting protection activities beneficial to PWD. This organization may also need the ability acquire conservation easements or land in sensitive areas to maintain protected areas.

- Efforts should be made to encourage PADEP and DRBC to address and prioritize the impacts of CSOs and untreated discharges of raw sewage upstream of drinking water intakes.

Public Meetings and Participation

- Public Kick-off meetings, Technical Advisory Group meetings, media articles and a website were some of the methods used to involve the public in the Source Water Assessment Program (SWAP).

- A Technical Advisory Group (TAG) was established to facilitate communication among stakeholders, and to gather information about the watershed. The TAG meets quarterly to assist the SWAP process.

- SWAP Project information was available to the public and stakeholders through the project website at www.phillywater.org/delaware.

Table I – Summary of Protection Priorities From Various Upstream Sources

Source	Protection Priority	Description	Priority Area(s)	Contaminants
Treated Sewage	A – C (Moderate – High)	Wastewater discharges from wastewater treatment plants	Camden to Trenton	Pathogens, bacteria, viruses, *Cryptosporidium*, nutrients, sediment, organic chemicals
Untreated Sewage	A (High)	Combined and sanitary sewer overflows/discharges	Camden to Trenton	Pathogens, bacteria, viruses, *Cryptosporidium*, nutrients
Urban/Residential Runoff	A – C (Moderate – High)	Stormwater runoff from roads, parking lots, roofs	Watershed wide	Pathogens, bacteria, viruses, *Cryptosporidium*, nutrients, metals, sediment
Agricultural Runoff	A – C (Moderate – High)	Stormwater runoff from croplands, pastures, livestock	Watershed wide	Pathogens, bacteria, viruses, *Cryptosporidium*, nutrients, sediment
Acid Mine Drainage	C (Moderate)	Discharge from abandoned coal mining areas	Lehigh	Metals
Industrial Facilities	C (Moderate)	Facilities that store or use hazardous chemicals	Camden to Trenton	Metals, nutrients, organic chemicals
Above Ground Storage Tanks	C (Moderate)	If storage tank spilled into river	Camden to Trenton	Petroleum hydrocarbons, metals, phosphorus
Landfills	C (Moderate)	Leaching of contaminants into streams	Camden to Trenton	Petroleum hydrocarbons, metals
Spills and Accidents	A – C (Moderate – High)	Car, truck, train, or pipeline accident spilling benzene	Watershed wide	Petroleum hydrocarbons, organic chemicals

Note: *Petroleum hydrocarbons include chemicals found in oils and greases.*
Organic chemicals include chemicals found in solvents, degreasers, varnishes, paints, gasoline, plastics, and insect and weed killers.

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Section 2
PWD - Baxter Water Treatment Plant

2.1 Watershed and Drinking Water System

Key Points

- **The Philadelphia Water Department's Baxter Intake is a public water supply intake on the Delaware River located at river mile 11.**
- **It is the farthest downstream public water supply located on the Delaware River in Pennsylvania.**

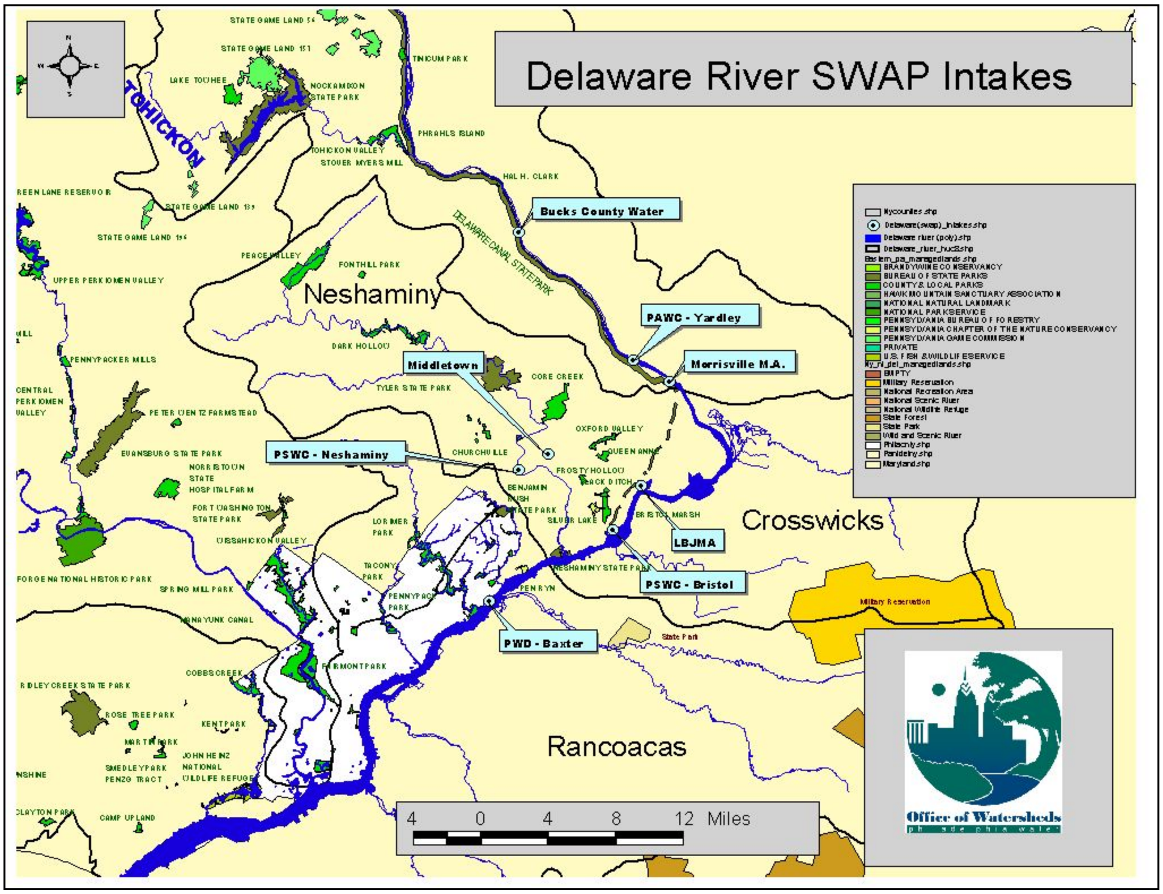
2.1.1 Watershed

The Philadelphia Water Department's Baxter Intake is located at Delaware River mile 11. As shown in Figure 2.1.1-1, the intake is located directly upstream of the confluence of the Pennypack Creek and the Delaware River. The Baxter Intake draws water into the "raw water lagoon" during high-tide. The Delaware River is tidal up until the natural fall line located between Morrisville, PA and Trenton, NJ.

The drainage area of the basin above the Baxter Intake is approximately 7,500 square miles. Land use of the area just upstream of the intake is primarily residential and light/heavy industrial. The closest active USGS flow monitoring station is located at Trenton, New Jersey. Moving upstream from the Delaware Estuary, the Baxter Intake is the first public water supply intake (see Figure 2.1.1-2) above the river's confluence with the Atlantic Ocean.

Figure 2.1.1-1 Aerial Photograph of Baxter Intake

Figure 2.1.1-2 Location of Water Supply Intakes in the Lower Delaware River Watershed



2.1.2 Geology, Soils, Hydrology, Physiography and Topography

Key Points

- **The Baxter facility is located in Northeast Philadelphia in the Atlantic Coastal Plain Province, which covers a large part of Southeastern Pennsylvania.**
- **Topography and types of soils in the watershed affect the amount and quality of runoff produced during precipitation events.**
- **Soils in the Lower SWAP Study Area are generally well drained, and generate moderate amounts of runoff.**
- **The soils surrounding the Baxter Intake are classified as urban land. They generally have the same soil particle size distribution as the original silty loams.**

2.1.2.1 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, as illustrated in Figure 2.1.2-1. Additional information on the Atlantic Coastal Plane Province can be found in section 2.1.2.4 of this report. The major rocks are briefly described here.

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).

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.

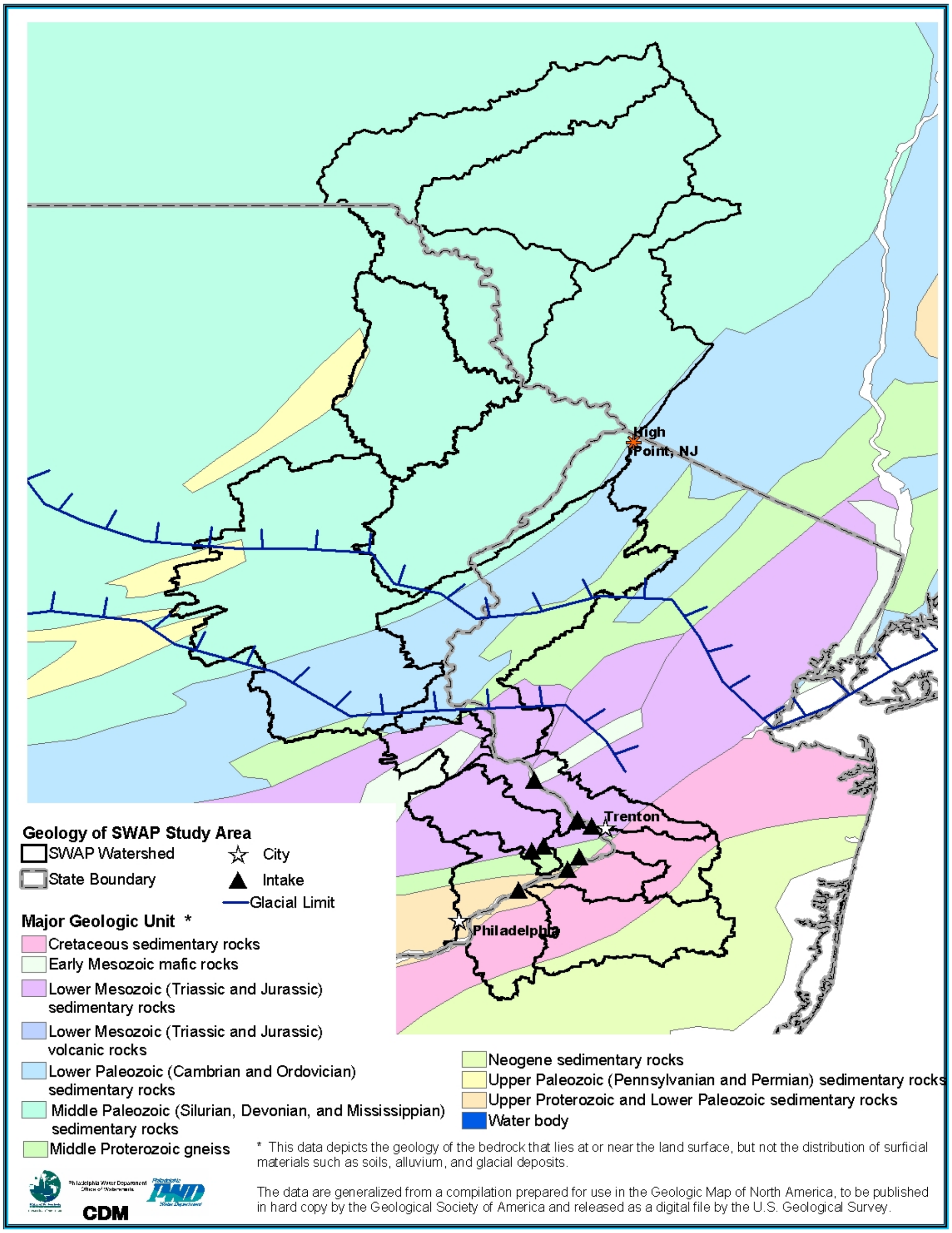
Lower Mesozoic Sedimentary Rocks

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 (onconsolidated) 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).

Figure 2.1.2-1 Geology of SWAP Study Area



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. As shown in Figure 2.1.2-2, the predominant soils surrounding the Baxter Intake include Chester, Downer, Pocomoke, Hammonton, and Sulfaquen types. Table 2.1.2-1 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.

Figure 2.1.2-2 General Distribution of Soils in the Lower SWAP Study Area

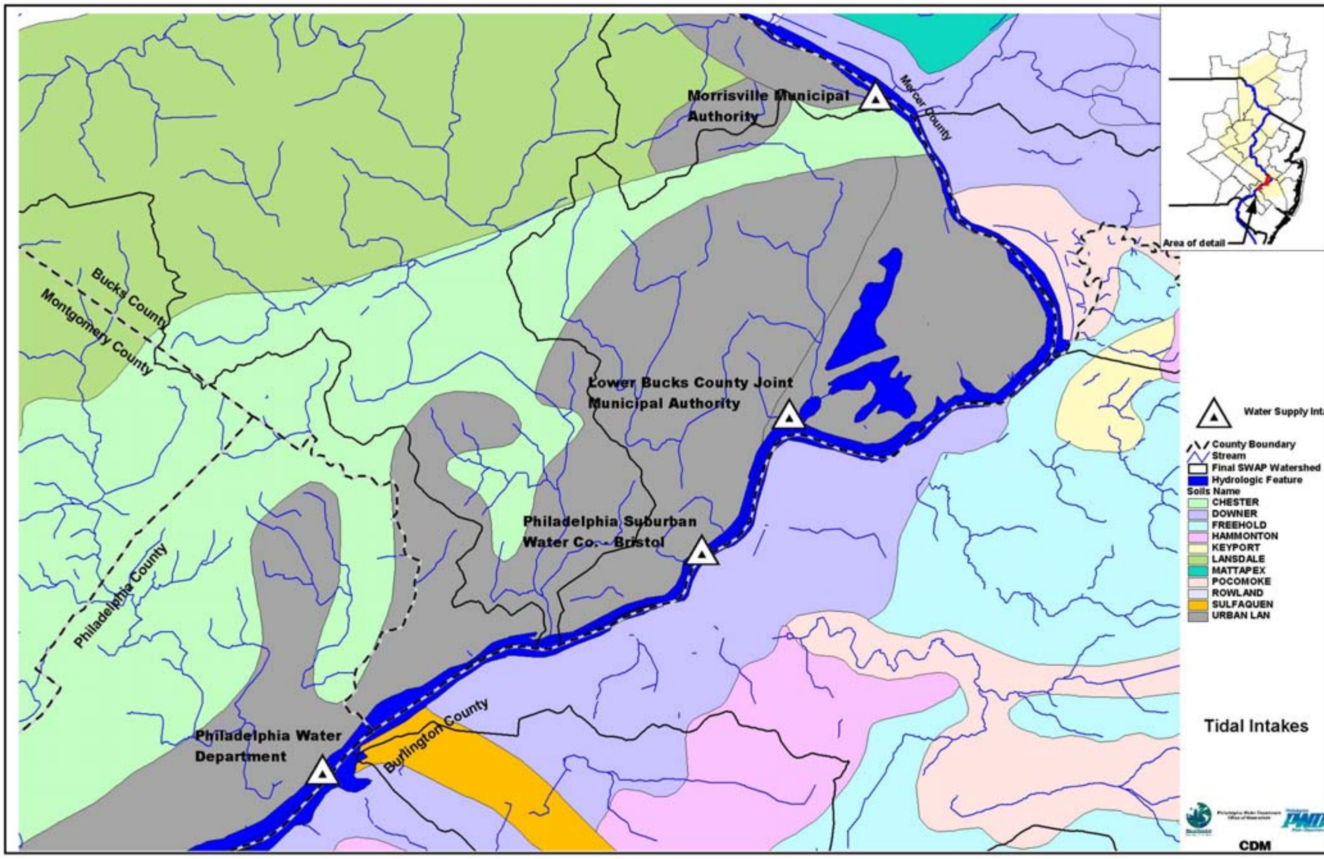


Table 2.1.2-1 Prevalence of Various Major Soil Types in the Lower Study Area

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.

2.1.2.2 Hydrogeology

The Baxter facility is located in Northeast Philadelphia in the Atlantic Coastal Plain Province, which covers a large part of Southeastern Pennsylvania. The sediments of this province are primarily unconsolidated formations of sands, clays, and gravels. In the Wilmington-Philadelphia, these formations are (in ascending order) the Cretaceous Raritan and Magothy formations and the Quaternary Pensauken and Cape May formations. The Wissahickon Formation occurs near the Fall Line as a result of streams having worn through the Pensauken Formation. The Raritan Formation, which consists mainly of unconsolidated sandstones and gravel, is a major source of groundwater and an excellent aquifer on account of the contact between the unconsolidated sandstone and the crystalline rock, which serves as a cap rock.

The Pensauken and Cape May formations have thicknesses between 30 and 40 feet. The wells in these formations are typically less than 200 feet deep, and yield between 400 and 800 gpm, although most of the water is contaminated and must be treated before use. Together with the upper sand deposits of the Raritan Formation, the Pensauken and Cape May formations comprise the most extensive aquifer in the Lower Delaware River Basin. (Majumdar, Miller, and Sage 1988)

In Pennsylvania, where the sediments are mainly Cretaceous and Tertiary, they have been divided into four sections: the Potomac Formation (the oldest, including its subdivisions: Patuxent, the Arundel, the Patapsco, and the Raritan formations), the Bryn Mawr Formation, the Bridgeton Formation, and the Pensauken Formation (youngest).

The Potomac Formation is located along the Delaware River between Delaware and Trenton, NJ, and is almost completely covered by the river and more recent deposits. In Pennsylvania, the Potomac Formation is Late Cretaceous. This formation dips gently to the southeast and ranges from 0 to 150 feet thick, with variation in thickness due to the presence of deep channels. The thick beds of pale-gray or grayish-orange sand are interbedded with beds of pale-red or pale-gray unctuous clay of varying thickness. There are gravel beds interstratified with the sands, particularly near the base of the formation. Quartz and quartzite comprise most of the gravel, with small concentrations of the heavy metals zircon, rutile, tourmaline, and staurolite mixed in, as well as ilmenite, whereas the sand beds contain some feldspar as well as quartz and are crossbedded for the most part, and horizontally stratified in some places. The finer sands usually contain mica. Kaolinite is the principal mineral in the clay beds, which occur in varying thicknesses, some of which contain high concentrations of illite. There are small concentrations of mixed-layer illite/smectite. Some of the white and pale-gray clay beds contain small, reddish-brown to pale-gray concentrations of siderite.

The Bryn Mawr Formation, also known as the Bryn Mawr Gravel, is comprised of isolated sand and gravel deposits on uplands greater than 180 feet above sea level. Most of these deposits with yellow gravel, some sand, and a little clay, are in Delaware County, west of the Schuylkill River. Quartz and quartzite comprise clasts in this region. The gravel has frequently been formed into hard rock by iron oxide. The exact thickness and age of this formation are still unknown. It is estimated that the thickness of the Bryn Mawr Foundation is about 20 feet. The age of this formation is still debated. While it is often thought to be Quaternary or Pliocene, there is evidence that it may be from a Miocene age, and different reports place it at the pre-middle Miocene, the late Miocene, or the late Oligocene.

The Bridgeton Formation is part of an extensive stretch of gravelly sands that covers much of the northern Atlantic Coastal Plain. It is primarily composed of sands interspersed with gravelly beds and boulders. The sands were deposited in a series of laterally migrating and upward-building channels in what is thought to be a braided stream complex, with some channels reaching depths of 60 feet. The pale orange to white sand, which is much less mature than that in the Bryn Mawr Formation, is locally stained with reddish brown iron oxide and small masses of manganese oxide in the more weathered parts of the sand. A dark maroon clay-like sand, thought to be a result of deep weathering, overlays most outcrops of the formation. The clay contains vermiculite, kaolinite, gibbsite, and a large amount of feldspar (compared to the older Potomac and Bryn Mawr formations). Common heavy minerals in the sands include hornblende, epidote, tremolite, and actinolite. Major opaque minerals include ilmenite and its weathering products, as well as locally abundant magnetite. The Bridgeton Formation is thought to be weathered to great depth on account of the high concentrations of halloysite and endellite in the clay-silt portion of the sands below the upper clay. As part of the undifferentiated Pensauken-Bridgeton Formation, Bridgeton deposits in Pennsylvania occur in a discontinuous band paralleling the Delaware River between Delaware and Trenton, NJ. For the most part, the deposits are located on hilltops at elevations between 100 and 140 feet, and are the highest level of gravelly sands within the Amboy-Salem trench (a former depositional lowland that parallels the Fall Line from Amboy to Salem, NJ. Due to its stratigraphic relationship with the Pensauken Formation which cuts through the Bridgeton, the age of the Bridgeton Formation is dated to the late Miocene. This formation covers a heavily urbanized area with minimal exposure. (Schultz, 1999).

The Pensauken Formation is a younger, similar-appearing gravel formation, but with lower elevations in comparison with the Bridgeton. It was deposited on the erosion surface east of Philadelphia, near Palmyra, NJ on a deltaic complex bordered by shelf deposits on its distal end in Delaware and Maryland—a common sedimentary association in most coastal formations in the Atlantic Coastal Plain. The only part of this formation in Pennsylvania is located in Turkey Hill, near Morrisville in Bucks County, a locale that has almost been completely removed by mining. The Pensauken Formation is dated to the upper middle to late Miocene due to biostratigraphic evidence to the south in Delaware. This formation is mainly sand, although the Pennsylvania portion is very gravelly. Quartzite boulders of up to 5 feet in diameter can be found at Turkey Hill. The sands are generally medium to very coarse grained, poorly sorted, and often cemented by iron oxides, with large-scale crossbedding averaging 3 feet or more in thickness. The horizontally bedded gravel beds range from a few inches to a few feet in thickness. Heavily weathered plagioclase and potassium feldspar make up 50% of the sand, with potassium feldspar being dominant. The Pensauken Formation has a similar heavy mineral makeup to the Bridgeton Formation, although Pensauken has more glauconite and reworked sand from the Coastal Plain formations of New Jersey. Due to heavy erosion, the Pensauken sediments in eastern Pennsylvania have a scattered distribution and a maximum thickness of 40 feet (Schultz, 1999).

2.1.2.3 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 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 rarely fluctuates within the Delaware River Basin; the area normally receives 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).

Long-term historical data in Philadelphia was initially assessed in order to gauge recent decade scale trends against the backdrop of natural regional variation in climate and hydrology. Monthly climate data based on a regional composite index developed by the National Climatic Data Center (NCDC) are available from 1895 through the present day. Historical climate data has been further summarized here by calculating annual totals for precipitation and averages for temperature based on monthly figures.

Annual precipitation in the Philadelphia area has shown a steady increase through the 1900s, with an extended period of drought in the 1960s. Precipitation was high in the 1970s and has most recently varied around the long-term mean for annual precipitation. Annual temperatures in the region have not shown such a strong trend over the entire century, although temperatures appear to have increased dramatically over the first half of the century, while decreasing since then, as shown by Figure 2.1.2-3.

Figure 2.1.2-3 Long-Term Average Annual Temperature at Philadelphia

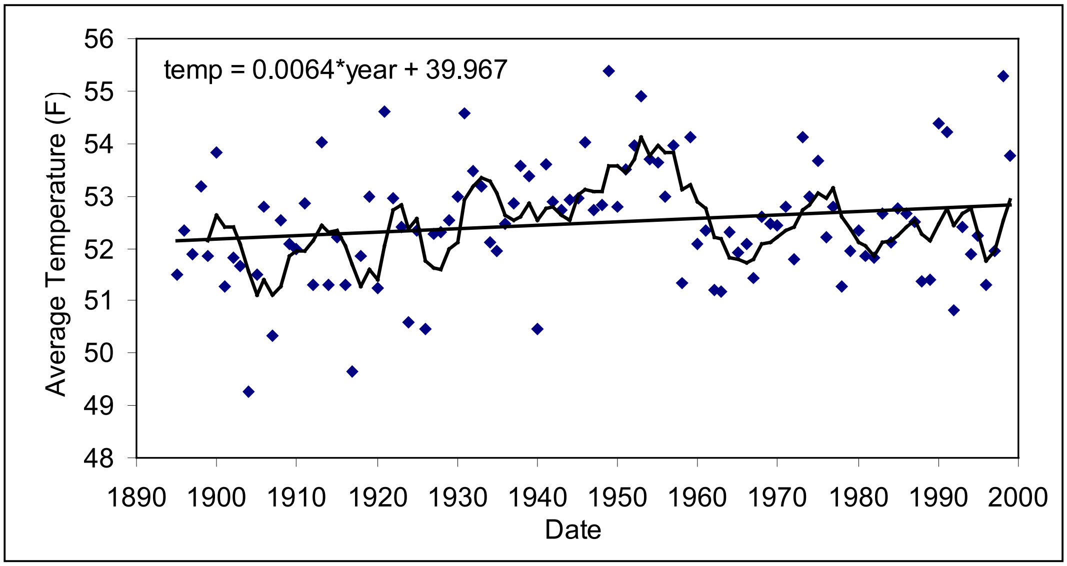
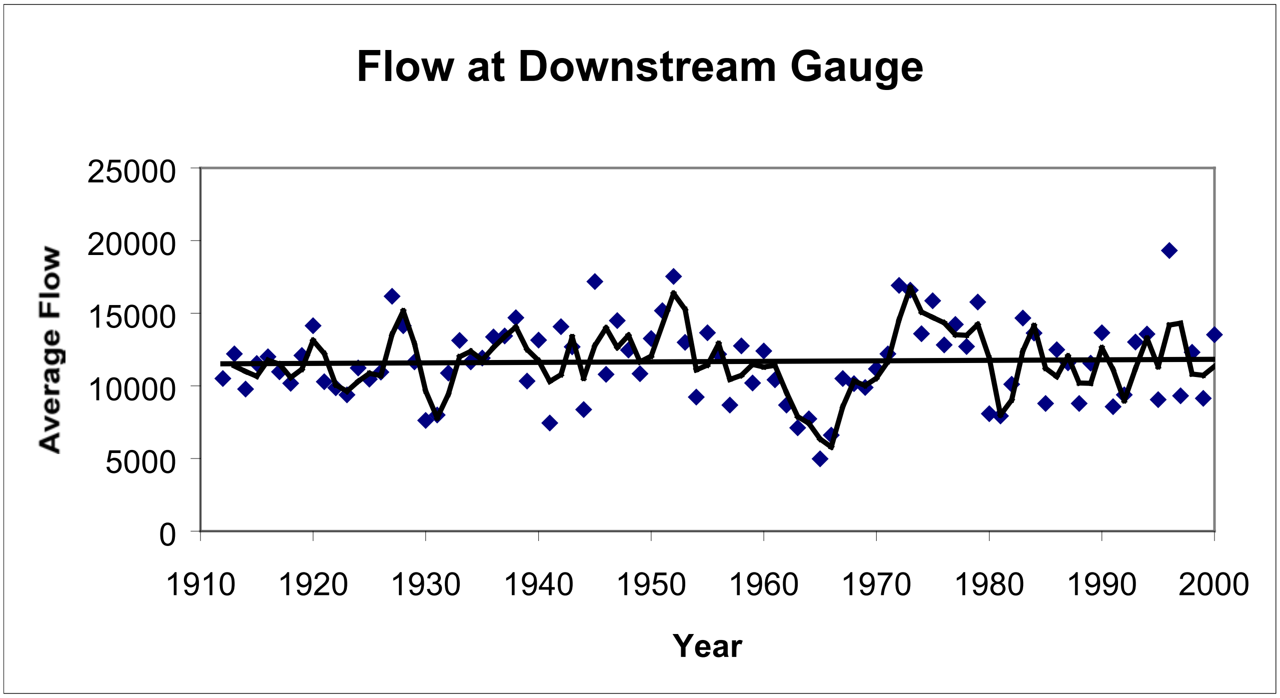


Figure 2.1.2-4 Annual Average Flow at Trenton Gauge of Delaware River

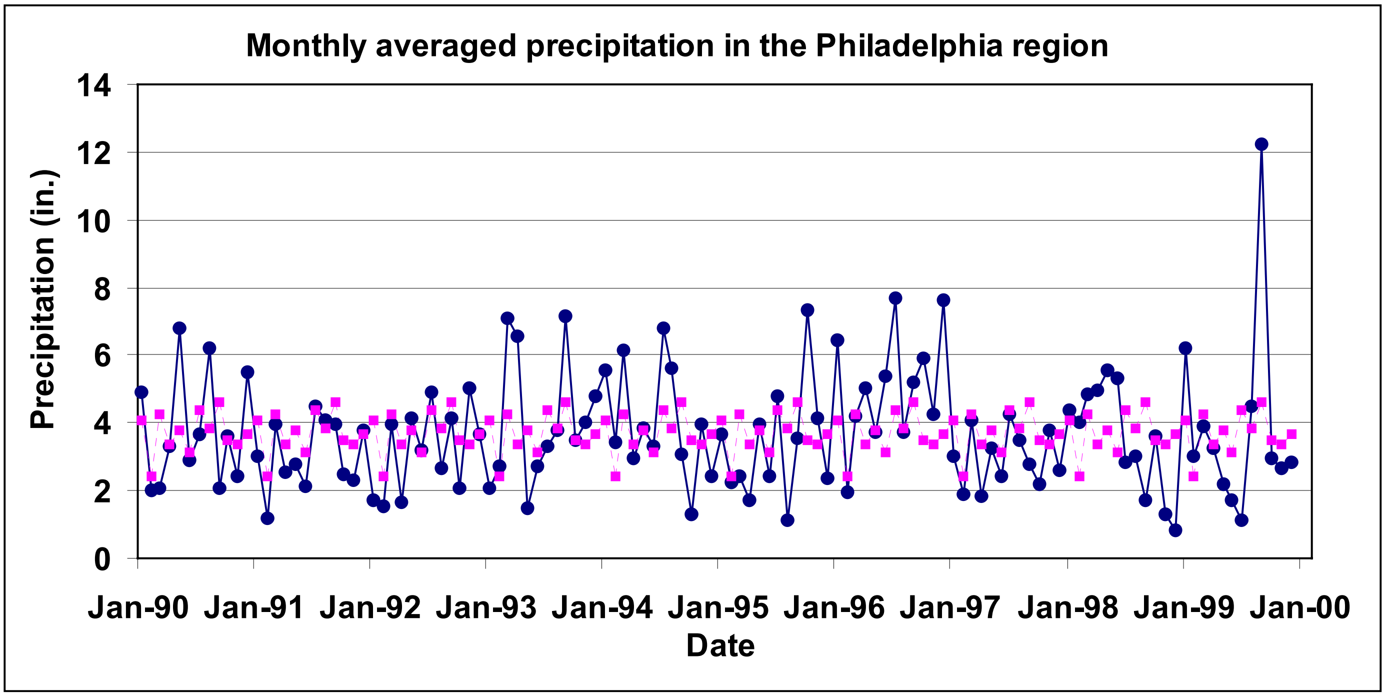


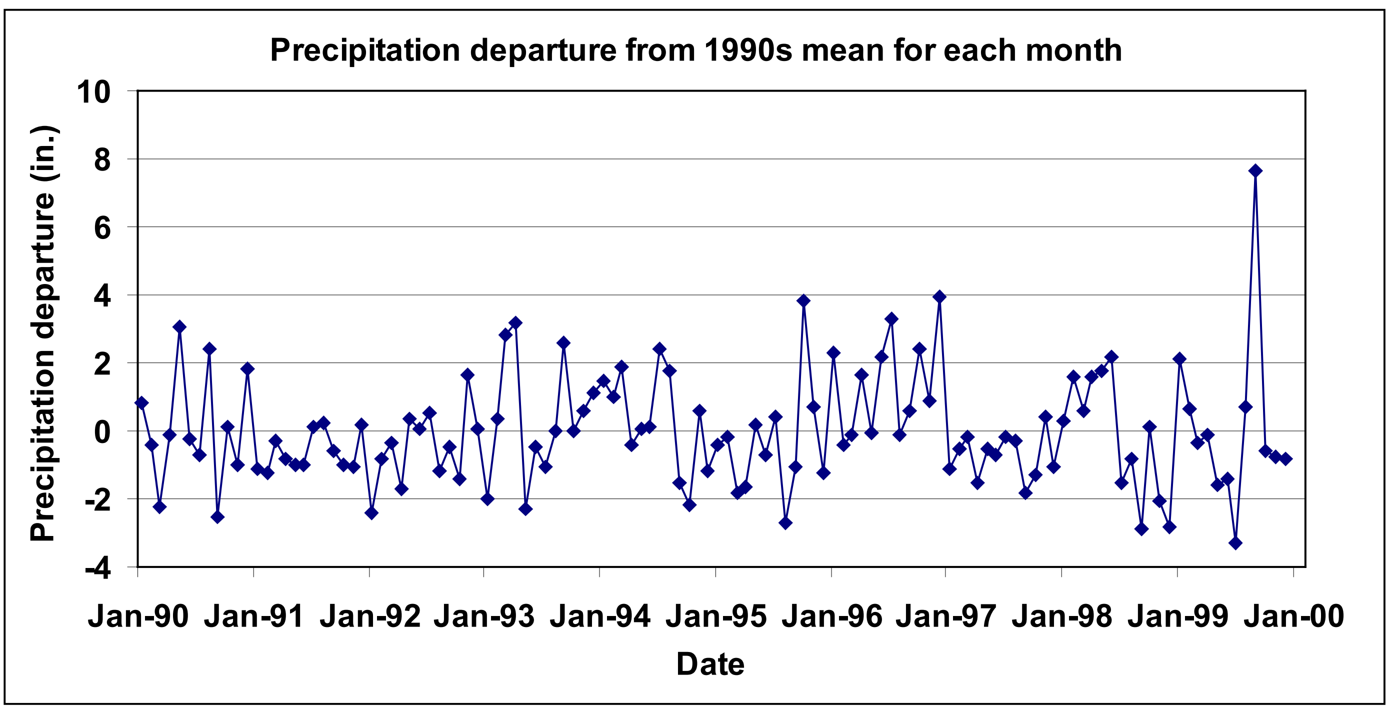
Historical flow in the Delaware River, measured as daily averaged flow at the Trenton gauge from 1910 through the present, is shown in Figure 2.1.2-4. Average annual flow dropped below 5000 cubic feet per second (CFS) only once over the period of record shown during the drought of the 1960s.

Recent decade scale patterns in climate and river flow for the region were also assessed to ascertain direct connections between these parameters and Philadelphia Water Department (PWD) intake water quality data. Monthly data for precipitation through the 1990s indicates extended dry periods through 1991 and 1997, along with severe short-term drought from May through July 1999 as illustrated by Figure 2.1.2-5. February has been particularly dry through the period, while the August average has been unusually high for summer months. Departures from monthly averages indicate variation from mean precipitation levels and are often a better indicator of climatic condition than are absolute values of precipitation.

Figure 2.1.2-5 Precipitation trends in Southeastern Pennsylvania through the 1990's

Small squares in top panel indicate 1990's monthly flow averages. Deviation from monthly averages indicates interannual trends toward particularly wet or dry weather. Averages are calculated by calendar month, so deviation in January, for instance, is the difference between the 1990's average January precipitation, and that occurring in a given year.





Stream flow within the Delaware Basin fluctuates immensely, as evidenced by Table 2.1.2-2. The maximum discharge occurs after the periods of heaviest precipitation with the passage of a tropical storm. The seasonal variation in terms of the amount of runoff recorded is driven by the melting of snow and the thawing of the ground in the late winter and early spring (maximum flows), as well as the time when evaporation of surface waters is highest (low flows), which occurs in late summer and early autumn. (Page, 1977 in Majumdar, Millar, and Sage, 1988).

Table 2.1.2-2 Streamflow Statistics for Selected Gauging Stations

	Years of Record	Drainage Area (sq.mile)	Average Annual Runoff (CSM)*	Mean Annual Flood (CSM)*	Ratio of 100-year to Mean Annual Flood	7-Day 10-Year Low Flow (CSM)*
Central Delaware River						
Neshaminy Creek near Langhorne	1934-72 38	210	1.3	60.6	3.4	0.04
Lower Delaware River						
Perkiomen Creek at Graterford	1914-72 58	279	1.3	56.4**	2.9**	0.05
Brandywine Creek at Chadds Ford	1911-53 1962-71 52	287	1.3	27.4	3.0	0.31

** Cubic feet per second per square mile*
*** Flood data for period 1957-72, 15 years*
***Source:** State Water Plan, Upper Delaware Basin, Central Delaware Basin, Lower Delaware Basin, 1983. Department of Environmental Resources, Office of Resources Management, Bureau of Water Resources Management, Harrisburg, PA. SWP2, SWP3, SWP4 in Sutton, O'Herron, and Zappalorti, 1996.*

Table 2.1.2-3 Duration Table of Daily Flow

	Delaware River												
Percent	**2**	**5**	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**95**	**98**
Trenton, NJ	47,500	33,500	24,800	17,400	13,200	10,400	8,300	6,600	5,100	3,850	2,750	2,180	1,780

Discharge, in cubic feet per second that was equaled or exceeded for indicated percentage of time.
Source: Busch, W.F. and L.C. Shaw, 1966. Pennsylvania Streamflow Characteristics, Low-Flow Frequency and Flow Duration. Pennsylvania Department of Forest and Waters. Harrisburg, PA, Water Resources Bulletin No. 1 in Sutton, O'Herron, and Zappalorti, 1996.

Average annual Delaware flow at Trenton is 9,149 CFS for the period 1912 through 1999 (USGS gauge data). Daily average Delaware River flow at Trenton through the 1990s is summarized in Figure 2.1.2-6 and indicates extremely low flow conditions in summer 1999, with less-pronounced low flow occurring in 1991. Lowest flows through the decade were not always associated with extended low levels of summer precipitation, suggesting that evaporation, groundwater storage, and surface water removal are important components in the water budget of the region.

Seasonal variation is driven primarily by precipitation, which is highest in spring, and evaporation, which is highest in summer months.

Figure 2.1.2-6 Daily Average Delaware River Flow at Trenton through the 1990's

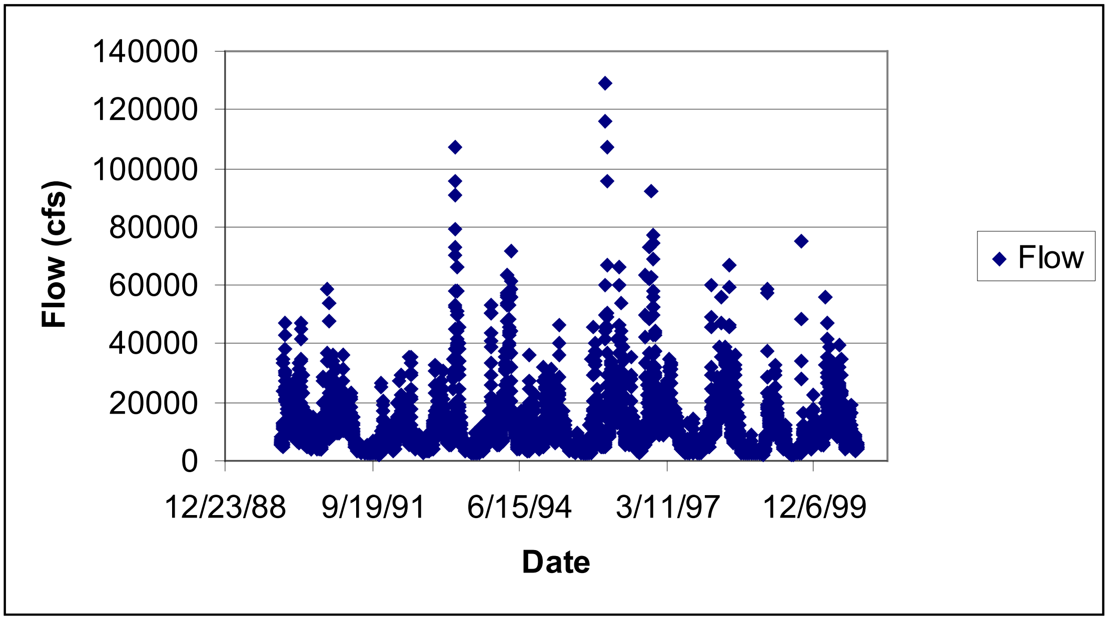


Table 2.1.2-4 summarizes the locations, drainage areas, annual mean flows, and annual runoff at gauging stations along the Lower Delaware River. The Trenton gauging station is the lowest station on the Delaware River that is not influenced by tidal patterns. Below Trenton, the Delaware River is influenced by the tides, and flows vary within the tidal cycle.

Table 2.1.2-4 Stream Gauging Data in the Lower Delaware River Basin

Station ID	Location	Drainage Area (mi2)	Period of Record *	Annual Mean Flow (cfs)	Annual Runoff (Inches)	10% Exceeds (cfs)	50% Exceeds (cfs)	90% Exceeds (cfs)
1463500	Delaware River at Trenton NJ	6780	1913-2000	11670	N/A	24600	7940	3000
1464000	Assunpink Creek at Trenton	90.6	1923-2000	133.64 **	N/A			
1465500	Neshaminy Creek near Langhorne PA	210	1935-2000	299	N/A	580	140	32
1465798	Poquessing Creek at Grant Ave. at Philadelphia PA	21.4	1965-2000	32.7	N/A	61	12	4.4
1467048	Pennypack Creek at Lower Rhawn St. Bridge Philadelphia PA	49.8	1965-2000	90.9	1.83	169	49	21

Table 2.1.2-5 gives a summary of the major tributaries in the Lower Delaware River (below Trenton New Jersey), their drainage areas, river mile location, and length. These Tributaries are located within the tidal zone, and are therefor affected by tidal changes. 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 therefor affect the water quality at the intake.

Table 2.1.2-5 Characteristics of Tributaries in the Lower Delaware River Watershed (in alphabetical order)

Major Tributary	Drainage Area (mi^2)	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 2.1.2-6 provides some information on three reservoirs located within the Tidal Delaware River Zone. Each of the Reservoirs is located within the Neshaminy River Drainage Area.

Table 2.1.2-6 Reservoirs within the Neshaminy River Watershed

RES #	STATE	RESERVOIR NAME	DAM NAME	RIVER NAME	DRAINAGE AREA (mi2)	PERCENT OF BASIN AREA	WATER TOT (DAYS)	DISCHARGE (gal/s)	NORMAL CAPACITY (billions of gallons)	SURFACE AREA (mi2)
	PA	Churchville Reservoir		Ironworks Creek	1.63		30*			0.26
	PA	Silver Lake		Mill Creek	1.45		30*			0.09
	PA	Core Creek		Core Creek	3.28		30*			0.27

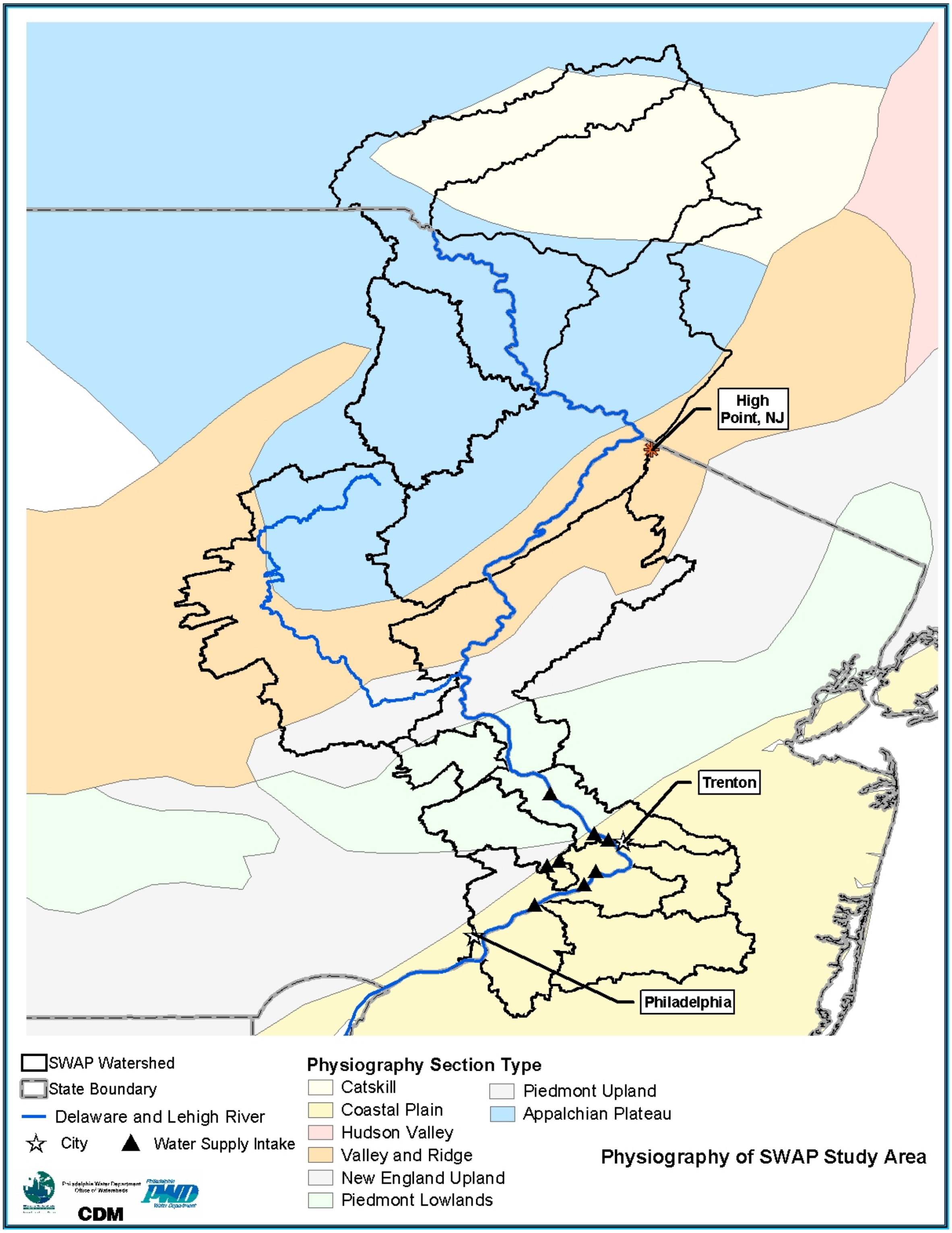
2.1.2.4 Physiography

The Delaware River Watershed covers a variety of physiographically distinct regional provinces. A physiographic province is an area of land that is composed of a particular type(s) of rock as a result of having undergone certain environmental processes over time which distinguish it from other surrounding areas. Each province is distinguishable by its physical landforms, unique rock formations, and groundwater characteristics.

From north to south, the five physiographic provinces in the SWAP study area are: the Appalachian Plateau, the Valley and Ridge, the New England Upland, the Piedmont, and the Atlantic Coastal Plain. (River Places (see Figure 1.2.3.1-1) http://www.riverplaces.com/drguide/DRGuideGeology.html). The physiographic section types are shown in Figure 2.1.2-7 below.

The Philadelphia Water Department Baxter Intake is located within the Atlantic Coastal Plain Providence. The Atlantic Coastal Plain Province is mainly lowlands with numerous streams and marshlands at about 100 feet above mean sea level (msl). The province is divided into two sections: the Outer Coastal Plain, which is comprised of southern New Jersey and eastern Delaware, and the Inner Coastal Plain, which consists of a narrow belt in Pennsylvania, northern Delaware, and an area in New Jersey located roughly 20 miles (32 km.) to the east of the Delaware River. Both sections, which are divided by a line of hills, contain clays, gravels, sands, and silts, but were formed in different geological time periods: the Inner Coastal Plain in the Cretaceous and Pleistocene Eras, and the Outer Coastal Plain in the Tertiary Era.

Figure 2.1.2-7 Physiographic Provinces Within the SWAP Study Area

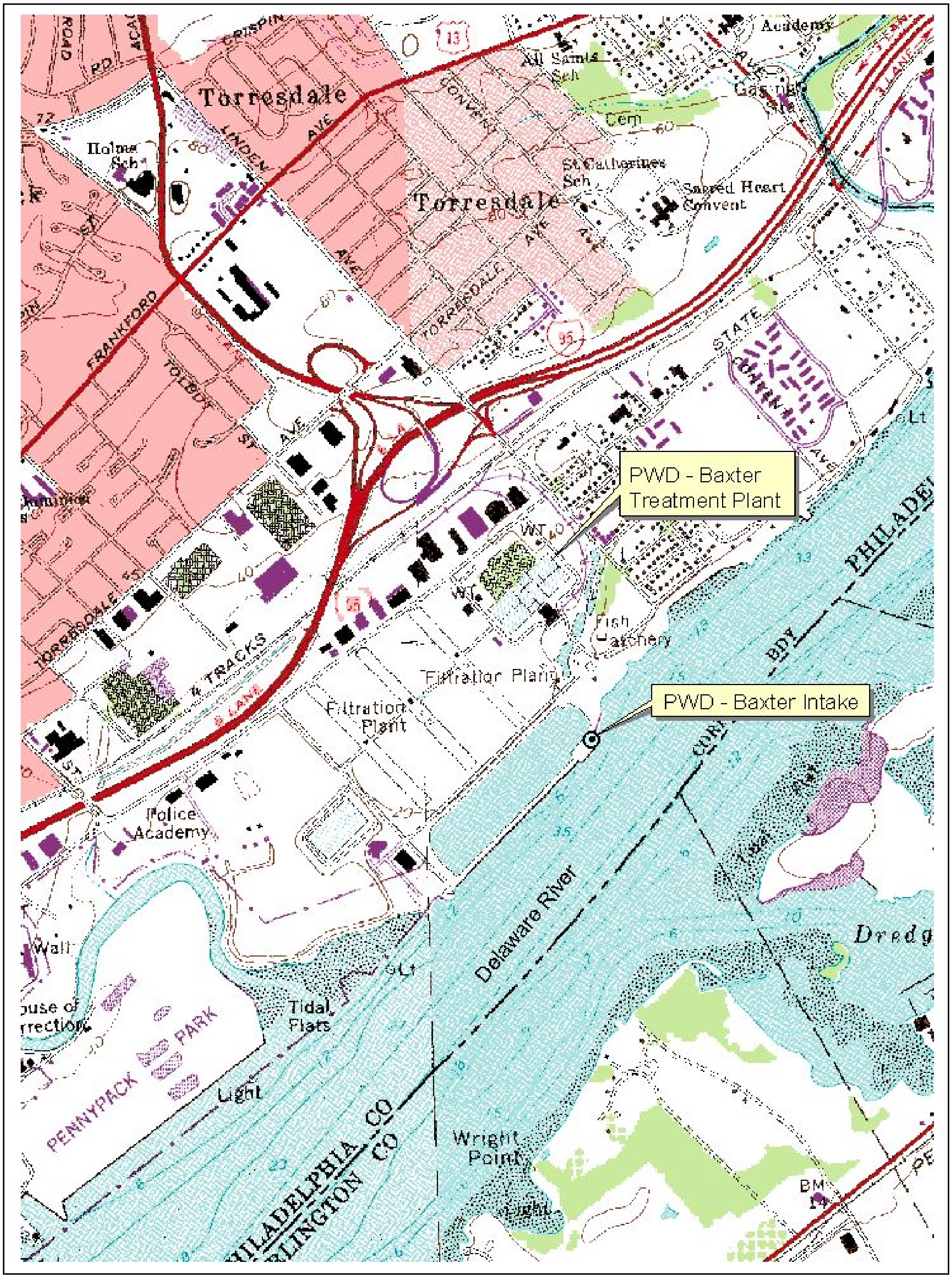


2.1.2.5 Topography

The general topography of the watershed can indicate where runoff issues may be important. Development on steeply sloping areas can create more of an impact on river water quality than development on gently sloped areas due to the potential to transport polluted runoff farther and faster. Topography of the area surrounding the Baxter Intake is shown in Figure 2.1.2-8. Understanding the topography of the area is an important aspect of source water assessment. The steep valley areas would be considered sensitive areas where runoff from particular sources or activities could have a potentially significant impact on river or stream water quality. These are also areas that would be ideal for preservation and protection against development pressure to minimize future runoff issues.

The combination of geologic, soil, and hydrologic characteristics found in the watershed make runoff of conservative contaminants from land activities into the adjacent surface waters very possible if no mitigation strategies are implemented. These characteristics also affect the quantity of the flow that can erode streambanks and deposit sediment in reservoirs.

Figure 2.1.2-8 Topographic Features Around the Baxter Intake



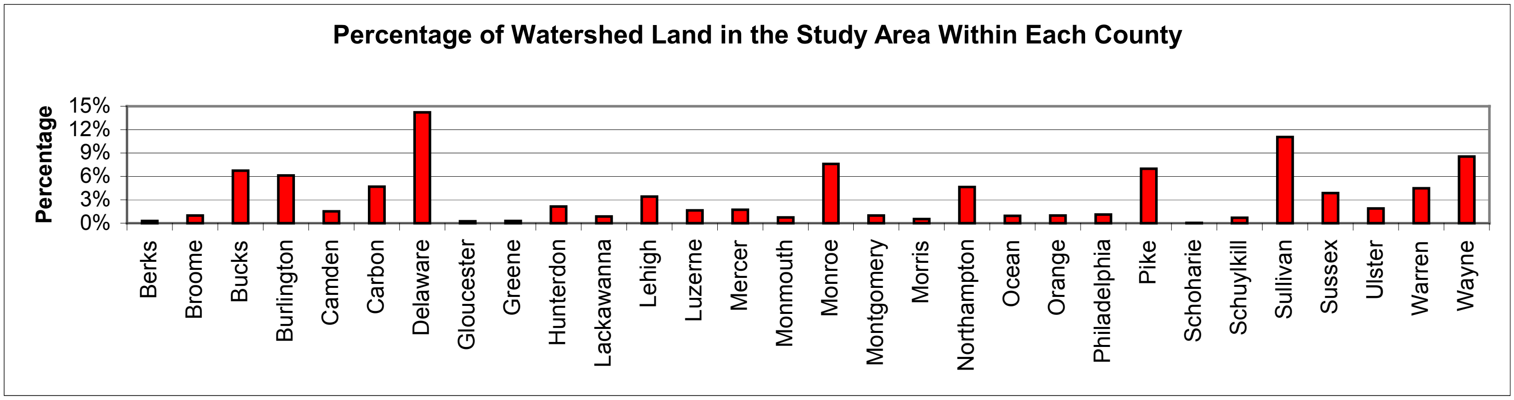
2.1.3 Land Use

Key Points

- **Recent land use studies conclude that the amount of developed land within the SWAP study area is approximately 10%. Forested lands account for about 70% of the land use.**
- **Studies of changing land use patterns in the watershed agree that the amount of developed land is increasing, as agricultural and forested lands decrease.**
- **Developed land areas are found mainly in the lower Delaware River Watershed, near major cities and transportation corridors.**
- **The effects of rapid development and increase in impervious surfaces in the Tidal NJ Lower, PA Bucks Direct, and Neshaminy Subwatersheds can be damaging to the area's natural environment and may impact the Philadelphia Water Department's drinking water supply.**

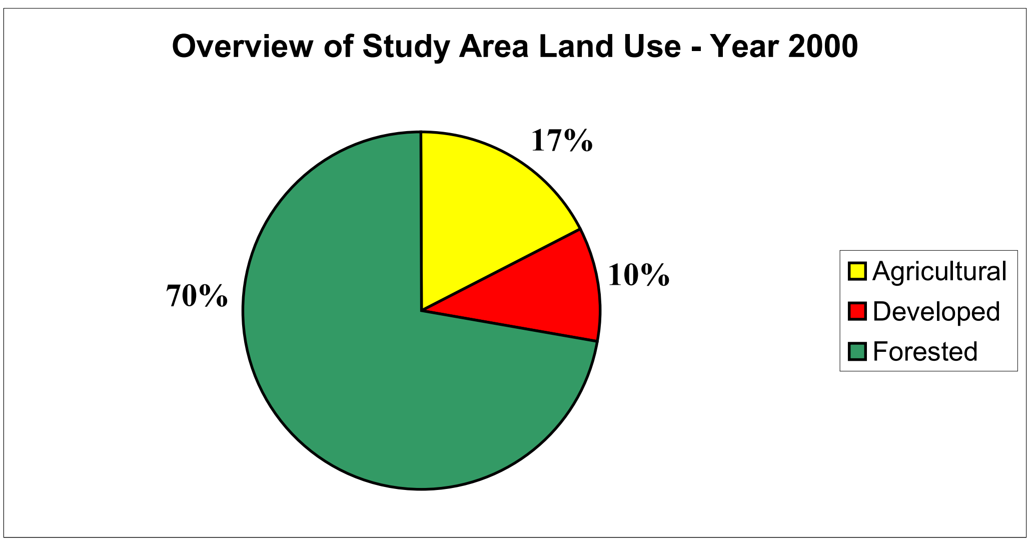
The SWAP study area is comprised of 30 counties located within Pennsylvania, New Jersey, and New York. Of these 30 counties, four (Warren County in New Jersey, Monroe, Northampton, and Pike Counties in Pennsylvania) are located entirely within the boundaries of the Delaware River Watershed. Sixty percent of Philadelphia County, where the Baxter Intake is located, is included within the watershed's total area. The USGS's National Land Cover Dataset (NLCD) land use coverage, detailed in Section 1.2.5, characterizes the entire study area. Figure 2.1.3-1 shows the percentage of watershed land in the study area within each county, and Figure 2.1.3-2 shows a general overview of the land use within the study area. Ten percent of the study area is characterized as developed. The majority of the remaining area is forested.

Figure 2.1.3-1 Percentage of Land Area in the Study Area Within Each County



Source: USGS National Land Cover Data 1992

Figure 2.1.3-2 Overview of the Study Area Land Use (2000)

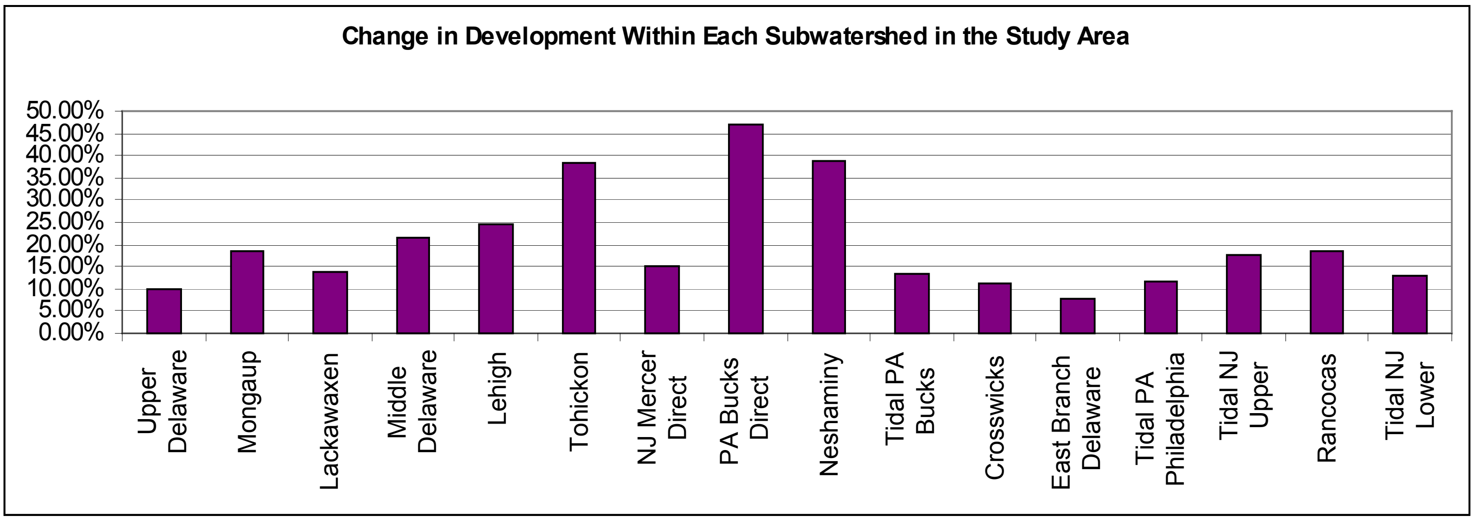


Source: USGS National Land Cover Data 1992

The Baxter Water Treatment Plant is the southern most intake within the Delaware River Watershed and SWAP study area and is located within the Tidal PA Philadelphia Subwatershed. This is the most developed subwatershed within the study area with a development rate of almost 80%. According to the 2000 Census, this subwatershed also has the single largest population in the study area. Heavy urbanization has run its course in the Philadelphia area and the Tidal PA Philadelphia Subwatershed did not experience a large increase in development activities between 1990 and 2000 as seen in some of the other subwatersheds. (Figure 2.1.3-3)

For example, the Tidal NJ Lower Subwatershed experienced a 13% change in development between 1990 and 2000. While 13% may not appear to be a large increase, this percentage is deceiving because it equals development of approximately 16.4 square miles. South Jersey currently depends upon groundwater for its water supply. If suburban sprawl in this area continues at this rate, the supply will be quickly depleted and New Jersey may ultimately need to use the Delaware River or possibly the Baxter Intake to obtain drinking water. The Neshaminy and PA Bucks Direct Subwatersheds had the highest change in development activities from 1990 to 2000. Both are located directly upstream from the Baxter Intake. Developed land use areas increased by approximately 35 square miles in the Neshaminy Watershed Subwatershed and by 5 square miles in the PA Bucks Direct Subwatershed.

Figure 2.1.3-3 Change in Development Within Each Subwatershed in the Study Area



Source: USGS National Land Cover Data 1992

The effects of this rapid development and increase in impervious surfaces can be damaging to the area's natural environment and possibly to the Philadelphia Water Department's drinking water supply. Municipalities within the study area need to recognize the potential impacts of this loss of agricultural and forested land and begin implementing ordinances that will help to protect these areas as well as the drinking water supply.

As shown in Figure 2.1.3-4, the area surrounding the Baxter Intake is primarily high density residential and commercial/industrial/transportation. This is to be expected, as the intake is located along the river within the City of Philadelphia and these types of land uses continue beyond the immediate area surrounding the intake. The Baxter Water Treatment Plant is adjacent to the Holmesburg Prison on the south and City-owned police and fire academies to the north. A fish hatchery is located directly on the Baxter Water Treatment Plant property at the southern end of the property. Further north of the intake, along the river, is a small area of forested lands and woody wetlands. Across from the intake in New Jersey, the land uses are predominantly low intensity residential with some commercial/industrial/transportation uses. The New Jersey side of the Delaware River also contains more forested and wetlands than the Pennsylvania side near the Baxter Intake. Areas indicated as industry may actually be abandoned or inactive property based on field inspections and tours of this watershed area. Figure 2.1.3–5 characterizes the land use percentages for the Baxter Intake's Zone B delineation.

Figure 2.1.3-4 Land Use Surrounding Baxter Intake

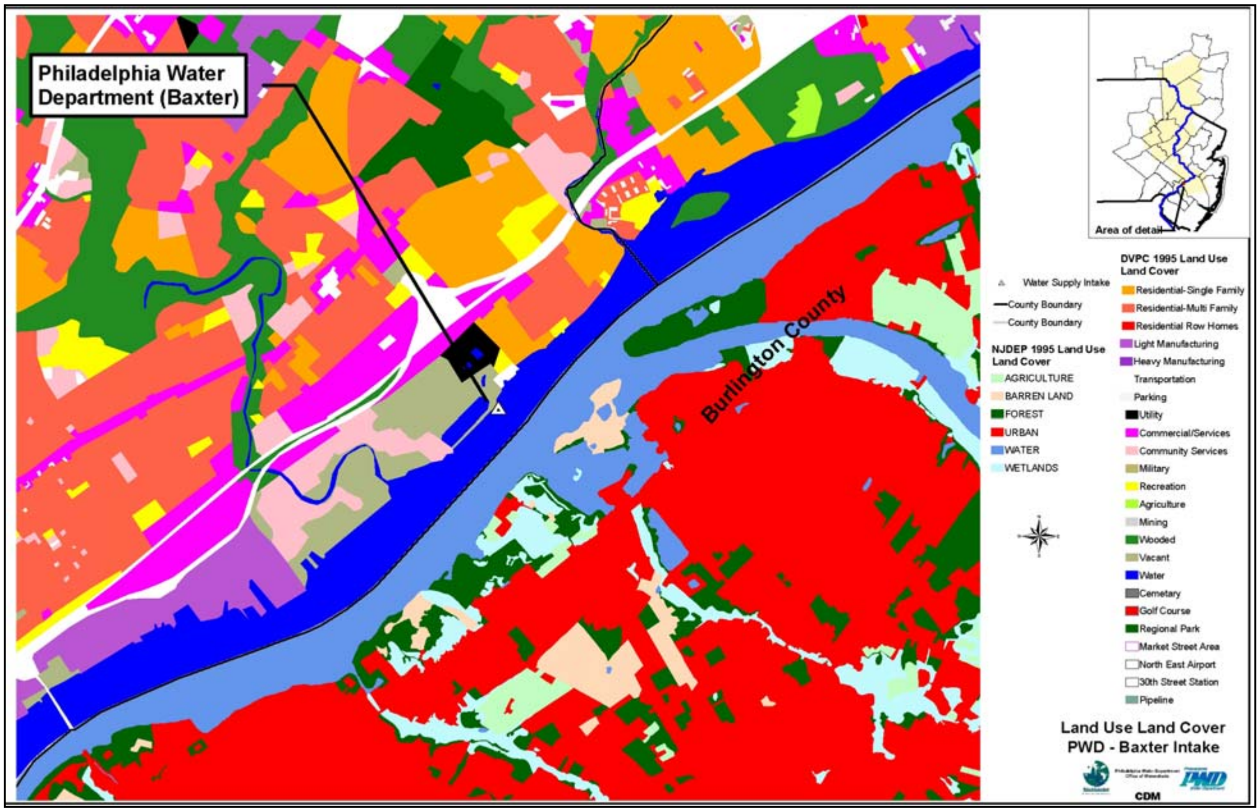
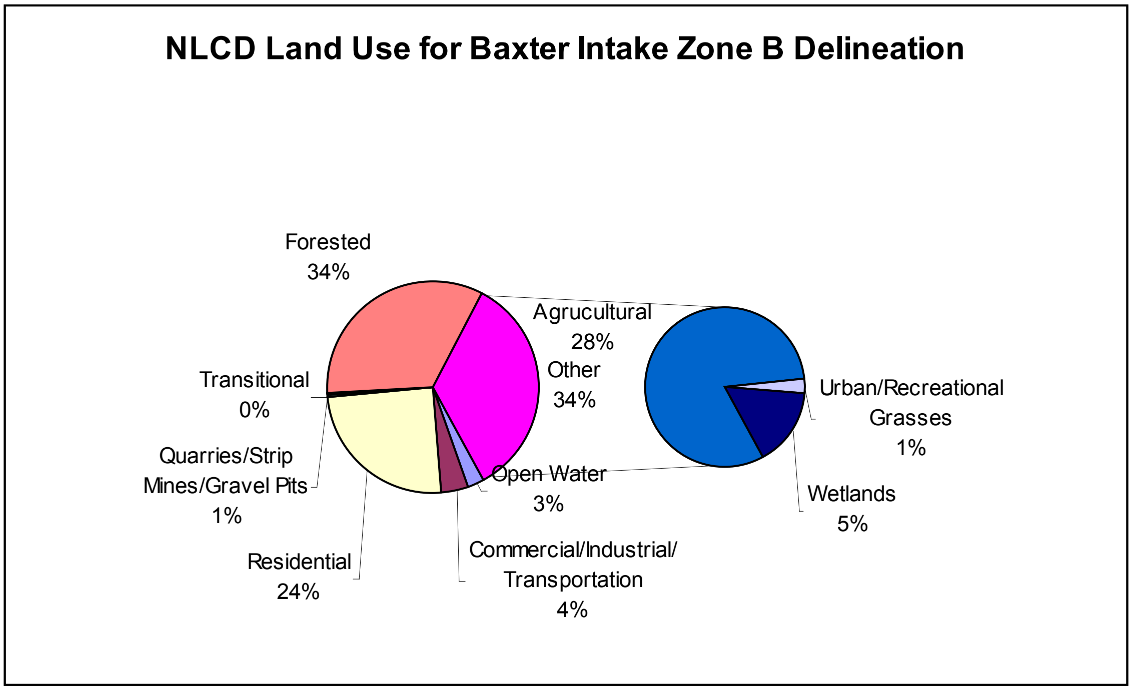


Figure 2.1.3-5 Updated NLCD Land Use for PWD Baxter Intake Zone B Delineation



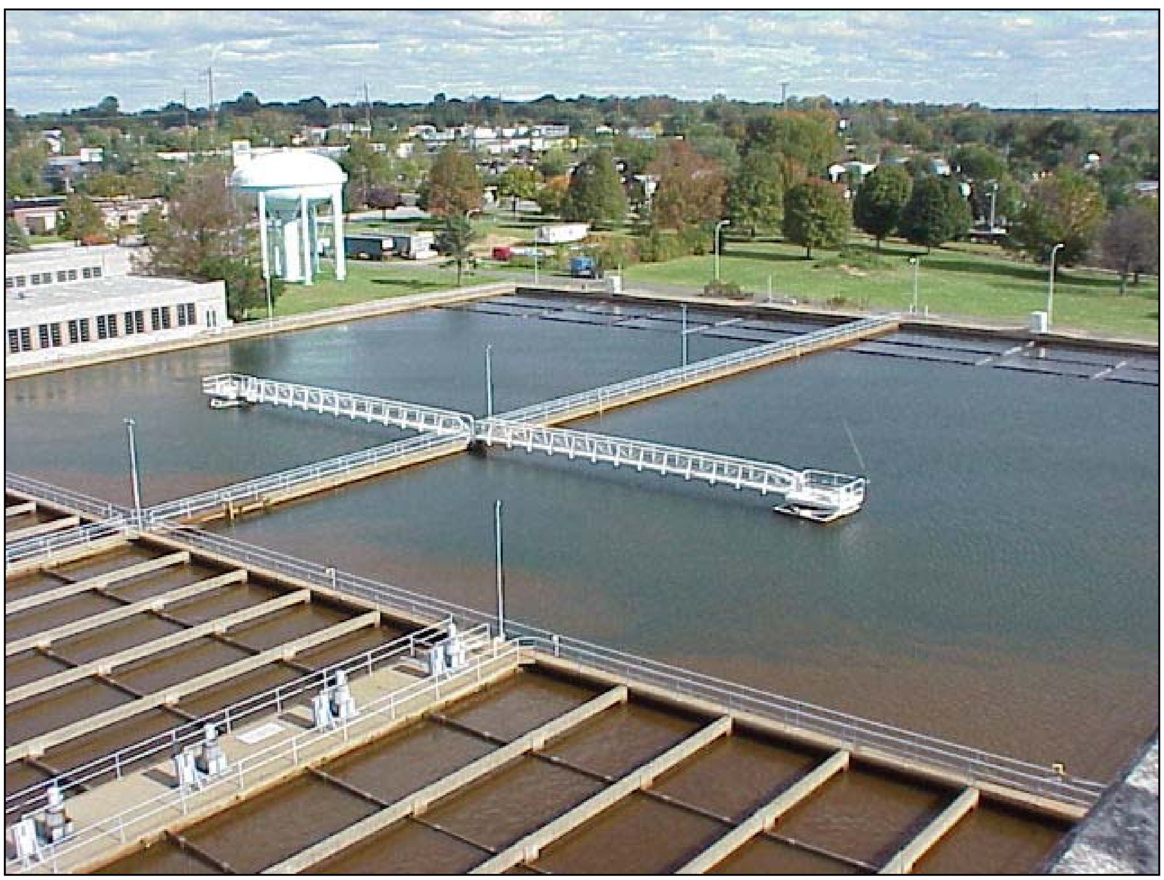
2.1.4 Drinking Water System

Key Points

- **The 175 million gallon per day (MGD) Baxter Water Treatment Plant (WTP) provides water to 750,000 people in Northeastern Philadelphia and Lower Bucks County.**
- **The Baxter Water Treatment Plant has won several awards for its outstanding treatment performance.**

The Baxter Water Treatment Plant (PWSID 1510001) of the Philadelphia Water Department is located in Torresdale just upstream of the confluence of the Pennypack Creek and Delaware River in Philadelphia County. Raw water is gravity fed via tidal elevation changes from the Delaware River at a daily average rate of 175 million gallons per day (MGD) with a maximum capacity of 320 MGD. The Baxter Water Treatment Plant services the entire region of Philadelphia east of Broad Street and parts of Lower Bucks County. Treated water from the Baxter WTP is delivered to about 750,000 people or 50% of the population of the City of Philadelphia. The treatment plant is shown below in Figure 2.1.4-1.

Figure 2.1.4-1 Philadelphia Water Department's Baxter Water Treatment Plant



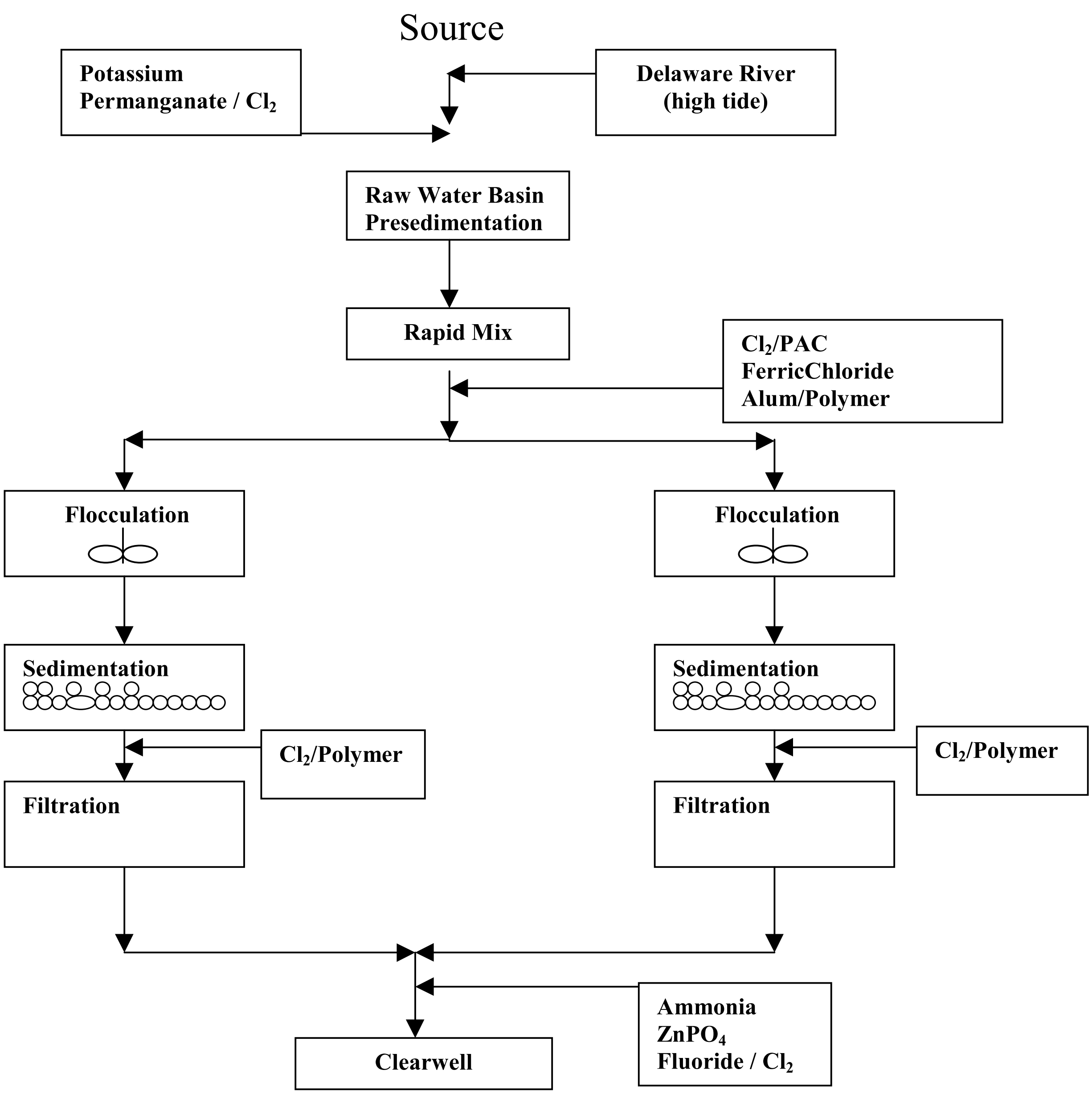
A process treatment schematic is found in Figure 2.1.4-2. As the raw water flows into the raw water basin during the high tide from the Delaware River Intake, it passes through screens for removal of large debris (leaves, branches, etc.) and is then held in a large basin at the Baxter WTP for at least 24 hours. The basin allows silt, sand, and other large particles to settle prior to conventional treatment. The pre-sedimentation basin has particular importance to remove pollutants during rain events or high flow conditions, when high concentrations of silt and large particles result from re-suspension of river sediment and runoff. Additionally, an oxidant or powdered activated carbon (PAC) may be added to the pre-sedimentation basin to mitigate algae or taste and odor episodes.

After pre-sedimentation, the coagulant ferric chloride is typically used to destabilize particles such as clay and viruses. Following coagulant addition, two stages of flocculation with gentle mixing are provided to allow the destabilized particles to agglomerate. Flocculation detention time is about 60 to 70 minutes. After floc is formed, it settles in basins with two to four hours of detention time. The floc that settles to the bottom of the basin is removed as sludge, which is sent to a City of Philadelphia Water Pollution Control Facility (WPCF). A chemical addition point, for chlorine, polymer, or pH adjustment is available after sedimentation.

Clarified water is then treated with dual media filtration. Dual media consists of anthracite and sand and removes remaining suspended material. Filters are usually terminated after two days time, prior to severe headloss or breakthrough. Ninety-four filters are available at the Baxter WTP. At average daily flow, the loading rate is less than two gallons per minute per square foot (gpm/sf). Upon termination, a filter is backwashed and spent backwash water is sent to the WPCF.

Disinfection at Baxter is achieved through addition of chlorine in the pre-sedimentation basin and after sedimentation. After filtration, ammonia is added for chloramination. This maintains a total chlorine residual of about two milligrams per liter (mg/L) in the distribution system for microbial control. After filtration, fluoride and zinc orthophosphate are also added to prevent tooth decay and for corrosion control, respectively. Filtered water is then stored in a clearwell and eventually pumped through a high-service pump station to the distribution system of the east and northeastern sections of Philadelphia and Lower Bucks County.

Figure 2.1.4-2 Schematic of Water Treatment Process at the Baxter WTP



2.1.5 Raw Water Quality

Key Points
- **Delaware River water quality is monitored to assess potential health risks, aesthetics, and treatment requirements.**
- **The Philadelphia Water Department routinely monitors pH, color, alkalinity, hardness, total dissolved solids, conductivity, turbidity, coliform, *Giardia* and *Cryptosporidium*, total organic carbon, UV absorbance, bromide, nitrogen, phosphorus, iron, manganese, sulfate, chloride and sodium at their Baxter Intake. Many other parameters are monitored as part of special studies.**
- **Turbidity and other suspended contaminants in the river tend to increase as a function of precipitation, runoff and river flow.**
- **Salt levels in the river appear to fluctuate seasonally, perhaps in response to application of road salts during the winter.**
- **Over the past decade, 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.**
- **Stream impairments in the lower Delaware River Watershed are primarily caused by stormwater runoff from urban and suburban areas.**

2.1.5.1 Water Quality Summary

Water Quality Parameters and Their Significance
A variety of parameters can be used to measure the health of our streams and rivers, as well as the suitability of these surface waters as a source of potable water supply. Table 2.1.5-1 summarizes the specific parameters sampled for at PWD's Baxter Intake. Table 2.1.5-1 also identifies the time period over which sampling was conducted, and the frequency of sampling. Most of the data is collected regularly by staff at the water treatment plant (WTP). That data is supplemented by measurements collected for compliance with the Information Collection Rule and by raw water measurements obtained at a pilot treatment facility located at the WTP.

Table 2.5.1-1 shows that an extensive amount of data has been collected to characterize almost all parameter groups at the Baxter Intake. Data generally spans 1990 to the present. A significant data set for parameters such as total suspended solids, metals, and nutrients, was available for detailed analysis of spatial and temporal trends. Data was very sparse for synthetic and volatile organic compounds, as well as for radionuclides. Data was supplemented by nearby sampling location of PWD Baxter Intake Pilot Plant. VOC, SOC and radionuclide data measured at the intake was limited and consequently supplemented by data from on-line databases.

Statistical summaries were developed for those parameter groups with sufficiently large data sets. Available water quality data for VOCs, SOCs, and radionuclides are analyzed separately due to incompleteness. In the statistical summaries, the minima and maxima are presented to show the range of values and variability of the data.

The means and medians are presented to show the central tendencies of the parameters – typically measured levels. A mean that is significantly greater than the median indicates that one or two high values are affecting the mean. Similarly, a mean that is significantly lower than the median indicates that one or two low values are reducing the average. The number of samples shows how many measurements were included in the computation of the statistics. The number of samples is related to the sampling frequency and time period given in Table 2.1.5-1. The number of non-detect measurements and the detection limit are also listed, where applicable. These were not included in computations of the minima, maxima, means and medians.

Table 2.1.5-1 Baxter Intake Sampling Summary

Parameter Group	Parameter	Frequency of Sampling	Time Frame	
Physical Parameters	pH	Weekly	Jan-90	Dec-99
	Apparent Color	Weekly	Jan-90	Aug-93
	Alkalinity	Weekly	Jan-90	Dec-99
	Hardness	Weekly	Jan-90	Jul-99
	Total Dissolved Solids	Sporadic	Jan-90	Jan-99
	Conductivity	Weekly	Jan-90	Dec-99
Particulates & Microbial Contaminants	Turbidity	Weekly	Jan-90	Dec-99
	TSS	Sporadic	Jan-90	Jun-99
	Total coliform (mf)	Sporadic	Mar-90	Dec-99
	E. coli (nut. Agar)	Weekly	May-95	Dec-99
DBP Precursors - (Organic Compounds & Bromide)	TOC	Weekly	Sep-93	Dec-99
	UVAbs@254nm	Bi-Weekly (look for data gap)	Jul-93	May-99
	Bromide	Weekly	May-95	Dec-99
Inorganic Compounds – Nutrients	Ammonia	Weekly	Jan-90	Feb-99
	Nitrite	Quarterly	Jan-90	Jun-99
	Nitrate	Bi-monthly	Feb-90	Dec-97
	D. Orthophosphate	Weekly	Jan-90	Feb-94
	T. Phosphate	Monthly	Jan-90	Jun-93
Inorganic Compounds – Metals	Iron, Total	Weekly	Jan-90	Jun-99
	Manganese, Total	Weekly	Feb-90	Jul-99
	Arsenic, Total	Quarterly	May-90	Jul-99
Inorganic Compounds – Secondary Contaminants	Sulfate	Monthly	Feb-90	Dec-99
	Chloride	Monthly	Jan-90	Feb-99
	Sodium	Monthly	Jan-90	Nov-99

Statistical results are discussed with respect to drinking water standards, which apply to the treated water. Although these standards or Maximum Contaminant Levels (MCLs) apply to treated water, they provide a good perspective on the quality of the raw water. Raw water quality results are also discussed with respect to impacts on treatment and finished water quality.

Physical Parameters

Physical parameters such as pH, alkalinity, color, taste, odor and conductivity may not be directly related to health risks but can be important measures of consumer satisfaction, as well as treatability.

The presence of very low levels of compounds that cause taste and odor events in drinking water can generate consumer complaints. Color, if not treated properly, can affect public perception of the water. Colored water generally indicates a higher level of organics or iron. Acid mine drainage from the Lehigh River Watershed may be contributing to manganese, and consequently, the color. Excessive nutrients can cause algae to bloom, which are also related to taste and odor compounds. Compounds that cause taste and odor or color do not generally pose health risks. However, they must be controlled to produce water that consumers want to drink. Expensive chemicals such as powdered activated carbon, potassium permanganate or ozone may need to be added during treatment to control formation. Effective watershed management can potentially save significantly on chemical treatment costs.

Two important parameters in maintaining effective treatment of drinking water are pH and alkalinity. They are monitoring tools that are essential to the drinking water treatment process. A water supply with high alkalinity may have increased chemical costs, because more pretreatment chemicals will be required for pH adjustment. Higher alkalinity is usually a naturally occurring phenomenon based on the hydrology of the region. Elevated pH levels can be indicative of algal blooms in the raw water supply. Algae are a concern because they can potentially clog WTP filters and because they can release very low levels of taste and odor compounds.

Conductivity measures the amount of ions (positive and negative) in the water and the ability of the water to conduct electricity. High levels of conductivity usually indicate high levels of salts, metals, or nutrients in the water. This parameter is a cheap and easy measurement used frequently in water quality studies. Table 2.1.5-2 summarizes the levels of physical parameters measured at PWD's Baxter Intake.

Table 2.1.5-2 Physical Parameters of Source Water

Parameter	Units	Minimum	Maximum	Mean	Median	No. of Samples
pH	pH units	6.3	8.5	7.5	7.5	504
Apparent Color	CU	5	100	32	25	175
Alkalinity	mg/L as CaCO3	18	86	41	41	504
Hardness	mg/L as CaCO3	1	121	63	64	309
Total Dissolved Solids	mg/L	70	240	125	121	65
Conductivity	umhos/cm	95	607	204	201	488

The statistics for the physical parameters show that the Delaware River is typical of most rivers in the northeast. The maximum pH of 8.5 at Baxter results from the algal blooms that can occur in late spring and early summer. The great range in apparent color, with the maximum of about 100 color units, is related to rain events. Apparent color measures color due to particulates and turbidity, as well as naturally occurring dissolved organic material. Consequently, apparent color values are influenced by rain events that increase the turbidity in the river.

The range in alkalinity is quite wide. In general, changes in alkalinity are related to base flow changes in the river. The median alkalinity and hardness of 41 and 64 milligrams per liter (mg/L) as $CaCO_3$, respectively, are reflective of moderately hard water. Increased hardness and alkalinity can increase chemical costs associated with reducing pH at the water treatment plant. Variability in total dissolved solids and conductivity may be due to changing salt levels in the river. Salt levels appear to fluctuate seasonally with the use of road salt in winter. Some of these seasonal and flow related trends are described in more detail in the spatial and temporal analysis sections.

Turbidity and Microbial Contaminants

Turbidity measures the clarity of the water. As water gets cloudier, the turbidity increases. This indicates that fine suspended particles that obscure light rays are present in the water. Turbidity can be caused by nearby roads, construction, erosion, and agricultural runoff. Levels of turbidity depend on the type of soils, slopes, land cover, and rain intensity.

Levels of microbial contaminants or pathogens determine whether a stream is safe for recreational swimming and help gauge the amount of fecal pollution entering it. Typical pathogen testing includes total coliforms, fecal coliforms, viruses, *E. coli*, *Giardia*, and *Cryptosporidium*.

As Table 2.1.5-3 shows, statistics for the particulates and microbial parameters are influenced by rain and runoff. On average, river turbidity and total suspended solids at Baxter are quite low with medians of 6 nephelometric turbidity units (NTU) and 16 mg/L, respectively. Maximum values of 65 NTU and 171 mg/l show how turbidity and solids can increase significantly as a result of rain events. As river flow increases above the annual median flow of 1,600 cubic feet per second (cfs), turbidity generally increases. Consequently, rain events may increase chemical usage at the WTP, but observed levels of turbidity are treatable. The pre-sedimentation basin at the WTP at Baxter is used to settle out much of these solids, prior to treatment.

Table 2.1.5-3 Particulate and Microbial Contaminants at Baxter Intake

Parameter	Units	Minimum	Maximum	Mean	Median	No. of Samples
Turbidity	NTU	0.3	65	8	6	502
Total Suspended Solids	mg/L	0.2	171	33	16	60
Total Coliforms	col/100mL	14	45000	3269	890	229
E. coli	#/100 mL	0.03	8000	433	120	216

Microbials will also increase during rain events, similar to the other particulates. Accordingly, median values for total coliforms and *E. coli* are one to two orders of magnitude lower than the maximum values. Although these parameters increase during rain events, disinfection with chlorine kills the *E. coli* and total coliform prior to distribution to consumers. However, disinfectant demand and associated costs may increase.

Table 2.1.5-4 *Giardia* and *Cryptosporidium* Detected at the Baxter WTP Intake from March 2001 through March 2002

Pathogen	No. of Samples	Min (oocysts/L)	Max (oocysts/L)	Mean (oocysts/L)	% Positive
Giardia	26	<0.1	2.1	0.367	69
Cryptosporidium	26	<0.1	0.2	0.032	27

Table 2.1.5-4 summarizes the most recent results from March 2001 through March 2002. As shown, *Giardia* is found frequently indicating routine impacts by sewage discharges upriver, while *Cryptosporidium* is detected in only one of four samples collected.

PWD has been studying *Giardia* and *Cryptosporidium* in their water supply since 1994. Since then a number of special studies have been conducted to identify the sources and influences on the concentrations of these pathogens in the river. However, the technology to adequately detect and analyze water samples for *Cryptosporidium* is not considered reliable or accurate enough for risk assessments and detailed quantitative comparisons. Given the limitations of the analytical methods, the following have been determined:

- *Giardia* and *Cryptosporidium* are detected more often in the river during storm events.

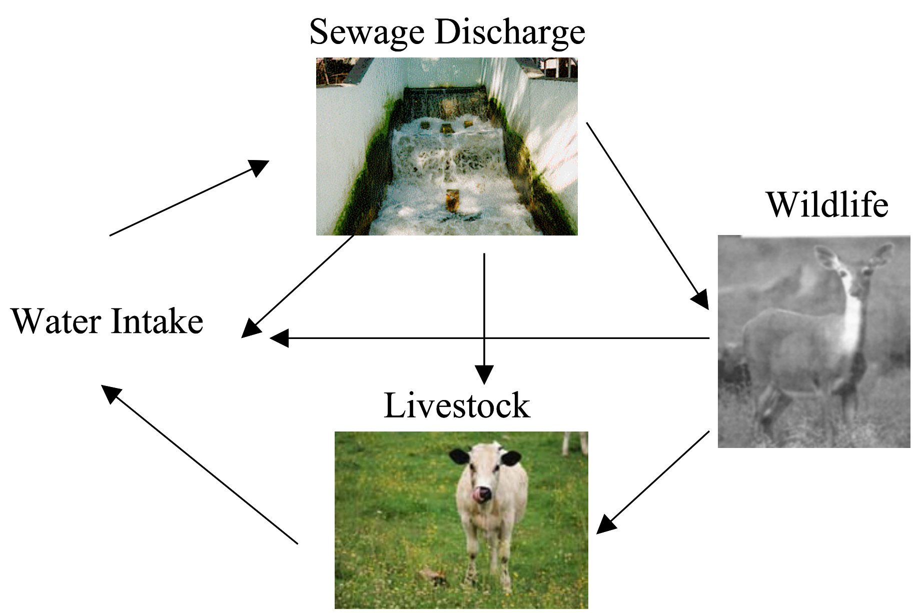
- *Giardia* and *Cryptosporidium* are typically found at higher concentrations in the river during storm events and correlate with higher turbidity concentrations.

- *Giardia* and *Cryptosporidium* are typically found at higher concentrations during winter and spring when water temperatures are colder and oocyst survival is improved.

- *Giardia* and *Cryptosporidium* are routinely found in sewage effluents and the feces of neonatal animals.

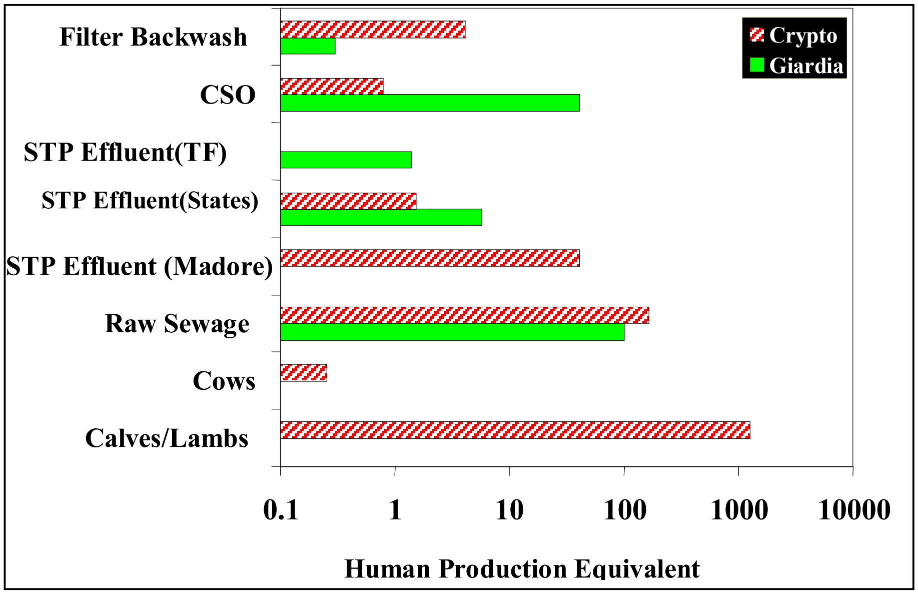
The previous findings indicate that runoff and sewage discharge influence the presence and concentrations of *Cryptosporidium* and *Giardia* in the Lower Delaware River Basin. Figure 2.1.5-1 provides a theoretical description of the cycle of how the pathogens are moved from one source to another and eventually into the river or water supply. As shown in Figure 2.1.5-2, one calf can produce as much *Cryptosporidium* in a day as 1,000 infected persons or over 100 adult cattle. Therefore, keeping young animals away from sensitive water supply areas is prudent.

Figure 2.1.5-1 Theoretical Pathogen Transport Cycles in a Multi-Use Watershed



Information to date suggests that treatment processes are sufficiently removing these pathogens. According to cases of cryptosporidiosis reported in Philadelphia from 1997 to 1999, none were related to drinking water. In fact, the main risk factors for cryptosporidiosis were identified as travel, swimming, contact with an infected person, day care, or farm animal contact. This is further corroborated by the observation that more cases of cryptosporidiosis are reported during the summer months when travel and swimming occur. During the summer months, *Cryptosporidium* and *Giardia* are found at their lowest levels in the local rivers and streams.

Figure 2.1.5-2 Comparison of Amount Produced by Various Sources of *Cryptosporidium* and *Giardia*



Disinfection By-product Precursors

Precursor compounds react with other chemicals (such as chlorine or ozone) used in the disinfection process to treat drinking water and may create disinfection by-products (DBPs). High levels of DBPs may cause human health impacts. Some of the precursors that are tested for include bromide, total organic carbon, and UV absorbance.

Total organic carbon (TOC) may include volatile organic compounds (VOCs) and synthetic organic compounds (SOCs), but is mostly comprised of natural organic matter from the decomposition of leaves and plants. The naturally occurring compounds that comprise TOC form chlorinated organic compounds, such as chloroform. These chlorinated organics may be carcinogens at certain levels of exposure. Absorbance of UV light is a good surrogate for dissolved natural organic matter and does not require the same level of technical laboratory analysis as TOC.

Bromide is a concern because it reacts with ozone to form bromate, a potential carcinogen. Bromide also reacts with chlorine and organics to form brominated chlorine by-products that may pose health risks.

The analytes shown in Table 2.1.5-5 are typical measures of DBP precursors. The agreement between the mean and median TOC values indicate that TOC at Baxter is typically less than 2.8 mg/L. This is a relatively low level of natural organic matter. The maximum TOC of 5.4 mg/L may be rain/run-off related, because TOC measures particulate organics. However, TOC increases in the summer and early fall due to more plant growth and decomposition. Formation of chlorination by-products is of particular concern during those seasons. UV absorbance shows similar trends as TOC.

Table 2.1.5-5 Organic Compounds – DBP Precursors at Baxter Intake

Parameter	Units	Minimum	Maximum	Mean	Median	No. of Samples
Total Organic Carbon	mg/L	0.7	5.4	2.8	2.6	250
UV Absorbance at 254nm	cm^{-1}	0.017	0.205	0.090	0.081	168
Bromide	mg/L	0.015	0.136	0.036	0.032	85

Bromide levels in the Delaware River are considered to be elevated compared to other rivers nationally. The maximum value, close to 0.136 mg/L, was typical of levels measured during the drought in the summer of 1999. As base flow in the river decreases, bromide levels increase significantly. This can be a potential concern for use of ozone as a disinfectant since bromate has a MCL of 0.01 mg/L. Bromide may also form harmful by-products in the presence of chlorine and organic matter.

Inorganic Compounds - Nutrients

Nutrients can cause excessive algal growth that can harm fish and impact water treatment. These measurements can determine the impacts of nutrient runoff from lawns, gardens, farms, and other sources. Some of the major nutrients measured are nitrite, nitrate, ammonia, phosphorus, and orthophosphate. High levels of nutrients cause algal blooms. The algae can then clog filters at the water treatment plant, or upon dying, release very small amounts of chemicals (parts per trillion levels) that can make the water taste or smell bad. Though these chemicals are not harmful, they must be removed during water treatment, using powdered activated carbon. Table 2.1.5-6 provides an overview of nutrient levels at the Baxter Intake.

Table 2.1.5-6 Inorganic Compounds – Nutrients at Baxter Intake

Parameter	Units	Minimum	Maximum	Mean	Median	No. of Samples
Ammonia	mg/L as N	0.01	0.95	0.11	0.08	431
Nitrite	mg/L as N	0.02	26	2.1	0.02	28
Nitrate	mg/L as N	0.85	2.53	1.19	1.17	59
Dissolved Orthophosphate	mg/L as P	0.01	0.15	0.06	0.06	167
Total Phosphate	mg/L as PO4	0.05	0.42	0.11	0.10	38

Median levels of the nutrients are fairly low and do not significantly affect drinking water treatment. Nitrite values are of particular concern in drinking water treatment due to blue baby syndrome. A general guideline for this is one mg/L of nitrite, of which the median value at Baxter is well below. However, the mean value of 2.1 mg/L and the maximum value of 26 mg/L are well above the general guideline and require careful observation. The maximum value of total nitrate of 2.53 mg/L is well below the MCL of ten mg/L. (DeZuane, 1997).

Inorganic Compounds – Metals

The presence of metals can cause various types of impacts on drinking water. Some metals, such as lead, may pose health risks at certain concentrations, if not removed at the WTP. The presence of lead in raw water is usually indicative of an industrial source. Lead is usually removed from the raw water by filtration. It may later leach into the water supply from distribution system pipes, but this can be controlled by chemical treatment.

Manganese is a concern for drinking water treatment because it can cause an unsightly color in the water at very low concentrations. Treatment of manganese with powdered activated carbon or potassium permanganate can be very costly. High levels of metals may also impact aquatic life. Metals are usually found at high levels in those areas of the Delaware River Watershed impacted by acid mine drainage, acid rain, or by erosion and earth disturbances. PWD monitors levels of arsenic, lead, iron and manganese, as shown in Table 2.1.5-7.

Table 2.1.5-7 Inorganic Compounds – Metals at Baxter Intake

Parameter	Units	Minimum	Maximum	Mean	Median	No. of Samples	No. of Non-Detects	Detection Limit
Arsenic	mg/L	0.001	0.002	0.001	0.001	19	13	0.0005-0.01
Lead	mg/L	0.001	18	0.39	0.004	47	1	0.001
Iron	mg/L	0.050	8.3	0.88	0.61	329	0	
Manganese	mg/L	0.010	0.63	0.08	0.07	332	0	

Lead and arsenic data are shown because they may pose potential health risks if present in the water supply. Median values at the intake are below the current MCLs of 0.050 mg/L and 0.015 mg/L for arsenic and lead, respectively. The iron values shown in Table 2.1.5-7 are quite variable, with a median of 0.6 mg/L and a maximum of 8.3 mg/L. Iron levels can increase significantly at Baxter due to rain events. Higher iron increases treatment costs for chemical addition and sludge disposal. The manganese data also shows variability that can be attributed to rain events. The median value of 0.07 mg/L for raw water at the intake is in excess of the Maximum Contaminant Level Goal for finished water of 0.02 mg/L. At Baxter, this is treated by using potassium permanganate or chlorine, resulting in increased treatment costs.

Inorganic Compounds – Secondary Contaminants

Salts are the secondary contaminant considered. Salts indicate whether the stream is a freshwater or saltwater environment. Salts are not typically removed by the water treatment process. High levels of salt in drinking water are not desirable for those with low-sodium diets. Sodium and chloride are the two major constituents of salts measured.

Table 2.1.5-8 presents statistics for sodium and chloride. Salt levels increase during the winter, as described further in the temporal analysis sections. From a drinking water perspective, high sodium values are of concern for individuals with hypertension. The median/mean value of about 22 mg/L is slightly above the EPA guidance value of 20 mg/L. Use of road salts in the winter should be limited or applied using more effective techniques.

Table 2.1.5-8 Inorganic Compounds – Secondary Contaminants at Baxter Intake

Parameter	Units	Minimum	Maximum	Mean	Median	No. of Samples
Chloride	mg/L	8	71	23	21	148
Sodium	mg/L	0.02	44	12	12	140

Synthetic Organic Compounds

Pesticides and herbicides comprise most of the synthetic organic compounds (SOCs). SOCs are manufactured chemicals that generally last a long time in the environment and may have toxic effects on human and aquatic life. Dozens of pesticides and herbicides, which can be tested for in water, exist. Generally, atrazine, a herbicide used for farming and agriculture is the most heavily used and widely found. The EPA website has more details about pesticides and herbicides, if more information is required.

Table 2.1.5-9 lists the SOCs tested for at the PWD intakes. Table 2.1.5-10 shows the SOCs that were detected in the Delaware River during a fall 2000 monitoring event. As shown in tables 2.1.5-9 and 2.1.5-10, a number of SOCs that have been banned or have limited use are still being detected in the river or its tributaries. In addition, though some of the SOCs detected were related to farming, the others appear to be related to urban, residential, commercial, transportation, or industrial activities (please see Table 2.1.5-12). It is also interesting to note the diversity of chemicals detected in upstream watershed areas such as the Wissahickon Creek. The detection of a number of pesticides and herbicides in this stream suggests that there is still significant use of herbicides and pesticides in this mainly residential watershed.

Table 2.1.5-11 compares the SOCs detected in or near the PWD Delaware intakes with those detected in the Delaware Watershed based upon preliminary results of the USGS NAWQA study. As shown, there are a number of common SOCs such as atrazine, alachlor, metolachlor, and simazine. These were all herbicides that are associated with agricultural activities. The similarities suggest that these activities have impacts on water resources throughout the Delaware River Basin and are not unique to the Delaware River.

Table 2.1.5-9 Herbicides, Pesticides, and SOCs Results for the Baxter WTP

	1995	1996	1997	1998	1999	2000
PESTICIDES						
Alachlor	ND	ND	ND	NA	NA	ND
Aldicarb	ND	ND	NA	NA	NA	NA
Aldicarb Sulfone	ND	ND	NA	NA	NA	NA
Aldicarb Sulfoxide	ND	ND	NA	NA	NA	NA
Atrazine	NA	+	ND	+	ND	+
Carbaryl	ND	ND	NA	NA	NA	NA
Carbofuran	ND	ND	ND	NA	NA	ND
Chlordane	ND	ND	ND	NA	NA	ND
Hexachlorocyclopentadiene	ND	ND	ND	NA	NA	+
Lindane	ND	ND	ND	NA	NA	+
Methomyl	ND	ND	NA	NA	NA	NA
Methoxychlor	ND	ND	ND	NA	NA	ND
Oxamyl	ND	ND	ND	NA	NA	ND
Simazine	ND	ND	ND	NA	NA	ND
3-Hydroxcarbofuran	ND	ND	NA	NA	NA	NA
HERBICIDES						
Dalapon	NA	+	NA	NA	NA	NA
Dicamba	ND	ND	NA	NA	NA	NA
Endothall	ND	ND	ND	NA	NA	ND
Metolachlor	+	ND	NA	NA	NA	NA
Metribuzin	ND	ND	NA	NA	NA	NA
Pentachlorophenol	ND	+	ND	ND	ND	+
Picloram	ND	ND	ND	NA	NA	ND
Propachlor	ND	ND	NA	NA	NA	NA
SYNTHETIC ORGANIC CHEMICALS						
Benzo[a]Pyrene	ND	ND	ND	NA	NA	ND
Di-2(ethylhexyl)Adipate	ND	ND	ND	NR	NR	ND
Di-2(ethylhexyl)Phthalate	ND	ND	+	NA	NA	ND
1, 2-Dibromo-3-Chloropropane	ND	ND	ND	NA	NA	ND
Ethylene Dibromide	ND	ND	ND	NA	NA	ND

Notes: NA - Not Analyzed; NR - Not Reported; ND - Not Detected

Table 2.1.5-10 SOCs Detected in Lower Delaware River Watersheds During Fall 2000 Monitoring Study

Chemical	MDL	Concentration Ranges	Pennypack Creek	Poquessing Creek	Tacony/ Frankford Creek
Lindane*	0.0038		ND	ND	ND
Dieldrin	0.0038	0.004-0.03	ND	Yes	Yes
Alachlor	0.15		ND	ND	ND
Diethylphthalate	0.04	0.05-0.13	Yes	Yes	Yes
Fluorene	0.02	0.02	ND	ND	Yes
Phenanthrene	0.02	0.02-0.06	Yes	Yes	Yes
Dibutylphthalate	0.11	0.11-0.19	Yes	ND	Yes
Pyrene	0.02	0.05-0.09	Yes	ND	Yes
Benzo(a)anthracene	0.02	0.03 - 0.05	Yes	ND	Yes
Chrysene	0.02	0.03 - 0.05	Yes	ND	Yes
Benzo(a)flouranthrene	0.05	0.05 - 0.07	ND	ND	Yes

Note: *All concentrations in ug/L (ppb)*
ND - Not Detected
**Insecticide for seed, lumber, livestock, pest control, most use restricted in 1980's*

Table 2.1.5-11 Comparison of SOCs Detected To Date by USGS NAWQA Study in the Delaware River Watershed

Chemical Name
Atrazine
Metalochlor
Simazine
Prometon
Diazinon
Carbaryl
Tebutheiuron
Trifluralin
Alachlor
Chlorpyrifos
Cyanazine
Acetochlor

Note: Shaded chemicals were also detected at the PWD WTPs in the Delaware River Watershed

Table 2.1.5-12 Uses and Possible Sources of Herbicides, Pesticides, and SOCs Detected at the PWD WTPs

Synthetic Organic Chemical	Use	Associated Activity
Atrazine	Herbicide	Farming (96percent used for corn & soybeans)
Hexachlorocyclopentadiene	Pesticide	Chemical/Petroleum Processing
Simazine	Herbicide	Farming
Dalapon	Herbicide	Farming
Metolachlor	Herbicide	Farming - used to control certain broadleaf and annual grassy weeds in field corn, farming, highway right of ways, and orchards
Pentachlorophenol*	Herbicide	Wood finishing / furniture
Di-2(ethylhexyl)phthalate	SOC	Unknown
Lindane**	Insecticide	Farming, golf courses, orchards, landscaping
Dieldrin	Insecticide, termiticide	Residential/agricultural termite / pesticide application
Alachlor	Herbicide on corn and soybeans	Farming
Diethylphthalate	Plasticizer, component in the processing of polyvinyl chloride (PVC)	PVC manufacturing, solvent; aircraft lubes; insect repellent, stp effluents, landfill leachate, tire manufacturing
Fluorene	Resins and dyes	Wastewater, petroleum production, landfill leachate, urban runoff, combustion, resins, dyes
Phenanthrene	Dyes, explosives, pharmaceuticals, fossil fuels	Wood and fossil fuel combustion, garages, metal foundries, timber processing
Dibutylphthalate	Insect repellent, plasticizer, solvent	Plastic production, landfill leachate, wastewater, pulp mills
Pyrene	Biochemical research and fossil fuels	Crude oil, tire manufacturing, fossil fuel combustion, aluminum manufacturing
Benzo(a)anthracene	Coal Tar/Crude Oil	Exhaust emissions, plastics production
Chrysene	Coal Tar	Exhaust emissions, telephone poles, railroad ties
Benzo(a)flouranthrene	Fossil Fuels	Exhaust emissions

**wood preservative, herbicide, defoliant - non-wood uses banned in 1987; antimicrobial disinfectant*
***insecticide for seed, lumber, livestock, pest control, most use restricted in 1980's*

Volatile Organic Compounds

Volatile organic compounds (VOCs) are synthetic, lightweight compounds that vaporize or evaporate easily. Some VOCs such as vinyl chloride and benzene are known to be carcinogenic, while others such as chloroform are suspected to be cancer-causing agents. Industrial point sources account for most direct discharges into surface waters, but municipal wastewater plants constitute a second major source. In general, VOCs are used in solvent and degreasing compounds. Some VOCs are frequently connected with hazardous waste sites. These pollutants, a result of industrialization, are usually present at extremely low concentrations that do not appear to pose immediate health risks.

Note that most organic compounds in water are naturally occurring and VOCs comprise ten percent of the total organic material found in water. (DeZuane 1997).

Measurements of volatile organic compounds (VOCs) at the Baxter Intake are sparse compared to the other parameters. Table 2.1.5-13 summarizes the VOCs analyzed for in PWD's drinking water. For VOCs, the DRBC data for the Betsy Ross Bridge and Ben Franklin Bridge sampling locations are combined with the PWD Baxter data in Table 2.1-14 and Table 2.1.5-15. Table 2.1.5-14 is a summary of VOCs analyzed at or near the PWD Baxter Intake. The data was broken into three sets depending on the location of sampling.

Table 2.1.5-13 Regulatory VOCs Tested for in PWD's Drinking Water

Contaminant Name	MCL	MDL
Benzene	0.005	0.0005
Carbon Tetrachloride	0.005	0.0005
1, 2-Dichloroethane	0.005	0.0005
o-Dichlorobenzene	0.6	0.0005
p-Dichlorobenzene	0.075	0.0005
1, 1-Dichloroethene	0.007	0.0005
cis-1, 2-Dichloroethene	0.07	0.0005
Trans-1, 2-Dichloroethene	0.1	0.0005
Dichloromethane	0.005	0.0005
1, 2-Dichloropropane	0.005	0.0005
Ethylbenzene	0.7	0.0005
Monochlorobenzene	0.1	0.0005
Styrene	0.1	0.0005
Tetrachloroethene	0.005	0.0005
Toluene	1	0.0005
1,2,4-Trichlorobenzene	0.07	0.0005
1, 1, 1-Trichloroethane	0.2	0.0005
1, 1, 2-Trichloroethane	0.005	0.0005
Trichloroethene	0.005	0.0005
m,p-Xylenes	10	0.0005
o-Xylene	10	0.0005

Results in mg/L

MCL = Maximum **C**ontaminant **L**evel

MDL = Method **D**etection **L**imit

(Note: These chemicals were not detected in the finished water)

Table 2.1.5-14 Volatile Organic Compound Summary at or near Baxter Intake

Data Set	Data Source	# of Parameters Analyzed	Parameters	Frequency of Sampling	Total # of Samples	# of Non-Detects	Time Frame
Set 1	PWD Baxter	13	chloroform; dibromochloromethane; dichlorobenzene-p; dichlorobromomethane, diss; methylene chloride; methyltbutylether; nonadienal-t2,c6; toluene; totalthm; trichloroethane-1,1,1; triclanisole-2,3,6; triclanisole-2,4,6; xylene-m,p	sporadic	135	63	Jan-90 – Oct-99
Set 2	BRBC – Betsy Ross Bridge Sampling Location	31	benzene; bromodichloromethane, whole water; bromoform; bromomethane, recoverable; carbon tetrachloride; chlorobenzene; chloroethane; chloroethylvinylether-2, total water; chloroform; chloromethane; dibromochloromethane; dichlorodifluoromethane, total; dichloroethane-1,1; dichloroethane-1,2; dichloroethene-t1,2, total; dichloroethylene-1,1; dichloropropane-1,2; dichloropropene-cis-1,3; dichloropropene-trans-1,3; dimethylcyclopentane; ethyl benzene; ethylbenzene, total; methyl bromide, total; methyl chloride, total; methylene chloride; tetrachloroethane-1,1,2,2; tetrachloroethylene; toluene; trichloroethane-1,1,1; trichloroethane-1,1,2; trichloroethylene; trichlorofluoromethane, total; vinyl chloride	sporadic	1595	1594	Jul-89 – Jun-97
Set 3	BRBC – Ben Franklin Bridge Sampling Location	31	benzene; bromodichloromethane, whole water; bromoform; bromomethane, total, water; carbon tetrachloride; chlorobenzene; chloroethane; chloroethylvinylether-2, total water; chloroform; chloromethane; dibromochloromethane; dichlorodifluoromethane, total; dichloroethane-1,1; dichloroethane-1,2; dichloroethene-t1,2, total; dichloroethylene-1,1; dichloropropane-1,2; dichloropropene-cis-1,3; dichloropropene-trans-1,3; dimethylcyclopentane; ethyl benzene; ethylbenzene, total; methyl bromide, total; methyl chloride, total; methylene chloride; tetrachloroethane-1,1,2,2; tetrachloroethylene; toluene; trichloroethane-1,1,1; trichloroethane-1,1,2; trichloroethylene; trichlorofluoromethane, total; vinyl chloride	sporadic	1392	1388	Jul-89 – Jun-97

Thirteen different parameters were analyzed in the first data set at the Baxter Intake yielding a total number of 135 samples. However, VOCs were only detected in 72 of those samples. Thirty-one different parameters were analyzed in the second data set at the Betsy Ross Bridge yielding a total number of 1594 samples. However, VOCs were detected in only one of the samples. Thirty-one different parameters were analyzed in the first data set yielding a total number of 1392 samples. However, VOCs were not detected in only four samples. This data suggests that more accurate sampling is occurring at the Baxter Intake.

Table 2.1.5-15 summarizes the results of the monthly sampling conducted from 1990 to 2000. Of those compounds detected, chloroform, p-dichlorobenzene, dichloroethane, methylene chloride, trichlorethane, and toluene are currently regulated. All chemicals measured in the river, were well below their regulatory drinking water MCL limits. Chloroform, dibromochloromethane, and total trihalomethanes all constitute trihalomethanes. Their presence is indicative of chlorine in the river, either due to an industrial source, chlorinated wastewater discharges, or road salt. The maximum value noted for chloroform of 9 μg/L is well below the drinking water MCL of 100 μg/L.

Table 2.1.5-15 Summary of Detectable VOCs at or near Baxter Intake

Compounds Detected	Sampling Location	Units	Min	Max	# of Samples Detected	Detection Limit	MCL
Chloroform	PWD-Baxter	μg/L	0.3	7.3	28	0.3	100
Dibromochloromethane	PWD-Baxter	μg/L	0.3	0.3	1	0.3	TTHM <80
Dichlorobenzene-p	PWD-Baxter	μg/L	0.3	0.3	1		75
Dichlorobromomethane	PWD-Baxter	μg/L	0.3	1.4	5		
Dichloroethane-1,2	DRBC - Ben Franklin Bridge	μg/L	1	2.5	4		5
Dichloroethane-1,2	DRBC - Betsy Ross Bridge	μg/L	1.3	1.3	1		5
Methylene chloride	PWD-Baxter	μg/L	0.4	1	4	0.3	5
methyltbutylether	PWD-Baxter	μg/L	1.01	1.01	1		
nonadienal-t2,c6	PWD-Baxter	μg/L	35.9	35.9	1		
Toluene	PWD-Baxter	μg/L	0.3	0.5	2	0.3	1,000
Total Trihalomethanes	PWD-Baxter	μg/L	0.3	9	28	0.3	TTHM <80
Trichloroethane-1,1,1	PWD-Baxter	μg/L	0.3	0.3	1		5

Note: the sample results that were (with qualifier J) estimated, were excluded form this table.

A further examination of regulatory VOC monitoring of 21 chemicals at the Baxter Intake from 1994 to 1999 did not identify VOCs related to source water impacts. Typically, other than the occasion of a gasoline, fuel oil, petroleum pipeline break, or related spill, VOCs from point or non-point sources have not had a routine or regulatory compliance impact on water quality in the 1990s at the Baxter WTP Intake.

MTBE is a specific VOC produced as a gasoline additive used to reduce air pollution. However, it is quite persistent and is easily tasted or smelled at very low concentrations and can impact drinking water aesthetics. Monitoring was conducted by PWD for methyl tertiary-butyl ether (MTBE) during periods from 1996 to 2000. Maximum concentrations detected were 3.8 ug/L, which is well below the recommended limits of 20 ug/L. Data to date for the Delaware River indicates that concentrations are highest during the summer periods when recreational boating is at its peak in the river. Recreational boat engines and in particular, jet skis or wave runners, have been observed by studies in California to represent the most significant source of MTBE. Boat engines and jet skis can release uncombusted gasoline directly into the water.

Radionuclides

Radioactivity is not typically a major health concern in surface waters based on actual concentrations and frequency of detections. Nevertheless, surface waters may be susceptible to radioactive contaminants from nuclear industrial accidents. Increased use of radioisotopes in the health industry may also be a potential source of pollution. Some radionuclides are naturally occurring due to soil and rock decomposition. Naturally occurring radionuclides are found at much higher concentrations in groundwater, than in surface water. The major concern with radionuclides is that they cannot be removed by known chemical or physical treatment and are generally very persistent in the environment. Natural decay can be an extremely slow process.

Radioactivity in water may be caused by four general categories of radiation: alpha and beta particles, gamma rays and neutrons. Chronic effects of radiation are still not well identified, so pending further research, health authorities have followed a basic tenet of keeping exposure to the lowest level. Maximum contaminant levels (MCLs) of gross alpha particles, gross beta particles and combined radium isotopes (226 + 228) are 5 pCi/L, 4 mrem/yr., and 5 pCi/L, respectively. Strontium-90 is another isotope of particular concern due to its toxicity and persistence (DeZuane, 1997).

In Table 2.1.5-16, radionuclides data in PWD's finished drinking water is presented for 1999. As shown in Table 2.1.5-16, no radionuclides have been detected.

Table 2.1.5-16 Radionuclides in PWD Drinking Water Effluents (1999)

Parameter	MCL	MDL	Effluent Concentration (pCi/L)
Gross Alpha	15 pCi/L	3 pCi/L	ND
Gross Beta	50 pCi/L ~ 4 mrem	4 pCi/L	ND
Strontium-90	8 pCi/L	10 pCi/L	ND
Tritium	20,000 pCi/L	1000 pCi/L	ND

MCL = Maximum **C**ontaminant **L**evel – a regulatory limit by the USEPA or PADEP
MDL = Method **D**etection **L**imit – the level of a contaminant that can be detected by current testing methods
NA = Not **A**nalyzed
ND = Not **D**etected (less than the MDL)

Algae and Taste and Odor Compounds

Blue green algae can have significant impacts on the taste and odor of water and require costly treatment to remove its unpleasant impacts. Typically, blue-green algae impacts occur during the spring in April and May, when water temperatures are colder, but they can occur in the fall and winter. Diatoms typically impact treatment operation by clogging filters and reducing filter run times. Diatom blooms usually occur during the summer months. Table 2.1.5-17 provides a summary of the monthly total algae and diatom concentrations in the Delaware River. They are mainly dictated by the availability of nutrients. As shown, diatoms make up a significant portion of the total algae observed in the water supply during the summer months.

Table 2.1.5-17 Monthly Concentrations of Algae and Diatoms at the Baxter WTP Intake - 1999

	BAXTER WTP INFLUENT					
	TOTAL ALGAE (count/ 1 mL)			TOTAL DIATOMS (count/ 1 mL)		
MONTH	AVERAGE	MINIMUM	MAXIMUM	AVERAGE	MINIMUM	MAXIMUM
April	2,167	1,000	3,300	2,033	1,000	2,900
May	3,750	3,000	4,700	3,500	2,900	4,700
June	2,740	2,100	3,300	2,560	2,100	3,300
July	4,660	400	17,400	4,580	400	8,200
August	8,400	2,300	15,100	8,300	2,100	14,900
September	1,400	600	2,300	1,300	600	2,300

2.1.5.2 Temporal Water Quality Analysis

Temporal water quality analysis consisted of assessing variation in climate, flows and water quality over a variety of time scales. Weather patterns and river flow rates were studied over the period of record, typically on the order of the past century. General trends in water quality were assessed using data collected at the Baxter Intake at Philadelphia by PWD over the period 1990-1999. Trends in precipitation chemistry and water quality data collected exclusively at the Baxter Intake were assessed for the past decade, with available data from 1990 through 1999.

Seasonal trends in water quality at the Baxter Intake from 1990 through 1999 (Figure 2.1.5-3) were typical of those found in north temperate river systems, although solute concentrations in the Delaware are at the high end of the range for these rivers in general. Observations from this figure also have been summarized in Table 2.1.5-18. Dissolved orthophosphate (ortho-P) was typically low in winter and spring months and higher in summer months. Despite seasonal fluctuations driven mainly by flow variation, dissolved ortho-P remained well above limiting levels for phytoplankton growth in all seasons. Ammonia exhibited its highest levels in the wintertime, although it was nearly always a small fraction of the total dissolved inorganic nitrogen (which was mostly nitrate). Nitrate levels were measured less frequently, but were typically lowest in spring associated with high flows and peaks in phytoplankton growth. Highest nitrate concentrations were generally in the fall and winter, but these were never near the MCL of 10 mg/l. Bulk measures of dissolved solutes, including conductivity and alkalinity, exhibited clear seasonal trends, with maximum levels occurring in summer and fall when flows were lowest. In a watershed with little impacts from impervious cover, concentrations of conductivity would be expected to reach their highest levels occurring in late summer. Also, relatively stable conservative ions like chloride and fluoride would generally be expected to mirror the conductivity trends when impervious cover impacts are not dominant. However, the highest levels of conductivity and chlorides were observed intermittently in wintertime, suggesting impacts of de-icing treatments to roadways during winter storms. Fluoride exhibited the expected trends for stable ions in watersheds not impacted by impervious cover suggesting influences by point source discharges. Turbidity appeared to be lowest in general during summer months, when precipitation and flow levels are lower and storms are infrequent. Manganese displayed no apparent trend, but was periodically at levels as high as 0.63 mg/l through the period of study.

Long-term variation at the intake is dominated by the previously mentioned patterns of increasing solute levels including measures of conductivity, alkalinity, chloride and sodium. Ammonia levels have generally decreased through the 1990s, although levels were elevated in winter months in all years (Figure 2.1.5-4). Conductivity, alkalinity, chloride and sodium levels all increased through the decade at Baxter, with sodium levels increasing at the fastest rate relative to initial (1990) concentrations. These observations also have been summarized in Table 2.1.5.19.

Figure 2.1.5-3 Seasonal Patterns in Water Quality at Baxter Intake During 1990 - 1999

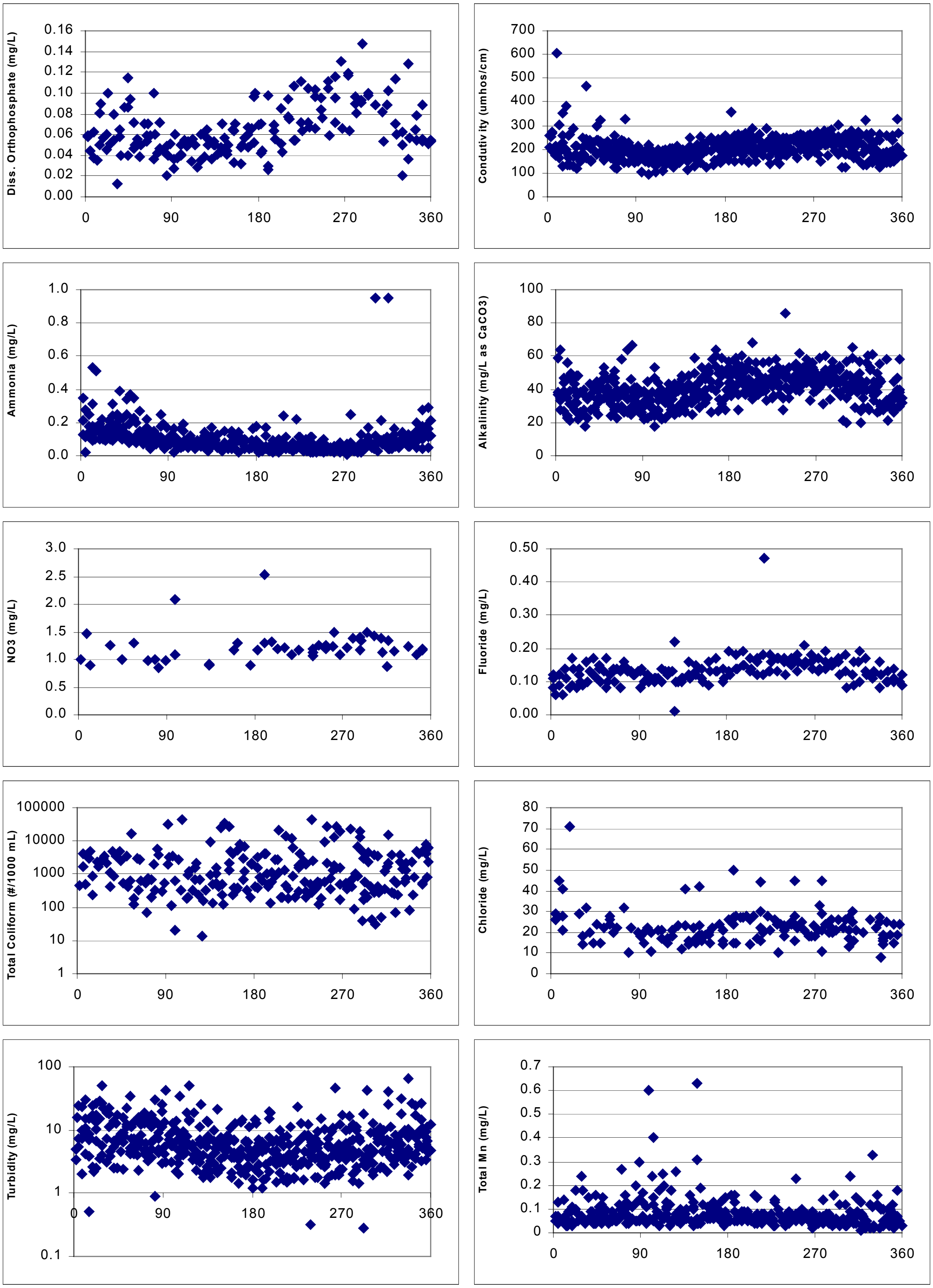


Table 2.1.5-18 Summary of Seasonal Water Quality Trends at Baxter Intake During 1990 - 1999

Parameter	Seasonal Trend	Peak During	Minimum During	Cause of Higher Values	Cause of Lower Values	Suspected Activities	Suspected Area(s)
Orthophosphate (Phosporus)	Yes	Fall / Winter	Summer	Lack of Biological Activity	Biological Activity	Wastewater Discharges, Agriculture	Watershed Wide
Ammonia	Yes	Winter	Summer	Lack of Biological Activity	Biological Activity	Wastewater Discharges, Agriculture	Watershed Wide
Nitrate	No	N/A	N/A	N/A	N/A	N/A	N/A
Total Coliform	No	N/A	N/A	N/A	N/A	N/A	N/A
Turbidity	Yes	Winter/Spring	Summer	Rainfall	Lack of Rainfall	Construction, Agriculture	Watershed Wide
Conductivity	Yes	Summer/ Fall	Spring	Road Runoff Low Flows	High Flows	De-icing of roadways	Lower Delaware
Alkalinity	Yes	Summer/ Fall	Spring	Low Flows High Groundwater Contribution	Rainfall, Acid Mine Drainage	Acid Mine Drainage, Acid rain	Lehigh River / New York
Fluoride	Yes	Summer/ Fall	Winter	High Flows	Low Flows	Wastewater Discharges, Groundwater	Unknown
Chloride	Yes	Summer/ Fall/ Winter	Spring	Road Runoff Low Flows	High Flows	De-icing of roadways	Lower Delaware
Manganese	No	N/A	N/A	N/A	N/A	N/A	N/A

Figure 2.1.5-4 Trends in Water Quality at Baxter Intake by Decade During 1990 - 1999

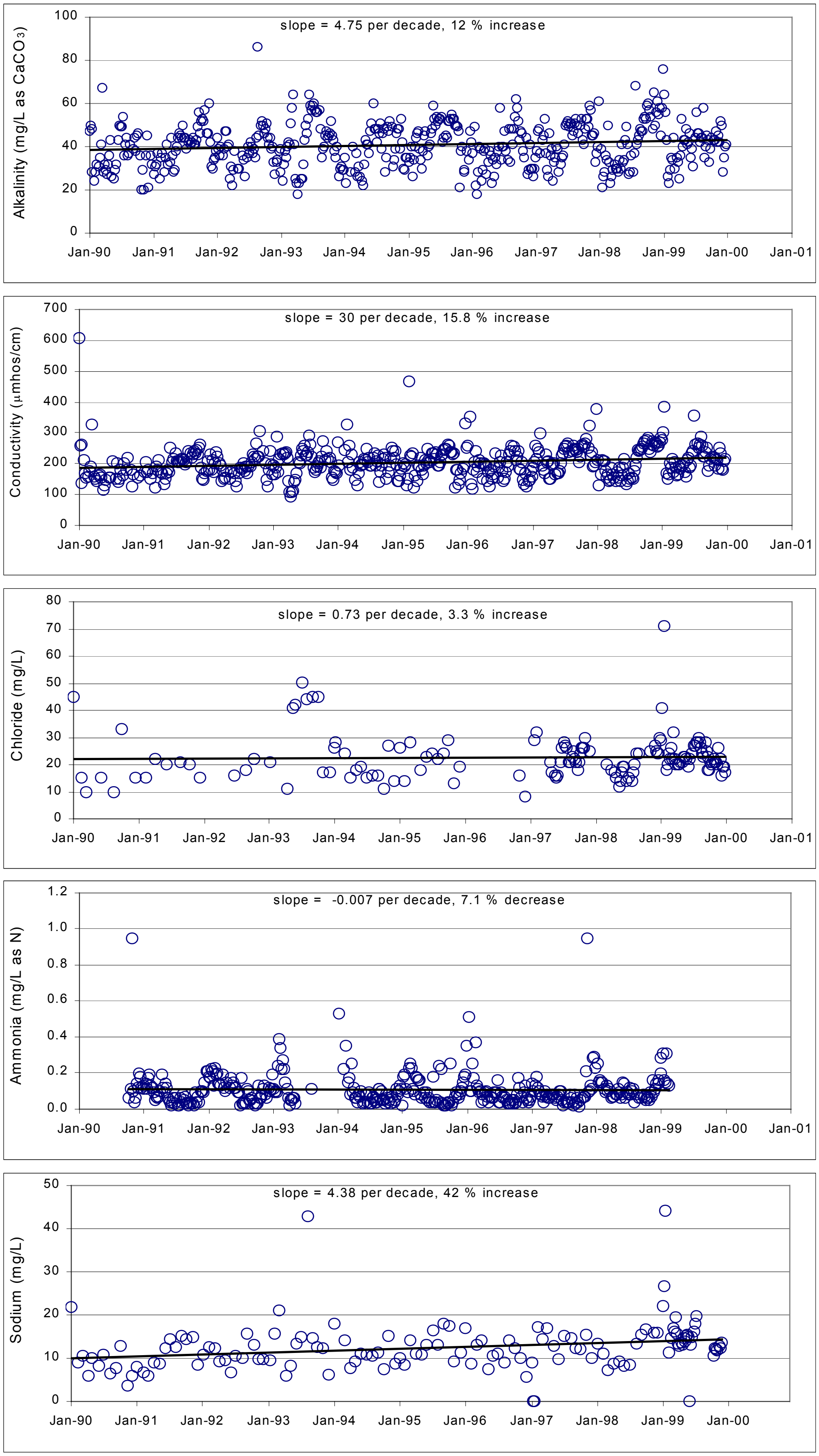


Table 2.1.5-19 Summary of Trends in Water Quality at Baxter Intake During 1990 - 1999

Parameter	Trends	Peaks	Peak Value	Peaks Typically Runoff/Flow Associated	Suspected Activities	Suspected Area(s)
Alkalinity (mg/L as $CaCO_3$)	Increasing	8/26/1992	86	Yes	Acid Mine Drainage / Acid Rain	Lehigh River / New York
Conductivity (μmhos/cm)	Increasing	2/9/1995	467	Yes	Residential / Road Runoff / Wastewater Discharge	Lower Delaware
Chloride (mg/L)	Increasing	1/19/1999	71	Yes	Residential / Road Runoff / Wastewater Discharge	Lower Delaware
Ammonia (mg/L as N)	Decreasing	10/30/1990, 11/12/1997	0.95	No	Improved wastewater treatment & reduced agriculture	Watershed Wide
Sodium (mg/L)	Increasing	1/19/1999	44	Yes	Residential / Road Runoff / Wastewater Discharge	Lower Delaware

2.1.5.3 Spatial Water Quality Analysis

Spatial analysis of water quality along the lower and middle Delaware is completed for the parameters of interest. This enables a determination as to whether the order of magnitude of data at Baxter agrees with other nearby intake and sampling locations along the river. The parameters of interest are plotted in box plots for six different locations. The locations are: the Ben Franklin Bridge at river mile 101, Betsy Ross Bridge at mile 105, PWD Baxter Intake at mile 111, Philadelphia Suburban Water Company Bristol Intake at mile 120, Trenton sampling location at mile 135 and Port Jervis sampling location at mile 255. It should be noted that for a given parameter the data from all six locations might not be available or as comprehensive.

Spatial analysis also shows whether temporal peaks and dips at Baxter agree with the other intake and sampling locations. Agreement among the various locations helps to validate trends. Also, the parameter of interest is plotted against the average daily river flow to investigate existence of any correlation between increase/decrease of the parameter value with river flow. For these plots, the PWD Baxter Intake data is used for the parameter of interest, however, for the average daily flow the Trenton sampling location data is used. The Delaware River transitions in the tidal zone after Trenton, therefore, the flow data from a location downstream of Trenton would not be valid in developing correlation. There is about 24 river-mile distance between these two locations along Delaware.

Turbidity
A box plot summary of turbidity data at the various locations in the Lower and Middle Delaware River Watersheds is found in Figure 2.1.5-5. Turbidity data is readily available for the drinking water intakes, since it is the basis of a standard for finished water quality. Turbidity is a surrogate of suspended material. The statistics were based on data over the same time frame, January 1990 through August 2000.

Figure 2.1.5-5 Summary of Spatial Turbidity Trends: January 1990 – August 2000

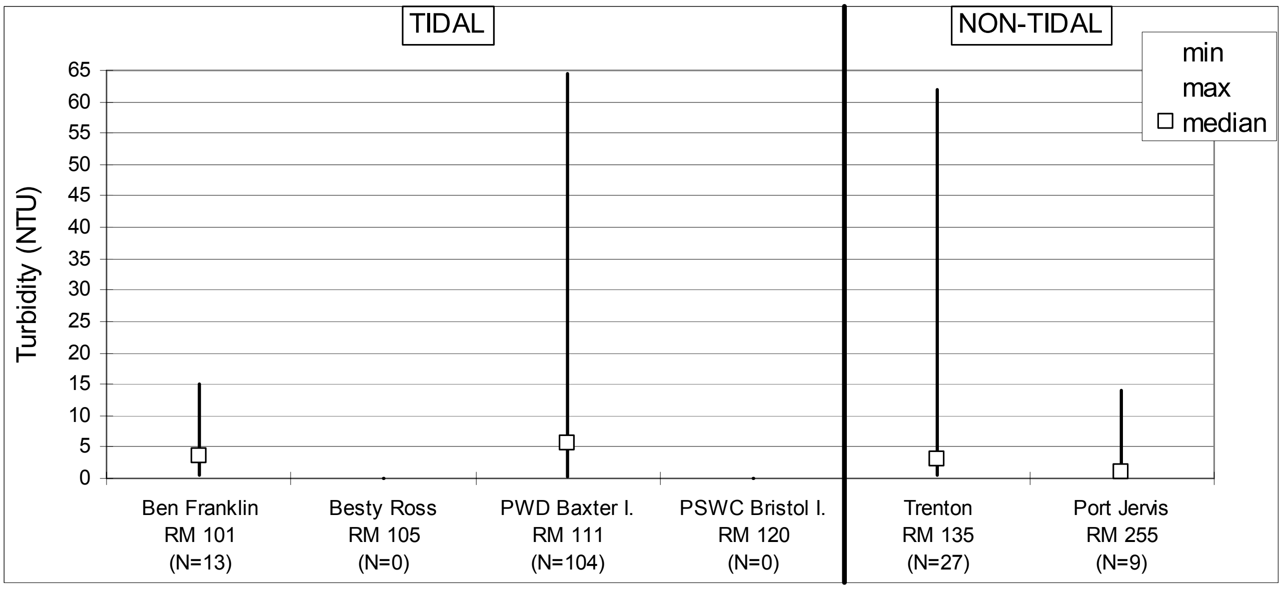
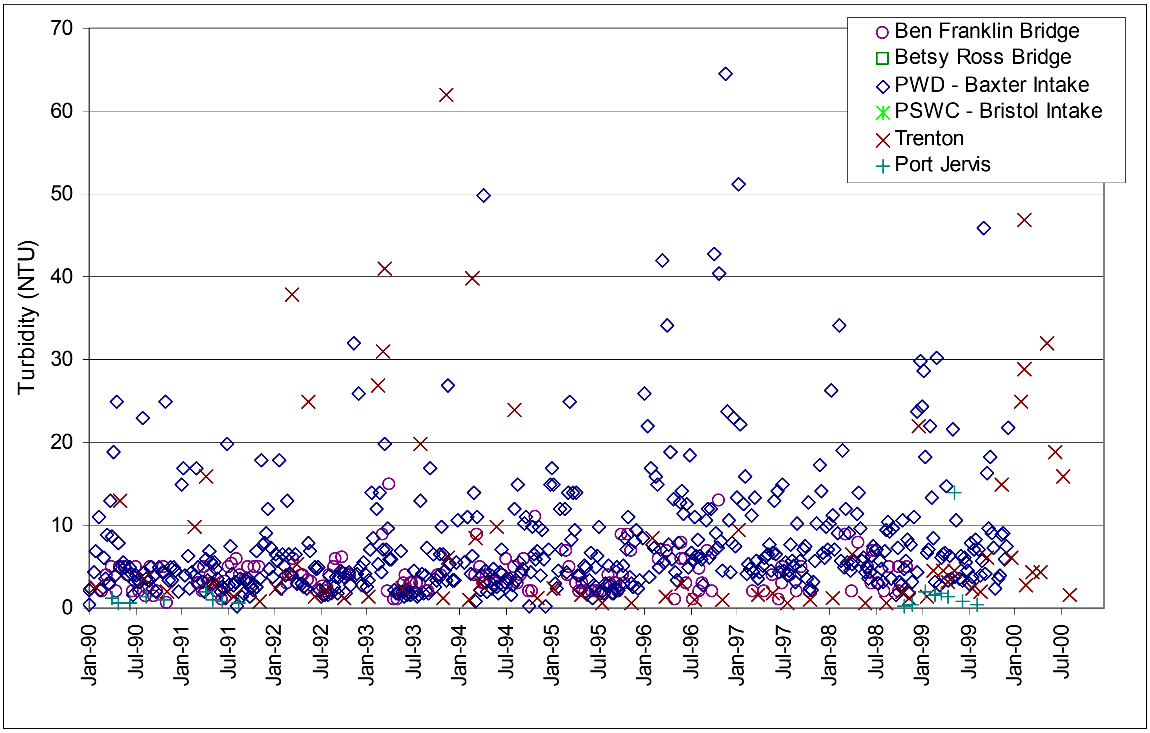


Figure 2.1.5-5 shows that median turbidity agrees well at the different locations and is about five NTU. Relatively a greater degree of variability is evident in the maximum values compared to the minima and medians. This variability is tied to run-off of particulates during rain events. Differences in the magnitude of the maximum values with location are due to disparities in the amount and time of sampling. Some locations such as Baxter, with more data, captured a wider range of turbidity. The discrete turbidity data for these locations over the same time frame is found in Figure 2.1.5-6.

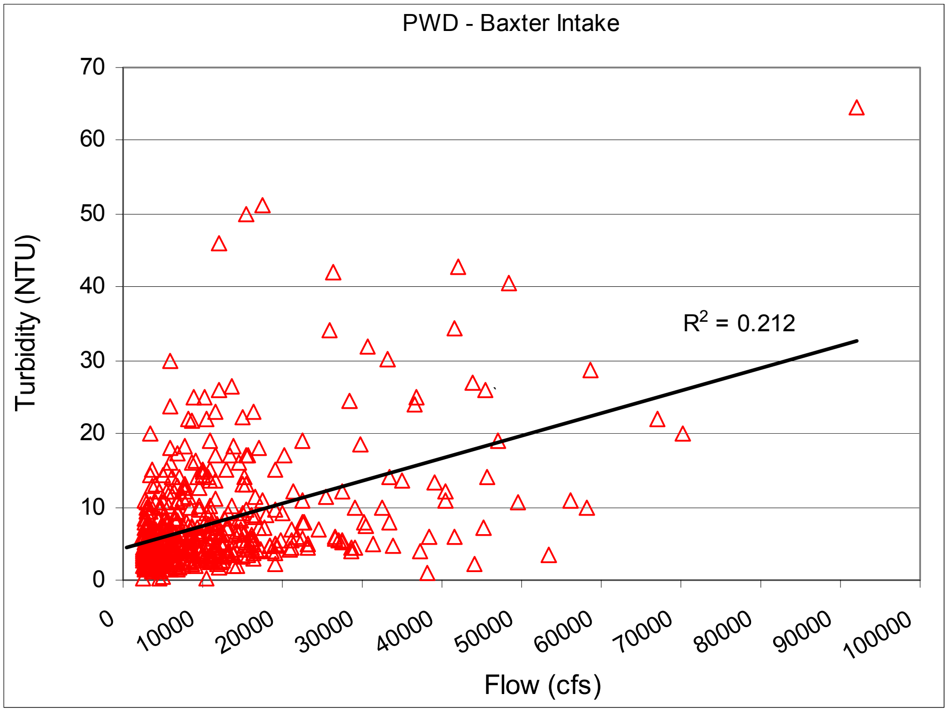
Data at the various locations in Figure 2.1.5-6 follow similar temporal trends. Times of peaks agree well as shown by the high concentrations at multiple locations during the same period. Locations that do not show the same peak are because sampling frequency was not as regular and the event was not captured. This supports that the peaks are run-off related because run-off and rain events generally affect the watershed regionally.

Figure 2.1.5-6 Spatial Turbidity Trends from January 1990 - August 2000



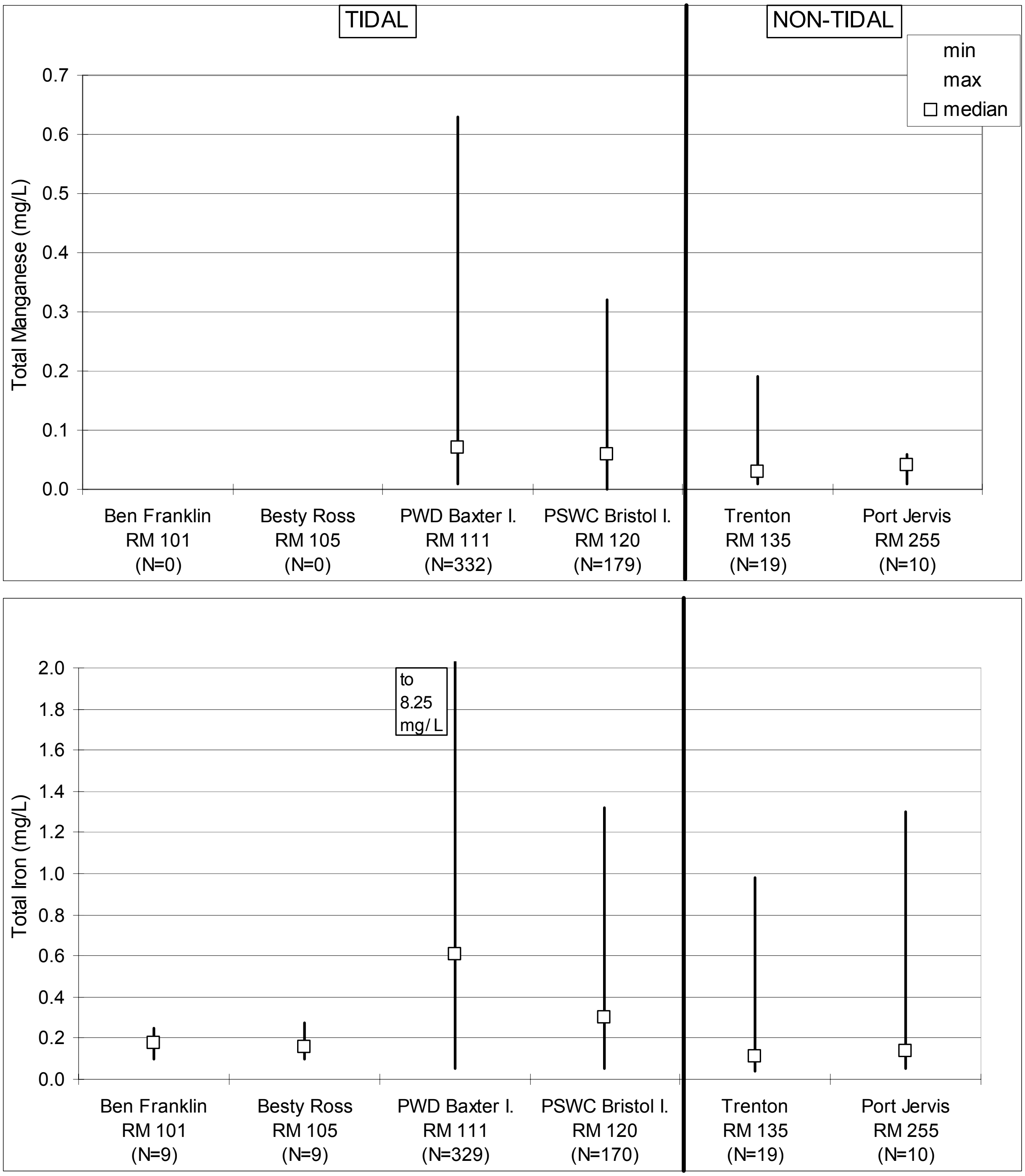
A plot shown in Figure 2.1.5-7 of average daily river flow and turbidity further substantiates the effect of runoff on increased turbidity levels in the river. Turbidity measurements from Baxter were plotted as a function of average daily flow at Trenton for days where data for both parameters were available. An increasing linear trend is observed, however the correlation is not very strong due to the tidal impacts on water quality in this area.

Figure 2.1.5-7 Turbidity/ Flow Trends: January 1990 - December 1999



Metals: Iron and Manganese
Figure 2.1.5-8 presents a box plot summary of total manganese and iron data at the same locations in the Lower and Middle Delaware River Watersheds. The box plot for manganese shows that the median is fairly constant across the locations at about 0.05 mg/L. Similar to turbidity, iron and manganese variability at each location, as indicated by the maximum values compared to the minima and medians, may be attributed to rain events. Rain events can increase runoff from land or increase acid mine drainage from Upper Delaware Watershed upstream locations. Differences in the magnitude of maximum values among the locations may also be due to different sampling dates and times.

Figure 2.1.5-8 Summary of Spatial Trends of Manganese and Iron: January 1990 - January 2002

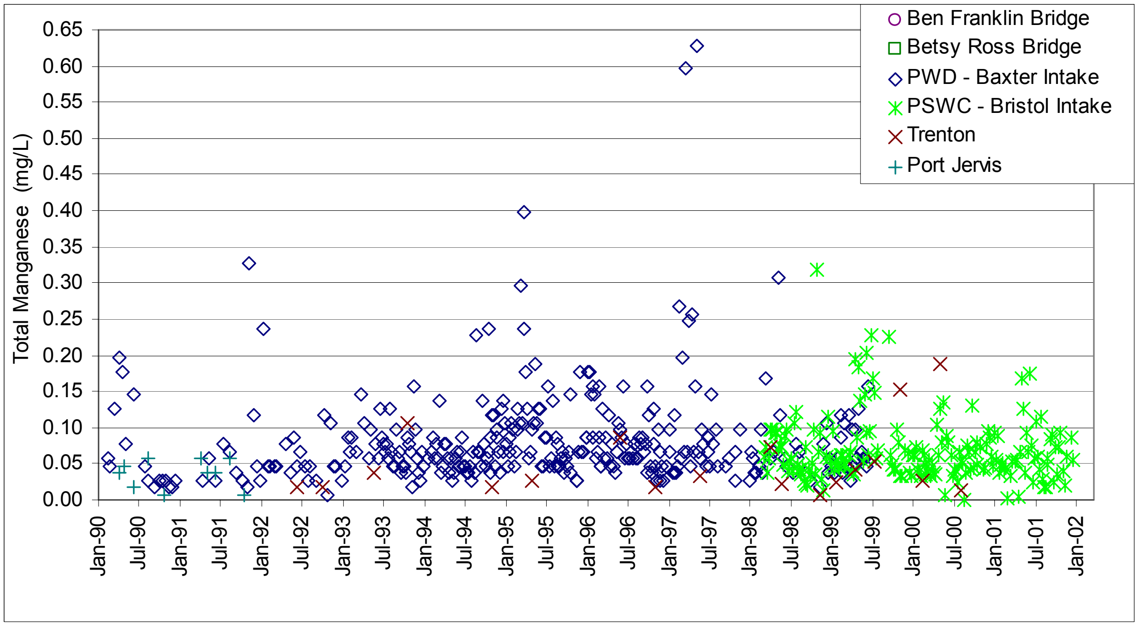


The box plot for iron shows more variability of median values with location than manganese. Median iron ranges from 0.11 mg/L to 0.61 mg/L with the highest median value observed at PWD Baxter Intake. Perhaps this is due to different sampling dates over the time frame, but it may also indicate that certain locations are more susceptible to other point or non-point sources of iron. Maximum values are also highest at the Philadelphia intakes. Iron, similar to manganese and turbidity, has a great deal of variability at each individual location. The differences in median iron concentration at the various locations in the box plot suggests that iron concentrations are highly variable in the river and require high monitoring frequencies to get a true measure of the median concentrations. This may be attributed to sources related to rain events. To further examine some of these trends, discrete iron and manganese data for the time frame of January 1990 to January 2002 is presented in Figure 2.1.5-9.

Figure 2.1.5-9 demonstrates that temporal trends are generally consistent across the various locations where data is available. Similar to Figure 2.1.5-8, the plot shows that at each location, total manganese is less than 0.65 mg/L. More variability is seen in the iron data. Specifically, data at Baxter is quite scattered. Iron and manganese trend similarly with time and location, in terms of peaks and dips suggesting similar sources or mechanisms are impacting their concentrations in the water column. Peaks are believed to be related to either increased particulate loads from run-off from upstream or acid mine drainage from the Lehigh River Watershed.

As seen in Figure 2.1.5-10, there were no statistically observable relations between rain events/flow and maximum manganese and iron as shown in Figure 2.1.5-10. This suggests that a combination of runoff sources impacting during wet weather periods and sporadic point source impacts (acid mine drainage or industrial discharges) during dry weather periods have alternating periods of dominant influence on manganese and iron. Rain may be a primary driving mechanism for acid mine drainage impacts, but due to the time of travel from the Lehigh River Watershed, acid mine drainage impacts would not be observed until after flows due to recent rains have decreased. This “lag” effect would need to be examined in more detail in future water quality studies.

Figure 2.1.5-9 Spatial Trends in Manganese and Iron from January 1990 - January 2002



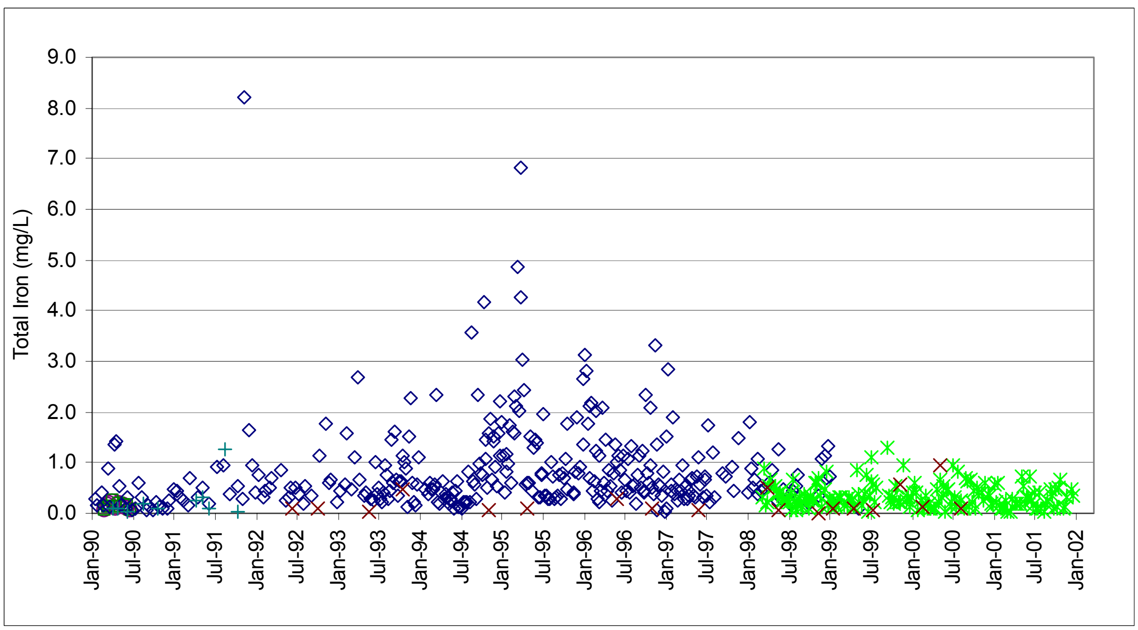
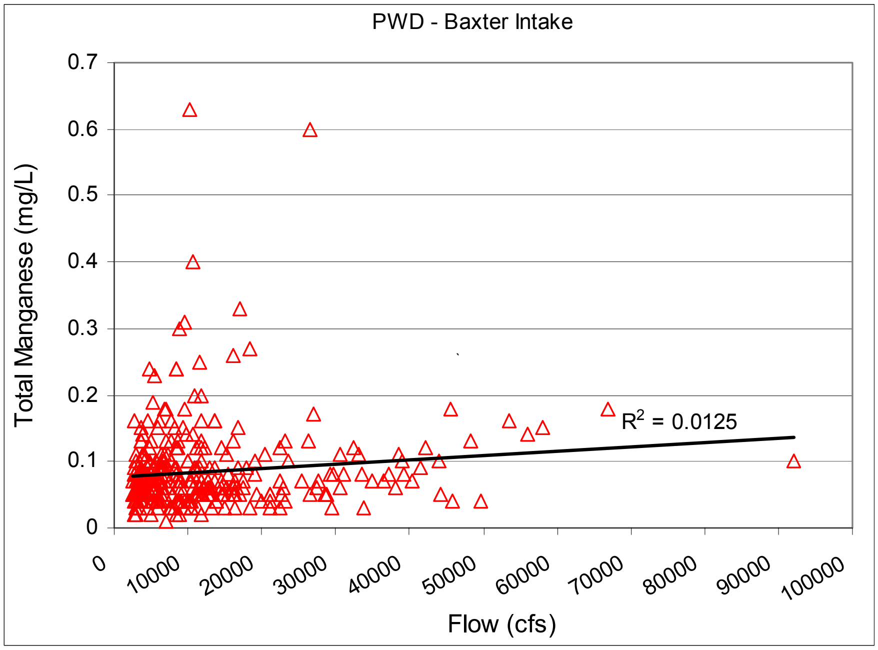
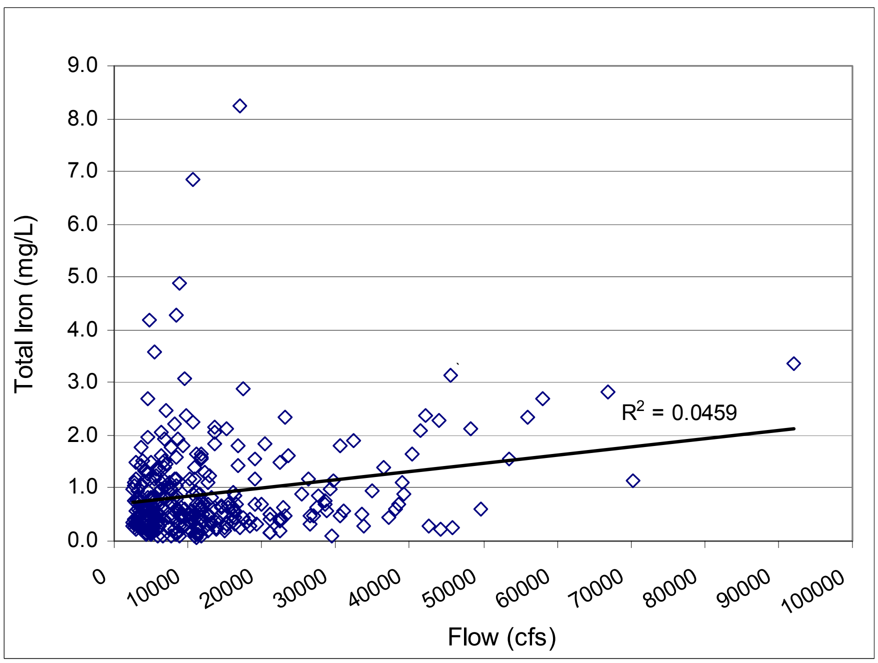


Figure 2.1.5-10 Flow Trends in Manganese and Iron: January 1990 - July 1999





Nutrients

Figure 2.1.5-11 presents a box plot summary of available nutrient data for the Lower and Middle Delaware River Watershed Intakes. Data was available for total ammonia, total nitrate, and dissolved orthophosphate over the time frame from January 1990 through December 2001. Median values for all three parameters are fairly consistent irrespective of sampling location. However, the median value for total ammonia and dissolved nitrate is relatively lower for upstream sampling location such as Trenton and Port Jervis. Maximum values vary most significantly from median and minimum values.

Overall, concentrations of nutrients in the tidal portion of the Delaware River are greater on average than those observed in the non-tidal section between Trenton and Port Jervis. It is suspected that point source discharges in the tidal area may be having the greatest influence on these concentrations. Though levels of nutrients are lower in the tidal Delaware River than the Schuylkill River, they are not limiting for biological growth.

The discrete data used in the summary is found in Figure 2.1.5-12. Temporal trends, as discussed in section 2.1.5.2, are also evident. Ammonia shows distinct peaks in the winter. This is due to either lack of biological nitrification in the cold water or use of urea as road salt. Nitrate and dissolved orthophosphate trend together.

Lastly, Figure 2.1.5-13 examines whether any of the available nutrients trend with river flow. Positive trends would indicate river concentrations of nutrients are runoff related. Ammonia levels in Figure 2.1.5-13 do not increase significantly with flow. Nitrate and dissolved orthophosphate levels decrease with flow, although the linear correlation is poor. This suggests that these nutrients are not greatly influenced by rain and runoff. This is probably because the nutrients analyzed are in dissolved form and are not affected by particulate runoff loads.

Figure 2.1.5-11 Summary of Spatial Trends of Nutrients: January 1990 - December 2001

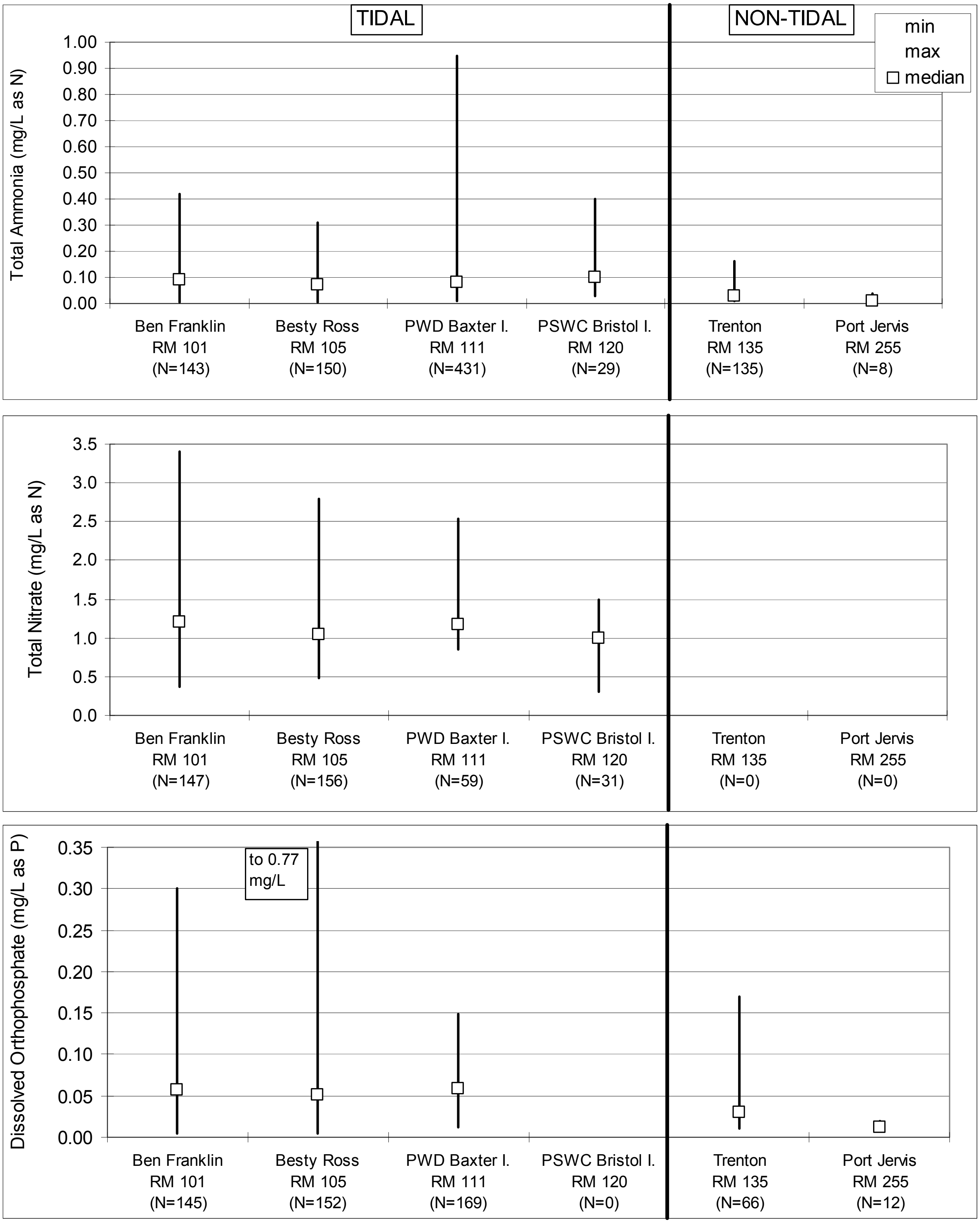


Figure 2.1.5-12 Spatial Trends of Nutrients from January 1990 - December 2001

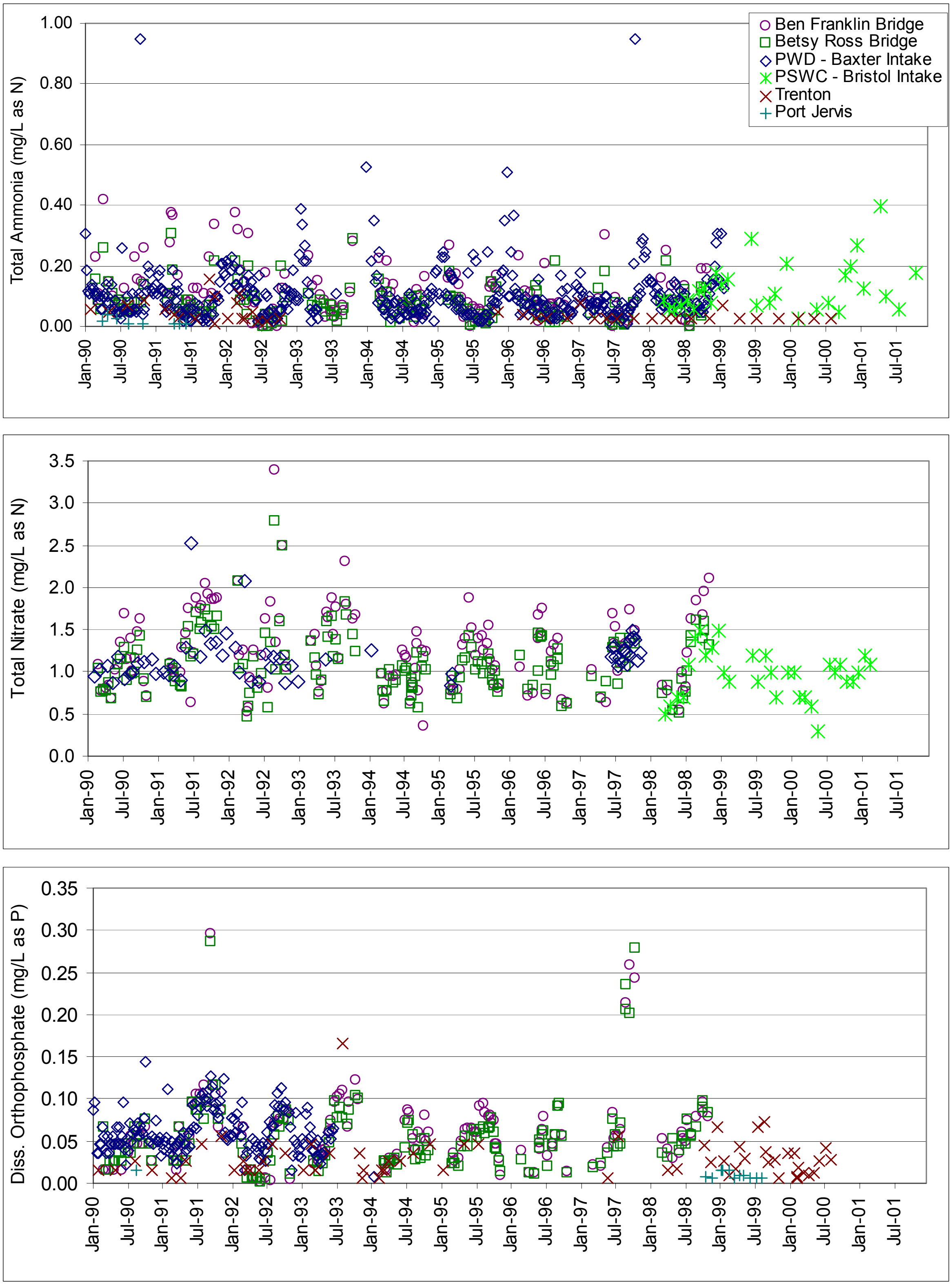
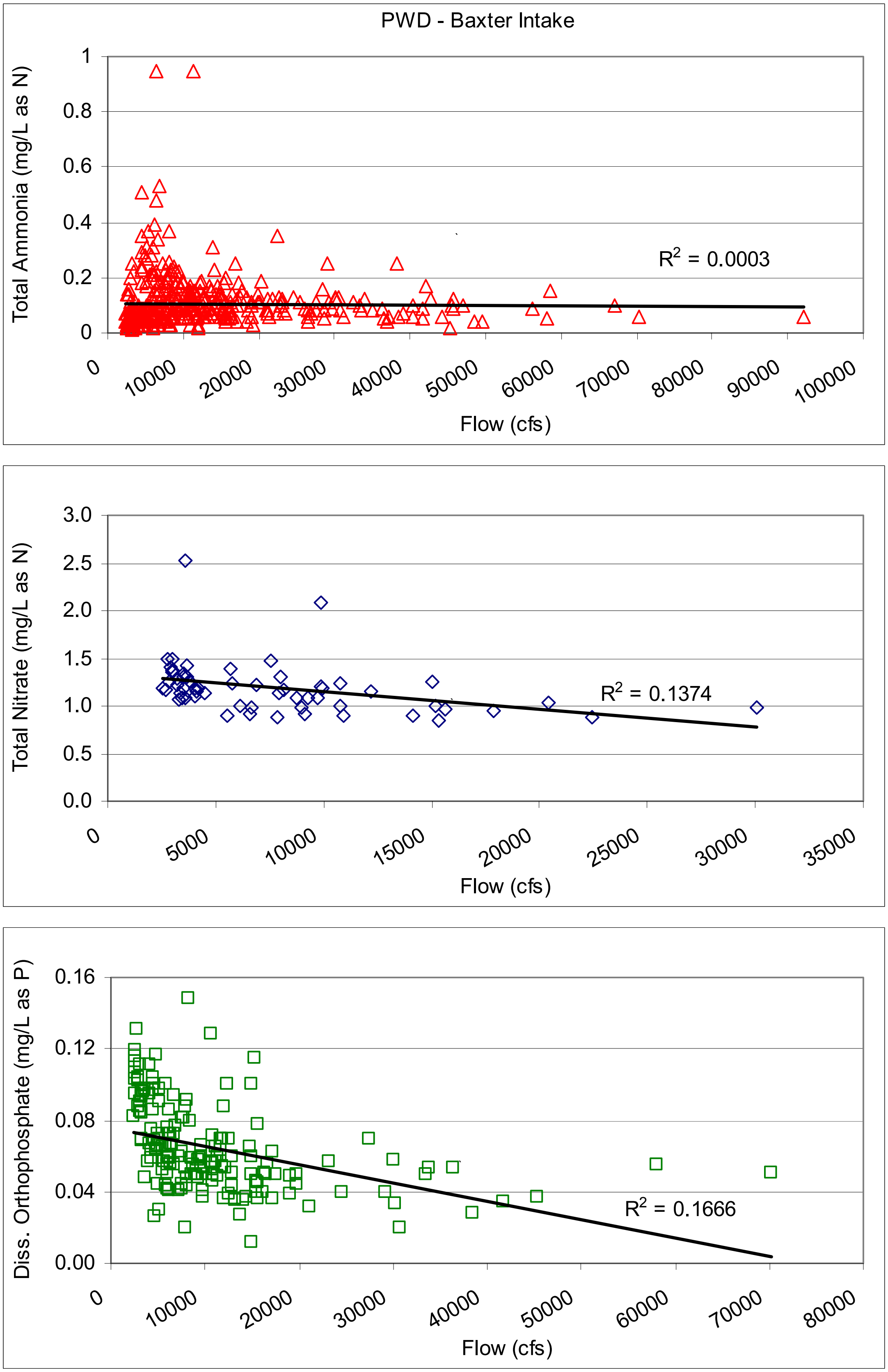


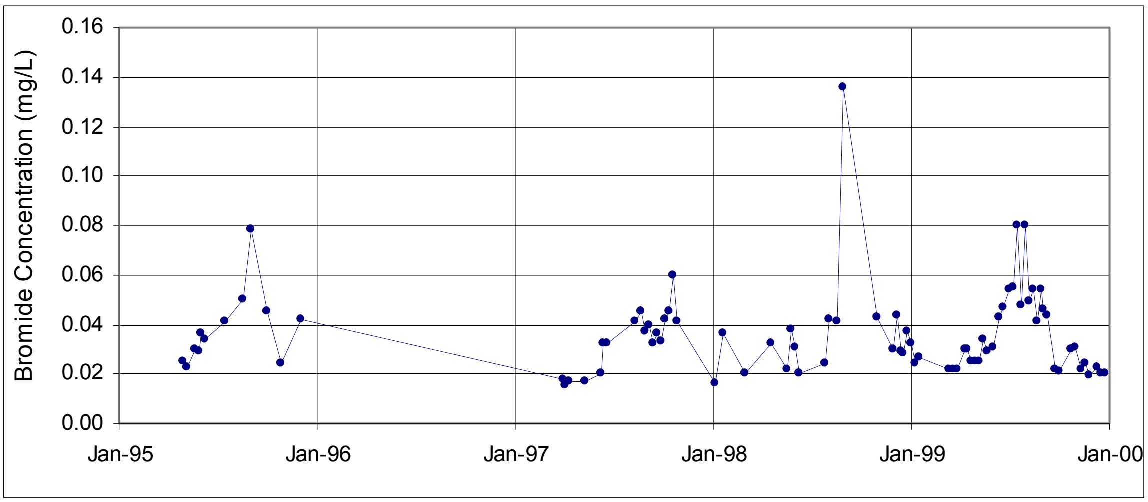
Figure 2.1.5-13 Flow/Nutrient Trends from January 1990 - February 1999



Bromide Temporal Analysis

Bromide is a concern for water treatment because under certain conditions and levels it can react with the chemicals used for disinfection such as chlorine or ozone to create disinfection by-products (DBPs). Exposure to specific DBPs over a lifetime could create chances for chronic illnesses such as cancer. Therefore, identifying and understanding the sources of these chemicals that can create potential DBPs is important. As shown in Figure 2.1.5-14, bromide is typically at its highest levels during periods of low river flow. This association suggests that the sources of bromide are typically point sources (discharges) or from groundwater that feeds the river during low-flow periods.

Figure 2.1.5-14 Historical Bromide Levels at PWD's Intakes



Notice the highest levels are associated with periods of low flow suggesting a groundwater or point source influence.

2.1.5.4 Analysis of Stream Impairments and Sources

In accordance with Section 305(b) of the Federal Clean Water Act, the Pennsylvania Department of Environmental Protection (PADEP) prepared a 305(b) Water Quality Assessment Report in 2000. The report summarizes water quality management programs, water quality standards and point and non-point source controls. The tidal portion of the Delaware River Watershed includes 2,782 miles of streams and creeks. Over 41% (1,148 miles) of these stream miles have been assessed to determine compliance with water quality standards. Applicable water quality standards were attained in one-third of the stream miles that were assessed (367 miles). Streams that are impacted by contaminant sources, (point sources, or non-point sources such as storm water runoff) and do not meet water quality standards, are designated as impaired. Two-thirds of the stream miles that have been assessed (781 miles) do not meet applicable water quality standards, and are designated as impaired. To date, 1635 miles, or 60%, of the stream miles have not been assessed.

Figure 2.1.5-15 displays sources of impairment throughout the tidal portion of the Delaware River Watershed in Pennsylvania. Stormwater runoff from urban and residential areas and municipal point sources were responsible for the majority of the stream impairments identified in the tidal portion of the Delaware River Watershed in Pennsylvania. The sources of impairment were not identified for the New Jersey portions of the watershed by NJDEP.

Figure 2.1.5-16 displays the causes of stream impairments throughout the tidal portion of the Delaware River Watershed in Pennsylvania. The leading causes of impairment are lead, mercury in fish tissue, siltation, and water/flow variability. Table 2.1.5-20 summarizes the number of miles impacted by each of the listed sources for each of the subwatersheds within the tidal portions of the Delaware River Watershed in Pennsylvania. A detailed breakdown of the causes of impairment for New Jersey and Pennsylvania are shown in Table 2.1.5-21 and 22. As shown, the causes of impairment in New Jersey focus on toxic substances and metals where in Pennsylvania the focus is mainly on impairments that impact habitat and diversity. It is not known that these different sources of impairment are due to true differing impacts, differing methods of assessment, or both. It is recommended that efforts be made to unify impairment protocols and determinations in multi-state watersheds.

As shown in Figures 2.1.5-17 and 2.1.5-18, the streams draining into the tidal sections of Philadelphia and Lower New Jersey showed the highest percentages of impairment. This includes smaller streams such as the Tacony-Frankford Creek, Pennypack Creek, and Poquessing Creeks. The level of impairment reduced in streams as they were located further upstream from Philadelphia and Trenton where there are less urbanized areas. However, impairments are still significant in the Neshaminy Creek, Rancocas Creek, and Mercer County area streams.

Figure 2.1.5-15 Summary of Miles Impaired by Primary Sources (Source PADEP)

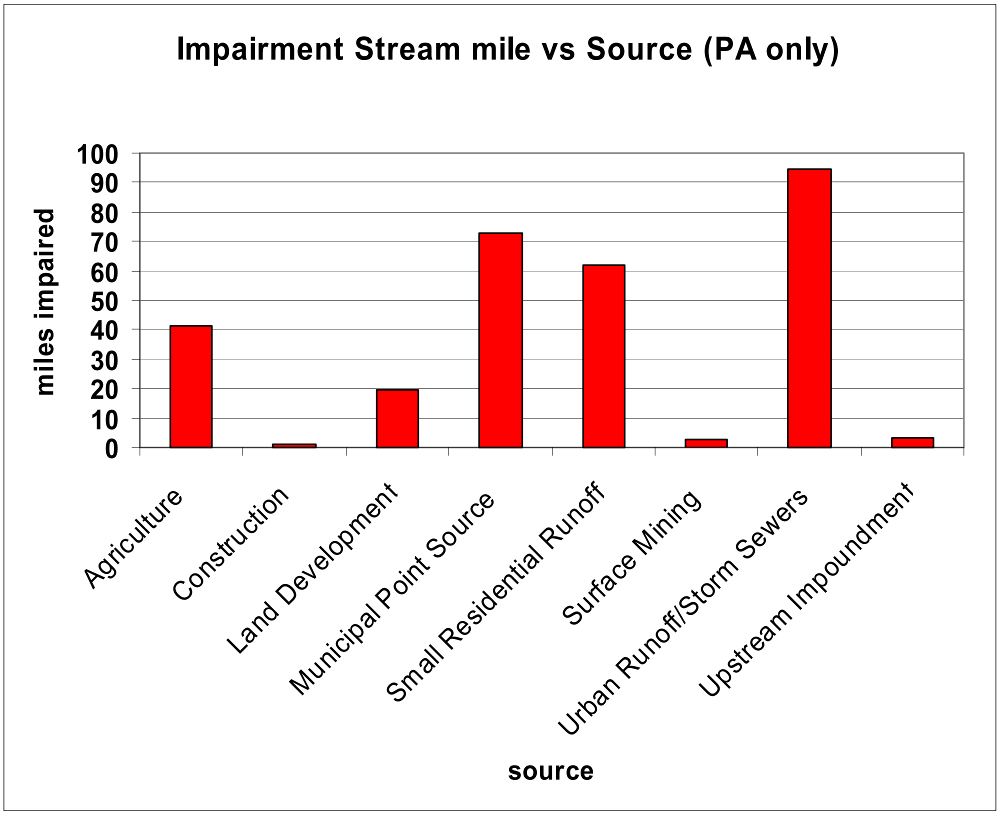


Figure 2.1.5-16 Summary of Miles of Impairment by Primary Causes (PA Side Only)

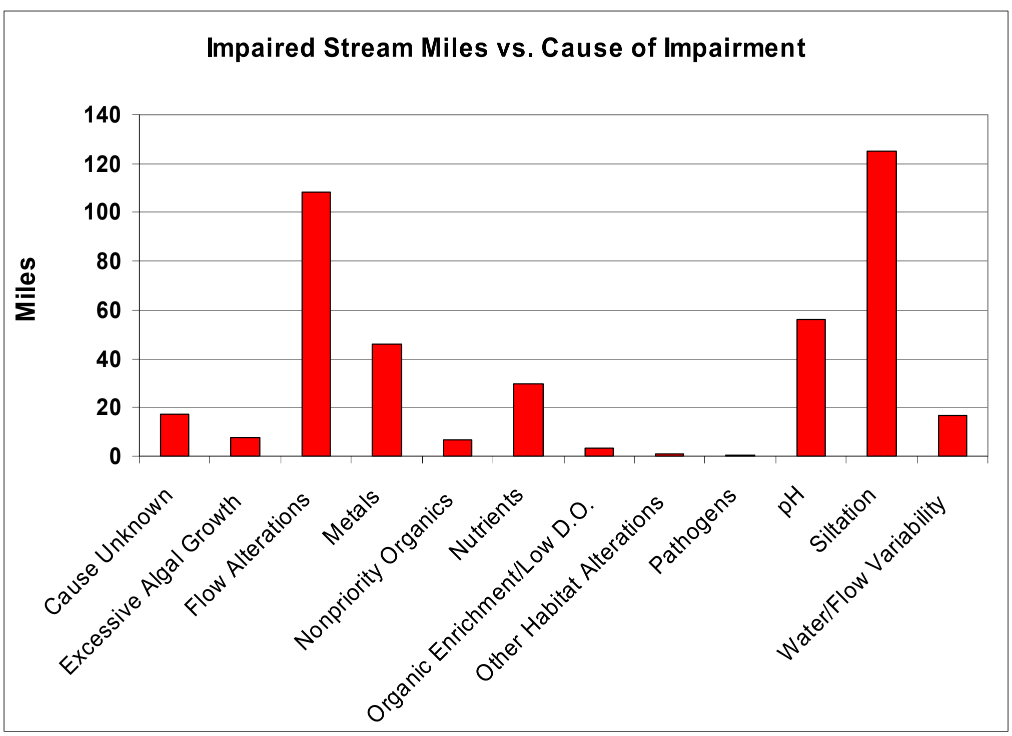


Table 2.1.5-20 Miles of Impairment by Primary Source and Watershed (PA side only)

IMP Sources	Neshaminy Creek	PA Bucks Co. Direct	Tidal Bucks Co.	Tidal PA Phila. Co.	Total
Abandoned Mine Drainage	0	0	0	0	0.00
Agriculture	**40.5**	**0**	**0**	**0.8**	**41.3**
Construction	1.3	0	0	0	1.3
Erosion from Derelict Land	0	0	0	0	0
Habitat Modification	0	0	0	0	0
Industrial Point Source	0	0	0	0	0
Land Development	**19.4**	**0**	**0**	**0**	**19.4**
Municipal Point Source	**72.3**	**0**	**0**	**0.3**	**72.7**
Natural Sources	0	0	0	0	0
Small Residential Runoff	**3.9**	**0**	**0**	**58.1**	**62.0**
Surface Mining	2.7	0	0	0	2.7
Urban Runoff/Storm Sewers	**38.3**	**0**	**0**	**56.5**	**94.8**
Upstream Impoundment	3.3	0	0	0	3.3
Package Plants	0	0	0	0	0
Other	0	0	0	0	0
Subtotal	181.7	0	115.7	0	297.4

Note: miles of stream impaired by a given source.

Table 2.1.5-21 Breakdown of Miles of Impairment by Primary Cause and Watershed (PA Side Only)

IMP Causes	Neshaminy Creek	PA Bucks direct	Tidal Bucks Co.	Tidal Pa Phila Co.	Total
Cause Unknown	1.42	0	0	10.53	11.95
Excessive Algal Growth	7.77	0	0	0	7.77
Flow Alterations	**3.4**	**0**	**0**	**104.81**	**108.21**
Metals	0	0	0	0	0.00
Nonpriority Organics	0	0	0	0	0.00
Nutrients	**29.95**	**0**	**0**	**0**	**29.95**
Organic Enrichment/Low D.O.	0	0	0	0	0.00
Other Habitat Alterations	0	0	0	0	0.00
Pathogens	0.12	0	0	0.34	0.46
pH	**36.85**	**0**	**0**	**0**	**36.85**
Siltation	**85.59**	**0**	**0**	**0**	**85.59**
Water/Flow Variability	**16.63**	**0**	**0**	**0**	**16.63**

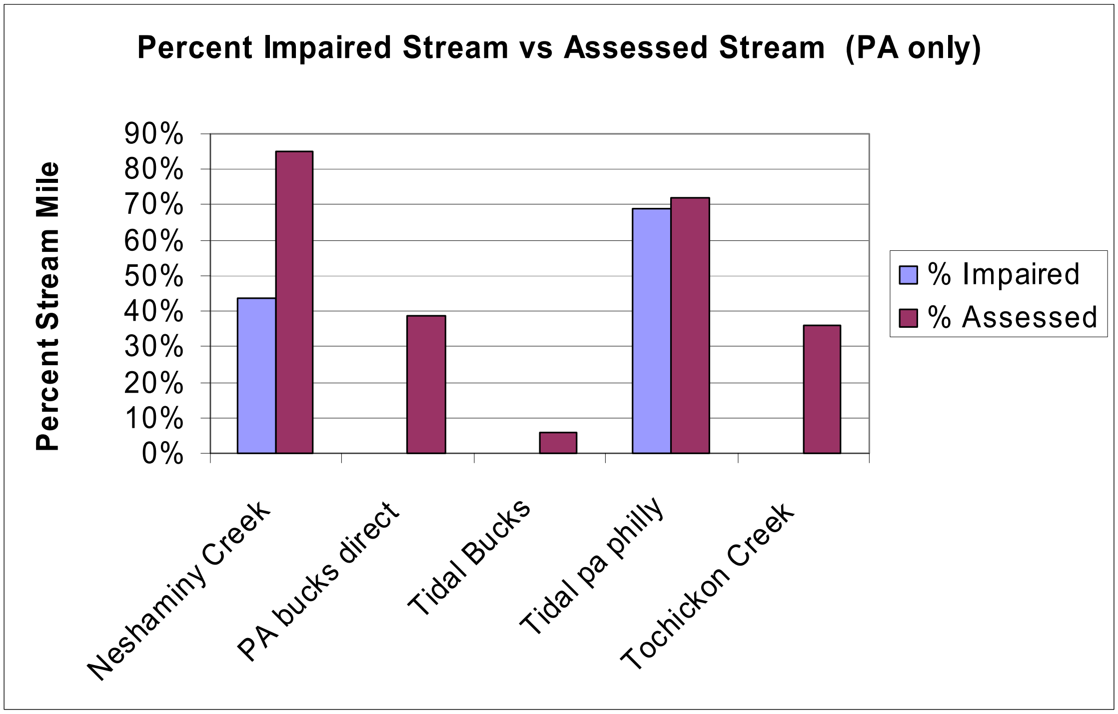
(Source: PADEP)

Table 2.1.5-22 Breakdown of Miles of Impairment by Primary Cause and Watershed (NJ Side Only)

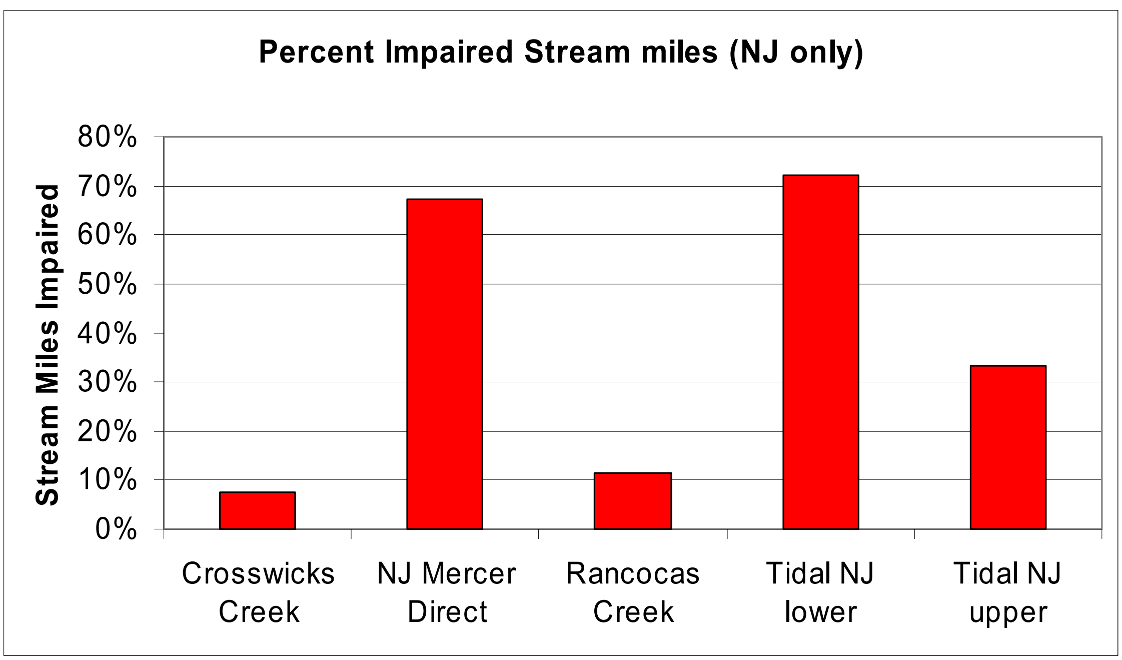
Impairment	Crosswicks Creek	NJ Mercer Direct	Rancocas Creek	Tidal NJ Lower	Tidal NJ Upper	Total
1,2-Dichloroethane	0.00	0.00	0.00	0.16	0.00	0.16
Algae	**0.42**	**5.51**	**10.39**	**7.02**	**0.46**	**23.80**
Arsenic	**2.65**	**0.00**	**0.00**	**0.00**	**27.72**	**30.37**
Beryllium	0.00	0.00	0.00	0.00	0.00	0.00
Cadmium	0.00	0.00	0.00	3.60	0.00	3.60
Chlordane in Fish Tissue	0.00	0.00	0.00	7.45	0.00	7.45
Chromium	**0.00**	**0.00**	**0.00**	**10.66**	**16.25**	**26.91**
Copper	0.00	0.00	0.00	11.76	0.00	11.76
Lead	**0.00**	**0.00**	**26.13**	**31.70**	**27.72**	**85.55**
Mercury	**0.00**	**0.00**	**36.47**	**0.00**	**0.00**	**36.47**
Mercury in Fish Tissue	**13.45**	**138.33**	**9.89**	**37.97**	**8.06**	**207.71**
PCBS & Chlordane in Fish Tissue	**0.00**	**0.00**	**0.00**	**36.57**	**0.00**	**36.57**
PCBS & Chlordane in Sediment	0.00	0.00	0.00	3.60	0.00	3.60
PH	**0.00**	**0.00**	**0.00**	**31.70**	**0.00**	**31.70**
Phosphorus	2.75	0.62	0.00	1.49	0.00	4.86
Sedimentation	0.00	0.00	0.00	1.20	0.00	1.20

Source: (USEPA)

Figure 2.1.5-17 Percentage of Watershed Miles Impaired and Assessed in the Lower Tidal Delaware River Basin

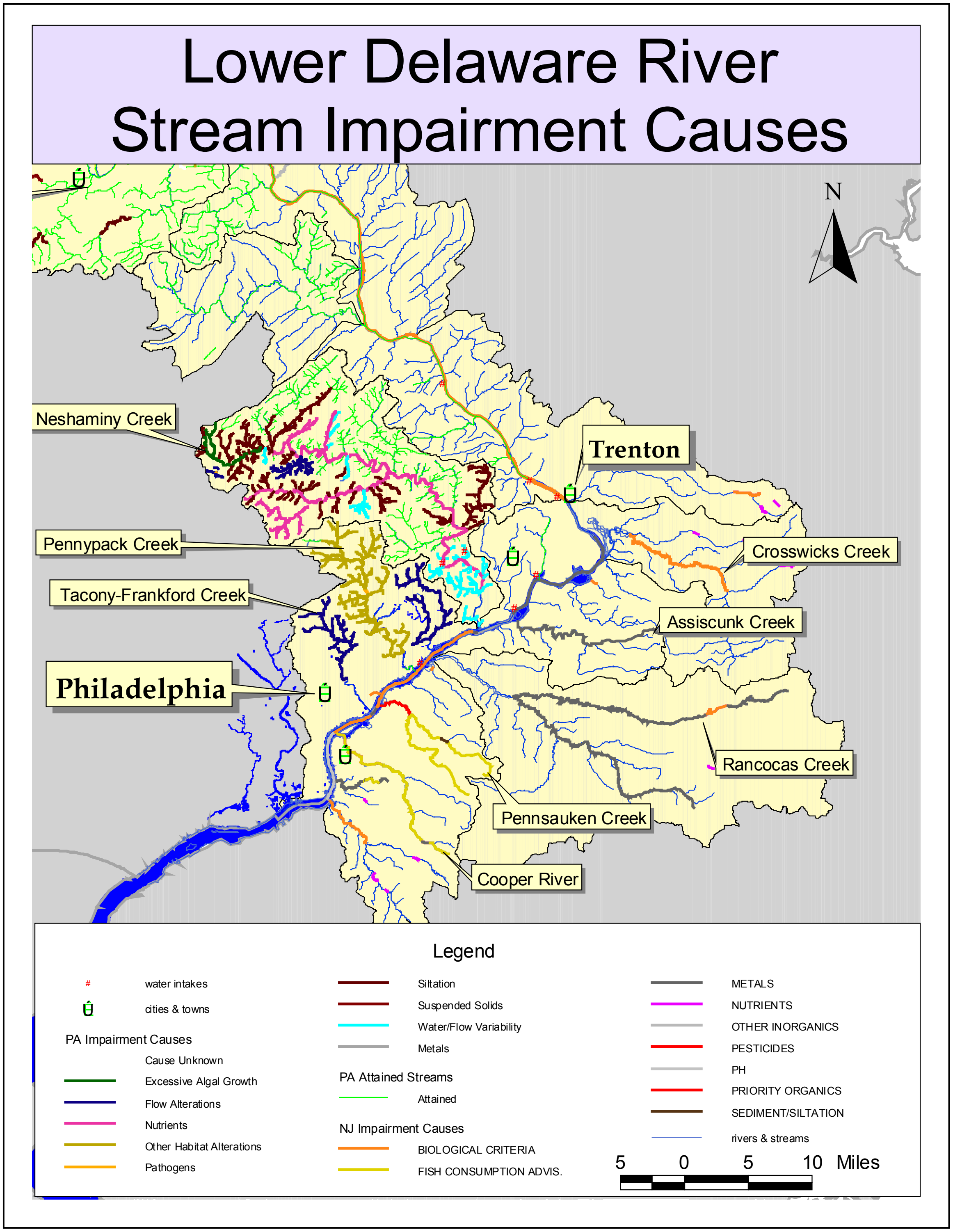


Source: PADEP



Source: PADEP

Figure 2.1.5-18 Impaired Stream Reaches in the Lower Delaware River Watershed



2.2 Source Water Assessment

2.2.1 Delineation of Source Water Assessment Zones

Key Points

- **Zone A, the area within a 5-hour time of travel of Philadelphia Water Department's Baxter Intake, includes 205 square miles of the Delaware River Watershed.**
- **Zone B, the area between the 5-hour and the 25-hour time of travel of the Baxter Intake, includes 2,060 square miles of the watershed.**
- **Zone C, the area beyond the 25-hour time of travel incorporates the remainder of the 8,100 square-mile Delaware River Watershed.**

2.2.1.1 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 identify all pertinent sources. This approach, as defined by the PADEP's 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 PADEP's SWA Plan divided the source water assessment area for a given intake into the following three zones and prioritized all contaminant source identification 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. Any potentially significant source within a five-hour time of travel of the water supply including one-quarter mile downstream and within a one-quarter mile-wide area on either side of the river/stream from the water supply should be included in the contaminant inventory. 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 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.

The Source Water Assessment Program (SWAP) for the Delaware River includes delineation of 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.

2.2.1.2 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, and delineated Zones A and B for the Baxter Intake. These zone calculations show that 5.5 feet per second is the underlying assumed velocity for the zone delineation, and this same average velocity was assigned to all river segments above Trenton. This same velocity was used in all time of travel calculations during the source prioritization.

2.2.1.3 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 unstratified 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 (ECOM) 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 are shown on Figure 2.1.1-1. The model extends 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.

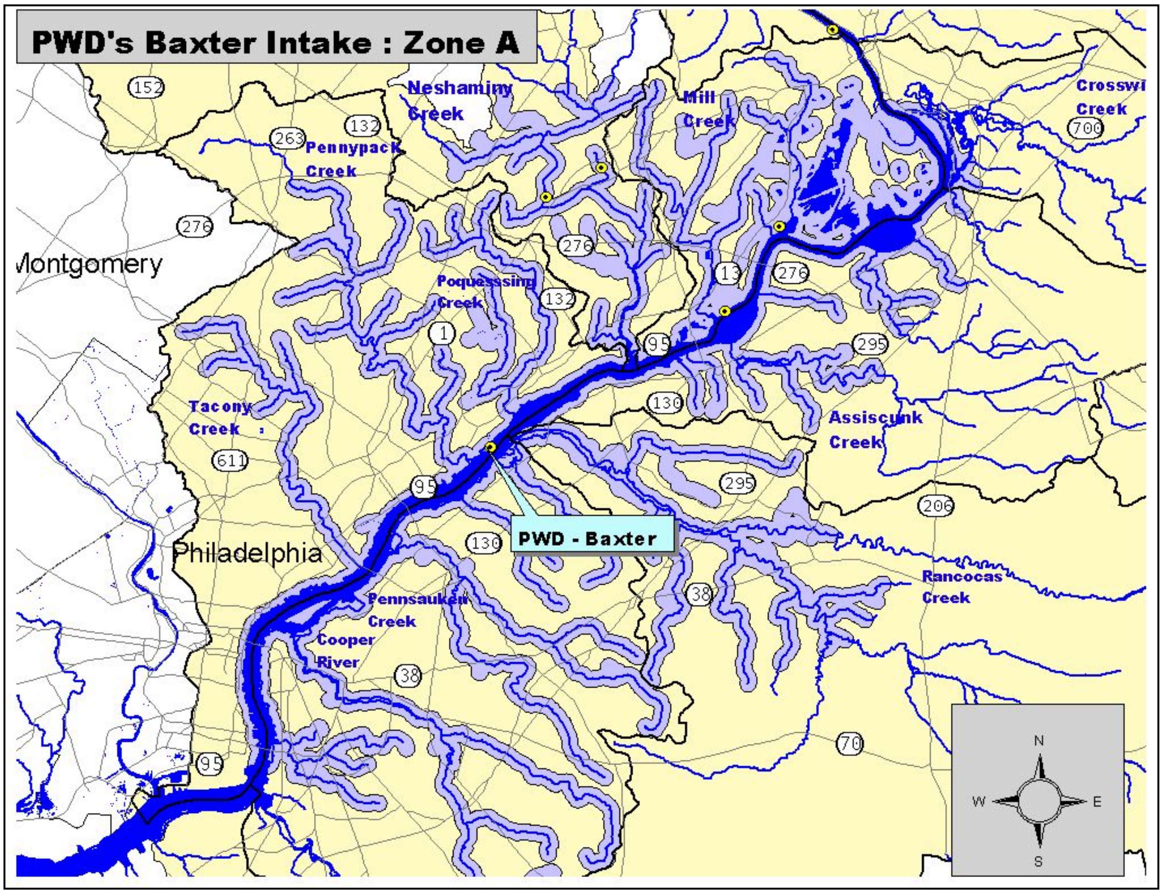
Figure 2.2.1-1 Model Grid

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.

2.2.1.4 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 conditions stream velocities. Zones were calculated on the Delaware River as well as along the main tributaries. Figure 2.2.1-2 displays the different zones delineated for the Baxter water supply intake for the Philadelphia Water Department. As shown, 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, 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.

Figure 2.2.1-2 PWD's Baxter Intake: Zone A

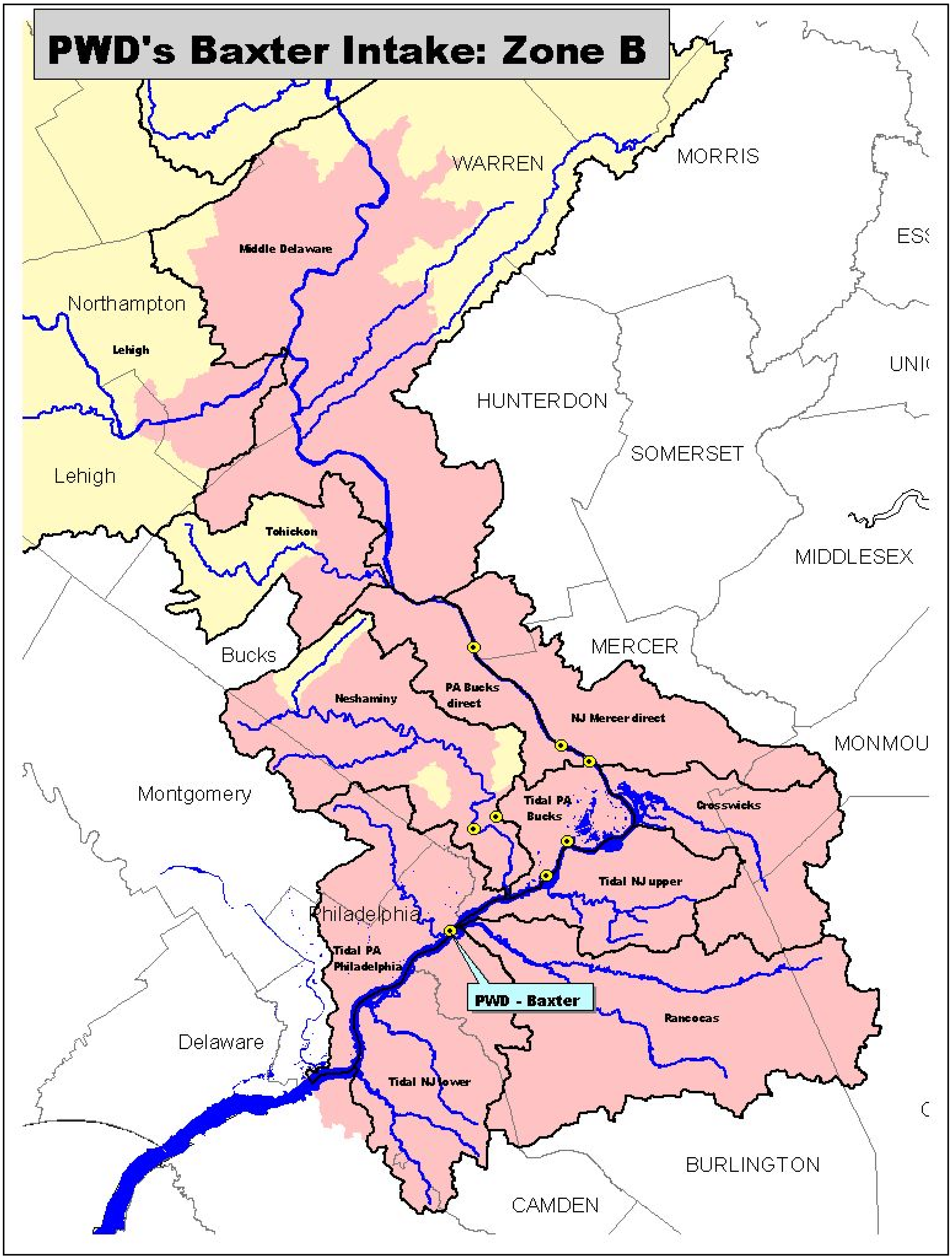


Zone B encompasses an area of 2,060 square miles and extends upstream to river mile 208 as shown by Figure 2.2.1-3. For the Baxter Intake, Zone B extends upstream from the intake to approximately 0.25 miles south of Portland, PA. Zone B also includes all the tributaries below the Lehigh River. Zone B 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 2.2.1-3 are the locations of other water supply intakes within the zones delineated for the water supply. As shown in Figure 2.2.1-2 and 2.2.1-3, the Zone A or B from the Baxter Intake overlaps with the Zone A or B from numerous other intakes. This overlapping of zones allows for a more detailed assessment of potential sources for the whole watershed area.

As described above, the time of travel of a release from a potentially significant source of contamination combined with the characteristics of that source will determine whether it is included in the contaminant inventory.

All of the zones of delineation were determined and provided by the United States Geological Survey (USGS) and approved by PADEP 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 2.2.1-3 PWD's Baxter Intake: Zone B



2.2.2 Point Source Contaminant Inventory

Key Points

- **Almost 6,000 potential point sources were identified within the 2,060 square mile Baxter Intake.**
- **Most of these potential sources do not – and will never – discharge to the Delaware River. They have been identified so that water suppliers can assess their potential impacts upon the water supply, and identify appropriate protective measures.**
- **Over 1,700 RCRA facilities are located upstream of the Baxter Intake.**
- **Most of the RCRA facilities are not large quantity generators.**
- **Sewerage systems, dry cleaning plants (except rug cleaning), and gasoline service stations are the most common.**
- **VOCs, petroleum hydrocarbons, and SOCs were the most frequently reported contaminants.**

2.2.2.1 Method

Based on PADEP guidelines for the statewide Source Water Assessment Program (SWAP), a contaminant inventory of point and non-point sources was developed. The inventory is an essential part of assessing the drinking water supply for the intake, because it compiles potential contaminant sources within the 5-hour, 25-hour, and beyond 25-hour time of travel delineation zones. This inventory is a powerful list enabling the water supplier to better understand their source water. The inventory is also the stepping-stone to prioritizing potential contaminant sources. The prioritization or ranking of contaminant sources is discussed in the susceptibility analysis described in section 2.2.4 below.

The focus of this report section is the point source contaminant inventory. Non-point sources are discussed in the land use section 1.2.5 and within intake section 2.2.3. Point source data was compiled from various federal and state databases available on the Internet. Sources were checked by stakeholders and verified for correct active status and location. An ACCESS® database was developed to efficiently store and manage information describing the point sources.

Database Compilation

The following federal databases were accessed for point sources in the Delaware River study area:

- Permit Compliance System (PCS);
- Resource Conservation and Recovery Act Information System (RCRIS);
- Comprehensive Environmental Response, Compensation, and Liability Act Information System (CERCLIS); and
- Toxic Release Inventory (TRI)

Regulated aboveground storage tanks (ASTs) were also compiled from the PADEP Storage Tank Program. Combined with the aforementioned federal databases, the database compilation was complete.

The databases were queried for facility, process, and violation information. Facility information included items such as name, facility identification numbers, owner, and location (street address and/or latitude, longitude). GIS information was used to locate the Delaware SWAP study area sources within the Baxter delineation zones. Process information included data identifying on-site contaminants and the quantities and/or loading rates. Violation information was related to type (administrative versus operation or effluent violation) and frequency.

Database population for many of the facilities and certain pieces of information required for ranking, such as contaminants and quantities, were still missing upon compiling the source database. This data was simply unavailable through the federal databases for many of the minor dischargers and RCRA facilities. Consequently, missing information was populated based on educated assumptions using the known data. Data population of missing fields affects the susceptibility analysis more than the inventory. The inventory discussed in this section is based on actual downloaded data.

Note that individual site contaminants were downloaded, where available, for each facility. Each contaminant was associated with one of ten categories. These categories were generally based on contaminant groups described in the PADEP SWAP guidance document. The contaminant categories were subgrouped into non-conservative (total/fecal coliform, turbidity, nutrients, VOC/SOCs, metals) and conservative (*Cryptosporidium*/*Giardia*, nutrients, DBP precursors, petroleum hydrocarbons, and salts) categories. Nutrients were included in both the non-conservative and conservative categories, because phosphorous is mostly associated with particulates and nitrogen compounds are typically dissolved.

2.2.2.2 Results

Point Source Contaminant Inventory

After the database compilation and population were completed, inventories specific to each intake were developed. PWD's Baxter Intake was delineated into three zones based on travel time. Zones A and B consist of the area of the watershed within a 25-hour travel time of the intake. Zone C extends beyond 25 hours of travel time and essentially captures the remainder of the study area. Consequently, the inventory of sources throughout the three zones is quite extensive for the Baxter Intake.

The completed inventory for Baxter compiles almost 6,000 sources. The inventory is sorted into three sections for zones A, B, and C and subsorted by source type, PCS, RCRA, etc. The inventory indicates facility information such as name, city and county. The source of the data is also indicated, that is, RCRA, PCS, etc. Other pertinent information includes industry classification by SIC code, whether the facility is a large quantity generator for RCRA sites, and a major discharger for PCS sites. If information was available for a specific facility, such as on-site or discharged chemicals, quantities of chemicals, capacity of the site, and discharge flow rates, it is listed.

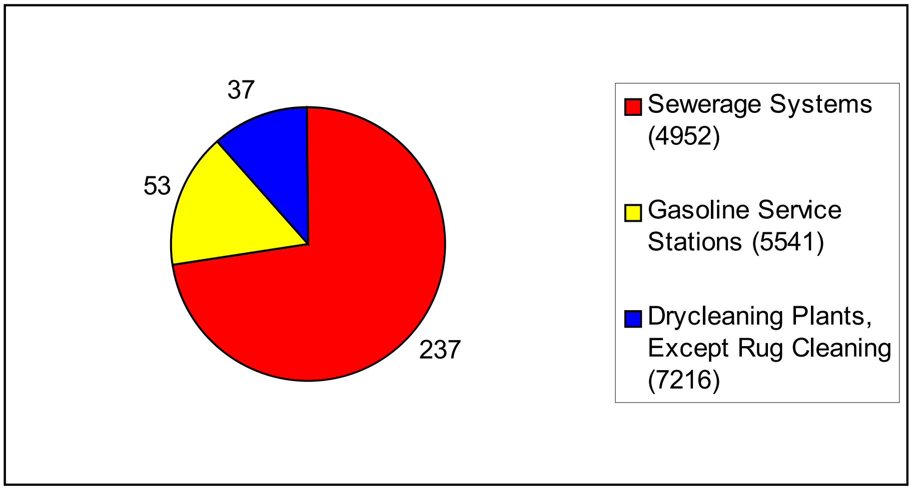
Inventory Characterization
Data from the complete Baxter inventory summarized in Table 2.2.2-1 identifies the most common contaminant source types and the zones in which they are concentrated. The characterization also seeks to find common industries or dischargers and the most common contaminants by category. Source type (PCS, RCRA, etc…) and zone of delineation (A, B, or C) organize the table. Table 2.2.2-1 indicates that a number of sources are found upstream of the Baxter Intake. On a positive note, the least number of sources are found in the area of the watershed within Zone A, 5 hours of travel time. Most sources are found within Zone B, between 5 and 25 hours of travel time. RCRA facilities are the most numerous with greater than 1,700, followed by aboveground storage tanks, and NPDES. There are over 1,500 direct discharges in the watershed upstream of Baxter, however only 150 are within Zone A. These sources are ranked for significance with respect to other criteria, such as contaminant category, quantity, and violations, in section 2.2.4.

Table 2.2.2-1 Summary of Point Source Types Delineation Zone

Source Type	Zone A, < 5hr	Zone B, > 5hr, < 25hr	Zone C, > 25hr	Total Count
AST	149	666	711	1526
CERCLA	116	427	112	655
NP	55	162	313	530
NPDES	137	360	277	774
RCRA	167	760	793	1720
TRI	79	312	116	507
Total	703	2687	2322	5712

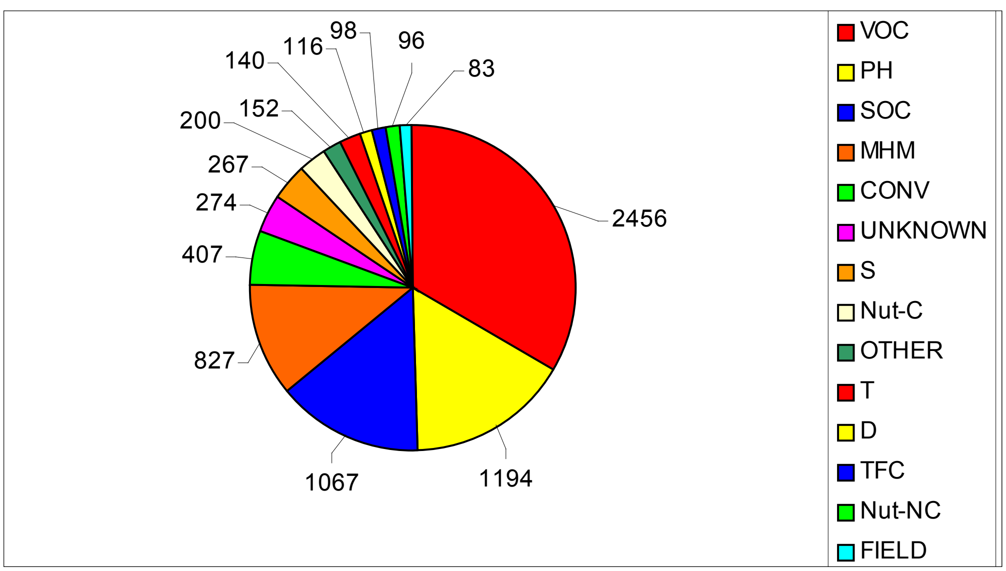
Figure 2.2.2-1 shows the most common industry types based on SIC code, throughout the Belmont delineation zones. The top three industry types are shown. The data is somewhat limited due to the amount of missing SIC codes, especially for the dischargers. Despite its limitations, the data provides an insightful overview of the prevalence of various industry types within the overall delineation zone. Sewerage systems were most numerous (SIC # 4952), followed by gasoline service stations (SIC # 5541), and dry cleaning plants-excluding rug cleaning (SIC # 7216).

Figure 2.2.2-1 Prevalent Industry Types for the Baxter Intake



Similar to Figure 2.2.2-2, parameter groups are summarized based on prevalence throughout the Baxter delineation zones in Figure 2.2.2-1. This is again based on a limited data set. Contaminant information was most complete for TRI sources. With this in mind, available data shows that VOCs are the most common contaminants reported by the sources, followed by petroleum hydrocarbons and SOCs. This is useful for water suppliers to keep in mind in monitoring efforts and surveillance of raw water.

Figure 2.2.2-2 Prevalent Contaminant Categories for the Baxter Intake



PCS Dischargers

A characterization of dischargers or PCS facilities within the Baxter Intake's delineation zone is examined in Table 2.2.2-2. Out of 774 dischargers, 124 are major (>one MGD). Wastewater treatment plants comprise the largest component, 236 of 774, for both major and minor dischargers. After sewerage systems, gasoline and water suppliers are the most common discharger types.

Table 2.2.2-2 PCS Discharger Summary

Total Dischargers	774
Major Dischargers	124
Major Sewerage Systems	81
Facilities with SIC Codes	702
Top 3 Discharge Types by SIC Code 4952 - Sewerage Systems 5541 - Gasoline Service Stations 4941 – Water Suppliers	 236 53 29
Dischargers with Available DMR Data	107
Most Common Parameters with DMR Data	Total Suspended Solids BOD5, Biological Oxygen Demand Flow Rate Carbonaceous BOD5 Ammonia-Nitrogen
Discharge Flow Rate Range (from DMRs)	0 – 40 MGD

Because so many of the dischargers are minor, Discharge Monitoring Report (DMR) data was available for 107 sites. The most common parameters found in the DMRs and effluent limits are indicated in Table 2.2.2-2. The common DMR parameters – TSS and BOD5 - correlate with turbidity and TOC (DBP precursor), which are of concern from a source water perspective. The flow rate poses some concern in drinking water supplies, but metals are much more toxic with respect to human health risks. The prevalence of nutrients is expected due to the number of wastewater plants.

Discharge Monitoring Report (DMR) data for Baxter sources are further summarized in Table 2.2.2-3 based on maximum reported quantities and parameter groups. This summary is quite similar to the entire study area summary presented in Section 1.5, because Baxter's delineation zone covers the majority of the Delaware River Study Area. The parameter groups generally follow those laid out in the PADEP SWAP guidance document. These groupings are used to rank potential contaminant sources in all of the intake report sections.

Since the ranking analysis is based on DMR maximum quantity data, this data is compiled in Table 2.2.2-3 to provide a frame of reference. The data also gives an idea, on a pounds per day basis, as to the "worst case" order of magnitude of releases. Note from Table 2.2.2-3 that this data was available for only 107 of the 702 dischargers in the delineation zone for Baxter. Available data was generally linked to major dischargers.

With that in mind, the data truly represents a worst-case estimate of individual loads being discharged in the study area within the delineation zones of the Baxter Intake.

Table 2.2.2-3 Summary of Available DMR Data

Parameter Type	Parameter Name	Range of Max Quantity [1]			AvgOfMaxQty	Count Of Max Qty
CONV	CARBONACEOUS BOD5	1.00000004749745E-03	-	11759	383.775104080529	1450
CONV	CHEMICAL OXYGEN DEMAND, COD	9.00000035762787E-02	-	1547.10205078125	189.457286648671	136
CONV	CHLORINE, TOTAL RESIDUAL	0	-	3191.80004882813	94.7602955698967	34
CONV	CYANIDE, TOTAL	0	-	795.767028808594	157.306528387546	25
CONV	pH	2.99999993294477E-02	-	2.99999993294477	2.99999993294477E-	1
CONV	SOLIDS, DISSOLVED TOTAL ,TDS	85	-	57304	17873.779838562	124
CONV	SULFATE as SO4	10499	-	30113	14105.88	50
CONV	SULFIDE as S	-0.331999987363815	-	0.58300000429153	1.42632910158025E-	79
CONV	TKN (TOT. KIELDAHL NITROGEN)	7.00000002980232E-02	-	131	24.0324657168495	73
D	BOD, CARBONACEOUS 5 DAY,5 C	28	-	51	39.6	5
D	BOD5, BIOLOGICAL OXYGEN DEMAND	-4.88100004196167	-	185656	1509.49896040956	3275
D	OXYGEN DEMAND, ULTIMATE	0.800000011920929	-	486	87.8884285151958	70
FIELD	FLOW RATE	7.00000018696301E-05	-	27984	70.4431161687595	2856
FIELD	TEMPERATURE	0	-	0	0	1
MHM	ALUMINUM, TOTAL	0.28999999165535	-	66	5.69205128153165	39
MHM	ALUMINUM, TOTAL RECOVERABLE	0.266460001468658	-	988	104.001528322697	13
MHM	ANTIMONY TOTAL RECOVERABLE	2.0000000949949E-03	-	0.23399999737739	9.39069761201566E-	43
MHM	ANTIMONY, TOTAL	3.80000006407499E-03	-	139.199996948242	17.5140997436078	31
MHM	ARSENIC, TOTAL	2.0000000949949E-03	-	58	11.1596713735988	7
MHM	ARSENIC, TOTAL RECOVERABLE	0	-	58.5999984741211	9.14406254002824	32
MHM	BARIUM, TOTAL	1.61999999545515E-03	-	151.300003051758	17.1145600409471	27
MHM	BERYLLIUM, TOTAL	3.32999997772276E-03	-	11.6999998092651	3.8083608833258	12
MHM	CADMIUM TOTAL RECOVERABLE	0	-	47.2999992370605	6.51294108041946	34
MHM	CADMIUM, TOTAL	1.9000000320375E-03	-	5.69999980926514	0.486641929905501	31
MHM	CHROMIUM TOTAL RECOVERABLE	9.08399969339371E-02	-	69.5999984741211	26.2245307894129	19
MHM	CHROMIUM, TOTAL	-0.123000003397465	-	68.0999984741211	1.09930142973199	138
MHM	CHROMIUM; HEXAVALENT	0.100000001490116	-	0.18899999558925	0.131333331267039	3
MHM	COPPER TOTAL RECOVERABLE	3.9999998989515E-04	-	2387	81.5398314254041	200
MHM	COPPER, TOTAL	-0.363000005483627	-	340	4.32366071704927	251
MHM	IRON TOTAL RECOVERABLE	9.60000038146973	-	2999	923.140000152588	5
MHM	IRON, TOTAL	9.00000035762787E-02	-	0.32600000500679	0.142999999721845	30
MHM	LEAD TOTAL RECOVERABLE	0	-	141.899993896484	6.98659912343884	55
MHM	LEAD, TOTAL	1.99999995529652E-02	-	22.7000007629395	1.92685759710995	33
MHM	MANGANESE, TOTAL	0.207000002264977	-	2396.97192382813	1300.75285633367	13
MHM	MERCURY TOTAL RECOVERABLE	2.0000000949949E-03	-	208	21.8133479978656	10
MHM	MERCURY, TOTAL	3.9999998989515E-04	-	1.79999995231628	0.550325000745943	8
MHM	NICKEL TOTAL RECOVERABLE	0	-	561	56.7314891499346	23
MHM	NICKEL, TOTAL	1.00000004749745E-03	-	1248	19.2085176412181	79
MHM	SELENIUM, TOTAL	2.0000000949949E-03	-	3.59999990463257	1.6260000000475	4
MHM	SELENIUM, TOTAL RECOVERABLE	0.025000000372529	-	34.7999992370605	18.496428203636	7
MHM	SILVER TOTAL RECOVERABLE	0	-	58.5999984741211	9.93665209728415	23
MHM	SILVER, TOTAL	0	-	69	3.06337056060917	34
MHM	THALLIUM, TOTAL	2.0000000949949E-03	-	58.5999984741211	19.3259993981467	9

Parameter Type	Parameter Name	Range of Max Quantity [1]			AvgOfMaxQty	Count Of Max Qty
MHM	ZINC TOTAL RECOVERABLE	-8.03000032901764E-02	-	991	59.1402115677993	256
MHM	ZINC, TOTAL	-2.30000000447035E-02	-	681	16.7642617248631	185
Nut-C	AMMONIA (AS N) + UNIONIZED AMMONIA	2.0000000949949E-03	-	60	16.4262631052039	38
Nut-C	AMMONIA-NITROGEN	0	-	1599	53.8965191134579	1362
Nut-C	NITRATE NITROGEN, TOTAL AS NO3	3.70000004768372	-	37.4000015258789	14.3670732393497	82
Nut-C	NITRATE-NITRITE, NITROGEN	15	-	505	210.25	20
Nut-C	NITRATE-NITROGEN as N	0.159999996423721	-	0.36000001430511	0.258888892001576	9
Nut-NC	PHOSPHORUS, TOTAL as P	-2.83599996566772	-	217	7.03795397646875	639
OTHER	DISSOLVED OXYGEN	0.017000000923872	-	0.01700000092387	0.017000000923872	2
PH	HYDROCARBONS,IN H2O,IR,CC14 EXT. CHROMAT	0	-	42.5	4.09123811516024	21
PH	OIL AND GREASE	0	-	3549	174.351865319046	118
PH	PETROL HYDROCARBONS TOTAL RECOVERABLE	0	-	6.73000001907349	0.54114084144969	71
PH	PETROLEUM HYDROCARBONS, TOTAL	0	-	42.5	4.09123811516024	21
SOC	(DIOXIN) 2,3,7,8-TCDD	0	-	3.46000008285046	1.15400002759998E-	3
SOC	1,2,4-TRICHLOROBENZENE	0	-	37.7999992370605	7.00619988481048	13
SOC	1,2-DICHLOROBENZENE	0	-	37.7999992370605	7.43257680495914	13
SOC	1,2-DIPHENYLHYDRAZINE	6.99999975040555E-04	-	37.7999992370605	10.4534442912878	9
SOC	1,3-DICHLOROBENZENE	0	-	29.2999992370605	5.99788454495585	13
SOC	1,4-DICHLOROBENZENE	0	-	29.2999992370605	5.65817849727214	14
SOC	2,4,6-TRICHLORO- PHENOL	1.00000004749745E-03	-	75.6999969482422	34.4304387793178	5
SOC	2,4-DICHLOROPHENOL	0	-	37.7999992370605	9.55802206116884	9
SOC	2,4-DIMETHYLPHENOL	0	-	75.6999969482422	19.1280215440654	9
SOC	2,4-DINITROPHENOL	0	-	37.7999992370605	9.55842206114903	9
SOC	2,4-DINITROTOLUENE	0	-	37.7999992370605	7.06396415328657	14
SOC	2,6-DINITROTOLUENE	0	-	37.7999992370605	9.55802206116884	9
SOC	2-CHLORONAPHTHALENE	1.00000004749745E-03	-	37.7999992370605	17.2044397101039	5
SOC	2-CHLOROPHENOL	0	-	75.6999969482422	19.1282215440749	9
SOC	2-NITROPHENOL	0	-	37.7999992370605	9.55806650560246	9
SOC	3,3'-DICHLORO- BENZIDINE	1.00000004749745E-03	-	37.7999992370605	10.8337220673889	9
SOC	4,4'-DDD	4.99999987368938E-05	-	1.16999995708466	0.28793499426259	6
SOC	4,4'-DDE (P,P'-DDE)	9.99999974737875E-06	-	1.16999995708466	0.286254993989739	6
SOC	4,4'-DDT (P,P'-DDT)	1.99999994947575E-05	-	1.16999995708466	0.300594995097223	6
SOC	4,6-DINITRO-o-CRESOL	0	-	37.7999992370605	9.55806650560246	9
SOC	4-CHLORO-3-METHYL PHENOL	1.00000004749745E-03	-	75.6999969482422	34.4304387793178	5
SOC	4-NITROPHENOL	0	-	37.7999992370605	9.55806650560246	9
SOC	A-BHC-ALPHA	0	-	0.57999998331069	0.17063999697566	5
SOC	A-ENDOSULFAN-ALPHA	2.99999992421363E-05	-	0.57999998331069	0.172376663813338	6
SOC	ACENAPHTHENE	0	-	15.1000003814697	4.2965000453114	8
SOC	ACENAPHTHYLENE	0	-	15.1000003814697	3.10153080151381	13
SOC	ALDRIN	0	-	0.57999998331069	0.181885710252183	7
SOC	ANTHRACENE	0	-	15.1000003814697	3.11806925680811	13
SOC	B-BHC-BETA	1.79999992251396E-02	-	0.57999998331069	0.234549993649125	4
SOC	B-ENDOSULFAN-BETA	2.99999992421363E-05	-	1.16999995708466	0.314926660388058	6
SOC	BENZIDINE	2.0000000949949E-03	-	151	41.2922776908769	9
SOC	BENZO (A) ANTHRACENE	0	-	15.1000003814697	3.16910772489008	13
SOC	BENZO (A) PYRENE	0	-	15.1000003814697	3.12661428504258	14
SOC	BENZO(B)FLUORANTHENE	0	-	15.1000003814697	3.76153848794862	13
SOC	BENZO(GHI)PERYLENE	6.99999975040555E-04	-	15.1000003814697	4.64319005531142	10

Parameter Type	Parameter Name	Range of Max Quantity [1]			AvgOfMaxQty	Count Of Max Qty
SOC	BENZO(K) FLUORANTHENE	0	-	15.1000003814697	3.58004616997026	13
SOC	BHC-DELTA	8.99999961256981E-03	-	0.57999998331069	0.213299996219575	4
SOC	BIS (2-CHLOROETHOXY) METHANE	1.00000004749745E-03	-	75.6999969482422	34.4304387793178	5
SOC	BIS (2-ETHYLHEXYL) PHTHALATE	0	-	257.299987792969	31.4262570620049	19
SOC	BIS(2-CHLOROISOPROPYL)ETHER	1.00000004749745E-03	-	37.7999992370605	9.84386083135614	10
SOC	BUTYLBENZYL PHTHALATE	6.99999975040555E-04	-	37.7999992370605	10.3068887100542	9
SOC	CHLORDANE (TECH MIX. AND METABOLITES)	7.00000018696301E-05	-	5.80000019073486	1.41120502983176	6
SOC	CHRYSENE	0	-	276	22.4044214524121	14
SOC	DI-N-BUTYLPHTHALATE	0	-	37.7999992370605	8.57223828395721	13
SOC	DI-N-OCTYL PHTHALATE	1.00000004749745E-03	-	75.6999969482422	34.4304387793178	5
SOC	DIBENZO (A,H) ANTHRACENE	1.00000004749745E-03	-	15.1000003814697	5.18434450900855	9
SOC	DIELDRIN	9.99999974737875E-06	-	1.16999995708466	0.279921661480936	6
SOC	DIETHYL PHTHALATE	0	-	75.6999969482422	13.892514910343	13
SOC	DIMETHYLPHTHALATE	0	-	75.6999969482422	12.3615929257901	15
SOC	ENDOSULFAN SULFATE	2.99999992421363E-05	-	1.16999995708466	0.313096659777026	6
SOC	ENDOSULFAN, TOTAL	2.99999992421363E-05	-	1.16999995708466	0.270546659104487	6
SOC	ENDRIN	1.99999994947575E-05	-	0.57999998331069	0.156373329099248	6
SOC	ENDRIN ALDEHYDE	1.99999994947575E-05	-	1.16999995708466	0.352761660070125	6
SOC	FLUORANTHENE	0	-	37.7999992370605	6.9352427324962	14
SOC	FLUORENE	0	-	15.1000003814697	3.21043078977471	13
SOC	GAMMA-BHC	1.00000004749745E-03	-	1.0900000333786	0.296025002593524	8
SOC	HEPTACHLOR	0	-	0.57999998331069	0.17063999697566	5
SOC	HEPTACHLOR EPOXIDE	0	-	1.50999999046326	0.457639994472265	5
SOC	HEXACHLOROBENZENE	0	-	37.7999992370605	7.12619990333377	13
SOC	HEXACHLOROBUTADIENE	0	-	37.7999992370605	7.13089989434677	13
SOC	HEXACHLOROCYCLO- PENTADIENE	2.0000000949949E-03	-	37.7999992370605	10.4974776208659	9
SOC	HEXACHLOROETHANE	0	-	37.7999992370605	7.22010757494718	13
SOC	ISOPHORONE	1.00000004749745E-03	-	37.7999992370605	10.3277331807573	9
SOC	N-NITROSODI-N- PROPYLAMINE	1.00000004749745E-03	-	75.6999969482422	34.4304387793178	5
SOC	N-NITROSODIMETHYL- AMINE	1.00000004749745E-03	-	75.6999969482422	20.4058548519517	9
SOC	N-NITROSODIPHENYL- AMINE	3.9999998989515E-04	-	75.6999969482422	18.0851193953713	10
SOC	NAPHTHALENE	0	-	15.1000003814697	2.67493849005013	13
SOC	NITROBENZENE	0	-	37.7999992370605	7.64680760795286	13
SOC	PCB-1016 (AROCHLOR 1016)	7.999999797903E-05	-	5.80000019073486	1.6285466886596	6
SOC	PCB-1221 (AROCHLOR 1221)	0	-	5.80000019073486	1.62703335725382	6
SOC	PCB-1232 (AROCHLOR 1232)	0	-	5.80000019073486	1.62703335725382	6
SOC	PCB-1242 (AROCHLOR 1242)	0	-	5.80000019073486	1.62703335725382	6
SOC	PCB-1248 (AROCHLOR 1248)	0	-	5.80000019073486	1.62703335725382	6
SOC	PCB-1254 (AROCHLOR 1254)	0	-	5.80000019073486	1.62703335725382	6
SOC	PCB-1260 (AROCHLOR 1260)	0	-	5.80000019073486	1.62703335725382	6
SOC	PENTACHLOROPHENOL	1.00000004749745E-03	-	37.7999992370605	17.2044397101039	5
SOC	PHENANTHRENE	0	-	15.1000003814697	2.57865335498548	15
SOC	PHENOL	0	-	58.5999984741211	14.4246245706454	8
SOC	PHENOLS	-6.92000016570091E-02	-	0.87550002336502	8.80762957885626E-	54
SOC	PHENOLS, TOTAL	7.00000002980232E-02	-	25.9419994354248	1.44919116455404	68
SOC	PYRENE	0	-	37.7999992370605	7.36145372217288	13
SOC	TOTAL BASE/NEUTRAL PRIORITY POLLUTANTS	1.30000002682209E-02	-	2.40000009536743	0.620500023476779	4
SOC	TOTAL PCBS	7.00000018696301E-05	-	5.80000019073486	1.91645402727445	5
SOC	TOTAL TOXIC ORGANICS (TTO) (40CFR433)	0	-	0.35499998927116 4	0.118333329757055	3

Parameter Type	Parameter Name	Range of Max Quantity [1]			AvgOfMaxQty	Count Of Max Qty
SOC	TOXAPHENE	1.99999994947575E-04	-	5.80000019073486	1.91510002021338	6
T	SOLIDS,SUSPENDED TOTAL TSS	-40.0400009155273	-	22666	374.490762914408	4817
TFC	FECAL COLIFORM	0.090999998152256	-	0.09099999815225	0.090999998152256	1
VOC	1,1,1-TRICHLOROETHANE	0	-	5.80000019073486	1.89065713704414	14
VOC	1,1,2,2-TETRACHLORO-ETHANE	1.00000004749745E-03	-	6.6399998664856	3.29049001048552	10
VOC	1,1,2-TRICHLOROETHANE	0	-	11.6999998092651	2.86422143944947	14
VOC	1,1-DICHLOROETHANE	3.9999998989515E-04	-	29.2999992370605	8.29546654477276	9
VOC	1,1-DICHLOROETHYLENE	0	-	11.6999998092651	2.71394288404762	14
VOC	1,2-DICHLOROETHANE	0	-	253	26.062999984622	10
VOC	1,2-DICHLOROETHANE, TOTAL WEIGHT	0	-	11.6999998092651	2.96097274287868	11
VOC	1,2-DICHLOROPROPANE	0	-	5.80000019073486	1.29418572520288	14
VOC	1,2-TRANS-DICHLOROETHYLENE	0	-	11.6999998092651	2.79418215662996	14
VOC	1,3-DICHLOROPROPYLENE	0	-	0	0	4
VOC	2-CHLOROETHYLVINYL ETHER	1.00000004749745E-03	-	58.5999984741211	26.3086994278128	6
VOC	4-BROMOPHENYL PHENYL ETHER	2.0000000949949E-03	-	37.7999992370605	17.2048797101248	5
VOC	4-CHLOROPHENYL PHENYL ETHER	2.0000000949949E-03	-	37.7999992370605	17.2048797101248	5
VOC	ACROLEIN	9.99999977648258E-03	-	189.199996948242	59.7657263985073	11
VOC	ACRYLONITRILE	0	-	94.620002746582	25.4213999516486	15
VOC	BENZENE	0	-	5.80000019073486	1.60701430768157	14
VOC	BIS (2-CHLOROETHYL) ETHER	1.00000004749745E-03	-	45	14.0262498330907	10
VOC	BROMOFORM	3.00000014249235E-04	-	5.80000019073486	2.86043001526268	10
VOC	BROMOMETHANE	1.15999998524785E-02	-	58.5999984741211	24.3101597291417	10
VOC	CARBON TETRACHLORIDE	0	-	11.6999998092651	3.07013847874343	13
VOC	CHLOROBENZENE	0	-	11.6999998092651	2.54985715546146	14
VOC	CHLOROETHANE, Total Weight	0	-	58.5999984741211	14.3712196223554	10
VOC	CHLOROFORM	0	-	21.4400005340576	7.350373398792	15
VOC	CHLOROFORM, DISSOLVED	0.236000001430511	-	34.9799995422363	8.11259995102882	10
VOC	CHLOROMETHANE	1.37000000104308E-02	-	58.5999984741211	23.2003697386943	10
VOC	CIS-1,3-DICHLORO PROPENE	7.40000000223517E-03	-	29.2999992370605	7.65253990530036	10
VOC	DIBROMOCHLOROMETHANE	1.99999994947575E-04	-	5.80000019073486	2.37474166746082	12
VOC	DICHLOROBROMOMETHANE	1.00000004749745E-03	-	67.6971969604492	2.34894611380385	65
VOC	ETHYL BENZENE	0	-	0	0	4
VOC	ETHYLBENZENE	3.00000014249235E-04	-	29.2999992370605	7.90842988007935	10
VOC	METHYL BROMIDE (BROMOMTHANE)	6.99999975040555E-04	-	7.999999797903E-	7.49999977415428E-	2
VOC	METHYL CHLORIDE (CHLOROMETHANE))	0	-	2.30000005103648 E-03	5.42857143695333E-04	7
VOC	METHYLENE CHLORIDE	0	-	11.6999998092651	2.44481112163824	18
VOC	TETRACHLOROETHENE	0	-	5.80000019073486	1.54865001422004	20
VOC	TOLUENE	0	-	18.2000007629395	3.54428580829075	7
VOC	TOLUENE, DISSOLVED	3.00000014249235E-04	-	29.2999992370605	9.31272489801995	8
VOC	TOTAL VOLATILE POLLUTANTS	3.00000002607703E-03	-	0.03400000184774	1.20000005699694E-	4
VOC	TRANS-1,3-DICHLORO PROPENE	3.00000014249235E-04	-	29.2999992370605	7.85601989983406	10
VOC	TRICHLOROETHENE	0	-	2.90000009536743	0.657082121963245	19
VOC	TRICHLOROETHYLENE, DISSOLVED	3.00000014249235E-04	-	5.80000019073486	2.26242501903471	8
VOC	VINYL CHLORIDE	0	-	29.2999992370605	6.67649325321351	15
VOC	VOLATILE COMPOUNDS, (GC/MS)	19	-	77.1999969482422	45.3749995231628	4

[1] Quantities in lbs/day unless otherwise indicated

Table 2.2.2-3 shows that total suspended solids loads are the highest of any parameter and have the greatest number of reported quantities. Total suspended solids are related to the turbidity parameter group. Turbidity is another indicator, such as TSS, of particulates in the water supply, but is a more meaningful measure of performance in drinking water treatment. Microbial data is very scarce, with only one reportable maximum quantities for fecal coliform. Maximum and average ammonia loads are greater than phosphorus loads. The table also indicates the various VOCs and SOCs discharged into the Delaware River. Vinyl chloride has the single largest discharged VOC quantity of 6.7 pounds per day. Relative to the other VOCs, Methylene Chlroide and Tetrachl Oroethene are also large average maximum discharge quantities. Total phenols are the largest discharged quantity of SOCs. Otherwise, quantities are similar across the many synthetic organic compounds. Of the metals, zinc is clearly the largest discharged quantity. High maximum quantities are also reported for aluminum, total chromium, total copper, total nickel, and total zinc. Chromium and lead pose the greatest risk in drinking water.

RCRA/AST Facilities

As summarized in Table 2.2.2-4, RCRA facilities comprise many of the point sources within the Baxter Intake's delineation zone. However, only 387 out of the 1 720 RCRA facilities are designated as "Large Quantity Generators". Data describing the industry type or capacity of the facilities is limited. Taking into account the limited number of SIC codes, most RCRA facilities are dry cleaning plants, followed by chemicals and chemical preparations not elsewhere classified, automotive transmission repair shops, electroplating, plating, polishing, etc. facilities, and top, body, and upholstery repair shops and paint shops. A relatively low number of RCRA sites are cited as having violations. Capacity information for use in ranking sites is available for merely ten sites, and contaminant information is not available. A range of 2 to 25 million gallons gives an idea of the capacity for the RCRA sites with available data.

Table 2.2.2-4 RCRA Facility Summary

Total RCRA Facilities	1720
Large Quantity Generators	387
Facilities with SIC Codes	702
Top 5 RCRA Industry Types by SIC Code 7216 – Drycleaning Plants, Except Rug Cleaning 2899– Chemicals And Chemical Preparations, Not Elsewhere Classified 7537 – Automotive Transmission Repair Shops 3471 – Electroplating, Plating, Polishing, etc. 7532 – Top, Body, And Upholstery Repair Shops and Paint Shops	 37 10 8 7 7
RCRA Facilities with Violations	282
RCRA Facilities with Capacity/Volume Data	10
Range of Capacity	2 - 25,000,000 gallons 1 – 3,456,000 gal/day
Most Common Parameters/Contaminants	Not Applicable – no contaminants linked to RCRA downloads

RCRA data was supplemented with Aboveground Storage Tank (AST) information from PADEP. PADEP AST data included useful and detailed information as to tank age, contaminants and volumes. AST data is summarized in Table 2.2.2-5.

Table 2.2.2-5 AST Facility Summary

Total AST Facilities	1526
AST Facility Overlap with RCRA Facilities	73
Total Number of Tanks	4674 Total/1904 ASTs
Tank Capacity Range	200 gal – 8 MG
Tank Age Range (years)	1 – 75
Number of Different Parameters/Contaminants	103
Most Common Parameters and Quantities by Number of Tanks Misc. Hazardous Substance Diesel Fuel Gasoline	 609 tanks/5.1 MG 235 tanks/6.7 MG 192 tanks/18.1 MG
Most Common Parameters/Contaminants and Quantities by Total Volume Heating Oil Gasoline Diesel	 78 MG 18 MG 7 MG

Table 2.2.2-5 shows that 1526 facilities throughout Baxter's delineation zones have aboveground storage tanks. Of those facilities, only 73 overlap with the RCRA facilities. This may be due to RCRA sites also comprising underground storage tanks. The AST data is still useful for characterizing potential contaminant sources in the watershed. Tanks range in capacities from 200 gallons to 8 million gallons and range in age from 1 to 75 years old. Older tanks may pose a greater risk for spills. The tanks contain 103 different substances. The most common of these by volume, as labeled in the original PADEP data, is a non-specific hazardous substance. The specific chemical was not given. After miscellaneous hazardous substances, gasoline and diesel fuels are most common by volume. The significance of these tanks as contamination sources depends on factors such as the total volume of substance at any one site, tank age, and the time of travel to the intake. These factors are considered in the intake specific susceptibility ranking.

TRI Facilities
A summary of TRI sources is presented in Table 2.2.2-6. A facility is listed in the TRI if a chemical from the inventory is used or manufactured on site. These sites are not necessarily dischargers. Data on which chemicals are on–site, quantities of chemicals, and releases are available for the TRI sources. The range of quantities is how much is used or manufactured in a given year. Releases may be to air, water or land. Information on the amount of a given chemical and the chemical released is not provided.

With that in mind, Table 2.2.2-6 indicates that 507 TRI facilities are found in the delineation zone for Baxter. A SIC code is identified for 504 of these industries. SIC codes are linked to activities that PADEP identified in the state SWAP document. Based on activity, most TRI facilities are chemical manufacturers, machine/metalworking shops, or plastics manufacturers.

Chemical and quantity data is very complete for the TRI facilities, however quantities are presented as ranges. Ammonia, copper, toluene, phosphoric acid, and nitric acid are the most common chemicals listed by the various TRI sites. Quantity ranges for these chemicals are shown in Table 2.2.2-6. This amount of substance is not necessarily released into a water body. Limited information is available on the number of releases to water for 507 of the TRI facilities. Based on this, chemical manufacturers have had the most reported number of releases.

Table 2.2.2-6 TRI Facility Summary

Total TRI Facilities	507
Facilities with SIC Codes	504
Top 3 Industry Types by Activity	
Chemical Manufacturing	115
Machine/Metalworking Shops	83
Plastics Manufacturing	63
Top 3 TRI Industries by SIC Code	
2819	15
2899	15
2851	15
Facilities with Quantity Data	12
Most Common Parameters for Facilities with Quantity Data	
Ammonia	37
Copper	20
Toluene	17
Phosphoric Acid	16
Nitric Acid	14
Facilities with Release Data	312
Facilities with Greatest Number of Releases	
Horsehead Development Co. Inc.	168 releases to water
Zinc Corp. of America	168 releases to water
Ashland Chemical Inc.	105 releases to water

CERCLA Facilities

Although data for CERCLA facilities is limited, Table 2.2.2-7 summarizes the available information within 25-hour time of travel and beyond for the Baxter Intake. Six hundred and fifty-five CERCLA facilities are in the Baxter delineation zone, but only 34 are on the final National Priority List. Information for 35 of the CERCLA facilities is available through the RCRA and TRI databases, where those facilities are also listed. Only 63 sites are found in the flood plain.

Table 2.2.2-7 CERCLA Facility Summary

Total Number of CERCLA Facilities	655
Number on the NPL List	34
Number also listed as RCRA	29
Number also listed as TRI	6
Number in Flood Plain	63

2.2.3 Runoff Loading Summary

Key Points

- **The Delaware River Runoff Loading Model was developed to estimate contaminant loadings to the river from storm runoff.**
- **The model uses the physical characteristics of the subwatersheds, 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 developed land areas associated with industrial/commercial land use and residential uses are 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.**
- **Unit *Cryptosporidium* and turbidity loadings are higher from agricultural areas.**

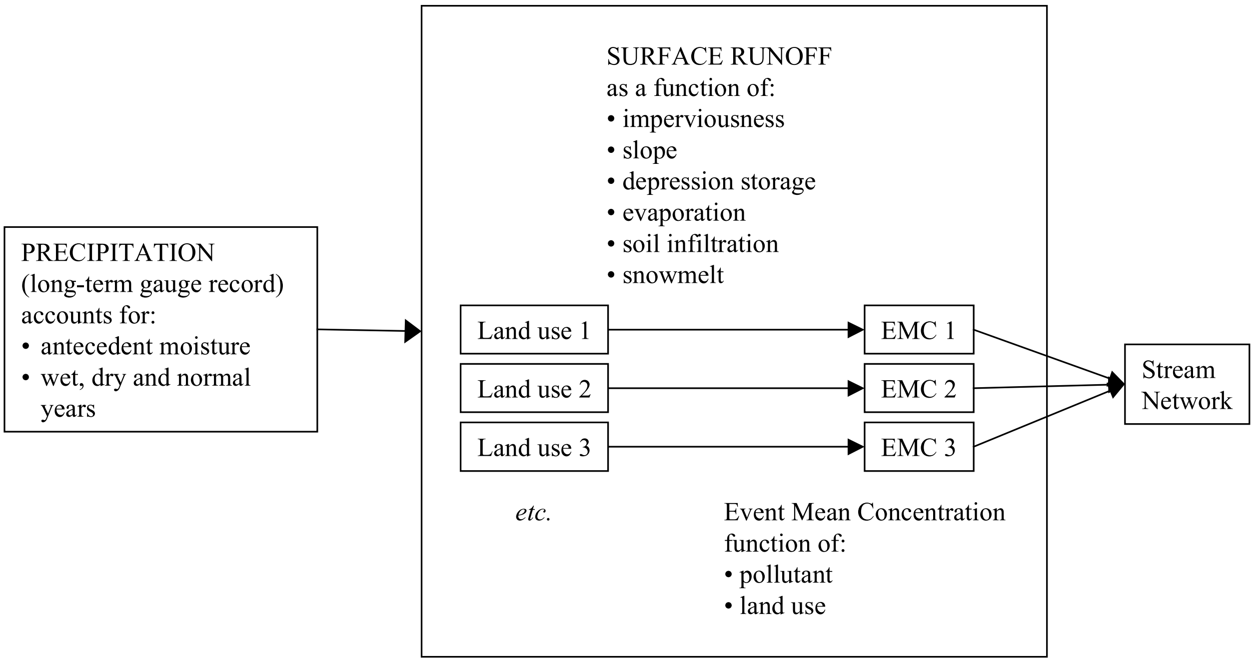
The Delaware River Source Water Assessment Partnership developed the Delaware Runoff Loading Model (DRLM) in an effort to estimate pollutant loads from rainfall runoff throughout the watershed. The DRLM results provide information on the relative contributions of surface runoff from various land use categories, as well as from different geographical areas. The procedure incorporates collection of data, model development and simulation, and post-processing of output data for further use in the susceptibility analysis. A database management system (DBMS) was created to assist with storing parameter data, creating the model, and post-processing model outputs.

2.2.3.1 Method

The RUNOFF Module of the U.S. EPA's Stormwater Management Model (SWMM) simulates rainfall-runoff quantities and quality at specified inlet locations. Figure 2.2.3-1 displays the structure of the SWMM RUNOFF Module. The model inputs subshed parameters, rainfall time-series, climatic data, and event mean concentrations (EMCs) for the land use categories, and outputs annual and monthly pollutant loads for the length of the simulation period. The model incorporates infiltration, depression storage, and roughness to estimate runoff flow and ultimately, runoff pollutant quantities.

The amount of a particular pollutant reaching the receiving stream is dependent on the volume of surface runoff and the concentration of that constituent in the runoff. An EMC is the total mass load of a pollutant yielded from a site during a storm divided by the total runoff water volume discharged during the storm. EMCs are related to the constituent of interest and the land use type. For a subshed, the surface runoff from a particular land use predicted by SWMM RUNOFF, is multiplied by the EMC for that land use type to yield a loading rate.

Figure 2.2.3-1 Watershed Loading Model Schematic Diagram



Subcatchments

The subcatchments of the Delaware River Watershed ultimately drain into the Chesapeake Bay. The Delaware Watershed Study area is composed of 391 subwatersheds and the area tributary to the PWD Baxter Intake includes 217 of the 391 subwatersheds, about 52% of the Delaware Watershed Study area. The subwatersheds were further divided into land use categories to track the contributing pollutant loads from each land use category. The land use categories were based on the USGS's NLCD dataset updated with 2000 Census data for residential and commercial areas, as detailed in Section 1.2.5.

The land use categories distinguish the amount of rainfall that runs off the surface of the subwatershed, as opposed to infiltrating into the subsurface or entering the atmosphere through evapotranspiration. For example, during a storm, more rainfall runs off from a residential area than from a forested area, since there are more impervious surfaces such as driveways, roads, and buildings in developed areas. The forested area retains more of the rainfall, which either infiltrates into the ground or evaporates. For modeling purposes, the land use categories were summed for each subwatershed in order to track individual land use loading contributions to the totals for each subwatershed. Figure 2.2.3-2 and Table 2.2.3-1 below summarize the land use characterization for the Delaware River Watershed Study area within the Zone B delineation for the PWD Baxter Intake and reflects modifications in residential development and increases in commercial areas based on increases in populations from the Census Bureau. For the defined area, 75% is characterized as agriculture, forests, and wetlands. Developed and urbanized areas account for about 23% of the Zone B delineated area for the PWD Baxter Intake.

Figure 2.2.3-2 Land Use Characterization for PWD Baxter Intake Zone B

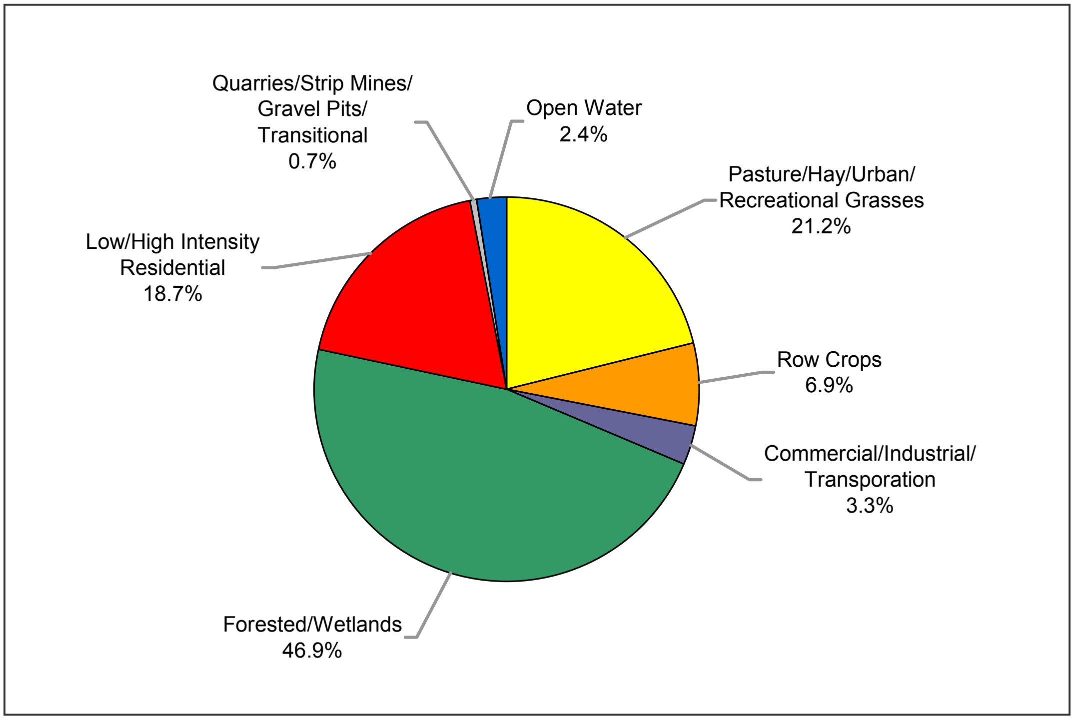


Table 2.2.3-1 Updated Land Use Categories

Land Use Subcategory	Area (acres)	Percentage of Zone B Delineated Area
Pasture/Hay/Urban/Recreational Grasses	439,302	21.2%
Row Crops	142,534	6.9%
Commercial/Industrial/Transporation	68,489	3.3%
Forested/Wetlands	972,877	46.9%
Low/High Intensity Residential	387,882	18.7%
Quarries/Strip Mines/Gravel Pits/Transitional	14,207	0.7%
Open Water	48,982	2.4%

The percentage of impervious area for all land use categories, excluding residential, were estimated according to values extracted from the Water Management Model (WMM) and adjusted during the calibration. The percentage of impervious area for residential areas was calculated using Hick's methodology, which calculates the percentage of total impervious area as a function of the population density.

For pervious areas, the portion of precipitation that runs off is affected by slope, depression storage, infiltration, vegetative cover, and evapotranspiration. Infiltration is determined primarily by the type of soil. The SWMM RUNOFF Module simulates infiltration using the Green-Ampt theory for both saturated and unsaturated soils. The Green-Ampt infiltration routine relates infiltration rate to the moisture conditions of the surface and the total volume of rainfall infiltrated. For the SLRM, the soil information was downloaded from the Natural Resources Conservation Service (NRCS) and the soils GIS coverage was intersected with subwatersheds to identify the soil types in each subwatershed.

Event Mean Concentrations (EMCs)

Applying EMCs to calculated runoff volumes provides reasonable estimates of runoff pollutant loadings. EMCs for the soluble pollutant categories were assigned according to the land use category. The SWMM RUNOFF Module allows the model to assume a constant concentration of a constituent for the duration of the storm event. The quantity of a constituent in surface runoff is a function of constant EMCs associated with the land use categories. The RUNOFF model water quality parameters included *Cryptosporidium*, disinfection by products, metals and heavy metals, conservative nutrients, non-conservative nutrients, petroleum hydrocarbons, salts, turbidity, and total/fecal coliform. For each of these contaminant types, a surrogate constituent was selected. For example, chloride was used as the surrogate for salts and the EMCs for chloride were used in the model. The complete list of EMCs can be found in Appendix .3.

Runoff volumes are computed for each land use category based on percent imperviousness of the land use, annual rainfall, slope of the subwatershed, evaporation, infiltration, and depression storage. This analysis was performed on a subwatershed-by-subwatershed basis and the results were used to determine load distributions according to the land use category. The pollutant mass load estimate is computed for each land use within each subwatershed as a product of the EMC and the surface runoff. By estimating the pollutant loading over the area of a land use type within a subwatershed and summing for all land uses, the total pollutant load from a subwatershed can be computed.

Meteorological Data

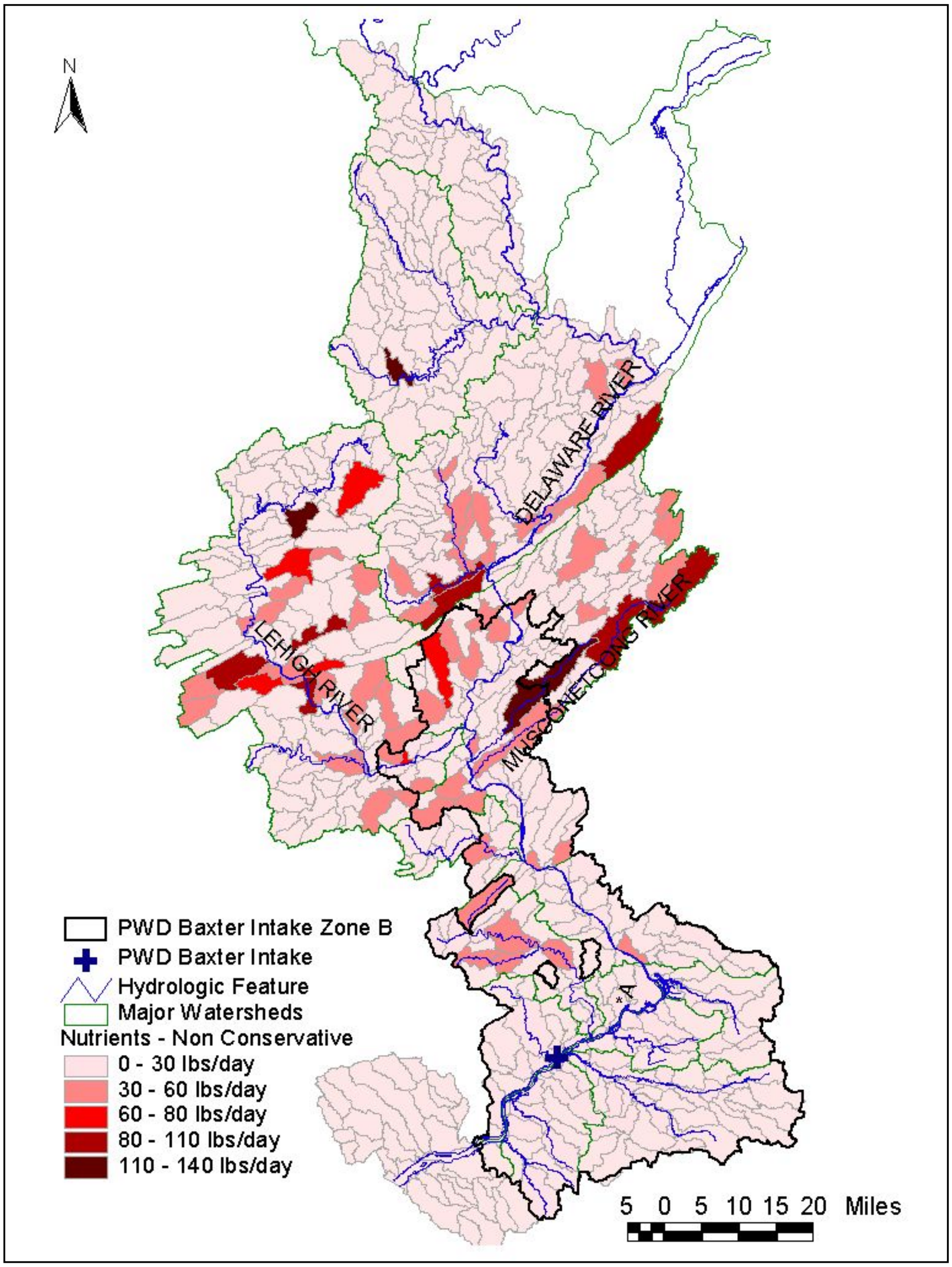
The amount of surface runoff is primarily driven by the precipitation. Long-term climate and precipitation records were used to drive the hydrology of the system. Using a long-term record represents a wide range of hydrologic conditions that occur in a given climate. Using a long-term record on a continuous basis accounts for antecedent moisture conditions and more accurately represents initial conditions at the beginnings of storm events. Snowfall and snowmelt affect the quantity and timing of surface runoff during the winter months and have been included in the long-term continuous simulation.

If available, rainfall, wind, and temperature data for a period of over ten years (1990-2000) were collected for RUNOFF model simulations. The hourly rainfall data were obtained from the National Weather Service (NWS) at stations in and surrounding the Delaware River Watershed. The hourly data was further discretized into 15-minute increments. To account for snowmelt, the daily minimum and maximum temperatures and average monthly wind speeds were obtained for the period of simulation.

2.2.3.2 Results

The DRLM was used to quantify contaminant loads for all pollutant categories included in the susceptibility analysis except for volatile organic compounds. Generally, the greater contaminant loads are found in the lower portion of the watershed. These areas tend to have more development, and thus greater impervious surfaces and runoff volumes. Figure 2.2.3-3 shows the results for the watershed for non-conservative nutrients for which the surrogate phosphorus was chosen. The darker areas, representing higher load estimates, are located closer to streams and rivers and are observed to be further downstream in the watershed. The lighter areas are less developed and less surface runoff results from rainfall events. The subwatersheds with greater pollutant loads tend to be distributed both within the Zone B delineation for the PWD Baxter Intake and along the major hydrologic features.

Figure 2.2.3-3 Non-Conservative Contaminant Runoff Loadings



The Zone A delineated area for an intake is defined as the area within a five-hour time of travel of the water supply intake, including one-quarter mile downstream and within a one-quarter mile wide area on either side of the stream from the intake. For the contaminant loads from rainfall-runoff, Zone A includes parts of the Neshaminy, tidal PA Bucks, Crosswicks, tidal PA Philadelphia, tidal NJ Upper, tidal NJ Lower and Rancocas subwatersheds.

Zone B for PWD's Baxter Intake encompasses Zone A and area further upstream in the Delaware Watershed including the NJ Mercer direct, PA Bucks direct, Tohickon, Middle Delaware and Lehigh subwatersheds. Since Zone B encompasses a larger area, the pollutant loads are greater for Zone B than for Zone A. As previously described, the area contained in the Zone B delineation is about 23% impervious surfacesThe average daily contaminant loadings for each of the Baxter Intake zones are summarized below by Table 2.2.3-2.

Table 2.2.3-2 Calculated Average Daily Contaminant Loadings

Zone	Area	*Cryto-sporidium*	Disinfection by Products	Metals and Heavy Metals	Conservative Nutrients	Non-Conservative Nutrients	Petroleum Hydrocarbons	Salts	Turbidity	Total/Fecal Coliforms
	(acres)	(oocysts/day)	(lbs./day)	(lbs./day)	(lbs./day)	(lbs./day)	(lbs./day)	(lbs./day)	(lbs./day)	(coliforms/day)
A	1,321,111	4.4E+08	24320	95	5744	742	8932	54801	7.4E+05	1.5E+13
B*	131,219	1.7E+09	88384	334	26851	3939	28858	185445	3.5E+06	5.0E+13
Total A&B	1,452,330	2.1E+09	112703	429	32595	4681	37789	240246	4.2E+06	6.5E+13

** Zone B values exclude Zone A*

On a smaller scale, the contributions from each of the major subwatersheds are summarized in Tables 2.2.3-3 and 2.2.3-4 below. Table 2.2.3-3 summarizes the total daily loads for each major subwatershed listed from upstream to downstream in the Delaware Watershed. Since only portions of some major subwatersheds are included in the Zone B delineation and the sizes of the subwatersheds vary, the values listed in Table 2.2.3-4 are the total daily loads divided by the contributing area of each major subwatershed. This provides a load per acre per day value.

Table 2.2.3-3 Daily Contaminant Loads for Major Subwatersheds

Majorshed*	Area (acres)	*Crytosporidium* (oocysts/day)	Disinfection by Products (lbs./day)	Metals/Heavy Metals (lbs./day)	Conservative Nutrients (lbs./day)	Non-Conservative Nutrients (lbs./day)	Petroleum Hydrocarbons (lbs./day)	Salts (lbs./day)	Turbidity (lbs./day)	Total/Fecal Coliforms (coliforms/day)
Crosswicks	92,066	7.2E+07	4,414	16	927	124	1,856	10,117	5.4E+04	2.9E+12
Lehigh	75,412	1.0E+09	55,630	227	17,252	2,461	17,975	123,595	2.7E+06	3.1E+13
Middle Delaware	379,996	1.4E+09	73,871	294	22,891	3,276	23,986	160,352	3.3E+06	4.2E+13
Neshaminy	135,263	3.1E+08	16,417	60	4,881	757	5,158	33,493	6.7E+05	9.1E+12
NJ Mercer direct	102,094	1.1E+08	5,510	17	1,529	238	1,838	9,993	1.0E+05	3.3E+12
PA Bucks direct	53,740	8.6E+07	3,913	11	1,500	244	1,042	6,023	1.2E+05	2.0E+12
Rancocas	225,815	1.7E+08	10,826	44	2,437	286	4,518	27,246	2.9E+05	6.9E+12
Tidal NJ lower	117,273	7.9E+07	4,697	18	1,094	134	1,949	10,866	7.5E+04	3.1E+12
Tidal NJ upper	69,183	6.1E+07	3,670	13	798	114	1,509	8,111	4.1E+04	2.4E+12
Tidal PA Bucks	36,423	5.0E+07	2,587	12	559	66	860	6,322	1.4E+05	1.4E+12
Tidal PA Philadelphia	101,377	1.5E+08	8,056	34	1,882	226	2,719	18,146	3.3E+05	4.8E+12
Tohickon	36,493	1.2E+08	5,205	13	2,239	387	1,219	6,884	1.7E+05	2.4E+12

** Areas reflect portions of the majorshed within the boundary of the Zone B delineation.*

Table 2.2.3-4 Daily Contaminant Loads per Acre for Major Subwatersheds

Majorshed*	Area (acres)	*Crytosporidium* (oocysts/day-acre)	Disinfection by Products (lbs./day-acre)	Metals/Heavy Metals (lbs./day-acre)	Conservative Nutrients (lbs./day-acre)	Non-Conservative Nutrients (lbs./day-acre)	Petroleum Hydrocarbons (lbs./day-acre)	Salts (lbs./day-acre)	Turbidity (lbs./day-acre)	Total/Fecal Coliforms (coliforms/day-acre)
Crosswicks	92,066	781	4.8E-02	1.7E-04	1.0E-02	1.3E-03	0.020	0.110	0.584	3.2E+07
Lehigh	75,412	954	5.9E-02	2.1E-04	1.2E-02	1.6E-03	0.025	0.134	0.713	3.9E+07
Middle Delaware	379,996	189	1.2E-02	4.1E-05	2.4E-03	3.3E-04	0.005	0.027	0.142	7.7E+06
Neshaminy	135,263	532	3.3E-02	1.2E-04	6.8E-03	9.2E-04	0.014	0.075	0.398	2.2E+07
NJ Mercer direct	102,094	705	4.3E-02	1.5E-04	9.1E-03	1.2E-03	0.018	0.099	0.527	2.9E+07
PA Bucks direct	53,740	1,339	8.2E-02	2.9E-04	1.7E-02	2.3E-03	0.035	0.188	1.001	5.4E+07
Rancocas	225,815	319	2.0E-02	7.0E-05	4.1E-03	5.5E-04	0.008	0.045	0.238	1.3E+07
Tidal NJ lower	117,273	613	3.8E-02	1.3E-04	7.9E-03	1.1E-03	0.016	0.086	0.459	2.5E+07
Tidal NJ upper	69,183	1,040	6.4E-02	2.3E-04	1.3E-02	1.8E-03	0.027	0.146	0.778	4.2E+07
Tidal PA Bucks	36,423	1,975	1.2E-01	4.3E-04	2.5E-02	3.4E-03	0.051	0.278	1.477	8.0E+07
Tidal PA Philadelphia	101,377	710	4.4E-02	1.6E-04	9.1E-03	1.2E-03	0.018	0.100	0.531	2.9E+07
Tohickon	36,493	1,971	1.2E-01	4.3E-04	2.5E-02	3.4E-03	0.051	0.277	1.474	8.0E+07

** Areas reflect portions of the majorshed within the boundary of the Zone B delineation.*

The contaminant loading results for the area within Zone B, including Zone A, for the Baxter Intake are summarized below:

Cryptosporidium: The areas of highest pollutant estimates are located in the Middle Delaware and Lehigh Subwatersheds. On a per acre basis, the highest load intensity occurs in the Tidal PA Bucks and Tohickon Subwatersheds.

Disinfection by-Products: The higher EMCs for disinfection by-products are associated with developed land use categories such as commercial/industrial/ transportation and residential. The areas of highest pollutant estimates are located in the Middle Delaware Subwatershed, with relatively high loading also occurring in the Lehigh and Neshaminy Subwatersheds. On a per acre basis, the most concentrated loading occurs in the Tidal PA Bucks and Tohickon Subwatersheds.

Metals/Heavy Metals: The areas of highest pollutant loading estimates are located in the Middle Delaware and Lehigh subwatersheds. On a per acre basis, the most concentrated loading occurs in the Neshaminy Subwatershed followed by Tidal NJ Lower, NJ Mercer Direct, and Tidal PA Philadelphia.

Conservative Nutrients: The areas of highest pollutant loading estimates are located in the Middle Delaware and Lehigh subwatersheds. On a per acre basis, the most concentrated loading occurs in the Crosswicks and Lehigh Subwatersheds.

Non-conservative Nutrients: The areas of highest pollutant loading estimates are located in the Middle Delaware and Lehigh Subwatersheds. On a per acre basis, the most concentrated loading occurs in the Tidal NJ Lower and Tidal PA Philadelphia Subwatersheds.

Petroleum Hydrocarbons: The highest EMCs for petroleum hydrocarbons are associated with commercial/industrial/transportation areas, followed by residential land use categories. The areas of highest pollutant loading estimates are located in the Middle Delaware and Lehigh Subwatersheds. Other relatively high loading areas are noted in the Neshaminy and Rancocas Subwatersheds. On a per acre basis, the most concentrated loading occurs in the Tidal PA Bucks and Tohickon Subwatersheds.

Salts: The higher EMCs for salts are associated with developed land use categories such as commercial/industrial/transportation, mining, and residential. The areas of highest pollutant loading estimates are located in the Middle Delaware and Lehigh Subwatersheds. On a per acre basis, the most concentrated loading occurs in the Tidal PA Bucks, Tohickon, and PA Bucks Direct Subwatersheds.

Turbidity: The highest EMCs for turbidity are associated with agricultural and forested areas, followed by wetlands, then developed land use categories. The areas of highest pollutant loading estimates are located in the Middle Delaware and Lehigh Subwatersheds. On a per acre basis Tidal PA Bucks, Tohickon, and PA Bucks Direct Subwatersheds have the highest loading concentrations.

Total/Fecal Coliform: the areas of highest pollutant loading estimates are located in the Middle Delaware and Lehigh Subwatersheds. On a per acre basis, the most concentrated loading occurs in the Middle Delaware Subwatershed.

The summary of the results from the DRLM show the pollutant loads over the entire watershed from each of the smaller subwatershed. The contaminant loads are not only dependent on the land use type, but also on soil properties, subwatershed slopes, depression storage, and climate conditions. The estimates from the DRLM were further used in the qualitative loading analysis portion of the susceptibility analysis.

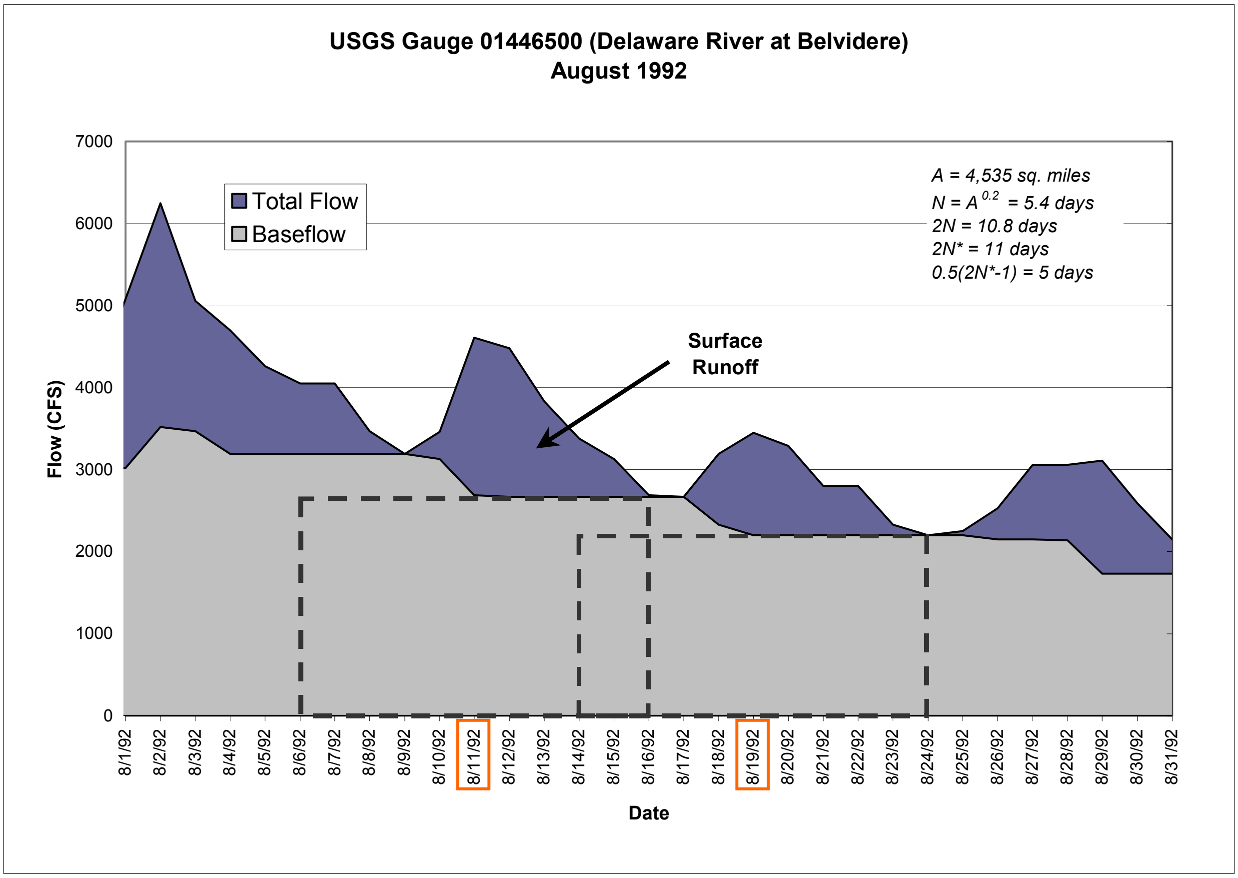
2.2.3.3 Hydrograph Separation for Baseflow and Runoff Calibration

In order to assess the reliability of the pollutant loads from SWMM, a hydrograph separation analysis was performed to compare with estimated runoff quantities and water quality loads from the DRLM. A hydrograph separation program was created in SAS® to divide the total flow into baseflow and surface runoff. This program was modeled after the USGS's HYSEP computer program, but assumes only one of its three hydrograph separation methods, the sliding-interval method. The hydrograph separation yields total flow, baseflow, and runoff values in daily, monthly, seasonal, and annual averages. The daily average flows were obtained from the USGS for gauges located in the Delaware River Basin.

The sliding-interval method associates a baseflow with a selected day by taking an equal interval before and after that day and assigning the lowest discharge to that day. The intervals are calculated based on the drainage area. For example, as shown in Figure 2.2.3-4, the drainage area for the USGS gauge located on the Delaware River at Belvidere is 4,535 square miles and the interval after surface runoff is 5.4 days. The interval for finding the baseflow is applied before and after a specified day. Thus, total duration is twice the calculated interval (10.8 days) and then rounded to the nearest odd number greater than that value (11 days) to include the interval before and after that day as well. Three is the minimum duration used in the sliding interval method. The selected day should be the median with equal duration before and after to associate the lowest discharge within the entire interval. For the Delaware River at Belvidere, the total interval is eleven days and the "windows" for August 11th, 1992 and August 19th, 1992 are displayed in Figure 2.2.3-4. The baseflow designated to August 11th, 1992 is 2,690 cubic feet per second (cfs) and August 19th, 1992 is 2,200 cfs.

The surface runoff is the difference between the total streamflow and the baseflow, as described above. In Figure 2.2.3-4 the area shaded blue is the remainder of the total flow that is designated as surface runoff.

Figure 2.2.3-4 Hydrograph Separation Analysis for the Delaware River at Belvidere for August 1992



The hydrograph separation was conducted for the active USGS gauges in the Delaware River Watershed. The values are average annual flows in cubic feet per second and inches per year for the period of record available for each gauge. The percent runoff is the amount of total flow that is assumed to be surface runoff. The total flow, baseflow, and runoff values were converted to inches per year by dividing the flows by the drainage area.
Since there is seasonal variation in the flows, the average baseflow and surface runoff values were also calculated by season. Generally, the average seasonal baseflow was highest in the spring, winter, summer, then fall (in descending order). Often the average seasonal baseflow was two to three times greater in the spring than the summer. Seasonal surface runoff for the winter, spring, summer, and fall averaged 9.9, 9.5, 4.7, 6.1 inches per year, respectively.

The USGS streamflow hydrograph separation results were used to calibrate the results from the DRLM. Since there is evidence of seasonal variability, the calibration of the DRLM was done on a seasonal basis. Comparing the simulated values with the hydrograph separation results, parameters in the DRLM were further refined.

2.2.4 Susceptibility Analysis

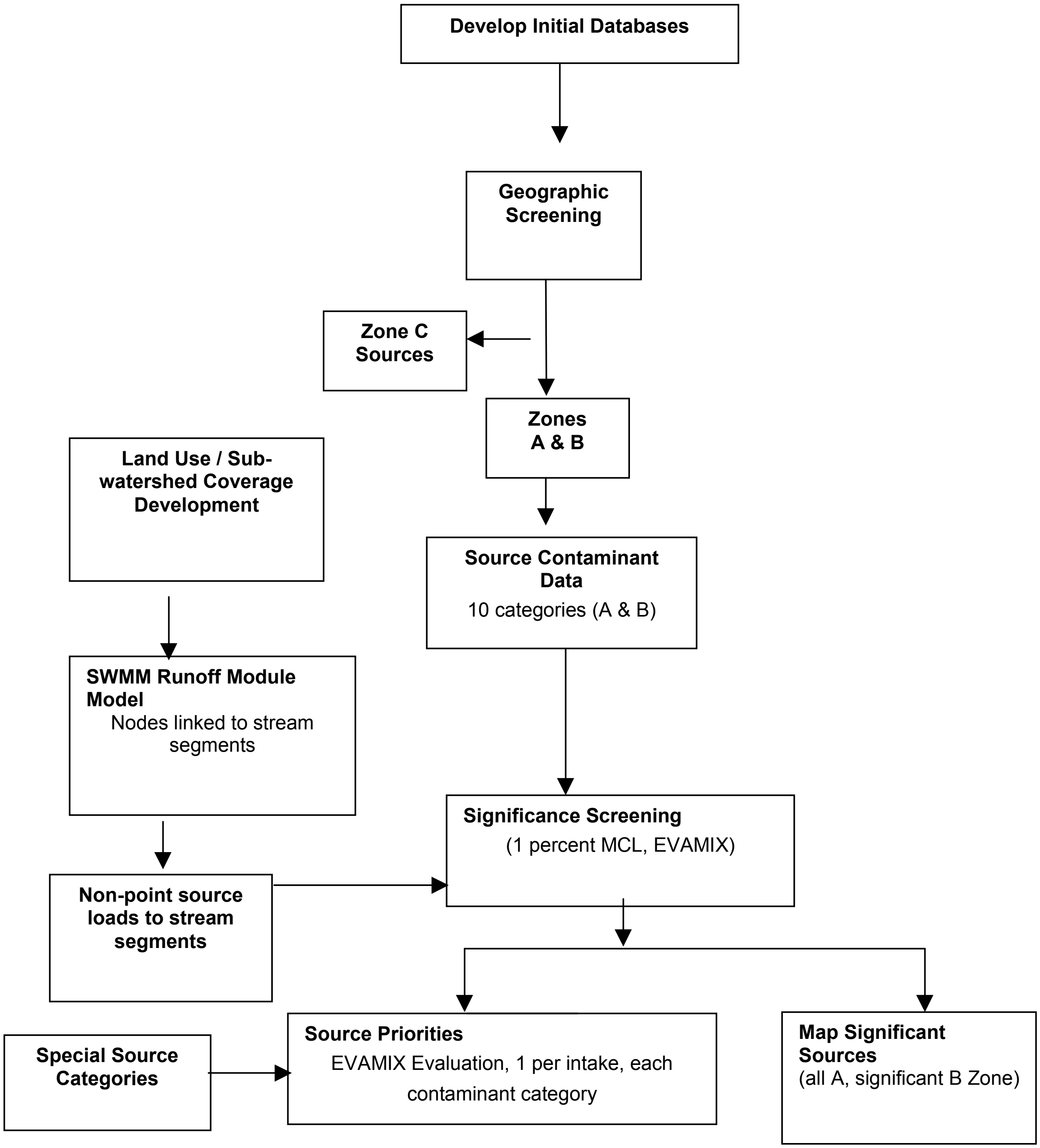
Key Points

- **A series of screenings was used to identify those sources that have the greatest potential to affect water quality at the Baxter Intake.**
- **Five non-conservative contaminant categories and five conservative contaminant categories were selected to represent all potential contaminants.**
- **For each category, a threshold value indicative of the significance of the concentrations of contaminants that could result from a potential spill or discharge was defined.**
- **EVAMIX, a multi-criteria software package was used along with information from the Technical Advisory Group, to prioritize the potential significance of each of the potential point sources within Baxter's Zone A and Zone B, and to evaluate the potential significance of non-point sources estimated by the Delaware River Runoff Loading Model.**
- **NPDES and non-point source discharges within the Baxter Intake's Zone A and Zone B were determined to have the highest protection priorities in the watershed.**
- **The potential significance of each source of contamination was designated A (potentially significant source of highest protection priority) through F (potential source of lowest protection priority). Those sources ranked A through C are potentially significant sources of contamination to the Baxter Intake.**
- **All of the highest ranked sources are either NPDES sites or storm water loadings from specific sub-watersheds.**
- **Contaminant sources actually discharging to the river (e.g., NPDES permitted point sources, or stormwater runoff) are estimated to have greater potential significance than those with only the potential to release contaminants to the River (e.g., a spill or leak).**
- **EVAMIX was also used to rank potential sources for each contaminant category.**

2.2.4.1 Method

Because of the large number of potential sources of contamination that have been identified, the method behind the susceptibility analysis relies on a process of successive screenings. These screenings help focus the efforts of source water protection on those sources that have the greatest potential to affect the water quality of the source water at the intake. The process of screening is shown in Figure 2.2.4-1, and described in this section. The section starts with an introduction to the ten contaminant categories being considered.

Figure 2.2.4-1 Source Prioritization Flow Diagram



Contaminant Categories

There are two difficulties faced in trying to prioritize potential sources of contamination of the drinking water. Because the Delaware River Watershed is very large, there are thousands of potential sources to be assessed. In addition, the assessments must also cover a full range of contaminant types. The PADEP guidance indicates that the best approach is to try to group all potential contaminants into a limited number of contaminant groups, and then assess all sources for each of the contaminant categories. For this study, ten contaminant categories have been developed. For each category, a planning level threshold concentration based either on ambient water quality in the river, or on regulatory standards such as the drinking water standard has been developed. This threshold value is used as a relative measure of the significance of contaminant concentrations that could potentially occur due to a spill or discharge from each of the sources. Each category is summarized below.

Non-Conservative Contaminants

There are five contaminant categories that can be considered "non-conservative" contaminants. Once spilled or discharged into the river, the concentration that results will decrease as the spill moves downstream, either because the contaminant dies off, evaporates into the air, or attaches itself to silt particles and settles to the bottom of the river. The non-conservative contaminant categories are:

1. Total/Fecal Coliform: Fecal coliform is used as the indicator contaminant for this category. The suggested threshold value is the recreational water standard of 200 count/100 ml. Fecal coliform tends to die off over time within the river.

2. Turbidity: Turbidity can be measured directly, but most existing data relates to Total Suspended Solids (TSS), and this is used as an indicator for turbidity. The suggested threshold comes from median ambient conditions in the river, of approximately 10 mg/l. TSS tends to settle to the bottom of the river over time.

3. Nutrients: There are several contaminants in the nutrient category. Phosphorous was selected as one indicator for this category. The suggested threshold value comes from the median ambient conditions in the river, of approximately 0.12 mg/l. Some portion of the total phosphorus concentration is associated with phosphorus adhering to silt particles, which tend to settle to the bottom of the river over time.

4. VOC/SOC: This category is particularly challenging because it includes hundreds of compounds. To meet this challenge, it was decided that the total amount of VOC/SOC present at a site would be used as an indicator for this category. Because there are so many different potential threshold values for this large and diverse category, a very conservative threshold of 5 ug/l is used. This is the drinking water standard for benzene, as well as many other toxic solvents. By comparing the total VOC/SOC concentration generated by a spill or discharge with this conservative threshold, even small spills or discharges will be deemed significant. VOCs and some SOCs can evaporate or "volatilize" from the river, others can attach themselves to silt and settle to the bottom of the river. Both have the effect of reducing concentrations in the river over time.

5. Metals: This category is also challenging because numerous metals are included. The total amount of metals present at a site is used as an indicator. Because there are many different potential threshold values for various metals, a conservative threshold of 0.015 mg/l was selected. This is the regulatory standard for lead in drinking water, and is lower than for most metals. Most metals tend to attach themselves to silt and settle to the bottom of the river, reducing concentrations in the river over time.

Conservative Contaminants
Five contaminant categories can be considered to be "conservative". Concentrations of conservative contaminants are only affected by dilution, and do not decrease through other means. The five categories are:

6. *Cryptosporidium/Giardia*: A potential threshold value is difficult to define for this important potential contaminant category for surface water sources. A value of only 1 oocyst per liter has been selected for a screening threshold based on potential health impacts.

7. Nutrients: Nitrate, a second, common nutrient was also selected for analysis because of its prevalence in the watershed. The drinking water standard of 10 mg/l was used for the threshold value.

8. DBP Precursors: Disinfection by-products are a concern for drinking water systems that disinfect with chlorination. A good indicator for this contaminant category is Total Organic Carbon (TOC). The threshold value was set based on the median ambient concentration in the river of approximately 2.7 mg/l.

9. Petroleum Hydrocarbons: Oil and oil-based products are common contaminants. This category contains a large variety of individual contaminants, and Total Petroleum Hydrocarbons (TPH) was chosen as the indicator contaminant. A threshold value of 5 mg/l was selected, based primarily on standards applied at hazardous waste site remediation.

10. Salts: For this category, chloride was selected as the indicator contaminant. The drinking water standard of 250 mg/l was selected as the threshold value.

Zone Based Screening
The first screen applied to eliminate less important potential sources makes use of the zone concept recommended by PADEP for use in the SWAP:

- Zone A: the critical segment covering ¼ mile on either side of the stream upstream of the intake within a 5-hour travel time to the intake. All potential sources within this zone are included in the subsequent steps.

- Zone B: a second segment located within 2 miles of either side of the stream upstream of the intake, within a 25-hour travel time to the intake. All potential sources within this zone are also included in the subsequent steps.

- Zone C: the rest of the upstream watershed. These sources remain listed in the database, but are eliminated from further analysis because they are deemed less significant than sources in zones A and B.

The PADEP zone concept is used to narrow the list of sources down to include only those with higher priority. Potential sources within Zone C sources are dropped from further analysis within this preliminary assessment, leaving those sources within zone A or B for the intake.

Multi-Criteria Evaluation (EVAMIX)

Following the zone based screening, the most important screening and evaluation method used for most of the analysis relied on a multi-criteria evaluation software package called EVAMIX. EVAMIX is a matrix-based, multi-criteria evaluation program that makes use of both quantitative and qualitative criteria within the same evaluation, regardless of the units of measure. The algorithm behind EVAMIX is unique in that it maintains the essential characteristics of quantitative and qualitative criteria, yet is designed to eventually combine the results into a single appraisal score. This critical feature gives the program much greater flexibility than most other matrix based evaluation programs, and allows the evaluation team to make use of all data available to them in its original form.

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

EVAMIX offers several important advantages when used in planning studies:

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

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

The other input variable required for the evaluation procedure is the selection of weighting factors for each of the criteria. While the scoring process strives to be as objective as possible and is carried out by the project team, the selection of weights is inherently subjective and should be done by the decision-makers, planners, or stakeholders. Unlike the matrix of scores, numerous possible weight sets are possible, and all are equally "valid".

A workshop was held in June 2001 at which members of the Technical Advisory Group for the Schuylkill River participated in an exercise designed to develop a representative set of criteria weights. Since the TAG representation for the Schuylkill River consisted of a good cross-section of stakeholders, the same weights were applied for evaluation on the Delaware River. These weights formed the basis for the evaluation.

Time of Travel Calculation Method

One of the criteria used in the screening evaluation, as well as in the final prioritization process using EVAMIX (described below), required an estimate of the time of travel from the point source to the intake. To do this, an estimate of velocity of the river under high flow conditions was needed. This estimate was made for two portions of the river: the Delaware River and all tributaries upstream of Trenton, and the Delaware River downstream of Trenton in the tidal zone.

Upstream of Trenton, the zone delineation was carried out by the USGS, based on extreme high flow conditions. The underlying, average flow velocity behind the Zone B and Zone A delineations is about 5.5 feet per second, which was determined on a gage by gage basis by correlating flows with measured velocities. This value of 5.5 feet per second flow velocity was used for transport of contaminants from sources upstream of Trenton on the Delaware River and all Tributaries.

Below Trenton, the tidal influences make the estimate of time of travel much more complex. Time of travel could only be estimated by using the three dimensional, time variable hydrodynamic and water quality models developed for the Delaware River Basin Commission (HydroQual, 1998). (see section 2.2.1) The hydrodynamic model is a version of the Estuarine, Coast and Ocean Model (ECOM) developed by Blumberg and Mellor (1980, 1987). This model shows that transport of contaminants within the tidal zone is a combination of advective transport (flow with the river water), and diffusion of the contaminant. The advective transport actually reverses direction with each tidal cycle, and net movement downstream is very slow. Diffusion is the primary mechanism that moves the contaminants from the point of entry to the intake. Based on a series of model simulations where contaminants were inserted at different sections of the river, the simulated time of arrival of the contaminants were plotted. In general, the net "velocity" of the contaminant based on the initial time of arrival at the intake divided by the distance from the insertion point and the intake was usually between 7 and 10 feet per second. This occurred whether the contaminant was moving upstream from below the intake, or downstream from above the intake. Most of this movement in the tidal zone was the result of diffusion.

Based on these results, the velocity of contaminants moving along the river in the tidal zone was assumed to be an average of 8 feet per second, and all time of travel calculations used this average velocity for extreme or worst case conditions.

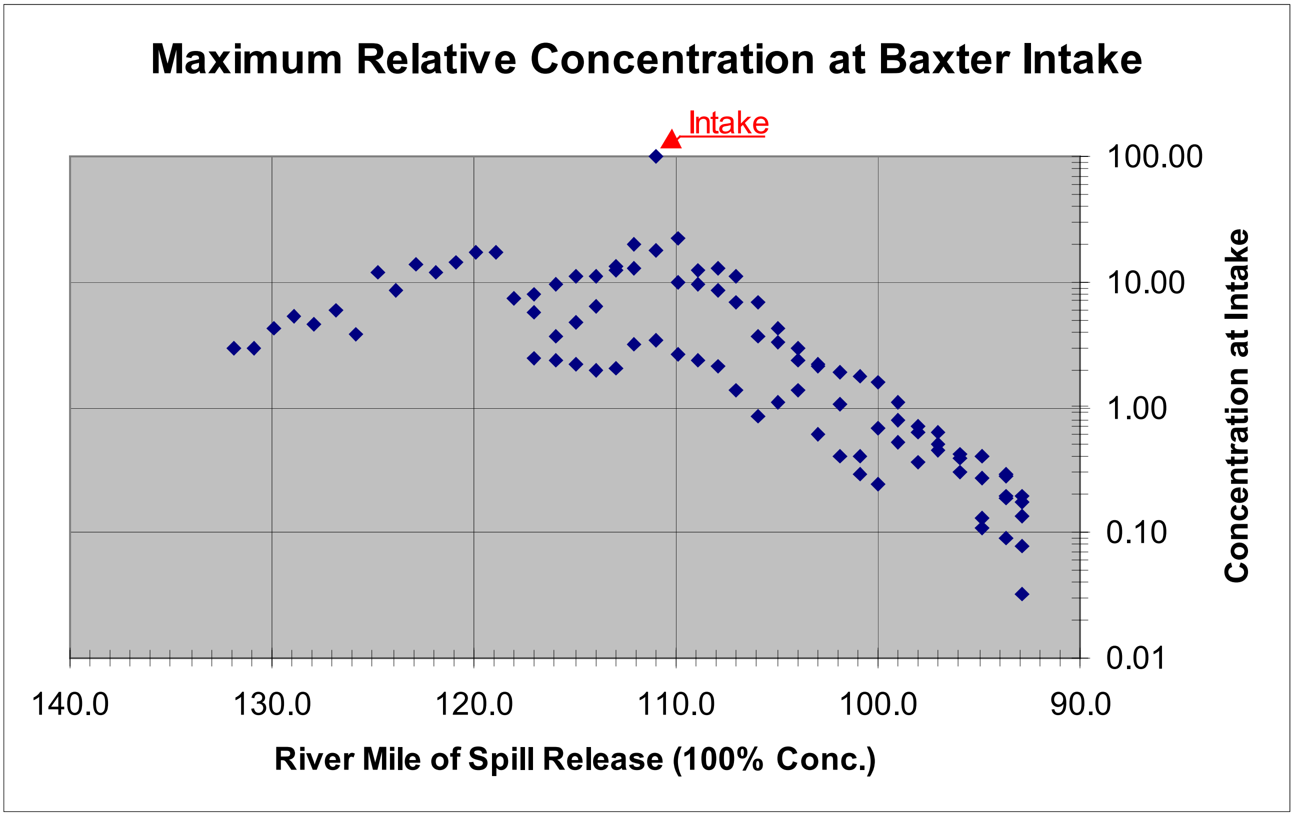
Estimated Concentration at Intake Method
Another of the criteria used in the screening evaluation, as well as in the final prioritization process using EVAMIX (described below), required an estimate of the concentration of the contaminant once it reached the intake. Because the intake is located in the tidal zone, two distinct reductions in concentration will occur. The first is due to the mixing of the contaminant with river water. The second occurs in the tidal zone as the contaminant diffuses due to the back and forth tidal motion. To estimate this, the following approach was used.

The contaminant mass was assumed to enter the river at the nearest point to the potential point source, or at the downstream end of a subwatershed for non-point sources. River dilution was calculated by dividing the mass of contaminant assumed to have entered the river by the median flow at the intake. In this case, this is based on the median flow at the Trenton gage. This provides the first dilution.

Because the intake is in the tidal zone, a second reduction in concentration occurs, this time based on the diffusion occurring in the tidal zone, as well as additional dilution as tidal water moves in and out of the tidal zone. To calculate this, the hydrodynamic model results were analyzed. Figure 2.2.4-2 shows the results of placing a contaminant at "100%" concentration at various points along the river. Figure 2.2.4-2 plots the location of the contamination insertion against the simulated relative concentration at the intake.

Based on the results in the figure, a reasonably conservative estimate of the tidal dilution effect is that the concentration at the intake will be only 10% of the concentration in the river for all spills or discharges occurring upstream of the intake. For spills or discharges occurring downstream of the river, the concentration of the contaminant at the intake will be only about 1% of the concentration in the river.

Figure 2.2.4-2 Maximum Relative Concentration at the Baxter Intake



Point Source Screening
Point source data comes from a number of data sources, and each database can contain hundreds of potential sources. Less significant point sources needed to be screened out, leaving only the most important sources for final ranking. A slightly different screening approach was needed for each type of source because of the data available and the structure of the databases.

The point source screening approaches for each of the main data sources are summarized in this section.

1. PCS Database

This database contained almost 800 individual facilities, over 200 of which are wastewater or sewage disposal facilities. These can be divided into major facilities with discharges of more than 1 million gallons per day (mgd) and minor facilities with discharges of less than 1 mgd. Default flows of 1 mgd for large facilities and 0.1 mgd for small facilities were used along with assumed concentrations based on the site SIC code and existing median concentrations for similar facilities where data were unavailable. The screening approach consisted of calculating potential concentrations of contaminants resulting from each source at the intake, and comparing against threshold values for each contaminant category. The estimated concentration at the intake for each site included in the PCS data was calculated including dilution at the intake but not including decay, volatilization, or die off. If the impact was more than 1 percent of the threshold, it passed the screen, otherwise it was screened out.

2. CERCLA

There were over 650 CERCLA sites representing hazardous waste sites of all kinds. These are known sites that have contamination, but cannot easily be fit into our point source screening because there is no discharge data or concentration data. For this reason, they must be handled separately in a narrative analysis that considers such characteristics as whether or not the site was on the National Priority List, if the site was in Zone A for the intake, if the site was in the flood plain, and if the site was identified within the self-assessment zone of the intake. The process and results are discussed in greater detail in Section 2.2.4.3.

3. RCRA

There are more than 1700 RCRA facilities in the study area with little actual data on quantities stored or used at the sites. To address this problem, default quantities were assigned. Chemicals used at each facility were estimated based on SIC codes. Where such codes were unavailable, the State Guidance categories were used.

The screening approach for RCRA sites contained several steps.

1. RCRA sites with only Underground Storage Tanks (USTs) were screened out because they pose little threat to the surface waters.

2. RCRA sites that are not UST or Aboveground Storage Tanks (ASTs) were screened using the following guidelines:

    - Floodplain: if the site is not in the floodplain, it is screened out, and

    - If there are no reported spills, violations, or releases according to the Right to Know data, it is screened out.

3. Those sites with ASTs required a separate EVAMIX screening. There were over 1500 of such sites with listed ASTs. The procedure for performing the impact screening relied on EVAMIX and the following screening criteria:

Total Tank Volume: in gallons of total tank volume. Larger tank volume meant a higher priority.

Volume Weighted Chemical Ranking: an additive score representing the types of chemicals stored onsite, each weighted by the percent of total tank volume used to store that category of contaminant. In this case, the chemicals are rated according to their impact on the treatment system and the ease with which the current treatment can handle the contaminant in the raw water. This results in a ranking of contaminant categories in order of decreasing importance to the treatment process with points assigned as follows: VOCs/SOCs (10), *Crytosporidium* (9), Metals (8), Petroleum Hydrocarbon (7), Nitrate (6), TSS (5), Chloride (4), TOC/DBP precursors (3), Phosphorus (2), Fecal Coliform (1). Each contaminant category gets a score (10 for VOCs, 9 for *Cryptosporidium* etc. down to 1 for Fecal Coliform.) For each category, the rank number is multiplied by the fraction of total tank volume of that contaminant to the total tank volume onsite. The weighted categories are then added up. For example, a site with VOCs (10,000 gal tank) and salts (90,000 gal) would score 10 x 0.1 + 4 x 0.9 = 4.6.

Leaks Reported: a qualitative score of 1 for a leak, a score of 0 for no leak.

Tank Age: a quantitative score in years after date of installation.

Location: a qualitative score that checks if the site is within floodplain or not (score of 3), in Zone A (score of 2), or in Zone B (score of 1).

Travel Time: a quantitative score in hours based on the time of travel from the site to the intake using peak flows and the estimated velocities above Trenton (5.5 feet per second) and below Trenton (8 feet per second). Note that sources downstream of the intake will also eventually reach the intake as well.

The criteria were weighted, based on the results of the Technical Advisory Group and discussions with the project team. The weights are:

- Tank Age: 12 percent
- Total Tank Volume: 36 percent
- Vol. Weighted Chemical Ranking: 15 percent
- Leak History: 10 percent
- Location: 21 percent
- Travel Time: 5 percent

The screening of RCRA sites resulted in two lists of sites moving through the screen: non-AST sites that reported spills and are within the floodplain, and ASTs that pass the EVAMIX screening.

4. TRI Sites

There are over 500 TRI sites that manufacture or use toxic chemicals. These sites, however, do not discharge contaminants. The database lists the contaminants onsite, including: VOCs, metals, nutrients, and chloride. To focus on the high priority sites, an EVAMIX screening was required, base on the following criteria:

Location: if in flood plain (3 points), zone A (2 points) or zone B (1 point):

Chemicals Listed: a score was given based on the acute effects on health of each contaminant category, resulting in the following scores: VOCs/SOCs (10), *Cryptosporidium* (9), Metals (8), Petroleum Hydrocarbon (7), Nitrate (6), TSS (5), Chloride (4), TOC, /DBP precursors (3), Phosphorus (2), Fecal Coliform (1). For sites with more than one category, the scores were the sum of the rank of chemicals listed (e.g. a site with VOCs and Metals would score 10+8 = 18)

Amount Stored: based on the range listed in the database, in kg per year

Number of releases to water: total number of releases in database

Travel Time: a quantitative score in hours based on the time of travel from the site to the intake using peak flows and the estimated velocities above Trenton (5.5 feet per second) and below Trenton (8 feet per second). Note that sources downstream of the intake will also eventually reach the intake as well.

Criteria weights were applied within the EVAMIX screening as follows:

- Location: 15 percent
- Chemicals Listed: 20 percent
- Amount Stored: 35 percent
- Number of releases to water: 25 percent
- Travel Time: 5 percent

Non-point Source Runoff Screening
Potential non-point sources were identified using the SWMM model and Event Mean Concentrations (EMCs) to calculate total annual pollutant loading for each subwatershed.

Because there are over 500 subwatersheds, EVAMIX screening was applied using three criteria. These were:

1. Relative Impact at Intake (weight 60 percent):

This criterion is based on the concentration of a contaminant caused by the potential source at the intake as a percent of the contaminant category threshold value. Since there are potentially 10 values, one for each contaminant category, only the highest ranked category or greatest relative impact chemical category was used for this criterion.

2. Time of Travel (weight 20 percent):

This is a quantitative score in hours based on the time of travel from the site to the intake using peak flows and the estimated velocities above Trenton (5.5 feet per second) and below Trenton (8 feet per second). Note that sources downstream of the intake will also eventually reach the intake as well.

3. Location (weight 20 percent)

This criterion scored watersheds as 2 if in Zone A, and 1 if in Zone B.

The highest ranked subwatersheds passed through to the full ranking of sources.

Source Priorities: Full EVAMIX Ranking of All Sites
Finally, all the significant (those that passed the screening) point sources and runoff loads (entered as pseudo point sources) were prioritized, accomplishing the main goal of the assessment. There were two types of final rankings. The first ranking was a combined ranking of sites from all categories, compared against each other. The second ranking was by contaminant type, with all significant sources contributing to a particular contaminant category included.

Multi-criteria Ranking using EVAMIX: Combined Sources
EVAMIX was used to rank all sources over the entire range of contaminant categories. Full ranking allowed us to compile a final list of sources, independent of contaminant class. The following criteria were used:

Relative Impact at Intake (weight 12 percent):

This criterion is based on the concentration of contamination potentially caused by the source at the intake as a percent of the contaminant category threshold value. Since there are potentially 10 values, one for each contaminant category, only the highest ranked category or greatest relative impact chemical category was used for this criterion.

Time of Travel (weight 5 percent):

This is a quantitative score in hours based on the time of travel from the site to the intake using peak flows and the estimated velocities above Trenton (5.5 feet per second) and below Trenton (8 feet per second). Note that sources downstream of the intake will also eventually reach the intake as well.

Potential for Release/Controls (weight 14 percent):

This was developed using the qualitative categories taken from the State SWAP guidelines.

High: no control practices, or a regulated discharge not in compliance with regulations (4 points)

Medium/High: a non-point source with no BMP in place, or regulated discharge and in compliance with regulations (3 points)

Medium: a non-point source with BMP in place, or a point source not regulated but contained in some way (retaining wall, double walled tank etc.) with no emergency response plan (2 points)

Low: a regulated point source by the State, containment, and/or emergency response plan (1 point)

Potential Release Frequency (weight 14 percent):

A qualitative criterion based on the following scores:

Very High: a continuous discharger, 5 points

High: an intermittent or rainfall related (CSO, SSO, NPS) discharger, 4 points

Medium: a discharge with roughly a monthly frequency, 3 points

Low: a discharge with roughly an annual frequency, 2 points

Very Low: a discharge that occurs only as a catastrophic spill, or a storm related discharge with about a 100-year occurrence frequency, 1 point

Violation Type/Frequency (weight 10 percent):

A qualitative criterion based on the following scoring:

High: Operation or Effluent Violations, 3 points

Medium: Management Violations, 2 points

Low: Administrative Violations or none, 1 point

In this case, points are cumulative for each violation within the last 3 years in each category. For example two violations for not filing paperwork (2x1) plus an effluent violation (3 points) would result in a score of 5 points.

Location (weight 5 percent):

A qualitative criterion based on GIS analysis according to the following categories:

In the Floodplain: 3 points

In Zone A: 2 points

In Zone B: 1 point

Existing Removal Capacity (weight 10 percent):

A criterion with qualitative scoring based on the chemical released and the ability of the existing treatment to remove it. Scoring was according to the following system:

Not removed (salts, radionuclides, nitrates): 3 points

Limited removal (Cryptosporidium, SOCs, VOCs, Petroleum Hydrocarbons, Phosphorus, TOC): 2 points

High removal (fecal coliform, TSS, metals): 1 point.

Scores were cumulative for each category present at the site.

Impact on Treatment Operation (weight 10 percent):

A criterion with qualitative scoring based on the contaminant released and its impact on the operation of the treatment systems in place. Scoring was according to the following system.

High (TSS, VOCs, Petroleum Hydrocarbon): 4 points

Medium/High (metals, TOC): 3 points

Medium (*Cryptosporidium*, nitrate, phosphorus): 2 points

Low (fecal coliform, chloride, radionuclides): 1 point

The score is cumulative over all categories present.

Potential Health Impacts (weight 20 percent):

A criterion with qualitative scoring based on the contaminant released and its potential acute impact on health if not removed. Scoring was according to the following system:

High (*Cryptosporidium*, SOCs, VOCs, radionuclides, fecal coliform): 3 points

Medium (TOC, metals, nutrients, nitrate): 2 points

Low (salts, TSS, phosphorus): 1 point

The score is cumulative over all categories present.

This ranking resulted in a single list of sources for the intake showing high, medium, and low priority sources from all categories.

EVAMIX Ranking by Contaminant Category
Ranking by contaminant category was completed using six criteria and the multi-criteria evaluation program EVAMIX. Criteria (with weights from the June 2001 Task Force Meeting) are given below.

Relative Impact at Intake (weight 40 percent):

This criterion is based on the concentration of contamination potentially caused by the source at the intake as a percent of the contaminant category threshold value.

Time of Travel (weight 5 percent):

This is a criterion calculated as the time of travel from source to intake, based on high flow velocity and the tidal zone velocities.

Potential for Release/Controls (weight 20 percent):

This was developed using the qualitative categories taken from the State SWAP guidelines.

High: no control practices, or a regulated discharge not in compliance with regulations (4 points)

Medium/High: a non-point source with no BMP in place, or regulated discharge and in compliance with regulations (3 points)

Medium: a non-point source with BMP in place, or a point source not regulated but contained in some way (retaining wall, double walled tank etc.) with no emergency response plan (2 points)

Low: a regulated point source by the State, containment, and/or emergency response plan (1 point)

Potential Release Frequency (weight 15 percent):

A qualitative criterion based on following scores:

Very High: a continuous discharger, 5 points

High: an intermittent or rainfall related (CSO, SSO, NPS) discharger, 4 points

Medium: a discharge with roughly a monthly frequency, 3 points

Low: a discharge with roughly an annual frequency: 2 points

Very Low: a discharge that occurs only as a catastrophic spill, or a storm related discharge with about a 100-year occurrence frequency, 1 point

Violation Type/Frequency (weight 15 percent):

A qualitative criterion based on the following scoring:

High: Operation or Effluent Violations, 3 points

Medium: Management Violations, 2 points

Low: Administrative Violations or none, 1 point

In this case, points are cumulative for each violation within the last 3 years in each category. For example two violations for not filing paperwork (2x1) plus an effluent violation (3 points) would result in a score of 5 points.

Location (weight 5 percent):

A qualitative criterion based on GIS analysis according to the following categories:

In the Floodplain: 3 points

In Zone A: 2 points

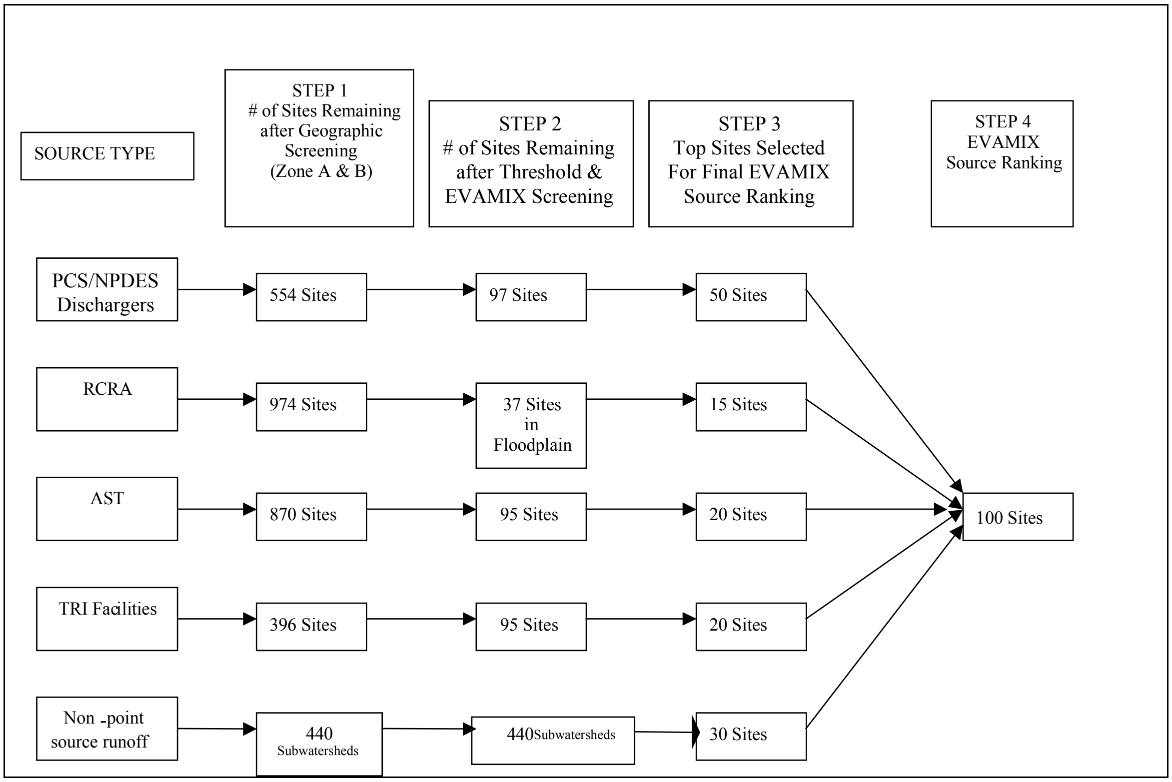
In Zone B: 1 point

Results from each of the ten contaminant categories based evaluations resulted in a listing of high, medium, and low priority sites for that contaminant category.

2.2.4.2 Results

Figure 2.2.4-2 is a flow diagram of the screening and ranking process that was used to successively select the most important sites from each of the databases available, and combine them in an organized manner to produce a final list of high priority sites. The process can be compared to a playoff elimination process, with various divisions providing a set number of teams to the overall playoff. Like such playoff structures, it can occur that a site will not be included in the final list because it was eliminated in competition with other sites within its categories. (To follow the analogy, the 4th best team in a division is not invited to the playoffs, even if it is better than the 3rd best team from another, weaker division, because only the top three teams are invited from each division.) Despite this fact, the process does provide the top sites from each database category, and provides valuable insight into the relative importance of each category of sites. Enough sites were included from each category to make sure that no highly ranked sites would be overlooked.

Figure 2.2.4-3 Screening and Ranking Process



The diagram shows that there were several screening steps (or elimination rounds) leading to the final ranking. These are described briefly below.

Zone Based Screening

The inventory of potential sources of contamination started with all of the sites included in the PCS, RCRA, AST, and TRI databases. After all had been located and coordinates assigned, those in Zone C were eliminated from consideration. This left 554 sites from the PCS database (essentially those with a surface water discharge permit), 870 sites listed with above ground storage tanks (ASTs), and 396 facilities from the TRI database (sites that generate or handle toxic chemicals). In addition, all of the subwatersheds that are within the travel times of the Baxter Intake's Zones A or B were also included (440 subwatersheds). RCRA sites that had underground storage tanks were eliminated. It was decided that only RCRA sites located within the flood plain were of concern in this round of analysis, and the 37 sites that met this condition were included in the analysis.

Database Based Screening

The zone based screening still left over 3200 sites that needed to be screened further to a manageable number. This was done either by simple threshold screening, based on the amount of contaminants stored or used, or by a more complex evaluation using several criteria.

Threshold Based Screening
For one of the categories, (PCS) simple threshold screening was an effective approach for screening.

PCS Sites: As described in section 2.2.4.1, the percent change in the concentration of a chemical at the intake due to releases from each site could be roughly estimated, and this was used to screen the 554 PCS (NPDES) sites. This threshold screening was performed to select the largest dischargers. A cutoff of a 1 percent change in concentration at the intake was established, based on the percent increase by the discharged mass loading. Of the 554 sites, only 97 discharges could potentially affect concentrations by more than 1 percent. Most of the others were much too small to have a measurable impact and were eliminated from further analysis. The top 50 were used in the final ranking.

Criteria Based Screening
For the AST sites, TRI sites, and the subwatersheds (stormwater pollutant loading), a more sophisticated approach was required to adequately select the most important sites from each category. Several criteria were used with the multi-criteria evaluation program EVAMIX to perform each of these screening analyses. EVAMIX output was used to complete the screening by ranking the sites in descending order of importance and then selecting the top sites based on the results of the ranking.

AST Sites: EVAMIX screening resulted in a ranking of all the sites based on six criteria. The criteria were age of the tank, storage volume of the tank, chemical ranking based on the mix of chemicals onsite, whether there had been leaks in the past, the location relative to the river, and the travel time to the intake (see section 2.2.4.1 for details). From the 870 sites, the 95 highest ranked sites passed the screen into the final ranking. Of these, the top ranked 20 sites were used in the final screening evaluation. The results of the final ranking (Table 2.2.4-1) confirmed that most AST sites had very low rankings, with only 2 sites making it into the top 100 sites.

TRI Sites: EVAMIX screening resulted in a ranking of all the TRI sites based on five criteria. The criteria were amount of chemical stored, chemical ranking based on the mix of chemicals onsite, whether or not releases to water have been reported, the location relative to the river, and the travel time to the intake (see section 2.2.4.1 for details). From the 396 sites, the 95 highest ranked sites passed the screen into the final ranking. Of these, the top 20 sites were used in the final ranking analysis.

NPS Subwatersheds: There were 440 subwatersheds that could be considered to be in the Baxter Intake's zone A or B. A screening of these subwatersheds for their potential impact due to stormwater pollutant loading was performed using EVAMIX and three criteria. The first criterion was the relative impact, measured as the expected concentration from the pollutant runoff at the intake, divided by the threshold number for that contaminant category. Because there were 9 contaminant categories relevant to stormwater runoff, the highest relative impact was used. The other two criteria were location and time of travel to the intake. The subwatersheds or NPS sources were relatively important, and the 30 highest ranked subwatersheds were included in the final ranking.

Source Priorities: Full EVAMIX Ranking of All Potential Sources

All of the significant point sources and runoff loads (entered as pseudo-point sources) that passed the screening process were lumped together for a final ranking, once again using EVAMIX. There were 135 mixed sites evaluated, eventually producing a list of the top 100 sites for the intake. This important, final ranking of the mixed group of sites used the nine criteria described above in section 2.2.4.1. The criteria weights were those established during the Technical Advisory Group workshop.

1. Relative Impact at Intake (weight 12 percent)

2. Time of Travel (weight 5 percent):

3. Potential for Release/Controls (weight 14 percent):

4. Potential Release Frequency (weight 14 percent):

5. Violation Type/Frequency (weight 10 percent):

6. Location (weight 5 percent):

7. Existing Removal Capacity (weight 10 percent):

8. Impact on Treatment Operation (weight 10 percent):

9. Potential Health Impacts (weight 20 percent):

Table 2.2.4-1 lists the 96 point sources and non-point sources that passed the screening. The table is organized into roughly three groups of sites in descending order of priority as calculated by EVAMIX. The table has eight columns.

Column 1: Source ID code: a unique database source code

Column 2: Source Name, the name as listed in the database

Column 3: Primary database containing information about the source used in the analysis

Column 4: Point Source subwatershed (NPS)

Column 5: Zone (either A or B)

Column 6: Estimated time of travel to the intake under high flow conditions

Column 7: Relative impact at the intake

Column 8: High, Medium, or Low Ranking based on EVAMIX numerical ranking output, nine criteria and selected criteria weights

Table 2.2.4-1 Final Ranking of Sources for Combined Contaminant Categories

Source ID	Source Name	Database Used	Subwatershed	Zone	Time of Travel	Relative Impact (%)	Priority
1515	GEORGIA PACIFIC CORPORATION	NPDES	Delaware River - 931	Floodplain	1.1	1.7500	Highest-A
1350	CINNAMINSON STP	NPDES	Delaware River - 930	Floodplain	0.0	94.3671	Highest-A
1513	SYBRON CHEMICALS INC	NPDES	RANCOCAS CR, N BR - 689	Zone B	4.0	0.0270	Highest-A
1390	CIRCUIT FOIL USA INC	NPDES	CROSSWICKS CR - 629	Zone B	4.0	0.0822	Highest-A
1325	ASBURY PARK WTP	NPDES	NESHAMINY R - 601	Zone B	4.6	9.7827	Highest-A
1550	MAPLE SHADE TOWNSHIP STP	NPDES	PENNSAUKEN CR - 706	Zone B	2.9	3.2347	Highest-A
1124	NORTHEAST MONMOUTH COUNTY RSA	NPDES	Pidcock Creek - 574	Zone B	8.8	25.4051	Highest-A
1395	UNITED STATES STEEL GROUP-USX	NPDES	Delaware River - 649	Zone A	2.9	0.8249	Highest-A
1444	COLORITE POLYMERS COMPANY	NPDES	Delaware River - 663	Floodplain	1.5	0.0822	Highest-A
1332	DELRAN SEWERAGE AUTHORITY	NPDES	Delaware River - 930	Floodplain	0.2	0.0822	Highest-A
1483	MT EPHRAIM BOROUGH OF	NPDES	BIG TIMBER CR - 769	Floodplain	3.3	0.0082	Highest-A
1563	CAMDEN COUNTY M.U.A.	NPDES	Newton Creek - 753	Floodplain	2.4	0.0082	Highest-A
1375	PSE&G MERCER GENERATING STA	NPDES	Delaware River - 927	Floodplain	3.7	0.0822	Highest-A
1463	MT LAUREL TWP MUA	NPDES	RANCOCAS CR - 695	Zone A	1.5	0.0822	Highest-A
1330	RIVERSIDE STP	NPDES	RANCOCAS CR - 680	Floodplain	0.2	0.0822	Highest-A
1079	HOFFMAN-LA ROCHE INC	NPDES	PEQUEST R - 405	Zone B	21.9	0.0822	Highest-A
1443	BURLINGTON CITY STP	NPDES	Delaware River - 663	Zone A	1.5	0.0822	Highest-A
1549	CHERRY HILL TOWNSHIP	NPDES	South Branch Pennsauken Creek - 724	Floodplain	2.4	0.0082	Highest-A
1214	CROWN PAPER CO	NPDES	Delaware River - 919	Floodplain	13.1	0.0822	Highest-A
1447	BEVERLY SEWERAGE AUTHORITY	NPDES	Delaware River - 929	Zone A	0.7	0.0822	Highest-A
1391	UPPER MORELAND-HATBORO JNT SEW	NPDES	Robinhood Brook - 628	Zone A	2.8	0.0082	Highest-A
1581	CHERRY HILL TOWNSHIP	NPDES	North Branch Cooper River - 756	Zone A	3.8	0.0082	Highest-A
1435	PSE&G BURLINGTON GENERATING ST	NPDES	Delaware River - 661	Floodplain	1.3	0.0822	Highest-A
1561	CHERRY HILL TOWNSHIP	NPDES	South Branch Pennsauken Creek - 724	Zone A	2.9	0.0082	Highest-A
1467	MOUNT HOLLY SEWERAGE AUTHORITY	NPDES	RANCOCAS CR, N BR - 698	Floodplain	2.6	0.0822	Highest-A
1401	BLACK'S CREEK WWTP	NPDES	Unknown - 651	Zone A	3.5	0.0822	Highest-A
1528	PEMBERTON	NPDES	RANCOCAS CR, N BR - 725	Floodplain	4.6	0.0822	Highest-A
1434	BRISTOL TWP WP CONTROL PLANT	NPDES	Delaware River - 661	Zone A	1.1	0.0480	Highest-A
1568	COOPER RIVER STP	NPDES	COOPER R - 738	Floodplain	2.9	0.0082	Highest-A
1127	OXFORD TEXTILE INC	NPDES	Unknown - 412	Zone B	24.0	0.0522	Highest-A
1595	CHERRY HILL TOWNSHIP	NPDES	North Branch Cooper River - 756	Zone A	4.2	0.0082	Highest-A
1341	WILLINGBORO WATER PCP	NPDES	RANCOCAS CR - 680	Zone A	0.7	0.0822	Moderately High-B
1413	FLORENCE TOWNSHIP STP	NPDES	Delaware River - 927	Zone A	2.0	0.0822	Moderately High-B
1580	WEST COLLINGSWOOD HEIGHTS STP	NPDES	Newton Creek - 753	Zone A	3.1	0.0082	Moderately High-B
2850	Rockledge Branch-645	NP	Rockledge Branch - 645	Zone A	0.4	0.2094	Moderately High-B
2866	Delaware River-666	NP	Delaware River - 666	Zone A	0.4	0.1861	Moderately High-B

Source ID	Source Name	Database Used	Subwatershed	Zone	Time of Travel	Relative Impact (%)	Priority
1498	RUNNEMEDE SEWERAGE AUTHORITY	NPDES	BIG TIMBER CR - 769	Zone B	3.5	0.0082	Moderately High-B
2849	Byberry Creek-641	NP	Byberry Creek - 641	Zone A	0.6	0.6254	Moderately High-B
2857	Walton Run-656	NP	Walton Run - 656	Zone A	0.6	0.3530	Moderately High-B
1569	COLES MILLS STP	NPDES	COOPER R - 738	Zone A	3.1	0.0082	Moderately High-B
2858	NESHAMINY R-657	NP	NESHAMINY R - 657	Zone A	1.1	0.2702	Moderately High-B
2854	Delaware River-649	NP	Delaware River - 649	Zone A	1.3	1.0168	Moderately High-B
1594	AUDUBON BOROUGH STP	NPDES	Newton Creek - 753	Zone A	3.3	0.0082	Moderately High-B
1571	COLLINGSWOOD BOROUGH OF	NPDES	Newton Creek - 753	Zone B	3.3	0.0082	Moderately High-B
2847	NESHAMINY R-637	NP	NESHAMINY R - 637	Zone A	1.6	0.5232	Moderately High-B
2853	Mill Creek-648	NP	Mill Creek - 648	Zone A	1.6	0.3055	Moderately High-B
2852	Unknown-647	NP	Unknown - 647	Zone A	1.6	0.2329	Moderately High-B
1488	WOODCREST STP	NPDES	COOPER R - 760	Zone A	4.0	0.0082	Moderately High-B
1418	GRIFFIN PIPE PRODUCTS CO	NPDES	Delaware River - 927	Zone B	2.0	0.0822	Moderately High-B
1502	SOMERDALE BORO STP	NPDES	COOPER R - 760	Zone A	4.0	0.0082	Moderately High-B
2833	Martins Creek-616	NP	Martins Creek - 616	Zone A	2.4	0.2217	Moderately High-B
2839	Mill Creek-626	NP	Mill Creek - 626	Zone A	2.6	0.3242	Moderately High-B
2840	Queen Anne Creek-627	NP	Queen Anne Creek - 627	Zone A	2.6	0.2825	Moderately High-B
1295	EWING-LAWRENCE SA	NPDES	Pond Run - 612	Zone B	5.4	0.0822	Moderately High-B
1371	HAMILTON TOWNSHIP WPCF	NPDES	CROSSWICKS CR - 629	Zone B	4.0	0.0822	Moderately High-B
1323	WARMINSTER TWP. MUN. AUTH.	NPDES	Little Neshaminy Creek - 610	Zone B	4.8	0.2875	Moderately High-B
2911	RANCOCAS CR-743	NP	RANCOCAS CR - 743	Zone A	3.1	0.3537	Moderately High-B
2836	Mill Creek-619	NP	Mill Creek - 619	Zone A	3.3	0.2389	Moderately High-B
1255	CHALFONT-NEW BRITAIN TWP JOINT	NPDES	NESHAMINY R - 580	Zone B	7.9	0.0822	Moderately High-B
1116	MONMOUTH CO BAYSHORE OUTFALL	NPDES	Delaware River - 559	Zone B	9.1	0.0822	Moderately High-B
2819	NESHAMINY R-601	NP	NESHAMINY R - 601	Zone B	4.0	0.7623	Moderately High-B
2825	Little Neshaminy Creek-610	NP	Little Neshaminy Creek - 610	Zone B	4.2	0.7108	Moderately High-B
2916	RANCOCAS CR-752	NP	RANCOCAS CR - 752	Zone B	4.4	0.4870	Moderately High-B
2808	NESHAMINY R-583	NP	NESHAMINY R - 583	Zone B	5.1	1.6627	Moderately High-B
2834	Little Neshaminy Creek-617	NP	Little Neshaminy Creek - 617	Zone B	5.1	0.9317	Moderately High-B
2896	RANCOCAS CR, N BR-716	NP	RANCOCAS CR, N BR - 716	Zone B	5.1	0.4041	Moderate-C
2823	Little Neshaminy Creek-606	NP	Little Neshaminy Creek - 606	Zone B	5.5	0.8733	Moderate-C
2803	Mill Creek-576	NP	Mill Creek - 576	Zone B	5.5	0.7337	Moderate-C
2801	Mill Creek-573	NP	Mill Creek - 573	Zone B	6.4	0.6328	Moderate-C
4462	ROHM & HAAS CROYDON	AST	Delaware River - 666	Floodplain	0.6	39777.3404	Moderate-C
2806	NESHAMINY R-580	NP	NESHAMINY R - 580	Zone B	7.7	0.4776	Moderate-C
1210	GPU GENERATION INC	NPDES	Delaware River - 918	Zone B	14.4	0.0822	Moderate-C
1157	MALLINCKRODT BAKER INC	NPDES	Delaware River - 914	Floodplain	17.9	0.0822	Moderate-C
1197	BETHLEHEM CITY	NPDES	LEHIGH R - 485	Floodplain	21.4	0.2865	Moderate-C
1198	BETHLEHEM STEEL – BETHLEHEM	NPDES	LEHIGH R - 485	Zone B	21.4	1.1285	Moderate-C

Source ID	Source Name	Database Used	Subwatershed	Zone	Time of Travel	Relative Impact (%)	Priority
2767	Gallows Run-523	NP	Gallows Run - 523	Zone B	14.7	0.7392	Moderate-C
2723	MUSCONETCONG R-459	NP	MUSCONETCONG R - 459	Zone B	15.5	1.5915	Moderate-C
948	ALUMINUM SHAPES INC.	TRI	Delaware River - 931	Zone B	1.1	1.1812	Moderate-C
5091	WILLOW GROVE AIR FORCE RESERVE STA	AST	Little Neshaminy Creek - 617	Zone B	5.1	55688.2765	Moderate-C
2685	POHATCONG R-394	NP	POHATCONG R - 394	Zone B	17.9	2.3733	Moderate-C
2719	Shoeneck Creek-453	NP	Shoeneck Creek - 453	Zone B	19.2	1.1215	Moderate-C
2713	Unknown-444	NP	Unknown - 444	Zone B	19.5	1.7868	Moderate-C
2697	Unknown-415	NP	Unknown - 415	Zone B	19.8	1.2608	Moderate-C
703	ROHM & HAAS DVI PHILADELPHIA PLANT	TRI	Mill Run - 675	Zone A	1.3	15.4160	Moderate-C
931	OCCIDENTAL CHEMICAL CORP.	TRI	ASSISCUNK CR - 662	Zone A	2.2	800.4507	Moderate-C
594	SPS TECHS. INC.	TRI	Rockledge Branch - 645	Zone A	2.8	0.9065	Moderate-C
700	PRE FINISH METALS INC.	TRI	Delaware River - 649	Zone B	3.9	29.6055	Moderate-C
519	COASTAL EAGLE POINT OIL CO.	TRI	BIG TIMBER CR - 769	Zone B	3.3	1291.8568	Moderate-C
957	U.S. PIPE & FNDY. CO.	TRI	ASSISCUNK CR - 662	Zone A	1.6	7.8302	Moderate-C
5726	G R O W S INC LANDFILL	RCRA	Delaware River - 649	Floodplain	2.8	0.1591	Moderate-C
543	OCCIDENTAL CHEMICAL CORP. BURLINGTON N. PLANT	TRI	Delaware River - 927	Zone A	2.0	246.4136	Moderate-C
5452	YATES FOIL USA INC	RCRA	Delaware River - 927	Floodplain	3.1	0.2829	Moderate-C
5951	AMSPEC CHEMICAL CORP	RCRA	Delaware River - 932	Floodplain	2.9	0.0016	Moderate-C
841	ASHLAND CHEMICAL INC.	TRI	LEHIGH R - 474	Floodplain	18.7	173.7606	Moderate-C
6482	COASTAL EAGLE POINT OIL CO	RCRA	BIG TIMBER CR - 769	Floodplain	3.3	0.4420	Moderate-C
5940	RHODIA INC	RCRA	Delaware River - 649	Floodplain	3.9	0.0078	Moderate-C
5839	MSC PRE FINISH METALS INC	RCRA	Delaware River - 649	Floodplain	3.9	0.0014	Moderate-C
926	AMSPEC CHEMICAL CORP.	TRI	Newton Creek - 753	Zone B	3.1	24.4227	Moderate-C
574	COURTAULDS AEROSPACE INC. & CHEMICAL CORP.	TRI	Delaware River - 932	Floodplain	2.8	7.8344	Moderate-C
904	ROCHE VITAMINS & FINE CHEMICALS	TRI	PEQUEST R - 405	Zone B	21.9	576.4406	Moderate-C

The final results of the rankings are broken down into six major categories according to PADEP's SWA Plan. These are represented by designations A through F, with A representing sources of highest protection priority and gradually decreasing to F for sources of lowest protection priority. This designation process was initially designed for intakes with a limited number of sources where the whole inventory could be ranked. However, given the large number of sources and the ranking process, sources that are represented by designations D through F were screened out in the significance screening process. Therefore, the sources ranked in the document are considered potentially significant sources of contamination and fall into categories A through C. They are described in Table 2.2.4-2.

Table 2.2.4-2 Contaminant Source Ranking Designations

Designation	Description
Potentially Significant Sources of Contamination to Water Supply	
A	Potentially Significant Source of Highest Protection Priority
B	Potentially Significant Source of Moderately High Protection Priority
C	Potentially Significant Source of Moderate Protection Priority
Remaining Sources From Inventory Screened Out By Significance Screening Criteria	
D	Potential Source of Moderately Low Protection Priority
E	Potential Source of Low Protection Priority
F	Potential Source of Lowest Protection Priority

As shown, the sources in categories A through C may require additional "ground-truthing" in order to provide a more accurate designation of their significance. Although not considered to be potentially significant, sources in category D may need to be evaluated, as more information becomes available.

The results provide significant insight into the relative threat that various types of sources might have on the water quality at the intake. The key results are:

- All of the highest ranked sites are either NPDES sites from the PCS database or stormwater pollutant loading represented by various subwatersheds. The top 22 ranked sources are NPDES, as well as 28 of the top 30 sites included as priorities in this combined rankings.

- Stormwater or NPS loading appears to also represent a high priority. There are 2 subwatersheds with stormwater related loading in the top priority sites.

- TRI sites are generally ranked lower. There are no TRI sites as high priority sites, and all TRI sites are found in the "moderate" priority category.

- RCRA sites, with or without ASTs, are generally ranked the lowest of all of the types of sites. Only 9 of these sites made it into the top priority sites.

- Results indicate that with a balanced assessment, those contaminant sources that are actually discharging to the river (NPDES permitted point sources or stormwater runoff) represent the greatest concern. Those with only the potential to release contaminants through spills or leaks (TRI, RCRA, AST) are generally given a lower priority.

- Despite the low overall rankings, the highest potential relative impacts appear to occur with the TRI and AST sites. The relative impact numbers show that, were a catastrophic spill or leak to occur at these highly ranked sites, concentrations at the intake could potentially be very high.

- Health Impacts, as scored in the assessment, had a large influence on the resulting rankings, with those sites ranked high on potential health impacts ranking as important sites.

- Treatment Impacts were also important in the final rankings, with those sites scoring high on potential impact to the treatment process also ending up highly ranked in the overall assessment.

- The geographic distribution of significant sources showed that most of the category A sources were from point sources in drainage areas of the Delaware River below Trenton and stormwater runoff sources in the upper Delaware River Watershed.

- A comparison of the types of sources indicated by the ranking process with the sources, indicated by water quality analysis and impaired stream information, (see section 2.1.5) corroborates that NPDES discharges and polluted runoff (non-point sources) from developed areas are the most important influences on water quality at the PWD Baxter Intake.

The rankings provided in Table 2.2.4-1 are based on a careful evaluation of existing data in the databases described in section 2.2.2. They are only as accurate as the data provided, and serve as a good starting point for data collection and field "ground-truthing" of these sites.

Figure 2.2.4-4 is a map of the site locations for point sources and subwatersheds in the Lower Delaware Watershed that scored highest in the ranking process. Figure 2.2.4-5 denotes the Middle Delaware Watershed and figure 2.2.4-6 shows the point sources and subwatersheds in the upper part of the watershed that scored the highest in the ranking process. The numbers indicated on the map correspond to identification numbers of the various sources in the tables.

Figure 2.2.4-4 Priority Point Sources and Subwatersheds for PWD's Baxter Intake in the Lower Delaware Watershed

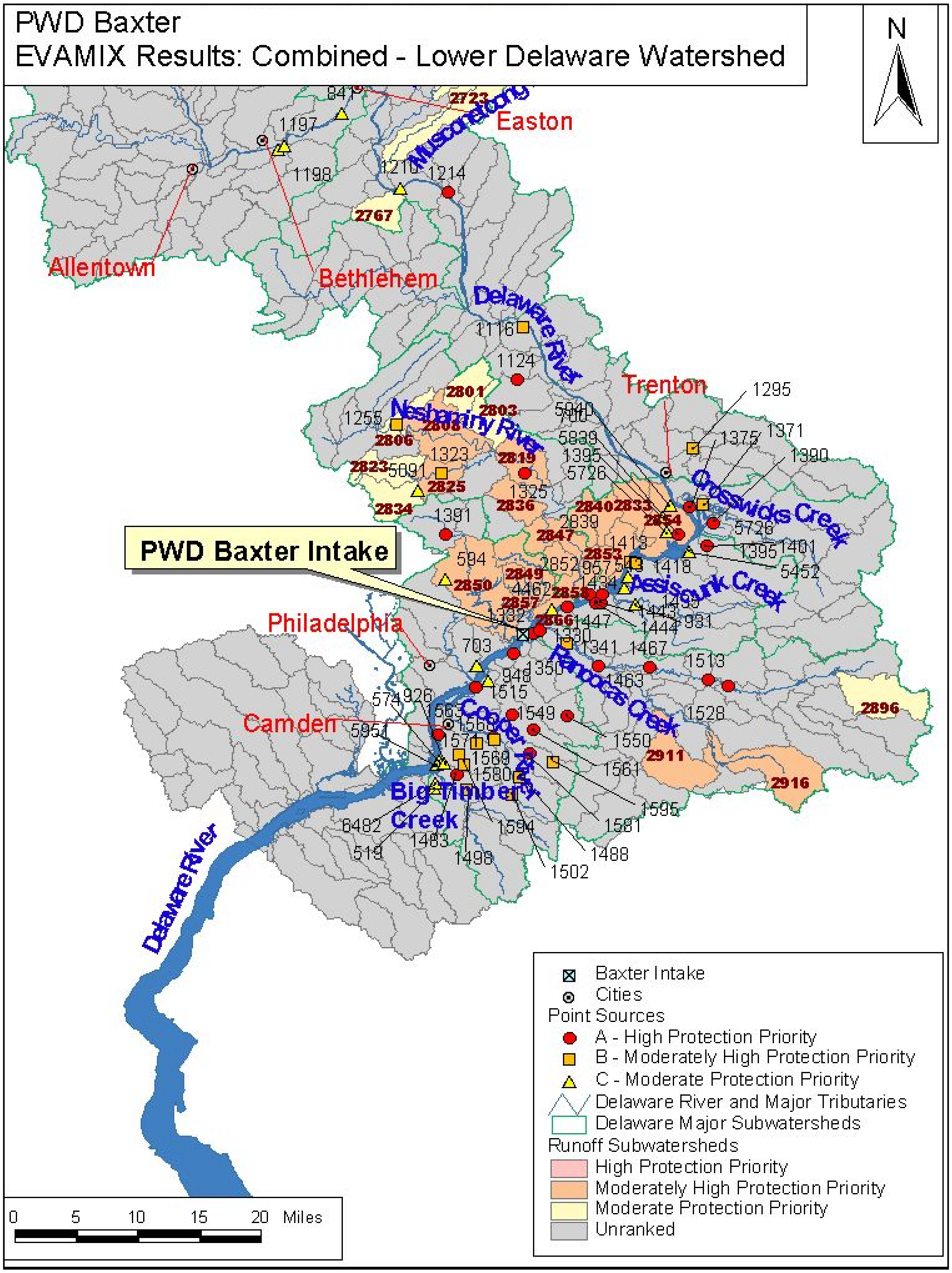


Figure 2.2.4-5 Priority Point Sources and Subwatersheds for PWD's Baxter Intake in the Middle Delaware Watershed

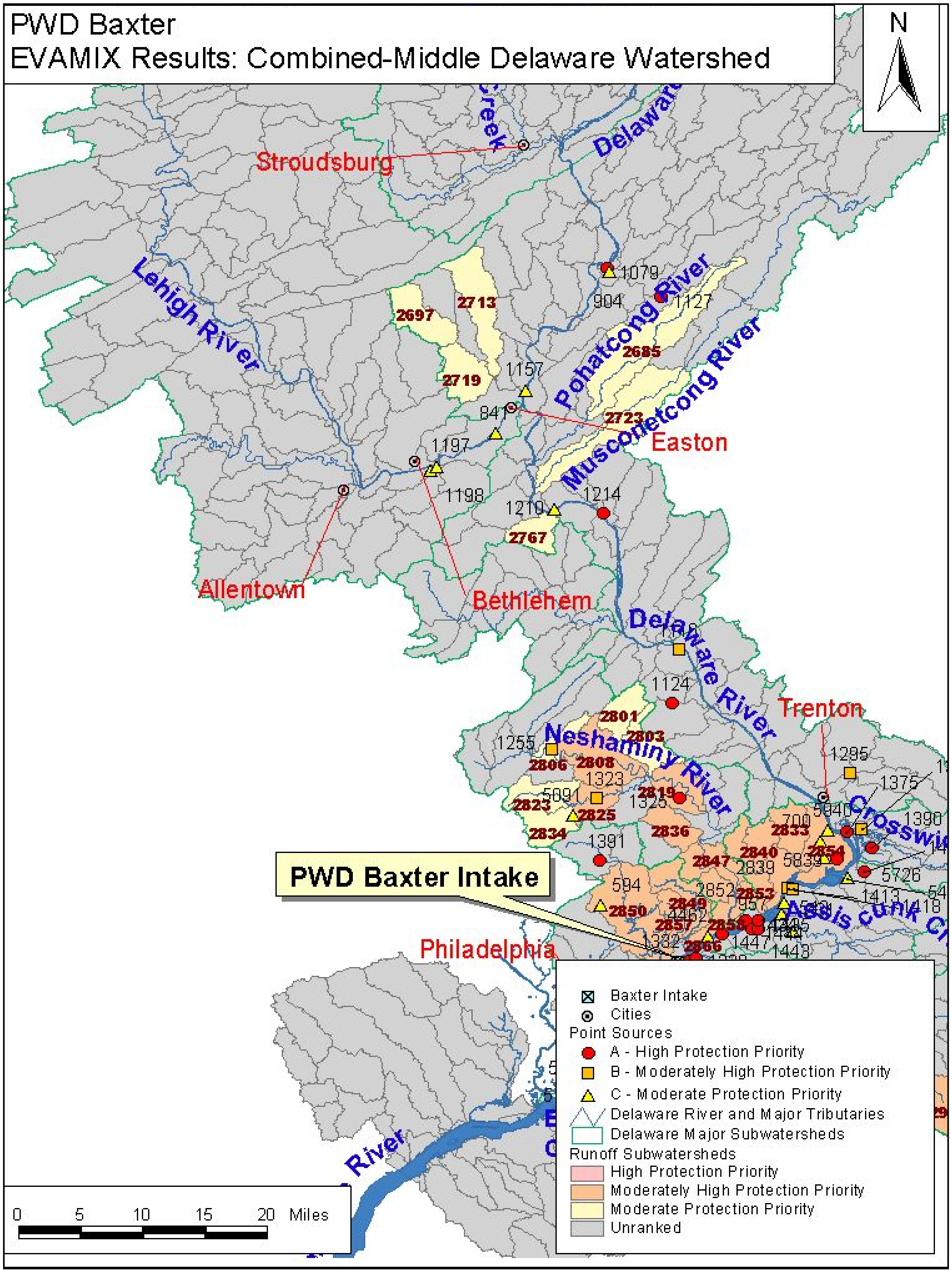
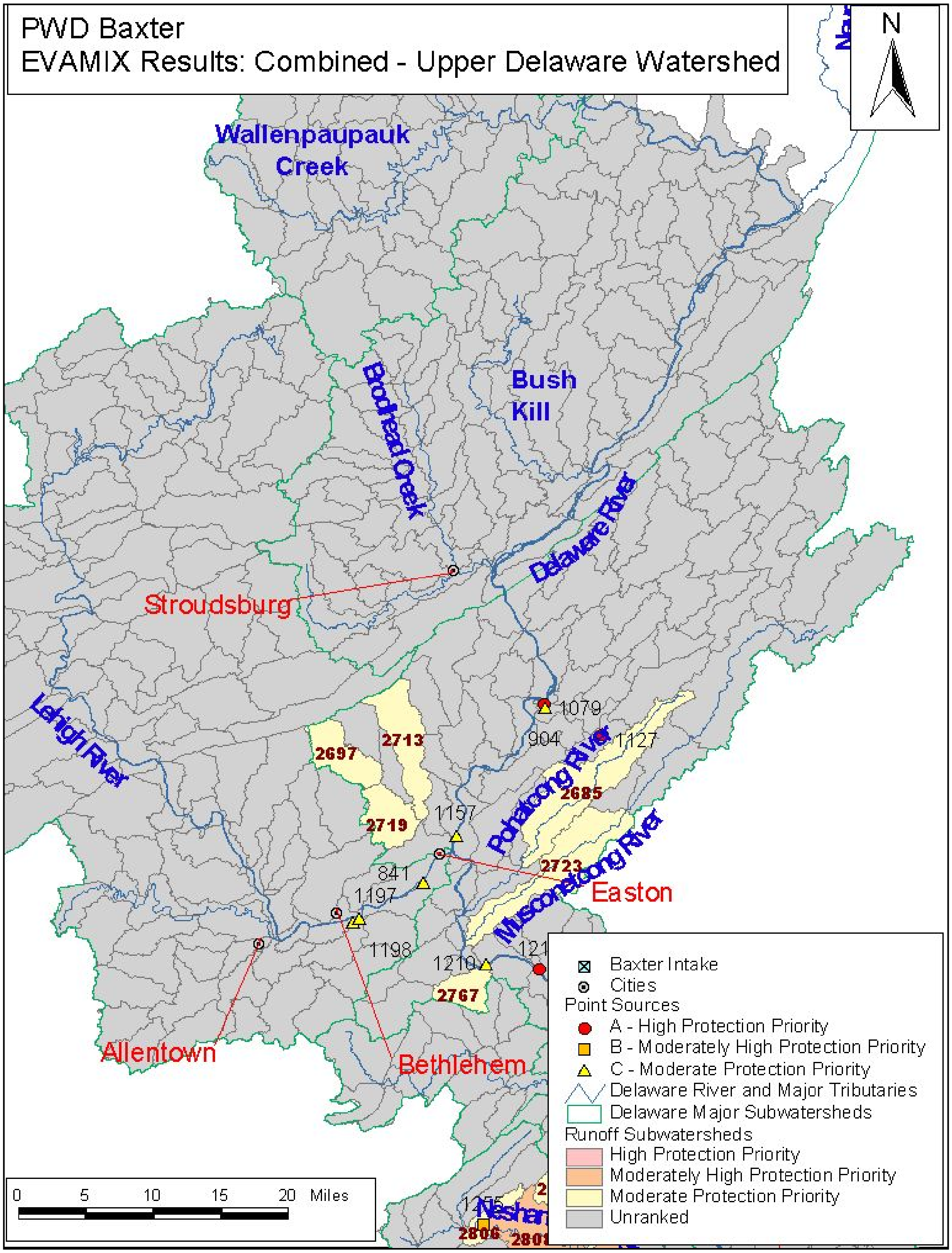


Figure 2.2.4-6 Priority Point Sources and Subwatersheds for PWD's Baxter Intake in the Upper Delaware Watershed



EVAMIX Ranking by Contaminant Category

The extensive screening of sites done for the combined ranking was not suitable for use in the contaminant-by-contaminant evaluation. The combined ranking screening was done in part based on the types of chemicals stored, and thus could conceivably screen out numerous sites for a given contaminant, simply because that contaminant is less critical than another contaminant. For those contaminant categories where the number of sites was too large, a simple threshold screening was performed based on the impact of that contaminant source on the potential concentration at the intake. In general, the following approach was used for selecting sites from each category for final ranking by contaminant category:

- 50 sites from the PCS database were included (including all the major dischargers);
- The top ranked 20 RCRA sites in the floodplain were included; and
- The top ranked 20 sites from the TRI database, the top 20 sites from the AST database, and the top 20 sites from the NPS database were included.

Ranking by contaminant category was completed using EVAMIX and six criteria (weights were provided by the technical advisory committee at the June 2001 workshop):

1. Relative Impact at Intake (weight 40 percent)

2. Time of Travel (weight 5 percent)

3. Potential for Release/Controls (weight 20 percent)

4. Potential Release Frequency (weight 15 percent)

5. Violation Type/Frequency (weight 15 percent)

6. Location (weight 5percent)

Tables 2.2.4-3 through 2.2.4-12 provide the rankings of the primary potential sources of each contaminant group. Each Table has 8 columns:

Column 1: Source ID code: a unique database source code

Column 2: Source Name, the name as listed in the database

Column 3: Primary database containing information about the source used in the analysis

Column 4: Point Source subwatershed (NPS)

Column 5: Zone (either A or B)

Column 6: Estimated time of travel to the intake under high flow conditions

Column 7: relative impact at the intake

Column 8: Final rank category based on nine criteria and selected criteria weights

Salts

Table 2.2.4-3 shows the results of the ranking for salts, as represented by estimated sources of chloride. The table indicates that the highest priority sources of chlorides are either stormwater runoff from urbanized watersheds, or potential releases of industrial salts from industrial sites as represented by sites listed in the TRI database. It should be noted that neither type of source individually appears to provide sufficient loading to cause water quality impairments at the intake, but combined, especially during winter periods, the runoff may result in some impacts. Geographically, most of the highest priority sources were located in the area near Easton, PA, along the Delaware downstream of Trenton, and along the Lehigh River, as shown by Figures 2.2.4-7 through 2.2.4-9.

Table 2.2.4-3 Contaminant Category Ranking for Salts (Chlorides)

Source ID	Source Name	Database Used	Subwatershed	Zone	Time of Travel	Relative Impact (%)	Priority
640	DIAL CORP.	TRI	Delaware River - 649	Zone A	1.6	0.0364	Highest-A
4462	ROHM & HAAS CROYDON	AST	Delaware River - 666	Floodplain	0.6	0.0313	Highest-A
904	ROCHE VITAMINS & FINE CHEMICALS	TRI	PEQUEST R - 405	Zone B	21.9	0.0131	Highest-A
841	ASHLAND CHEMICAL INC.	TRI	LEHIGH R - 474	Floodplain	18.7	0.0066	Highest-A
90649	Delaware River-649	NP	Delaware River - 649	Zone A	1.3	0.0018	Highest-A
90651	Unknown-651	NP	Unknown - 651	Zone A	3.3	0.0012	Highest-A
90583	NESHAMINY R-583	NP	NESHAMINY R - 583	Zone B	5.1	0.0025	Highest-A
90394	POHATCONG R-394	NP	POHATCONG R - 394	Zone B	17.9	0.0045	Highest-A
90752	RANCOCAS CR-752	NP	RANCOCAS CR - 752	Zone B	4.4	0.0014	Highest-A
90601	NESHAMINY R-601	NP	NESHAMINY R - 601	Zone B	4.0	0.0013	Highest-A
90617	Little Neshaminy Creek-617	NP	Little Neshaminy Creek - 617	Zone B	5.1	0.0014	Highest-A
90459	MUSCONETCONG R-459	NP	MUSCONETCONG R - 459	Zone B	15.5	0.0033	Highest-A
90606	Little Neshaminy Creek-606	NP	Little Neshaminy Creek - 606	Zone B	5.5	0.0013	Highest-A
956	CIRCUIT FOIL USA INC. (FORMERLY YATES IND.)	TRI	Delaware River - 927	Zone B	3.1	0.0007	Highest-A
90444	Unknown-444	NP	Unknown - 444	Zone B	19.5	0.0030	Highest-A
90496	Nishisakawick Creek-496	NP	Nishisakawick Creek - 496	Zone B	12.8	0.0014	Highest-A
90349	Martins Creek-349	NP	Martins Creek - 349	Zone B	20.8	0.0027	Highest-A
90523	Gallows Run-523	NP	Gallows Run - 523	Zone B	14.7	0.0013	Moderately High-B
90415	Unknown-415	NP	Unknown - 415	Zone B	19.8	0.0021	Moderately High-B
90443	Lopatcong Creek-443	NP	Lopatcong Creek - 443	Zone B	17.6	0.0016	Moderately High-B
90453	Shoeneck Creek-453	NP	Shoeneck Creek - 453	Zone B	19.2	0.0019	Moderately High-B

Source ID	Source Name	Database Used	Subwatershed	Zone	Time of Travel	Relative Impact (%)	Priority
90470	Monocacy Creek-470	NP	Monocacy Creek - 470	Zone B	21.4	0.0023	Moderately High-B
90525	Cooks Creek-525	NP	Cooks Creek - 525	Zone B	16.8	0.0012	Moderately High-B
90512	Saucon Creek-512	NP	Saucon Creek - 512	Zone B	17.9	0.0013	Moderately High-B
90393	Martins Creek-393	NP	Martins Creek - 393	Zone B	19.8	0.0015	Moderately High-B
90389	Oughoughton Creek-389	NP	Oughoughton Creek - 389	Zone B	20.6	0.0016	Moderately High-B
90406	Unknown-406	NP	Unknown - 406	Zone B	19.8	0.0013	Moderately High-B
90378	Waltz Creek-378	NP	Waltz Creek - 378	Zone B	20.8	0.0014	Moderately High-B
90371	PEQUEST R-371	NP	PEQUEST R - 371	Zone B	23.5	0.0018	Moderately High-B
578	LACLEDE FAIRLESS	TRI	Queen Anne Creek - 627	Floodplain	2.9	0.0023	Moderately High-B
90358	Jacoby Creek-358	NP	Jacoby Creek - 358	Zone B	24.3	0.0012	Moderately High-B
493	NATIONAL MEDICAL CARE INC.	TRI	Unknown - 691	Zone A	0.4	0.0015	Moderately High-B
641	CORCO CHEMICAL CORP.	TRI	Queen Anne Creek - 627	Floodplain	2.9	0.0006	Moderately High-B
931	OCCIDENTAL CHEMICAL CORP.	TRI	ASSISCUNK CR - 662	Zone A	2.2	0.0005	Moderately High-B
607	WONDER CHEMICAL CORP.	TRI	Delaware River - 649	Zone A	3.9	0.0002	Moderate-C
644	USS FAIRLESS WORKS	TRI	Queen Anne Creek - 627	Floodplain	2.9	0.0086	Moderate-C
909	WITCO CORP. BRAINARDS FACILITY	TRI	Delaware River - 914	Floodplain	18.4	0.0015	Moderate-C
757	SOLVAY AUTOMOTIVE INC.	TRI	Mill Creek - 648	Zone B	2.0	0.0008	Moderate-C
510	CONSOLIDATED CHEMEX CORP.	TRI	Delaware River - 930	Zone B	0.0	0.0003	Moderate-C
550	COLONIAL CHEMICAL CO.	TRI	RANCOCAS CR - 743	Zone B	3.1	0.0007	Moderate-C
870	PFIZER PIGMENTS INC.	TRI	Shoeneck Creek - 462	Zone B	18.4	0.0026	Moderate-C
796	HI-PURE CHEMICALS INC.	TRI	Unknown - 444	Zone B	21.1	0.0029	Moderate-C
805	HARCROS PIGMENTS INC.	TRI	Shoeneck Creek - 462	Zone B	18.4	0.0010	Moderate-C
917	MAGNESIUM ELEKTRON INC.	TRI	Lockatong Creek - 522	Zone B	23.0	0.0018	Moderate-C
914	GULCO INC.	TRI	Lopatcong Creek - 443	Zone B	18.7	0.0009	Moderate-C
833	CABOT CORP.	TRI	Gallows Run - 523	Zone B	15.2	0.0002	Moderate-C
890	VICTAULIC CO. OF AMERICA APEX FACILITY	TRI	Merrill Creek - 446	Zone B	18.2	0.0004	Moderate-C
806	APOLLO METALS LTD.	TRI	Monocacy Creek - 470	Zone B	21.9	0.0003	Moderate-C
598	RHONE-POULENC AG CO.	TRI	Little Neshaminy Creek - 617	Zone B	5.1	0.0007	Moderate-C
950	SYBRON CHEMICALS INC.	TRI	RANCOCAS CR, N BR - 740	Zone B	5.3	0.0004	Moderate-C
891	J. T. BAKER INC.	TRI	Lopatcong Creek - 443	Zone B	18.7	0.0015	Moderate-C

Figure 2.2.4-7 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for Salts in the Lower Delaware River Watershed

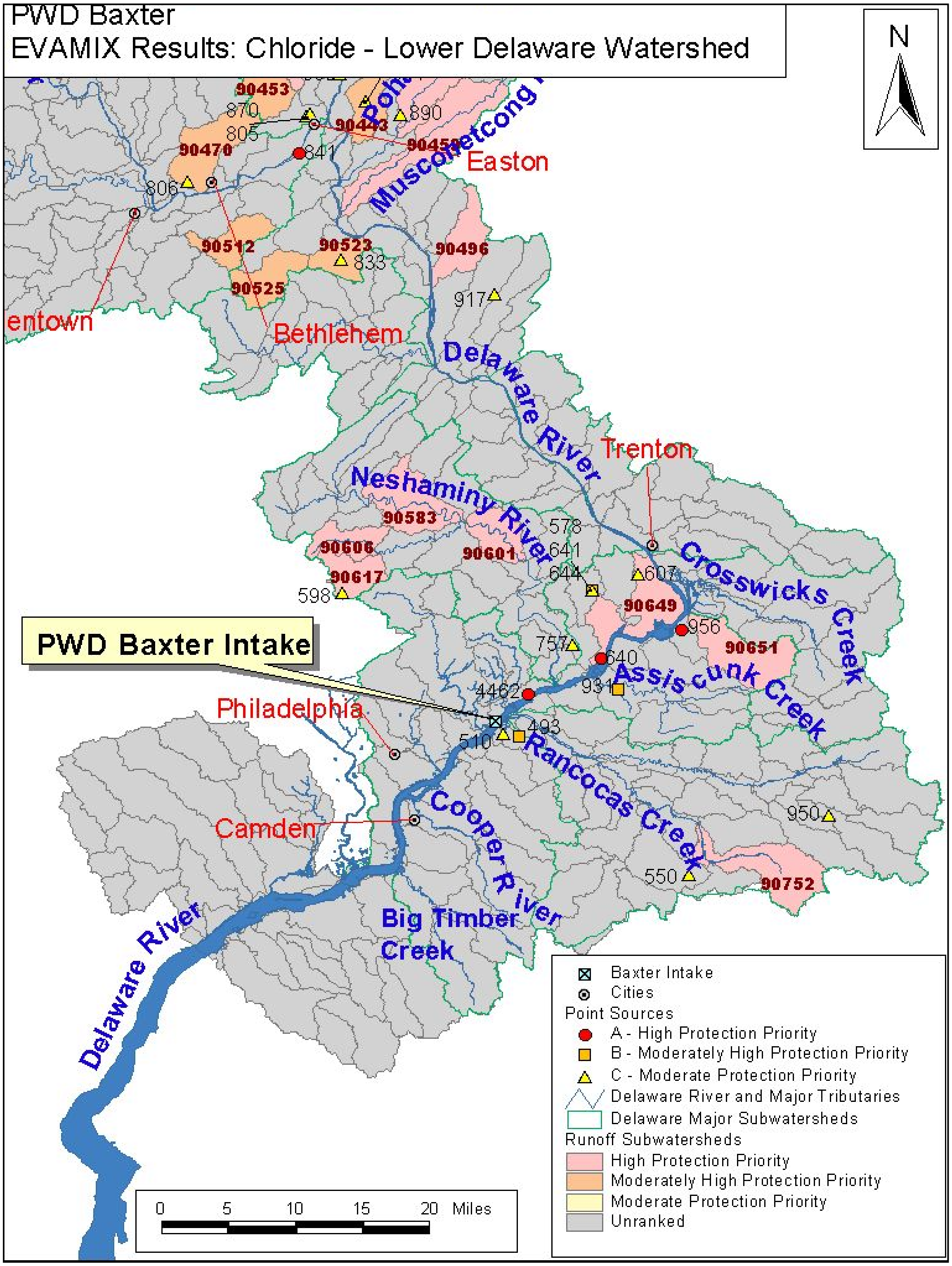


Figure 2.2.4-8 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for Salts in the Middle Delaware River Watershed

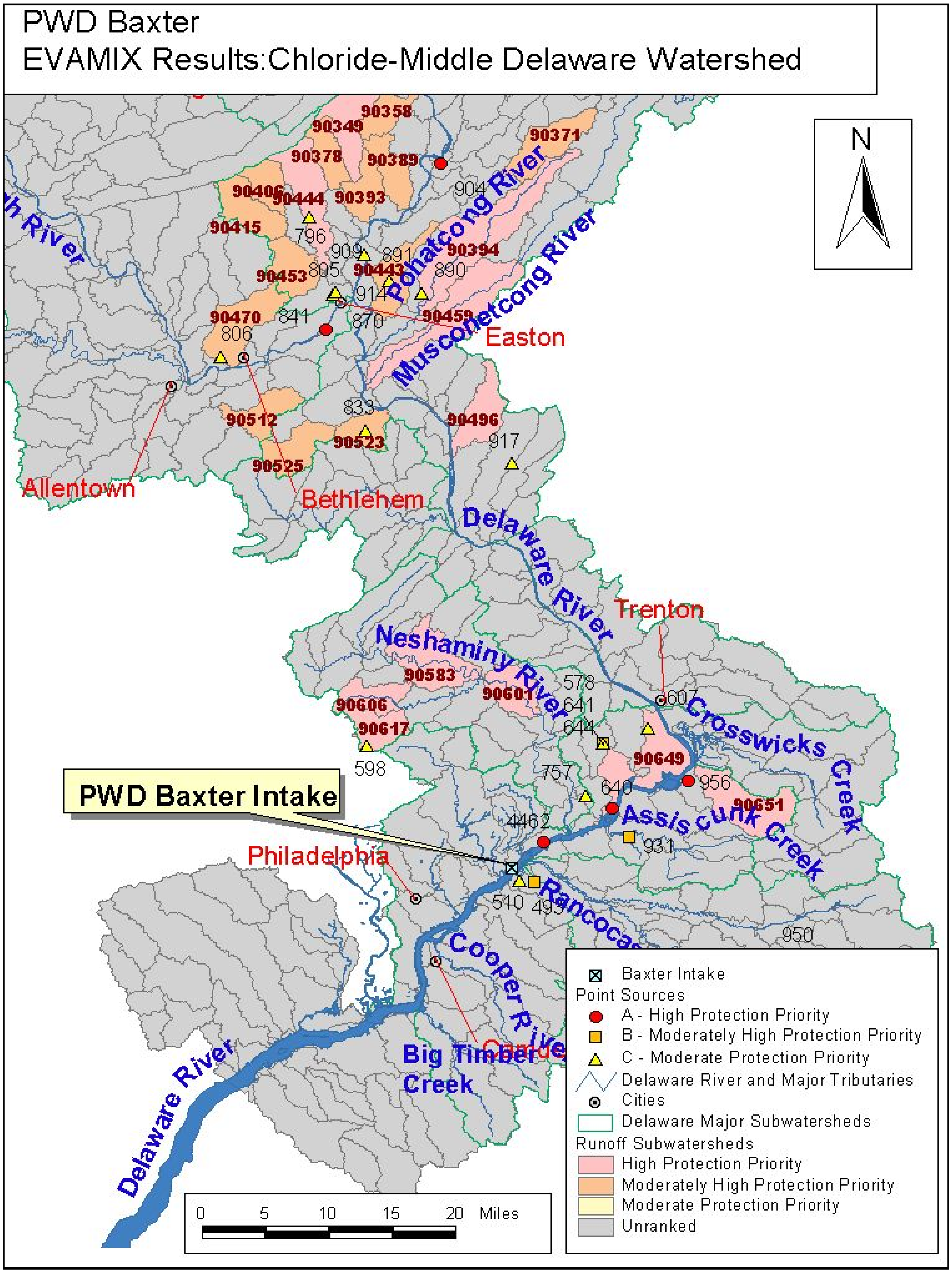
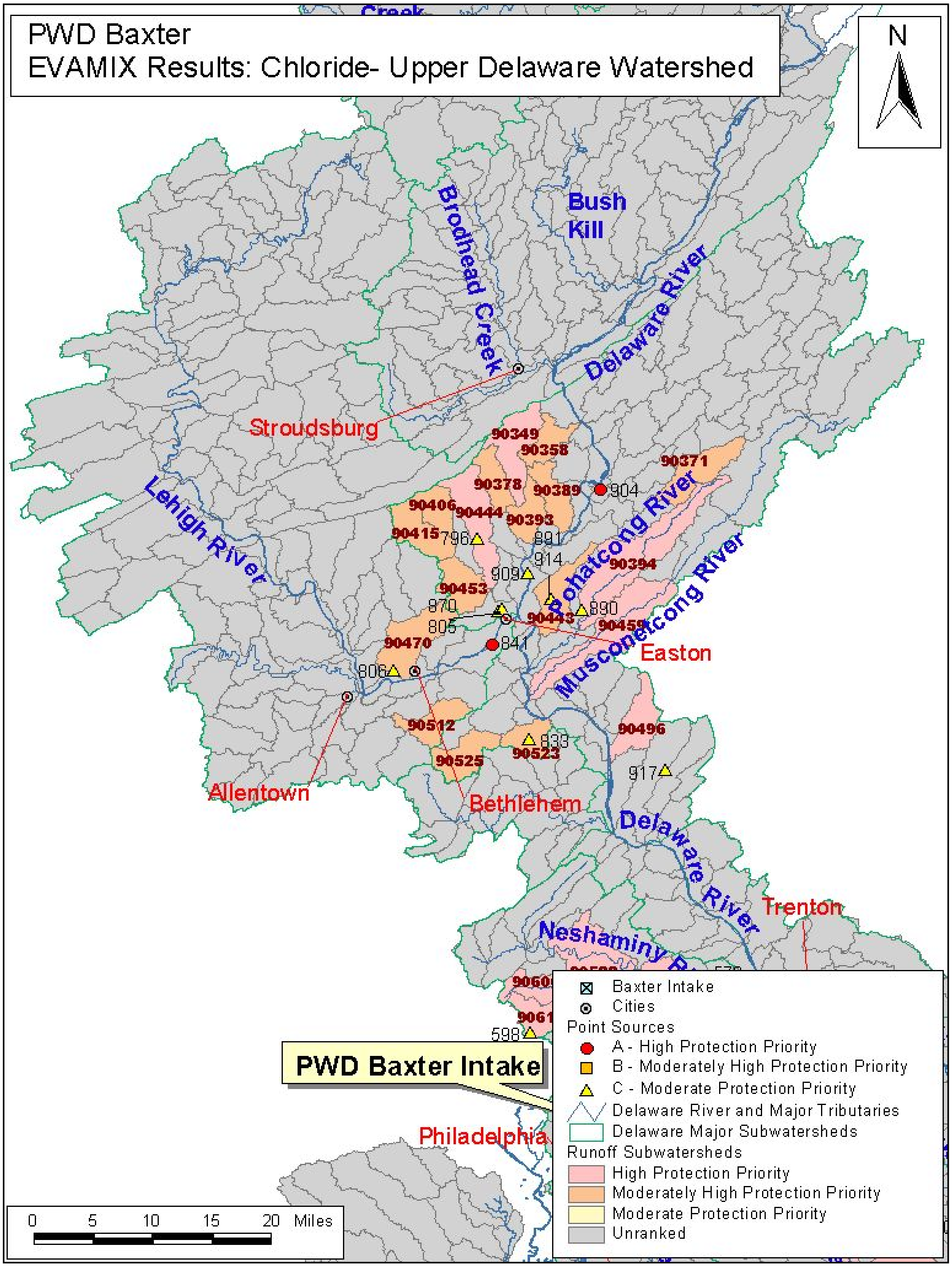


Figure 2.2.4-9 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for Salts in the Upper Delaware River Watershed



Cryptosporidium

Table 2.2.4–4 shows the results of the ranking for pathogens, as represented by estimated sources of *Cryptosporidium*. The table indicates that sources of pathogens are either stormwater runoff from agricultural or urbanized watersheds, and permitted discharges from wastewater treatment plants. NPDES sources are represented in the high priority category (category A). Most sources appear to be relatively minor contributors. However, there are some sources that could provide sufficient loads to have a cumulative impact on the water quality. Geographically, high priority sources were located along the mainstem Delaware River, Rancocas Creek, Neshaminy Creek and the Lehigh River. Figures 2.2.4-10 through 2.2.4-12 illustrate the priority point sources and subwatersheds for *Cryptosporidium* in the lower and upper Delaware River Watershed.

Table 2.2.4-4 Contaminant Category Ranking for *Cryptosporidium*

Source ID	Source Name	Database Used	Subwatershed	Zone	Time of Travel	Relative Impact (%)	Priority
1463	MT LAUREL TWP MUA	NPDES	RANCOCAS CR - 695	Zone A	1.5	0.00013	Highest-A
1443	BURLINGTON CITY STP	NPDES	Delaware River - 663	Zone A	1.5	0.00013	Highest-A
1444	COLORITE POLYMERS COMPANY	NPDES	Delaware River - 663	Floodplain	1.5	0.00013	Highest-A
1214	CROWN PAPER CO	NPDES	Delaware River - 919	Floodplain	13.1	0.00013	Highest-A
1332	DELRAN SEWERAGE AUTHORITY	NPDES	Delaware River - 930	Floodplain	0.2	0.00013	Highest-A
1401	BLACK'S CREEK WWTP	NPDES	Unknown - 651	Zone A	3.5	0.00013	Highest-A
1330	RIVERSIDE STP	NPDES	RANCOCAS CR - 680	Floodplain	0.2	0.00013	Highest-A
1528	PEMBERTON	NPDES	RANCOCAS CR, N BR - 725	Floodplain	4.6	0.00013	Highest-A
1447	BEVERLY SEWERAGE AUTHORITY	NPDES	Delaware River - 929	Zone A	0.7	0.00013	Highest-A
1513	SYBRON CHEMICALS INC	NPDES	RANCOCAS CR, N BR - 689	Zone B	4.0	0.00013	Highest-A
1116	MONMOUTH CO BAYSHORE OUTFALL	NPDES	Delaware River - 559	Zone B	9.1	0.00013	Highest-A
1295	EWING-LAWRENCE SA	NPDES	Pond Run - 612	Zone B	5.4	0.00013	Highest-A
1350	CINNAMINSON STP	NPDES	Delaware River - 930	Floodplain	0.0	0.00013	Highest-A
1434	BRISTOL TWP WP CONTROL PLANT	NPDES	Delaware River - 661	Zone A	1.1	0.00013	Highest-A
1255	CHALFONT-NEW BRITAIN TWP JOINT	NPDES	NESHAMINY R - 580	Zone B	7.9	0.00013	Highest-A
1323	WARMINSTER TWP. MUN. AUTH.	NPDES	Little Neshaminy Creek - 610	Zone B	4.8	0.00013	Highest-A
1413	FLORENCE TOWNSHIP STP	NPDES	Delaware River - 927	Zone A	2.0	0.00013	Highest-A
1210	GPU GENERATION INC	NPDES	Delaware River - 918	Zone B	14.4	0.00013	Highest-A
1371	HAMILTON TOWNSHIP WPCF	NPDES	CROSSWICKS CR - 629	Zone B	4.0	0.00013	Highest-A
1467	MOUNT HOLLY SEWERAGE AUTHORITY	NPDES	RANCOCAS CR, N BR - 698	Floodplain	2.6	0.00013	Highest-A
1325	ASBURY PARK WTP	NPDES	NESHAMINY R - 601	Zone B	4.6	0.00013	Highest-A
1157	MALLINCKRODT BAKER INC	NPDES	Delaware River - 914	Floodplain	17.9	0.00013	Highest-A
1177	EASTON CITY	NPDES	Delaware River - 451	Zone B	17.4	0.00013	Highest-A
1197	BETHLEHEM CITY	NPDES	LEHIGH R - 485	Floodplain	21.4	0.00013	Highest-A
1418	GRIFFIN PIPE PRODUCTS CO	NPDES	Delaware River - 927	Zone B	2.0	0.00013	Highest-A

Source ID	Source Name	Database Used	Subwatershed	Zone	Time of Travel	Relative Impact (%)	Priority
1124	NORTHEAST MONMOUTH COUNTY RSA	NPDES	Pidcock Creek - 574	Zone B	8.8	0.00013	Highest-A
1352	USATC & FORT DIX (WASTEWATER)	NPDES	RANCOCAS CR, N BR - 686	Zone B	5.9	0.00013	Highest-A
1341	WILLINGBORO WATER PCP	NPDES	RANCOCAS CR - 680	Zone A	0.7	0.00013	Highest-A
1435	PSE&G BURLINGTON GENERATING ST	NPDES	Delaware River - 661	Floodplain	1.3	0.00013	Highest-A
1123	LAMBERTVILLE SEWAGE AUTHORITY	NPDES	Delaware River - 923	Zone B	8.0	0.00013	Highest-A
1440	LA GORCE SQUARE PLANT	NPDES	ASSISCUNK CR - 662	Zone A	1.8	0.00013	Highest-A
1138	WITCO CORPORATION	NPDES	Delaware River - 913	Zone B	19.2	0.00013	Highest-A
1170	INGERSOLL DRESSER PUMP CO	NPDES	Delaware River - 914	Zone B	17.1	0.00013	Highest-A
1349	HOEGANAES CORPORATION	NPDES	Delaware River - 930	Floodplain	0.0	0.00013	Moderately High-B
1445	BURLINGTON TWP MAIN STP	NPDES	Delaware River - 663	Zone A	1.5	0.00013	Moderately High-B
1410	ROEBLING INDUSTRIES	NPDES	Crafts Creek - 655	Floodplain	2.8	0.00013	Moderately High-B
1565	MEDFORD TOWNSHIP STP	NPDES	Southwest Branch South Branch - 755	Zone B	3.7	0.00013	Moderately High-B
1375	PSE&G MERCER GENERATING STA	NPDES	Delaware River - 927	Floodplain	3.7	0.00013	Moderately High-B
1340	MCGUIRE AIR FORCE BASE STP	NPDES	CROSSWICKS CR - 668	Zone B	8.4	0.00013	Moderately High-B
1079	HOFFMAN-LA ROCHE INC	NPDES	PEQUEST R - 405	Zone B	21.9	0.00013	Moderately High-B
1366	TRENTON SEWER UTILITY	NPDES	Delaware River - 927	Zone B	3.9	0.00013	Moderately High-B
1430	HERCULES INCORPORATED	NPDES	ASSISCUNK CR - 662	Zone A	1.5	0.00013	Moderately High-B
1403	LOWER BUCKS COUNTY JOINT M.A.	NPDES	Delaware River - 649	Zone A	2.2	0.00013	Moderately High-B
1192	FIBERMARK	NPDES	MUSCONETCONG R - 459	Zone B	16.6	0.00013	Moderately High-B
1396	STEPAN CHEMICAL CO INC	NPDES	Delaware River - 649	Zone A	3.3	0.00013	Moderately High-B
1390	CIRCUIT FOIL USA INC	NPDES	CROSSWICKS CR - 629	Zone B	4.0	0.00013	Moderately High-B
1362	MORRISVILLE BORO MUN AUTH-STP	NPDES	Delaware River - 649	Zone B	4.3	0.00013	Moderately High-B
1592	ELMWOOD WWTP	NPDES	Southwest Branch South Branch - 759	Zone B	4.8	0.00013	Moderately High-B
1309	FEDERATED METALS	NPDES	Pond Run - 612	Zone B	5.1	0.00013	Moderately High-B
1266	HATFIELD TWP MUN AUTH	NPDES	West Branch Neshaminy Creek - 586	Zone B	9.0	0.00013	Moderately High-B
1077	BANGOR BORO AUTH	NPDES	Martins Creek - 349	Floodplain	21.4	0.00013	Moderately High-B
1517	PEMBERTON TOWNSHIP MUA STP	NPDES	RANCOCAS CR, N BR - 699	Floodplain	4.2	0.00013	Moderately High-B
1153	NAZARETH BORO MUN AUTH	NPDES	Shoeneck Creek - 453	Zone B	20.3	0.00013	Moderately High-B
1249	LONG BRANCH SEWERAGE AUTHORITY	NPDES	Pidcock Creek - 574	Zone B	8.8	0.00013	Moderately High-B
1127	OXFORD TEXTILE INC	NPDES	Unknown - 412	Zone B	24.0	0.00013	Moderately High-B
1436	PUBLIC SERVICE ELECTRIC & GAS	NPDES	Delaware River - 663	Zone A	1.3	0.00013	Moderately High-B
1427	ROHM & HAAS COMPANY	NPDES	Mill Creek - 648	Zone A	1.6	0.00013	Moderately High-B
1088	WIND GAP MUN AUTH	NPDES	Unknown - 444	Floodplain	21.9	0.00013	Moderately High-B

Source ID	Source Name	Database Used	Subwatershed	Zone	Time of Travel	Relative Impact (%)	Priority
1232	MAGNESIUM ELEKTRON INC	NPDES	Plum Brook - 519	Zone B	11.5	0.00013	Moderately High-B
1164	HARCROS PIGMENTS INC	NPDES	Shoeneck Creek - 462	Zone B	18.4	0.00013	Moderately High-B
1386	PRE FINISH METALS, INC.	NPDES	Delaware River - 649	Zone A	3.9	0.00013	Moderately High-B
1198	BETHLEHEM STEEL - BETHLEHEM	NPDES	LEHIGH R - 485	Zone B	21.4	0.00013	Moderately High-B
1272	LANSDALE BORO	NPDES	West Branch Neshaminy Creek - 588	Zone B	9.4	0.00013	Moderately High-B
90394	POHATCONG R-394	NP	POHATCONG R - 394	Zone B	17.9	0.00020	Moderately High-B
1515	GEORGIA PACIFIC CORPORATION	NPDES	Delaware River - 931	Floodplain	1.1	0.00001	Moderately High-B
1483	MT EPHRAIM BOROUGH OF	NPDES	BIG TIMBER CR - 769	Floodplain	3.3	0.00001	Moderately High-B
1563	CAMDEN COUNTY M.U.A.	NPDES	Newton Creek - 753	Floodplain	2.4	0.00001	Moderately High-B
1429	BRISTOL BORO WAT & SEW AUTH	NPDES	Mill Creek - 648	Zone A	1.6	0.00013	Moderate-C
1395	UNITED STATES STEEL GROUP-USX	NPDES	Delaware River - 649	Zone A	2.9	0.00013	Moderate-C
1561	CHERRY HILL TOWNSHIP	NPDES	South Branch Pennsauken Creek - 724	Zone A	2.9	0.00001	Moderate-C
1391	UPPER MORELAND-HATBORO JNT SEW	NPDES	Robinhood Brook - 628	Zone A	2.8	0.00001	Moderate-C
1549	CHERRY HILL TOWNSHIP	NPDES	South Branch Pennsauken Creek - 724	Floodplain	2.4	0.00001	Moderate-C
1595	CHERRY HILL TOWNSHIP	NPDES	North Branch Cooper River - 756	Zone A	4.2	0.00001	Moderate-C
1581	CHERRY HILL TOWNSHIP	NPDES	North Branch Cooper River - 756	Zone A	3.8	0.00001	Moderate-C
1498	RUNNEMEDE SEWERAGE AUTHORITY	NPDES	BIG TIMBER CR - 769	Zone B	3.5	0.00001	Moderate-C
1263	FERMENTA ANIMAL HEALTH CO	NPDES	*C - 590	Zone B	6.4	0.00013	Moderate-C
1580	WEST COLLINGSWOOD HEIGHTS STP	NPDES	Newton Creek - 753	Zone A	3.1	0.00001	Moderate-C
1571	COLLINGSWOOD BOROUGH OF	NPDES	Newton Creek - 753	Zone B	3.3	0.00001	Moderate-C
1211	JERSEY CENTRAL POWER & LIGHT	NPDES	Delaware River - 918	Zone B	14.4	0.00013	Moderate-C
1569	COLES MILLS STP	NPDES	COOPER R - 738	Zone A	3.1	0.00001	Moderate-C
1488	WOODCREST STP	NPDES	COOPER R - 760	Zone A	4.0	0.00001	Moderate-C
1568	COOPER RIVER STP	NPDES	COOPER R - 738	Floodplain	2.9	0.00001	Moderate-C
1594	AUDUBON BOROUGH STP	NPDES	Newton Creek - 753	Zone A	3.3	0.00001	Moderate-C
1133	PP&L (MARTINS CREEK UNIT)	NPDES	Delaware River - 399	Zone B	20.6	0.00013	Moderate-C
1502	SOMERDALE BORO STP	NPDES	COOPER R - 760	Zone A	4.0	0.00001	Moderate-C
1558	RAMBLEWOOD STP	NPDES	PENNSAUKEN CR - 706	Zone A	2.6	0.00001	Moderate-C
1639	PHILADELPHIA CITY WATER DEPT -	NPDES	Delaware River - 704	Zone B	1.3	0.00001	Moderate-C
90459	MUSCONETCONG R-459	NP	MUSCONETCONG R - 459	Zone B	15.5	0.00015	Moderate-C
1601	CLEMENTON SEWAGE AUTHORITY	NPDES	BIG TIMBER CR, N FK - 776	Zone B	5.1	0.00001	Moderate-C
1593	AMSPEC CHEMICAL CORP	NPDES	Delaware River - 932	Floodplain	2.9	0.00001	Moderate-C
1618	LINDENWOLD BOROUGH SEWAGE	NPDES	COOPER R - 760	Zone A	4.6	0.00001	Moderate-C
1638	PHILADELPHIA CITY WATER DEPT -	NPDES	Delaware River - 711	Zone B	2.4	0.00001	Moderate-C
90444	Unknown-444	NP	Unknown - 444	Zone B	19.5	0.00014	Moderate-C

Source ID	Source Name	Database Used	Subwatershed	Zone	Time of Travel	Relative Impact (%)	Priority
1497	BARRINGTON SEWER UTILITY	NPDES	BIG TIMBER CR - 769	Zone B	3.7	0.00001	Moderate-C
90583	NESHAMINY R-583	NP	NESHAMINY R - 583	Zone B	5.1	0.00012	Moderate-C
1637	PECO ENERGY COMPANY-DELAWARE	NPDES	Delaware River - 704	Floodplain	1.6	0.00001	Moderate-C
1537	MOORESTOWN TOWNSHIP STP	NPDES	PENNSAUKEN CR - 706	Floodplain	2.0	0.00001	Moderate-C
1573	WOODSTREAM STP	NPDES	South Branch Pennsauken Creek - 724	Floodplain	3.3	0.00001	Moderate-C
1550	MAPLE SHADE TOWNSHIP STP	NPDES	PENNSAUKEN CR - 706	Zone B	2.9	0.00001	Moderate-C
1596	GLOUCESTER CITY TITANIUM CO	NPDES	Delaware River - 932	Zone B	2.9	0.00001	Moderate-C

Figure 2.2.4-10 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for *Cryptosporidium* in the Lower Delaware River Watershed

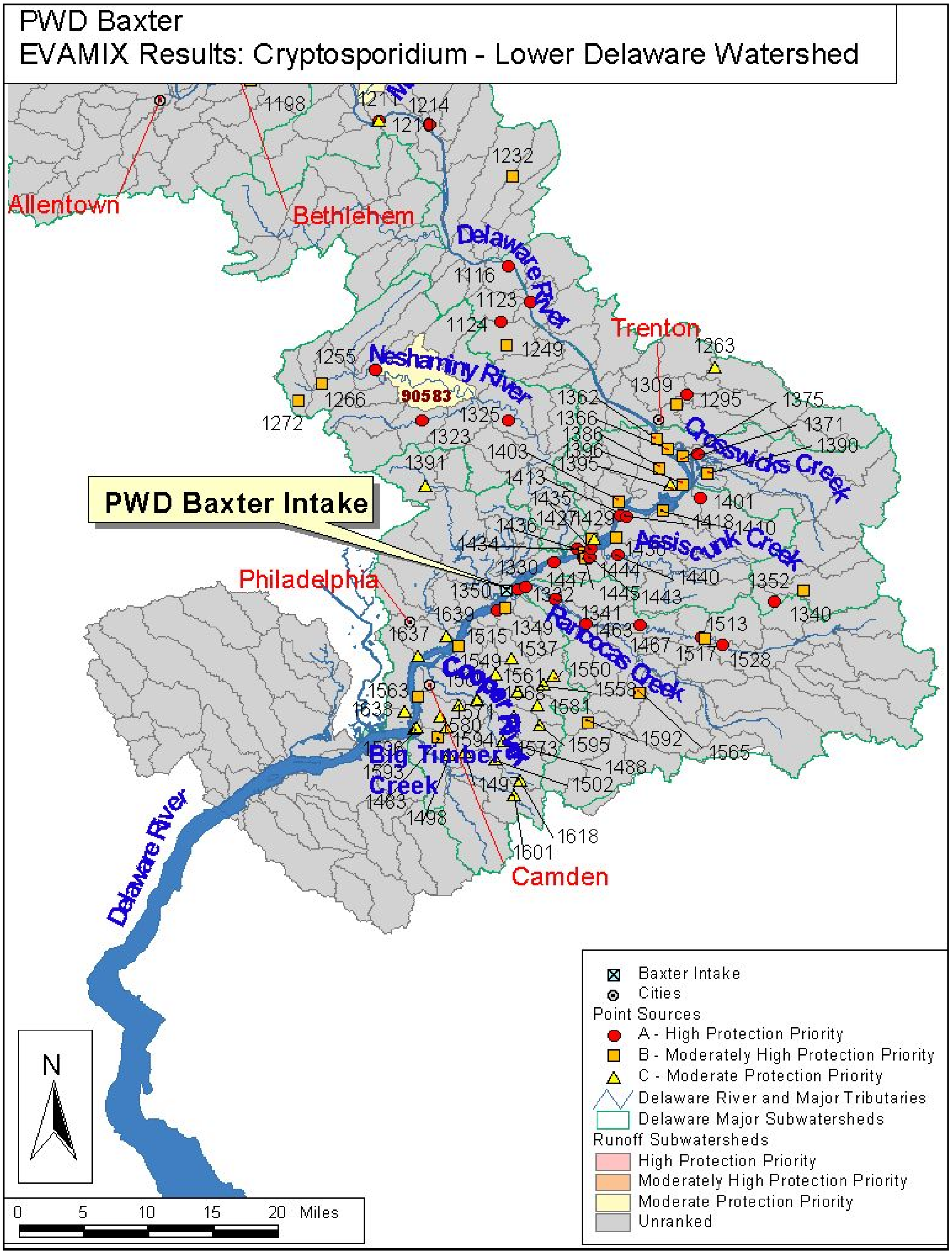


Figure 2.2.4-11 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for *Cryptosporidium* in the Middle Delaware River Watershed

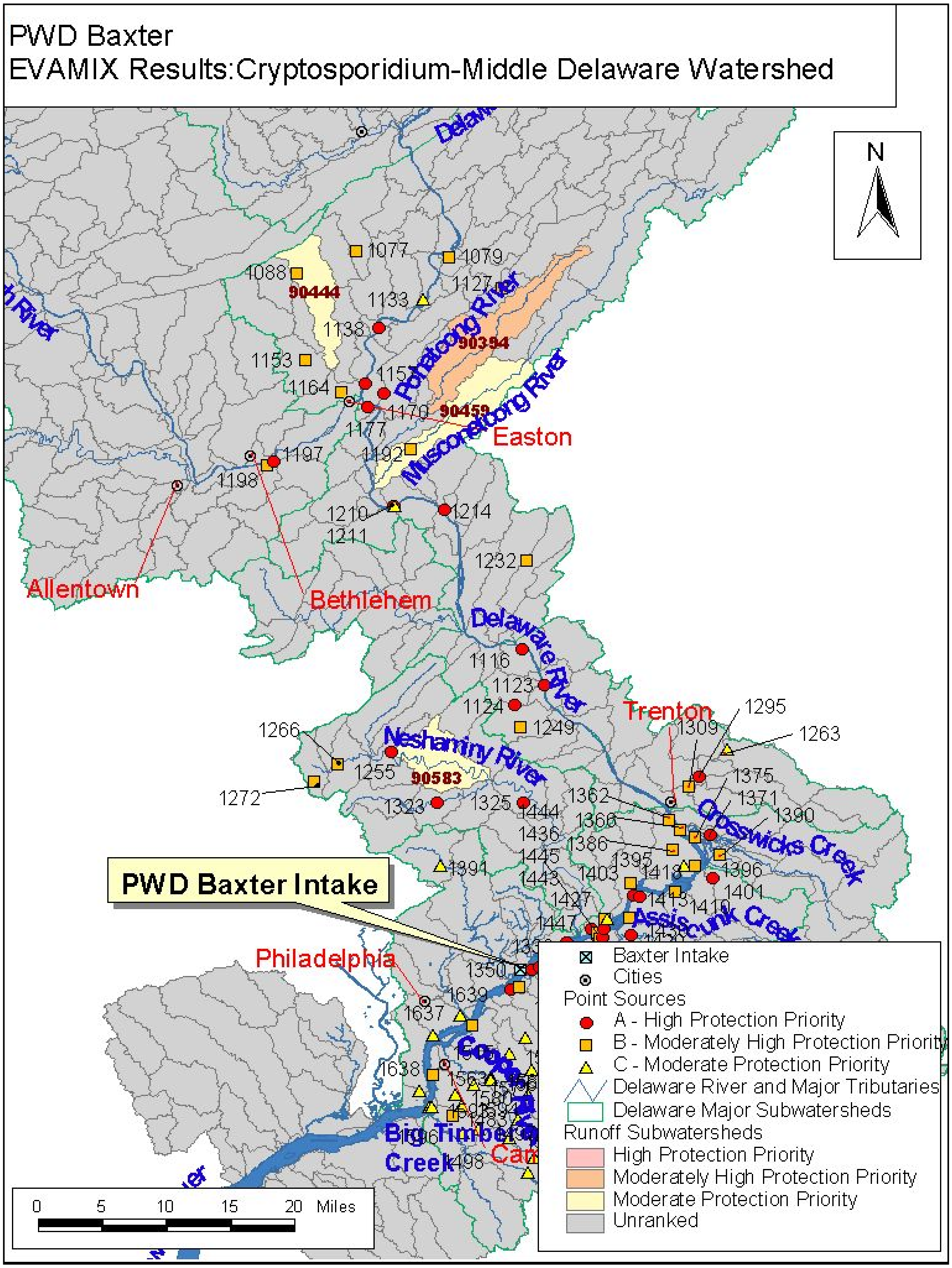
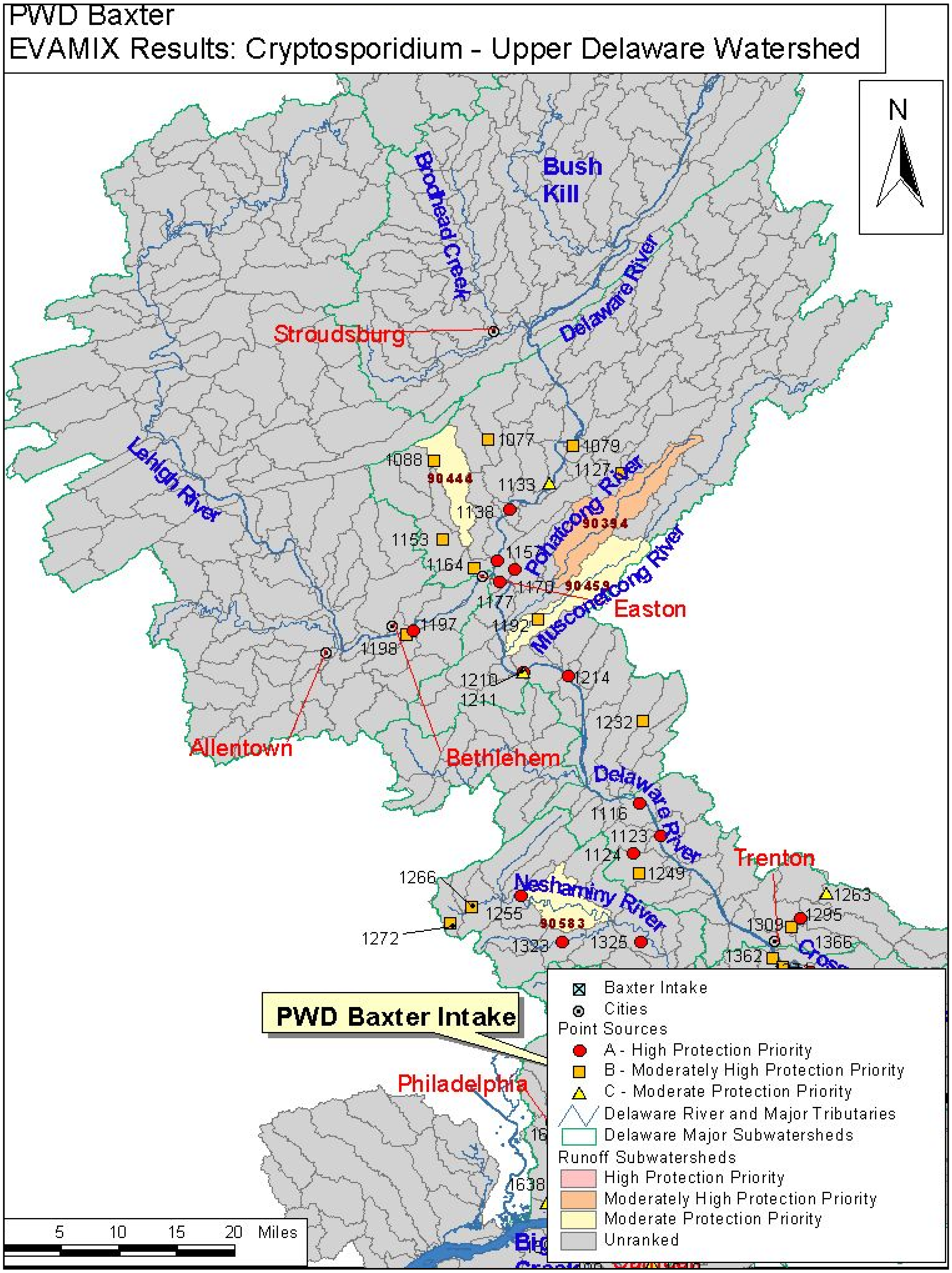


Figure 2.2.4-12 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for *Cryptosporidium* in the Upper Delaware River Watershed



Fecal Coliform

Table 2.2.4-5 shows the results of the ranking for fecal coliform. The table indicates that sources are either stormwater runoff from agricultural or urbanized watersheds, and permitted discharges from wastewater treatment plants. Although both sources are represented in the high priority category (category A), the results suggest that periodic loading from stormwater is orders of magnitude higher than the loading from wastewater treatment plants. The table shows that during dry weather flows, wastewater loading is insignificant at the Baxter Intake, but that during storm events, fecal coliform would be expected to increase by orders of magnitude. Geographically, priority point sources are located in the lower portion of the Delaware Watershed, while the priority stormwater runoff subwatersheds are in the upper Delaware Watershed. Figures 2.2.4-13 through 2.2.4-15 illustrate the priority point sources and subwatersheds for coliform in the upper and lower Delaware River Watershed.

Table 2.2.4-5 Contaminant Ranking for Fecal Coliform

Source ID	Source Name	Database Used	Subwatershed	Zone	Time of Travel	Relative Impact (%)	Priority
90394	POHATCONG R-394	NP	POHATCONG R - 394	Zone B	17.9	0.31010	Highest-A
90459	MUSCONETCONG R-459	NP	MUSCONETCONG R - 459	Zone B	15.5	0.23143	Highest-A
90444	Unknown-444	NP	Unknown - 444	Zone B	19.5	0.21318	Highest-A
90583	NESHAMINY R-583	NP	NESHAMINY R - 583	Zone B	5.1	0.16836	Highest-A
90349	Martins Creek-349	NP	Martins Creek - 349	Zone B	20.8	0.17971	Highest-A
1515	GEORGIA PACIFIC CORPORATION	NPDES	Delaware River - 931	Floodplain	1.1	0.00001	Highest-A
1483	MT EPHRAIM BOROUGH OF	NPDES	BIG TIMBER CR - 769	Floodplain	3.3	0.00001	Highest-A
1463	MT LAUREL TWP MUA	NPDES	RANCOCAS CR - 695	Zone A	1.5	0.00013	Highest-A
1563	CAMDEN COUNTY M.U.A.	NPDES	Newton Creek - 753	Floodplain	2.4	0.00001	Highest-A
1443	BURLINGTON CITY STP	NPDES	Delaware River - 663	Zone A	1.5	0.00013	Highest-A
1444	COLORITE POLYMERS COMPANY	NPDES	Delaware River - 663	Floodplain	1.5	0.00013	Highest-A
1581	CHERRY HILL TOWNSHIP	NPDES	North Branch Cooper River - 756	Zone A	3.8	0.00001	Highest-A
1332	DELRAN SEWERAGE AUTHORITY	NPDES	Delaware River - 930	Floodplain	0.2	0.00013	Highest-A
1391	UPPER MORELAND-HATBORO JNT SEW	NPDES	Robinhood Brook - 628	Zone A	2.8	0.00001	Highest-A
1330	RIVERSIDE STP	NPDES	RANCOCAS CR - 680	Floodplain	0.2	0.00013	Highest-A
1401	BLACK'S CREEK WWTP	NPDES	Unknown - 651	Zone A	3.5	0.00013	Highest-A
1561	CHERRY HILL TOWNSHIP	NPDES	South Branch Pennsauken Creek - 724	Zone A	2.9	0.00001	Highest-A
1549	CHERRY HILL TOWNSHIP	NPDES	South Branch Pennsauken Creek - 724	Floodplain	2.4	0.00001	Highest-A
90470	Monocacy Creek-470	NP	Monocacy Creek - 470	Zone B	21.4	0.15862	Highest-A
1595	CHERRY HILL TOWNSHIP	NPDES	North Branch Cooper River - 756	Zone A	4.2	0.00001	Highest-A
1214	CROWN PAPER CO	NPDES	Delaware River - 919	Floodplain	13.1	0.00013	Highest-A
1447	BEVERLY SEWERAGE AUTHORITY	NPDES	Delaware River - 929	Zone A	0.7	0.00013	Highest-A
1528	PEMBERTON	NPDES	RANCOCAS CR, N BR - 725	Floodplain	4.6	0.00013	Highest-A
1498	RUNNEMEDE SEWERAGE AUTHORITY	NPDES	BIG TIMBER CR - 769	Zone B	3.5	0.00001	Highest-A

Source ID	Source Name	Database Used	Subwatershed	Zone	Time of Travel	Relative Impact (%)	Priority
1350	CINNAMINSON STP	NPDES	Delaware River - 930	Floodplain	0.0	0.00013	Highest-A
1513	SYBRON CHEMICALS INC	NPDES	RANCOCAS CR, N BR - 689	Zone B	4.0	0.00013	Highest-A
90415	Unknown-415	NP	Unknown - 415	Zone B	19.8	0.15042	Highest-A
90649	Delaware River-649	NP	Delaware River - 649	Zone A	1.3	0.11159	Highest-A
1434	BRISTOL TWP WP CONTROL PLANT	NPDES	Delaware River - 661	Zone A	1.1	0.00013	Highest-A
1295	EWING-LAWRENCE SA	NPDES	Pond Run - 612	Zone B	5.4	0.00013	Highest-A
1580	WEST COLLINGSWOOD HEIGHTS STP	NPDES	Newton Creek - 753	Zone A	3.1	0.00001	Highest-A
1413	FLORENCE TOWNSHIP STP	NPDES	Delaware River - 927	Zone A	2.0	0.00013	Highest-A
1571	COLLINGSWOOD BOROUGH OF	NPDES	Newton Creek - 753	Zone B	3.3	0.00001	Highest-A
1116	MONMOUTH CO BAYSHORE OUTFALL	NPDES	Delaware River - 559	Zone B	9.1	0.00013	Moderately High-B
1323	WARMINSTER TWP. MUN. AUTH.	NPDES	Little Neshaminy Creek - 610	Zone B	4.8	0.00013	Moderately High-B
1467	MOUNT HOLLY SEWERAGE AUTHORITY	NPDES	RANCOCAS CR, N BR - 698	Floodplain	2.6	0.00013	Moderately High-B
1569	COLES MILLS STP	NPDES	COOPER R - 738	Zone A	3.1	0.00001	Moderately High-B
1255	CHALFONT-NEW BRITAIN TWP JOINT	NPDES	NESHAMINY R - 580	Zone B	7.9	0.00013	Moderately High-B
1371	HAMILTON TOWNSHIP WPCF	NPDES	CROSSWICKS CR - 629	Zone B	4.0	0.00013	Moderately High-B
1325	ASBURY PARK WTP	NPDES	NESHAMINY R - 601	Zone B	4.6	0.00013	Moderately High-B
1488	WOODCREST STP	NPDES	COOPER R - 760	Zone A	4.0	0.00001	Moderately High-B
1568	COOPER RIVER STP	NPDES	COOPER R - 738	Floodplain	2.9	0.00001	Moderately High-B
1594	AUDUBON BOROUGH STP	NPDES	Newton Creek - 753	Zone A	3.3	0.00001	Moderately High-B
1418	GRIFFIN PIPE PRODUCTS CO	NPDES	Delaware River - 927	Zone B	2.0	0.00013	Moderately High-B
90651	Unknown-651	NP	Unknown - 651	Zone A	3.3	0.10314	Moderately High-B
1341	WILLINGBORO WATER PCP	NPDES	RANCOCAS CR - 680	Zone A	0.7	0.00013	Moderately High-B
1502	SOMERDALE BORO STP	NPDES	COOPER R - 760	Zone A	4.0	0.00001	Moderately High-B
1435	PSE&G BURLINGTON GENERATING ST	NPDES	Delaware River - 661	Floodplain	1.3	0.00013	Moderately High-B
1210	GPU GENERATION INC	NPDES	Delaware River - 918	Zone B	14.4	0.00013	Moderately High-B
1440	LA GORCE SQUARE PLANT	NPDES	ASSISCUNK CR - 662	Zone A	1.8	0.00013	Moderately High-B
90496	Nishisakawick Creek-496	NP	Nishisakawick Creek - 496	Zone B	12.8	0.12478	Moderately High-B
1352	USATC & FORT DIX (WASTEWATER)	NPDES	RANCOCAS CR, N BR - 686	Zone B	5.9	0.00013	Moderately High-B
1349	HOEGANAES CORPORATION	NPDES	Delaware River - 930	Floodplain	0.0	0.00013	Moderately High-B
1558	RAMBLEWOOD STP	NPDES	PENNSAUKEN CR - 706	Zone A	2.6	0.00001	Moderately High-B
90453	Shoeneck Creek-453	NP	Shoeneck Creek - 453	Zone B	19.2	0.13380	Moderately High-B
1124	NORTHEAST MONMOUTH COUNTY RSA	NPDES	Pidcock Creek - 574	Zone B	8.8	0.00013	Moderately High-B
1638	PHILADELPHIA CITY WATER DEPT -	NPDES	Delaware River - 711	Zone B	2.4	0.00001	Moderately High-B

Source ID	Source Name	Database Used	Subwatershed	Zone	Time of Travel	Relative Impact (%)	Priority
1445	BURLINGTON TWP MAIN STP	NPDES	Delaware River - 663	Zone A	1.5	0.00013	Moderately High-B
1157	MALLINCKRODT BAKER INC	NPDES	Delaware River - 914	Floodplain	17.9	0.00013	Moderately High-B
1123	LAMBERTVILLE SEWAGE AUTHORITY	NPDES	Delaware River - 923	Zone B	8.0	0.00013	Moderately High-B
1410	ROEBLING INDUSTRIES	NPDES	Crafts Creek - 655	Floodplain	2.8	0.00013	Moderately High-B
1177	EASTON CITY	NPDES	Delaware River - 451	Zone B	17.4	0.00013	Moderately High-B
1593	AMSPEC CHEMICAL CORP	NPDES	Delaware River - 932	Floodplain	2.9	0.00001	Moderately High-B
1601	CLEMENTON SEWAGE AUTHORITY	NPDES	BIG TIMBER CR, N FK - 776	Zone B	5.1	0.00001	Moderately High-B
1565	MEDFORD TOWNSHIP STP	NPDES	Southwest Branch South Branch - 755	Zone B	3.7	0.00013	Moderately High-B
1375	PSE&G MERCER GENERATING STA	NPDES	Delaware River - 927	Floodplain	3.7	0.00013	Moderately High-B
1639	PHILADELPHIA CITY WATER DEPT -	NPDES	Delaware River - 704	Zone B	1.3	0.00001	Moderately High-B
1366	TRENTON SEWER UTILITY	NPDES	Delaware River - 927	Zone B	3.9	0.00013	Moderate-C
1430	HERCULES INCORPORATED	NPDES	ASSISCUNK CR - 662	Zone A	1.5	0.00013	Moderate-C
1618	LINDENWOLD BOROUGH SEWAGE	NPDES	COOPER R - 760	Zone A	4.6	0.00001	Moderate-C
1403	LOWER BUCKS COUNTY JOINT M.A.	NPDES	Delaware River - 649	Zone A	2.2	0.00013	Moderate-C
1197	BETHLEHEM CITY	NPDES	LEHIGH R - 485	Floodplain	21.4	0.00013	Moderate-C
1340	MCGUIRE AIR FORCE BASE STP	NPDES	CROSSWICKS CR - 668	Zone B	8.4	0.00013	Moderate-C
1396	STEPAN CHEMICAL CO INC	NPDES	Delaware River - 649	Zone A	3.3	0.00013	Moderate-C
1497	BARRINGTON SEWER UTILITY	NPDES	BIG TIMBER CR - 769	Zone B	3.7	0.00001	Moderate-C
90672	Barkers Brook-672	NP	Barkers Brook - 672	Zone B	3.5	0.09818	Moderate-C
1390	CIRCUIT FOIL USA INC	NPDES	CROSSWICKS CR - 629	Zone B	4.0	0.00013	Moderate-C
1362	MORRISVILLE BORO MUN AUTH-STP	NPDES	Delaware River - 649	Zone B	4.3	0.00013	Moderate-C
1170	INGERSOLL DRESSER PUMP CO	NPDES	Delaware River - 914	Zone B	17.1	0.00013	Moderate-C
1592	ELMWOOD WWTP	NPDES	Southwest Branch South Branch - 759	Zone B	4.8	0.00013	Moderate-C
1309	FEDERATED METALS	NPDES	Pond Run - 612	Zone B	5.1	0.00013	Moderate-C
1138	WITCO CORPORATION	NPDES	Delaware River - 913	Zone B	19.2	0.00013	Moderate-C
1637	PECO ENERGY COMPANY-DELAWARE	NPDES	Delaware River - 704	Floodplain	1.6	0.00001	Moderate-C
1537	MOORESTOWN TOWNSHIP STP	NPDES	PENNSAUKEN CR - 706	Floodplain	2.0	0.00001	Moderate-C
90525	Cooks Creek-525	NP	Cooks Creek - 525	Zone B	16.8	0.11448	Moderate-C
90371	PEQUEST R-371	NP	PEQUEST R - 371	Zone B	23.5	0.12480	Moderate-C
1573	WOODSTREAM STP	NPDES	South Branch Pennsauken Creek - 724	Floodplain	3.3	0.00001	Moderate-C
90623	DOCTORS CR-623	NP	DOCTORS CR - 623	Zone B	4.4	0.09282	Moderate-C
90443	Lopatcong Creek-443	NP	Lopatcong Creek - 443	Zone B	17.6	0.11408	Moderate-C
1550	MAPLE SHADE TOWNSHIP STP	NPDES	PENNSAUKEN CR - 706	Zone B	2.9	0.00001	Moderate-C
1596	GLOUCESTER CITY TITANIUM CO	NPDES	Delaware River - 932	Zone B	2.9	0.00001	Moderate-C
1517	PEMBERTON TOWNSHIP MUA STP	NPDES	RANCOCAS CR, N BR - 699	Floodplain	4.2	0.00013	Moderate-C

Source ID	Source Name	Database Used	Subwatershed	Zone	Time of Travel	Relative Impact (%)	Priority
1266	HATFIELD TWP MUN AUTH	NPDES	West Branch Neshaminy Creek - 586	Zone B	9.0	0.00013	Moderate-C
1436	PUBLIC SERVICE ELECTRIC & GAS	NPDES	Delaware River - 663	Zone A	1.3	0.00013	Moderate-C
1427	ROHM & HAAS COMPANY	NPDES	Mill Creek - 648	Zone A	1.6	0.00013	Moderate-C
90484	Hakihokake Creek-484	NP	Hakihokake Creek - 484	Zone B	13.4	0.10490	Moderate-C
90572	Delaware River-572	NP	Delaware River - 572	Zone B	5.9	0.09226	Moderate-C
1192	FIBERMARK	NPDES	MUSCONETCONG R - 459	Zone B	16.6	0.00013	Moderate-C
1079	HOFFMAN-LA ROCHE INC	NPDES	PEQUEST R - 405	Zone B	21.9	0.00013	Moderate-C
1386	PRE FINISH METALS, INC.	NPDES	Delaware River - 649	Zone A	3.9	0.00013	Moderate-C

Figure 2.2.4-13 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for Fecal Coliform in the Lower Delaware River Watershed

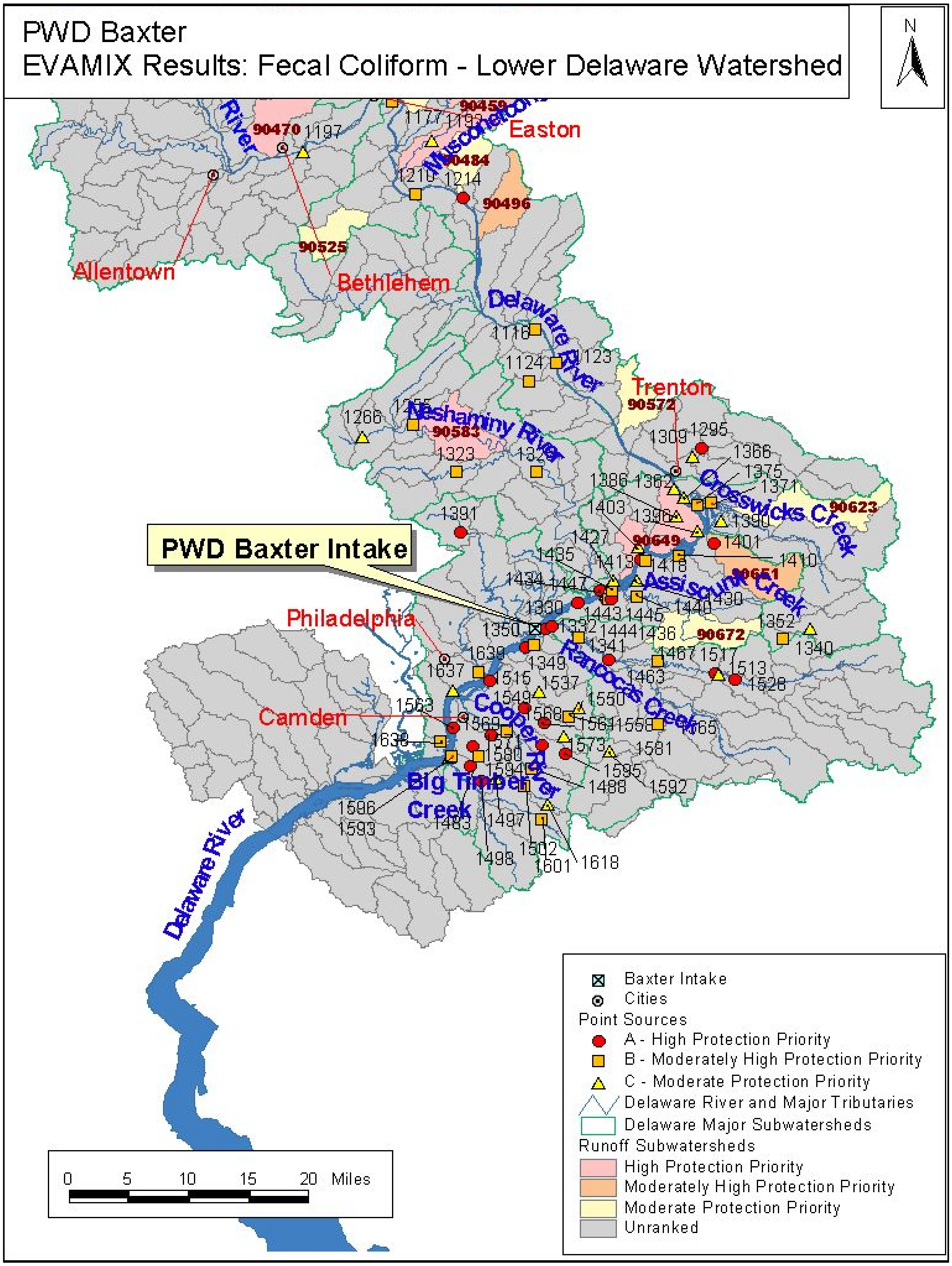


Figure 2.2.4-14 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for Fecal Coliform in the Middle Delaware River Watershed

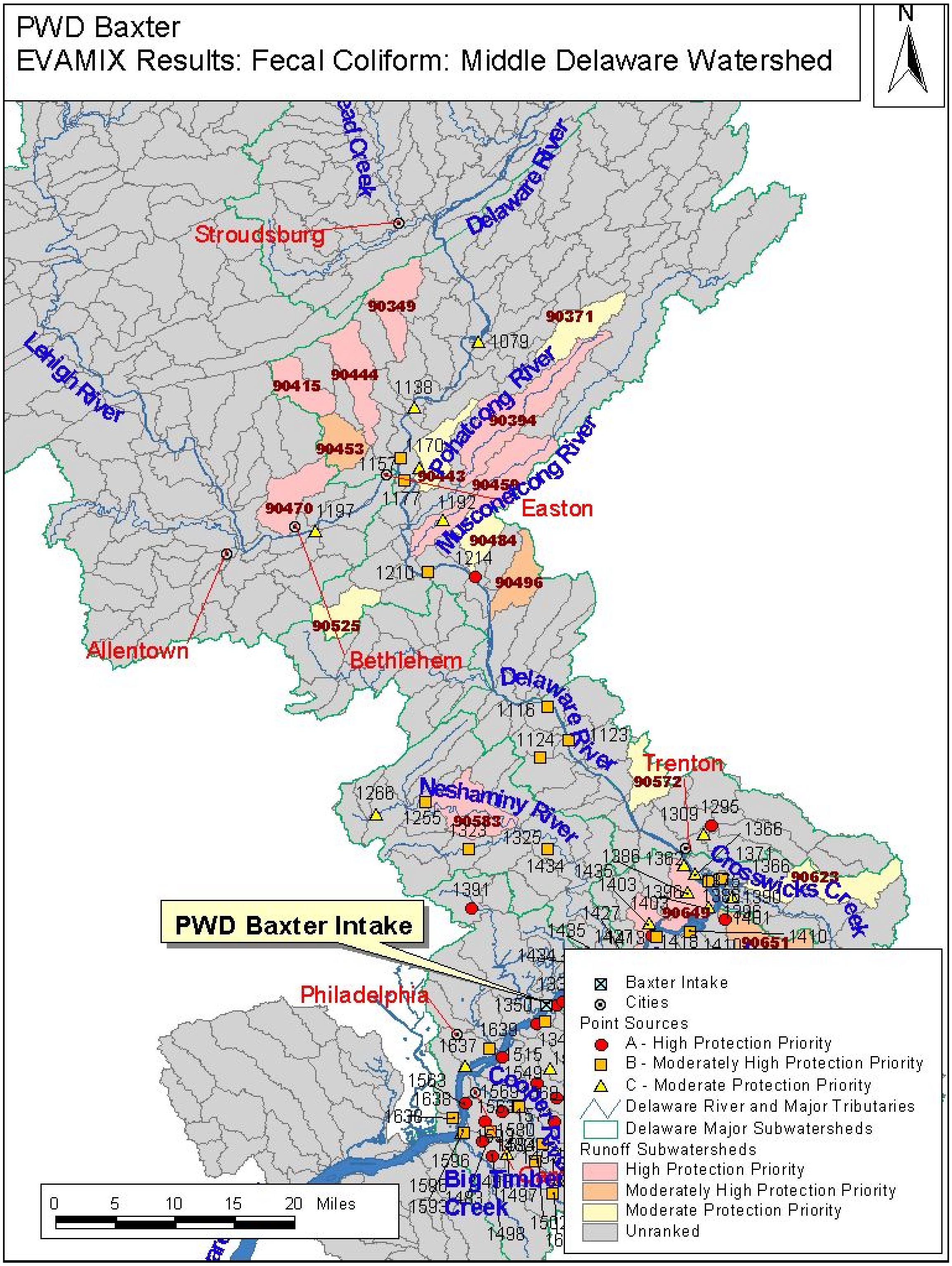
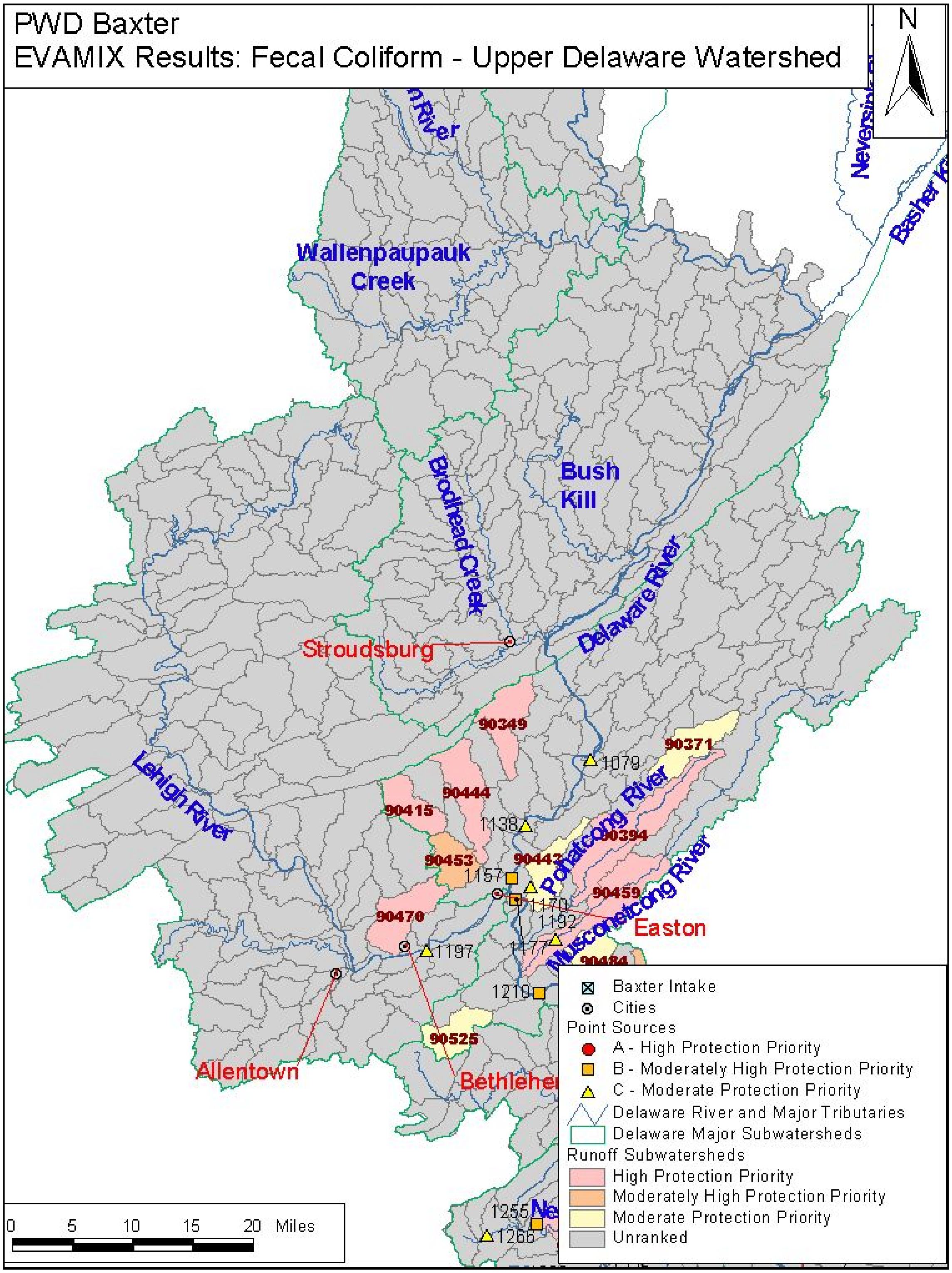


Figure 2.2.4-15 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for Fecal Coliform in the Upper Delaware River Watershed



Metals

Table 2.2.4-6 provides the results of the heavy metal source ranking. Results generally show that NPDES permitted discharges are the primary sources. Some TRI sites with significant storage or use of metals are also rated as high priority sources, primarily because a catastrophic leak or spill would result in extremely high concentrations. Most of the TRI sites fall into the high protection priority category (category A). Only one AST site is listed as a high priority. It is important to note that acid mine drainage could not be included in this analysis and may be a more significant source than any of the other source categories (see section 2.1.5.4). Most sites were located in the watershed below Trenton. However, a few sites were in Upper Delaware areas. Figures 2.2.4-16 through 2.2.4-18 identify the priority point sources for metals in the lower and upper parts of the Delaware River Watershed.

Table 2.2.4-6 Contaminant Category Ranking for Metals

Source ID	Source Name	Database Used	Subwatershed	Zone	Time of Travel	Relative Impact (%)	Priority
956	CIRCUIT FOIL USA INC. (FORMERLY YATES IND.)	TRI	Delaware River - 927	Zone B	3.1	2368.223	Highest-A
731	HARSCO CORP. HECKETT DIV. PLANT 15	TRI	Queen Anne Creek - 627	Floodplain	2.9	1392.510	Highest-A
4565	US STEEL FAIRLESS WORKS	AST	Martins Creek - 616	Zone A	3.1	1325.911	Highest-A
644	USS FAIRLESS WORKS	TRI	Queen Anne Creek - 627	Floodplain	2.9	1055.986	Highest-A
1515	GEORGIA PACIFIC CORPORATION	NPDES	Delaware River - 931	Floodplain	1.1	0.000	Highest-A
1463	MT LAUREL TWP MUA	NPDES	RANCOCAS CR - 695	Zone A	1.5	0.017	Highest-A
1332	DELRAN SEWERAGE AUTHORITY	NPDES	Delaware River - 930	Floodplain	0.2	0.017	Highest-A
1444	COLORITE POLYMERS COMPANY	NPDES	Delaware River - 663	Floodplain	1.5	0.017	Highest-A
1443	BURLINGTON CITY STP	NPDES	Delaware River - 663	Zone A	1.5	0.017	Highest-A
1563	CAMDEN COUNTY M.U.A.	NPDES	Newton Creek - 753	Floodplain	2.4	0.002	Highest-A
1483	MT EPHRAIM BOROUGH OF	NPDES	BIG TIMBER CR - 769	Floodplain	3.3	0.002	Highest-A
1350	CINNAMINSON STP	NPDES	Delaware River - 930	Floodplain	0.0	12.672	Highest-A
1330	RIVERSIDE STP	NPDES	RANCOCAS CR - 680	Floodplain	0.2	0.017	Highest-A
1447	BEVERLY SEWERAGE AUTHORITY	NPDES	Delaware River - 929	Zone A	0.7	0.017	Highest-A
1549	CHERRY HILL TOWNSHIP	NPDES	South Branch Pennsauken Creek - 724	Floodplain	2.4	0.002	Highest-A
1391	UPPER MORELAND-HATBORO JNT SEW	NPDES	Robinhood Brook - 628	Zone A	2.8	0.002	Highest-A
1581	CHERRY HILL TOWNSHIP	NPDES	North Branch Cooper River - 756	Zone A	3.8	0.002	Highest-A
804	BETHLEHEM APPARATUS CO. INC.	TRI	Saucon Creek - 512	Zone B	17.9	607.134	Highest-A
1561	CHERRY HILL TOWNSHIP	NPDES	South Branch Pennsauken Creek - 724	Zone A	2.9	0.002	Highest-A
1434	BRISTOL TWP WP CONTROL PLANT	NPDES	Delaware River - 661	Zone A	1.1	0.017	Highest-A
1401	BLACK'S CREEK WWTP	NPDES	Unknown - 651	Zone A	3.5	0.017	Highest-A
1595	CHERRY HILL TOWNSHIP	NPDES	North Branch Cooper River - 756	Zone A	4.2	0.002	Highest-A
1413	FLORENCE TOWNSHIP STP	NPDES	Delaware River - 927	Zone A	2.0	0.017	Highest-A
1528	PEMBERTON	NPDES	RANCOCAS CR, N BR - 725	Floodplain	4.6	0.017	Highest-A
1467	MOUNT HOLLY SEWERAGE AUTHORITY	NPDES	RANCOCAS CR, N BR - 698	Floodplain	2.6	0.017	Highest-A

Source ID	Source Name	Database Used	Subwatershed	Zone	Time of Travel	Relative Impact (%)	Priority
1349	HOEGANAES CORPORATION	NPDES	Delaware River - 930	Floodplain	0.0	0.017	Highest-A
1498	RUNNEMEDE SEWERAGE AUTHORITY	NPDES	BIG TIMBER CR - 769	Zone B	3.5	0.002	Highest-A
1341	WILLINGBORO WATER PCP	NPDES	RANCOCAS CR - 680	Zone A	0.7	0.017	Highest-A
1435	PSE&G BURLINGTON GENERATING ST	NPDES	Delaware River - 661	Floodplain	1.3	0.017	Highest-A
1580	WEST COLLINGSWOOD HEIGHTS STP	NPDES	Newton Creek - 753	Zone A	3.1	0.002	Highest-A
1568	COOPER RIVER STP	NPDES	COOPER R - 738	Floodplain	2.9	0.002	Highest-A
1569	COLES MILLS STP	NPDES	COOPER R - 738	Zone A	3.1	0.002	Highest-A
1513	SYBRON CHEMICALS INC	NPDES	RANCOCAS CR, N BR - 689	Zone B	4.0	0.004	Highest-A
1571	COLLINGSWOOD BOROUGH OF	NPDES	Newton Creek - 753	Zone B	3.3	0.002	Moderately High-B
1418	GRIFFIN PIPE PRODUCTS CO	NPDES	Delaware River - 927	Zone B	2.0	0.017	Moderately High-B
1594	AUDUBON BOROUGH STP	NPDES	Newton Creek - 753	Zone A	3.3	0.002	Moderately High-B
1440	LA GORCE SQUARE PLANT	NPDES	ASSISCUNK CR - 662	Zone A	1.8	0.017	Moderately High-B
1488	WOODCREST STP	NPDES	COOPER R - 760	Zone A	4.0	0.002	Moderately High-B
1325	ASBURY PARK WTP	NPDES	NESHAMINY R - 601	Zone B	4.6	9.783	Moderately High-B
1445	BURLINGTON TWP MAIN STP	NPDES	Delaware River - 663	Zone A	1.5	0.017	Moderately High-B
1371	HAMILTON TOWNSHIP WPCF	NPDES	CROSSWICKS CR - 629	Zone B	4.0	0.017	Moderately High-B
1295	EWING-LAWRENCE SA	NPDES	Pond Run - 612	Zone B	5.4	0.017	Moderately High-B
1323	WARMINSTER TWP. MUN. AUTH.	NPDES	Little Neshaminy Creek - 610	Zone B	4.8	0.162	Moderately High-B
1558	RAMBLEWOOD STP	NPDES	PENNSAUKEN CR - 706	Zone A	2.6	0.002	Moderately High-B
1638	PHILADELPHIA CITY WATER DEPT -	NPDES	Delaware River - 711	Zone B	2.4	0.002	Moderately High-B
1502	SOMERDALE BORO STP	NPDES	COOPER R - 760	Zone A	4.0	0.002	Moderately High-B
1410	ROEBLING INDUSTRIES	NPDES	Crafts Creek - 655	Floodplain	2.8	0.017	Moderately High-B
1430	HERCULES INCORPORATED	NPDES	ASSISCUNK CR - 662	Zone A	1.5	0.017	Moderately High-B
1593	AMSPEC CHEMICAL CORP	NPDES	Delaware River - 932	Floodplain	2.9	0.002	Moderately High-B
1639	PHILADELPHIA CITY WATER DEPT -	NPDES	Delaware River - 704	Zone B	1.3	0.002	Moderately High-B
1403	LOWER BUCKS COUNTY JOINT M.A.	NPDES	Delaware River - 649	Zone A	2.2	0.017	Moderately High-B
1375	PSE&G MERCER GENERATING STA	NPDES	Delaware River - 927	Floodplain	3.7	0.017	Moderately High-B
1565	MEDFORD TOWNSHIP STP	NPDES	Southwest Branch South Branch - 755	Zone B	3.7	0.017	Moderately High-B
1396	STEPAN CHEMICAL CO INC	NPDES	Delaware River - 649	Zone A	3.3	0.017	Moderately High-B
1255	CHALFONT-NEW BRITAIN TWP JOINT	NPDES	NESHAMINY R - 580	Zone B	7.9	0.017	Moderately High-B
1366	TRENTON SEWER UTILITY	NPDES	Delaware River - 927	Zone B	3.9	0.017	Moderately High-B
1637	PECO ENERGY COMPANY-DELAWARE	NPDES	Delaware River - 704	Floodplain	1.6	0.002	Moderately High-B
1352	USATC & FORT DIX (WASTEWATER)	NPDES	RANCOCAS CR, N BR - 686	Zone B	5.9	0.017	Moderately High-B

Source ID	Source Name	Database Used	Subwatershed	Zone	Time of Travel	Relative Impact (%)	Priority
1618	LINDENWOLD BOROUGH SEWAGE	NPDES	COOPER R - 760	Zone A	4.6	0.002	Moderately High-B
1124	NORTHEAST MONMOUTH COUNTY RSA	NPDES	Pidcock Creek - 574	Zone B	8.8	25.405	Moderately High-B
1116	MONMOUTH CO BAYSHORE OUTFALL	NPDES	Delaware River - 559	Zone B	9.1	0.017	Moderately High-B
1537	MOORESTOWN TOWNSHIP STP	NPDES	PENNSAUKEN CR - 706	Floodplain	2.0	0.002	Moderately High-B
1601	CLEMENTON SEWAGE AUTHORITY	NPDES	BIG TIMBER CR, N FK - 776	Zone B	5.1	0.002	Moderately High-B
1497	BARRINGTON SEWER UTILITY	NPDES	BIG TIMBER CR - 769	Zone B	3.7	0.002	Moderately High-B
1214	CROWN PAPER CO	NPDES	Delaware River - 919	Floodplain	13.1	0.017	Moderately High-B
1390	CIRCUIT FOIL USA INC	NPDES	CROSSWICKS CR - 629	Zone B	4.0	0.005	Moderately High-B
1436	PUBLIC SERVICE ELECTRIC & GAS	NPDES	Delaware River - 663	Zone A	1.3	0.017	Moderately High-B
1362	MORRISVILLE BORO MUN AUTH-STP	NPDES	Delaware River - 649	Zone B	4.3	0.017	Moderate-C
1550	MAPLE SHADE TOWNSHIP STP	NPDES	PENNSAUKEN CR - 706	Zone B	2.9	3.235	Moderate-C
1592	ELMWOOD WWTP	NPDES	Southwest Branch South Branch - 759	Zone B	4.8	4.843	Moderate-C
1596	GLOUCESTER CITY TITANIUM CO	NPDES	Delaware River - 932	Zone B	2.9	0.002	Moderate-C
1427	ROHM & HAAS COMPANY	NPDES	Mill Creek - 648	Zone A	1.6	0.017	Moderate-C
1573	WOODSTREAM STP	NPDES	South Branch Pennsauken Creek - 724	Floodplain	3.3	0.002	Moderate-C
1309	FEDERATED METALS	NPDES	Pond Run - 612	Zone B	5.1	0.017	Moderate-C
1123	LAMBERTVILLE SEWAGE AUTHORITY	NPDES	Delaware River - 923	Zone B	8.0	0.017	Moderate-C
1517	PEMBERTON TOWNSHIP MUA STP	NPDES	RANCOCAS CR, N BR - 699	Floodplain	4.2	0.017	Moderate-C
1386	PRE FINISH METALS, INC.	NPDES	Delaware River - 649	Zone A	3.9	0.017	Moderate-C
1340	MCGUIRE AIR FORCE BASE STP	NPDES	CROSSWICKS CR - 668	Zone B	8.4	0.017	Moderate-C
1210	GPU GENERATION INC	NPDES	Delaware River - 918	Zone B	14.4	0.017	Moderate-C
1266	HATFIELD TWP MUN AUTH	NPDES	West Branch Neshaminy Creek - 586	Zone B	9.0	0.017	Moderate-C
1249	LONG BRANCH SEWERAGE AUTHORITY	NPDES	Pidcock Creek - 574	Zone B	8.8	0.017	Moderate-C
578	LACLEDE FAIRLESS	TRI	Queen Anne Creek - 627	Floodplain	2.9	148.765	Moderate-C
1157	MALLINCKRODT BAKER INC	NPDES	Delaware River - 914	Floodplain	17.9	0.017	Moderate-C
1177	EASTON CITY	NPDES	Delaware River - 451	Zone B	17.4	0.017	Moderate-C
1232	MAGNESIUM ELEKTRON INC	NPDES	Plum Brook - 519	Zone B	11.5	0.017	Moderate-C
1170	INGERSOLL DRESSER PUMP CO	NPDES	Delaware River - 914	Zone B	17.1	0.017	Moderate-C
515	EASTMAN WIRE & CABLE CO.	TRI	PENNSAUKEN CR - 706	Zone A	1.3	107.636	Moderate-C
1272	LANSDALE BORO	NPDES	West Branch Neshaminy Creek - 588	Zone B	9.4	0.017	Moderate-C
1192	FIBERMARK	NPDES	MUSCONETCONG R - 459	Zone B	16.6	0.017	Moderate-C
1197	BETHLEHEM CITY	NPDES	LEHIGH R - 485	Floodplain	21.4	0.026	Moderate-C
1138	WITCO CORPORATION	NPDES	Delaware River - 913	Zone B	19.2	0.017	Moderate-C
859	WILDON IND. INC.	TRI	Delaware River - 345	Zone B	24.3	403.626	Moderate-C
5726	G R O W S INC LANDFILL	RCRA	Delaware River - 649	Floodplain	2.8	0.159	Moderate-C
1512	GEORGIA PACIFIC CORPORATION	NPDES	Delaware River - 931	Floodplain	1.1	0.002	Moderate-C
5951	AMSPEC CHEMICAL CORP	RCRA	Delaware River - 932	Floodplain	2.9	0.002	Moderate-C

Source ID	Source Name	Database Used	Subwatershed	Zone	Time of Travel	Relative Impact (%)	Priority
1429	BRISTOL BORO WAT & SEW AUTH	NPDES	Mill Creek - 648	Zone A	1.6	0.017	Moderate-C
498	HOEGANAES CORP.	TRI	Delaware River - 930	Zone A	0.0	46.659	Moderate-C
1079	HOFFMAN-LA ROCHE INC	NPDES	PEQUEST R - 405	Zone B	21.9	0.017	Moderate-C
1164	HARCROS PIGMENTS INC	NPDES	Shoeneck Creek - 462	Zone B	18.4	0.017	Moderate-C
1077	BANGOR BORO AUTH	NPDES	Martins Creek - 349	Floodplain	21.4	0.017	Moderate-C

Figure 2.2.4-16 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for Metals in the Lower Delaware River Watershed

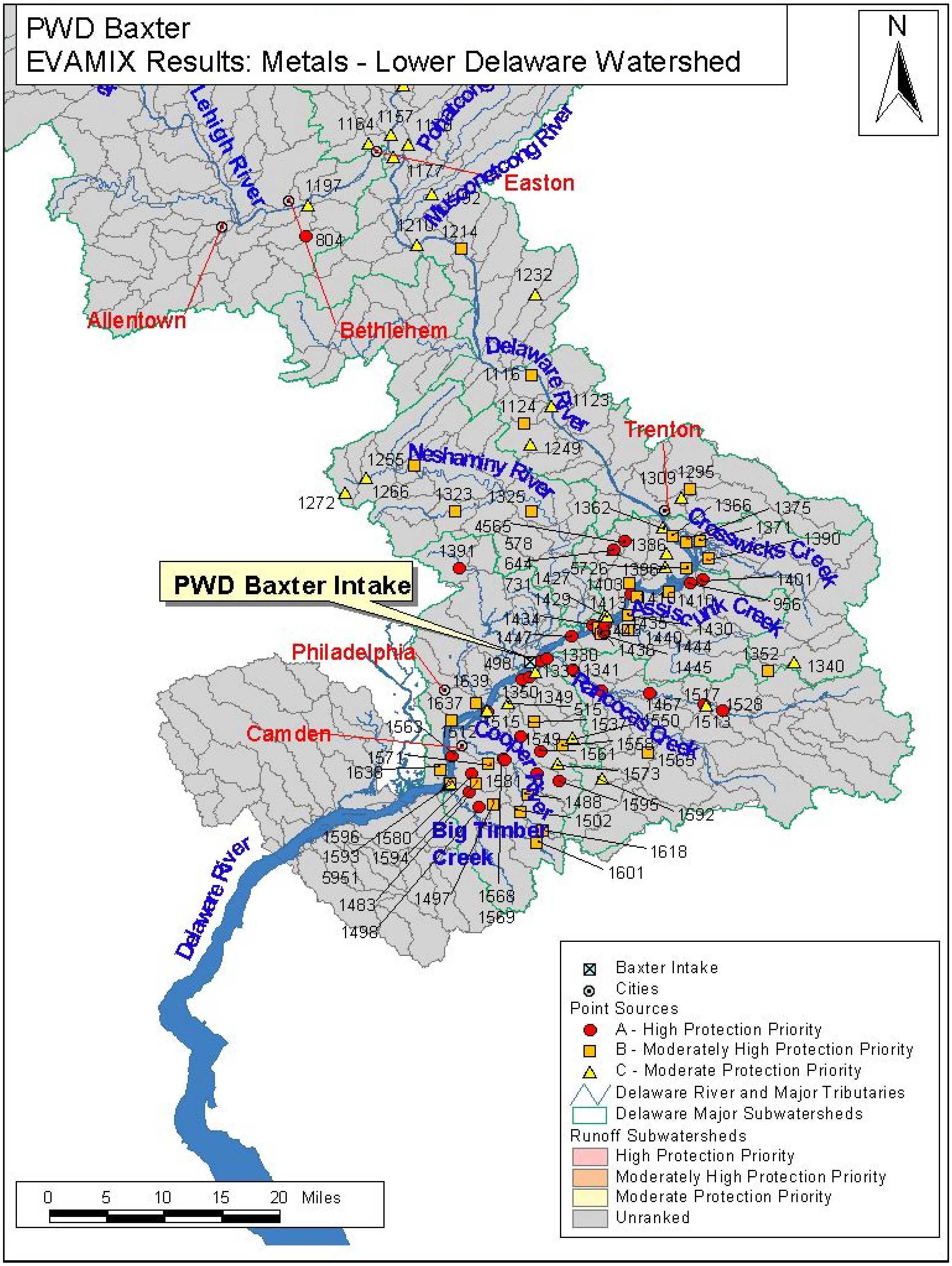


Figure 2.2.4-17 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for Metals in the Middle Delaware Watershed

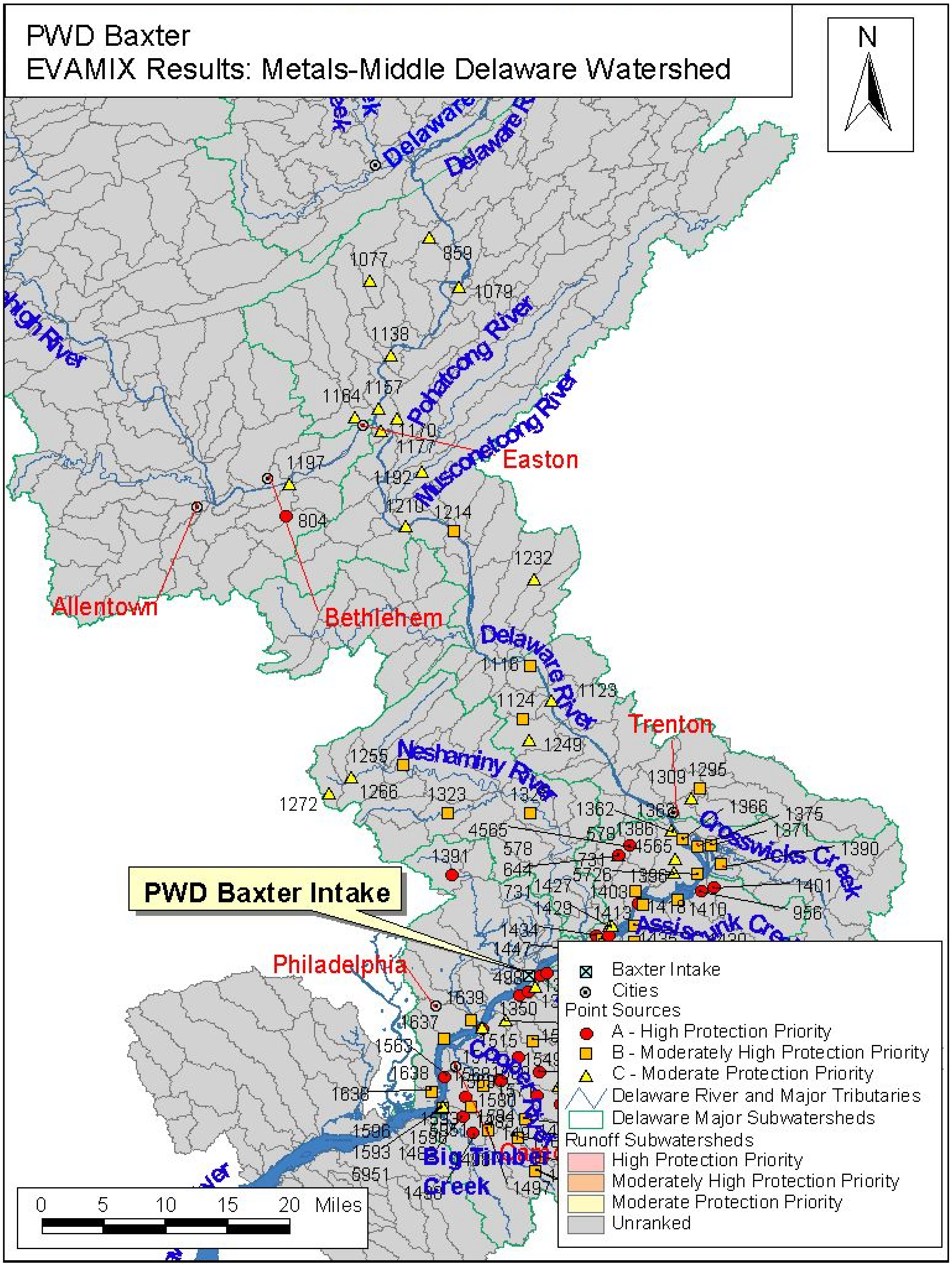
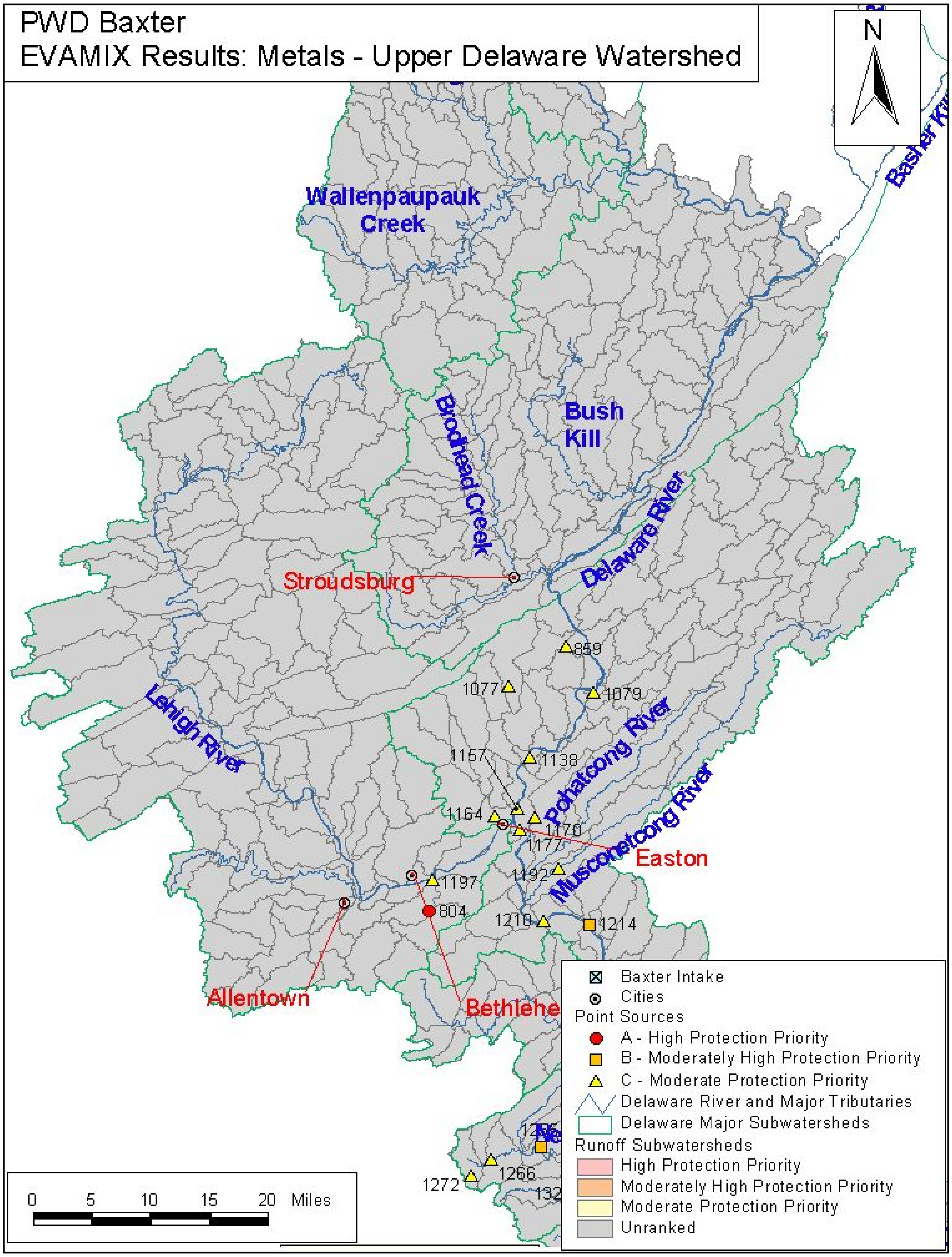


Figure 2.2.4-18 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for Metals in the Upper Delaware Watershed



Nitrates

Table 2.2.4-7 shows the ranking of sites for nitrate loading. The high category (category A) is dominated by NPDES dischargers, primarily wastewater treatment plants. Most of the loading from these sites appears to be relatively low, and is not likely to cause a cumulative impact that would cause an exceedance of the nitrate standard at the intake. Moderate priority sites (category C) are a mixture of NPDES sites and TRI sites. The potentially significant sources were located in the floodplain of the Delaware River and Zones A and B for the Baxter Intake. Therefore, efforts to reduce nitrate impacts will be necessary watershed wide. Figures 2.2.4-19 through 2.2.4-21 illustrate the priority point sources and subwatersheds for nitrates in the lower and upper Delaware River watersheds.

Table 2.2.4-7 Contaminant Category Ranking for Nitrates

Source ID	Source Name	Database Used	Subwatershed	Zone	Time of Travel	Relative Impact (%)	Priority
4462	ROHM & HAAS CROYDON	AST	Delaware River - 666	Floodplain	0.6	0.99443	Highest-A
1403	LOWER BUCKS COUNTY JOINT M.A.	NPDES	Delaware River - 649	Zone A	2.2	0.09152	Highest-A
1350	CINNAMINSON STP	NPDES	Delaware River - 930	Floodplain	0.0	0.01811	Highest-A
1515	GEORGIA PACIFIC CORPORATION	NPDES	Delaware River - 931	Floodplain	1.1	0.00009	Highest-A
1463	MT LAUREL TWP MUA	NPDES	RANCOCAS CR - 695	Zone A	1.5	0.00094	Highest-A
1332	DELRAN SEWERAGE AUTHORITY	NPDES	Delaware River - 930	Floodplain	0.2	0.00094	Highest-A
1444	COLORITE POLYMERS COMPANY	NPDES	Delaware River - 663	Floodplain	1.5	0.00094	Highest-A
1443	BURLINGTON CITY STP	NPDES	Delaware River - 663	Zone A	1.5	0.00094	Highest-A
1323	WARMINSTER TWP. MUN. AUTH.	NPDES	Little Neshaminy Creek - 610	Zone B	4.8	0.03144	Highest-A
1330	RIVERSIDE STP	NPDES	RANCOCAS CR - 680	Floodplain	0.2	0.00094	Highest-A
1563	CAMDEN COUNTY M.U.A.	NPDES	Newton Creek - 753	Floodplain	2.4	0.00009	Highest-A
1434	BRISTOL TWP WP CONTROL PLANT	NPDES	Delaware River - 661	Zone A	1.1	0.01000	Highest-A
1483	MT EPHRAIM BOROUGH OF	NPDES	BIG TIMBER CR - 769	Floodplain	3.3	0.00009	Highest-A
1447	BEVERLY SEWERAGE AUTHORITY	NPDES	Delaware River - 929	Zone A	0.7	0.00094	Highest-A
1391	UPPER MORELAND-HATBORO JNT SEW	NPDES	Robinhood Brook - 628	Zone A	2.8	0.00009	Highest-A
1549	CHERRY HILL TOWNSHIP	NPDES	South Branch Pennsauken Creek - 724	Floodplain	2.4	0.00009	Highest-A
1581	CHERRY HILL TOWNSHIP	NPDES	North Branch Cooper River - 756	Zone A	3.8	0.00009	Highest-A
1561	CHERRY HILL TOWNSHIP	NPDES	South Branch Pennsauken Creek - 724	Zone A	2.9	0.00009	Highest-A
1401	BLACK'S CREEK WWTP	NPDES	Unknown - 651	Zone A	3.5	0.00094	Highest-A
1413	FLORENCE TOWNSHIP STP	NPDES	Delaware River - 927	Zone A	2.0	0.00094	Highest-A
1349	HOEGANAES CORPORATION	NPDES	Delaware River - 930	Floodplain	0.0	0.00094	Highest-A
1595	CHERRY HILL TOWNSHIP	NPDES	North Branch Cooper River - 756	Zone A	4.2	0.00009	Highest-A
1467	MOUNT HOLLY SEWERAGE AUTHORITY	NPDES	RANCOCAS CR, N BR - 698	Floodplain	2.6	0.00094	Highest-A
1341	WILLINGBORO WATER PCP	NPDES	RANCOCAS CR - 680	Zone A	0.7	0.00094	Highest-A
1498	RUNNEMEDE SEWERAGE AUTHORITY	NPDES	BIG TIMBER CR - 769	Zone B	3.5	0.00009	Highest-A
1528	PEMBERTON	NPDES	RANCOCAS CR, N BR - 725	Floodplain	4.6	0.00094	Highest-A
1435	PSE&G BURLINGTON GENERATING ST	NPDES	Delaware River - 661	Floodplain	1.3	0.00094	Highest-A

Source ID	Source Name	Database Used	Subwatershed	Zone	Time of Travel	Relative Impact (%)	Priority
1580	WEST COLLINGSWOOD HEIGHTS STP	NPDES	Newton Creek - 753	Zone A	3.1	0.00009	Highest-A
1513	SYBRON CHEMICALS INC	NPDES	RANCOCAS CR, N BR - 689	Zone B	4.0	0.00154	Highest-A
1568	COOPER RIVER STP	NPDES	COOPER R - 738	Floodplain	2.9	0.00009	Highest-A
1569	COLES MILLS STP	NPDES	COOPER R - 738	Zone A	3.1	0.00009	Highest-A
1418	GRIFFIN PIPE PRODUCTS CO	NPDES	Delaware River - 927	Zone B	2.0	0.00094	Highest-A
1571	COLLINGSWOOD BOROUGH OF	NPDES	Newton Creek - 753	Zone B	3.3	0.00009	Highest-A
1440	LA GORCE SQUARE PLANT	NPDES	ASSISCUNK CR - 662	Zone A	1.8	0.00094	Moderately High-B
1594	AUDUBON BOROUGH STP	NPDES	Newton Creek - 753	Zone A	3.3	0.00009	Moderately High-B
1445	BURLINGTON TWP MAIN STP	NPDES	Delaware River - 663	Zone A	1.5	0.00094	Moderately High-B
1488	WOODCREST STP	NPDES	COOPER R - 760	Zone A	4.0	0.00009	Moderately High-B
1371	HAMILTON TOWNSHIP WPCF	NPDES	CROSSWICKS CR - 629	Zone B	4.0	0.00094	Moderately High-B
1558	RAMBLEWOOD STP	NPDES	PENNSAUKEN CR - 706	Zone A	2.6	0.00009	Moderately High-B
1295	EWING-LAWRENCE SA	NPDES	Pond Run - 612	Zone B	5.4	0.00094	Moderately High-B
1638	PHILADELPHIA CITY WATER DEPT -	NPDES	Delaware River - 711	Zone B	2.4	0.00009	Moderately High-B
1325	ASBURY PARK WTP	NPDES	NESHAMINY R - 601	Zone B	4.6	0.00094	Moderately High-B
1430	HERCULES INCORPORATED	NPDES	ASSISCUNK CR - 662	Zone A	1.5	0.00094	Moderately High-B
1639	PHILADELPHIA CITY WATER DEPT -	NPDES	Delaware River - 704	Zone B	1.3	0.00009	Moderately High-B
1410	ROEBLING INDUSTRIES	NPDES	Crafts Creek - 655	Floodplain	2.8	0.00094	Moderately High-B
1502	SOMERDALE BORO STP	NPDES	COOPER R - 760	Zone A	4.0	0.00009	Moderately High-B
1593	AMSPEC CHEMICAL CORP	NPDES	Delaware River - 932	Floodplain	2.9	0.00009	Moderately High-B
1375	PSE&G MERCER GENERATING STA	NPDES	Delaware River - 927	Floodplain	3.7	0.00094	Moderately High-B
1565	MEDFORD TOWNSHIP STP	NPDES	Southwest Branch South Branch - 755	Zone B	3.7	0.00094	Moderately High-B
1396	STEPAN CHEMICAL CO INC	NPDES	Delaware River - 649	Zone A	3.3	0.00094	Moderately High-B
1366	TRENTON SEWER UTILITY	NPDES	Delaware River - 927	Zone B	3.9	0.00094	Moderately High-B
1592	ELMWOOD WWTP	NPDES	Southwest Branch South Branch - 759	Zone B	4.8	0.00773	Moderately High-B
1255	CHALFONT-NEW BRITAIN TWP JOINT	NPDES	NESHAMINY R - 580	Zone B	7.9	0.00094	Moderately High-B
1352	USATC & FORT DIX (WASTEWATER)	NPDES	RANCOCAS CR, N BR - 686	Zone B	5.9	0.00094	Moderately High-B
1618	LINDENWOLD BOROUGH SEWAGE	NPDES	COOPER R - 760	Zone A	4.6	0.00009	Moderately High-B
1637	PECO ENERGY COMPANY-DELAWARE	NPDES	Delaware River - 704	Floodplain	1.6	0.00009	Moderately High-B
1497	BARRINGTON SEWER UTILITY	NPDES	BIG TIMBER CR - 769	Zone B	3.7	0.00009	Moderately High-B
1601	CLEMENTON SEWAGE AUTHORITY	NPDES	BIG TIMBER CR, N FK - 776	Zone B	5.1	0.00009	Moderately High-B
1390	CIRCUIT FOIL USA INC	NPDES	CROSSWICKS CR - 629	Zone B	4.0	0.00094	Moderately High-B
1537	MOORESTOWN TOWNSHIP STP	NPDES	PENNSAUKEN CR - 706	Floodplain	2.0	0.00009	Moderately High-B
1116	MONMOUTH CO BAYSHORE OUTFALL	NPDES	Delaware River - 559	Zone B	9.1	0.00094	Moderately High-B
1436	PUBLIC SERVICE ELECTRIC & GAS	NPDES	Delaware River - 663	Zone A	1.3	0.00094	Moderately High-B
1362	MORRISVILLE BORO MUN AUTH-STP	NPDES	Delaware River - 649	Zone B	4.3	0.00094	Moderately High-B
1550	MAPLE SHADE TOWNSHIP STP	NPDES	PENNSAUKEN CR - 706	Zone B	2.9	0.00050	Moderately High-B
1427	ROHM & HAAS COMPANY	NPDES	Mill Creek - 648	Zone A	1.6	0.00094	Moderately High-B
1596	GLOUCESTER CITY TITANIUM CO	NPDES	Delaware River - 932	Zone B	2.9	0.00009	Moderately High-B

Source ID	Source Name	Database Used	Subwatershed	Zone	Time of Travel	Relative Impact (%)	Priority
1309	FEDERATED METALS	NPDES	Pond Run - 612	Zone B	5.1	0.00094	Moderately High-B
1214	CROWN PAPER CO	NPDES	Delaware River - 919	Floodplain	13.1	0.00094	Moderate-C
1573	WOODSTREAM STP	NPDES	South Branch Pennsauken Creek - 724	Floodplain	3.3	0.00009	Moderate-C
1123	LAMBERTVILLE SEWAGE AUTHORITY	NPDES	Delaware River - 923	Zone B	8.0	0.00094	Moderate-C
1124	NORTHEAST MONMOUTH COUNTY RSA	NPDES	Pidcock Creek - 574	Zone B	8.8	0.00094	Moderate-C
1517	PEMBERTON TOWNSHIP MUA STP	NPDES	RANCOCAS CR, N BR - 699	Floodplain	4.2	0.00094	Moderate-C
1386	PRE FINISH METALS, INC.	NPDES	Delaware River - 649	Zone A	3.9	0.00094	Moderate-C
1340	MCGUIRE AIR FORCE BASE STP	NPDES	CROSSWICKS CR - 668	Zone B	8.4	0.00094	Moderate-C
1266	HATFIELD TWP MUN AUTH	NPDES	West Branch Neshaminy Creek - 586	Zone B	9.0	0.00094	Moderate-C
1210	GPU GENERATION INC	NPDES	Delaware River - 918	Zone B	14.4	0.00094	Moderate-C
1249	LONG BRANCH SEWERAGE AUTHORITY	NPDES	Pidcock Creek - 574	Zone B	8.8	0.00094	Moderate-C
1232	MAGNESIUM ELEKTRON INC	NPDES	Plum Brook - 519	Zone B	11.5	0.00094	Moderate-C
1157	MALLINCKRODT BAKER INC	NPDES	Delaware River - 914	Floodplain	17.9	0.00094	Moderate-C
1177	EASTON CITY	NPDES	Delaware River - 451	Zone B	17.4	0.00094	Moderate-C
1170	INGERSOLL DRESSER PUMP CO	NPDES	Delaware River - 914	Zone B	17.1	0.00094	Moderate-C
1272	LANSDALE BORO	NPDES	West Branch Neshaminy Creek - 588	Zone B	9.4	0.00094	Moderate-C
1512	GEORGIA PACIFIC CORPORATION	NPDES	Delaware River - 931	Floodplain	1.1	0.00009	Moderate-C
1192	FIBERMARK	NPDES	MUSCONETCONG R - 459	Zone B	16.6	0.00094	Moderate-C
1138	WITCO CORPORATION	NPDES	Delaware River - 913	Zone B	19.2	0.00094	Moderate-C
1197	BETHLEHEM CITY	NPDES	LEHIGH R - 485	Floodplain	21.4	0.00094	Moderate-C
1429	BRISTOL BORO WAT & SEW AUTH	NPDES	Mill Creek - 648	Zone A	1.6	0.00094	Moderate-C
498	HOEGANAES CORP.	TRI	Delaware River - 930	Zone A	0.0	0.01211	Moderate-C
1395	UNITED STATES STEEL GROUP-USX	NPDES	Delaware River - 649	Zone A	2.9	0.00094	Moderate-C
841	ASHLAND CHEMICAL INC.	TRI	LEHIGH R - 474	Floodplain	18.7	0.08991	Moderate-C
1164	HARCROS PIGMENTS INC	NPDES	Shoeneck Creek - 462	Zone B	18.4	0.00094	Moderate-C
1079	HOFFMAN-LA ROCHE INC	NPDES	PEQUEST R - 405	Zone B	21.9	0.00094	Moderate-C
644	USS FAIRLESS WORKS	TRI	Queen Anne Creek - 627	Floodplain	2.9	0.03028	Moderate-C
757	SOLVAY AUTOMOTIVE INC.	TRI	Mill Creek - 648	Zone B	2.0	0.02099	Moderate-C
1077	BANGOR BORO AUTH	NPDES	Martins Creek - 349	Floodplain	21.4	0.00094	Moderate-C
1153	NAZARETH BORO MUN AUTH	NPDES	Shoeneck Creek - 453	Zone B	20.3	0.00094	Moderate-C
641	CORCO CHEMICAL CORP.	TRI	Queen Anne Creek - 627	Floodplain	2.9	0.00462	Moderate-C
1088	WIND GAP MUN AUTH	NPDES	Unknown - 444	Floodplain	21.9	0.00175	Moderate-C
528	WILLING B WIRE CORP.	TRI	RANCOCAS CR - 676	Zone A	1.5	0.00154	Moderate-C
569	CUMBERLAND FARMS INC.	TRI	ASSISCUNK CR - 662	Zone A	2.2	0.00323	Moderate-C

Figure 2.2.4-19 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for Nitrates in the Lower Delaware Watershed

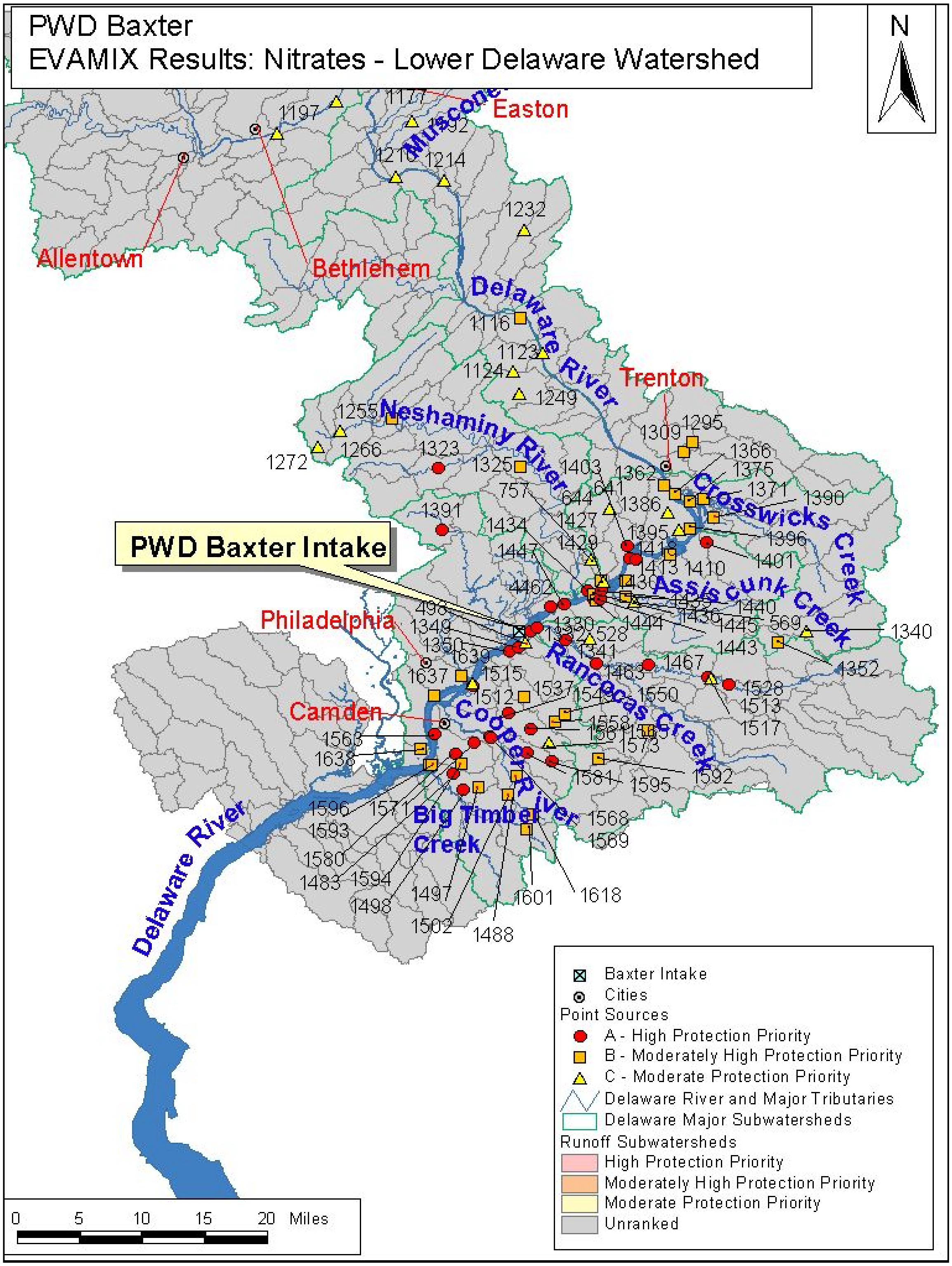


Figure 2.2.4-20 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for Nitrates in the Middle Delaware Watershed

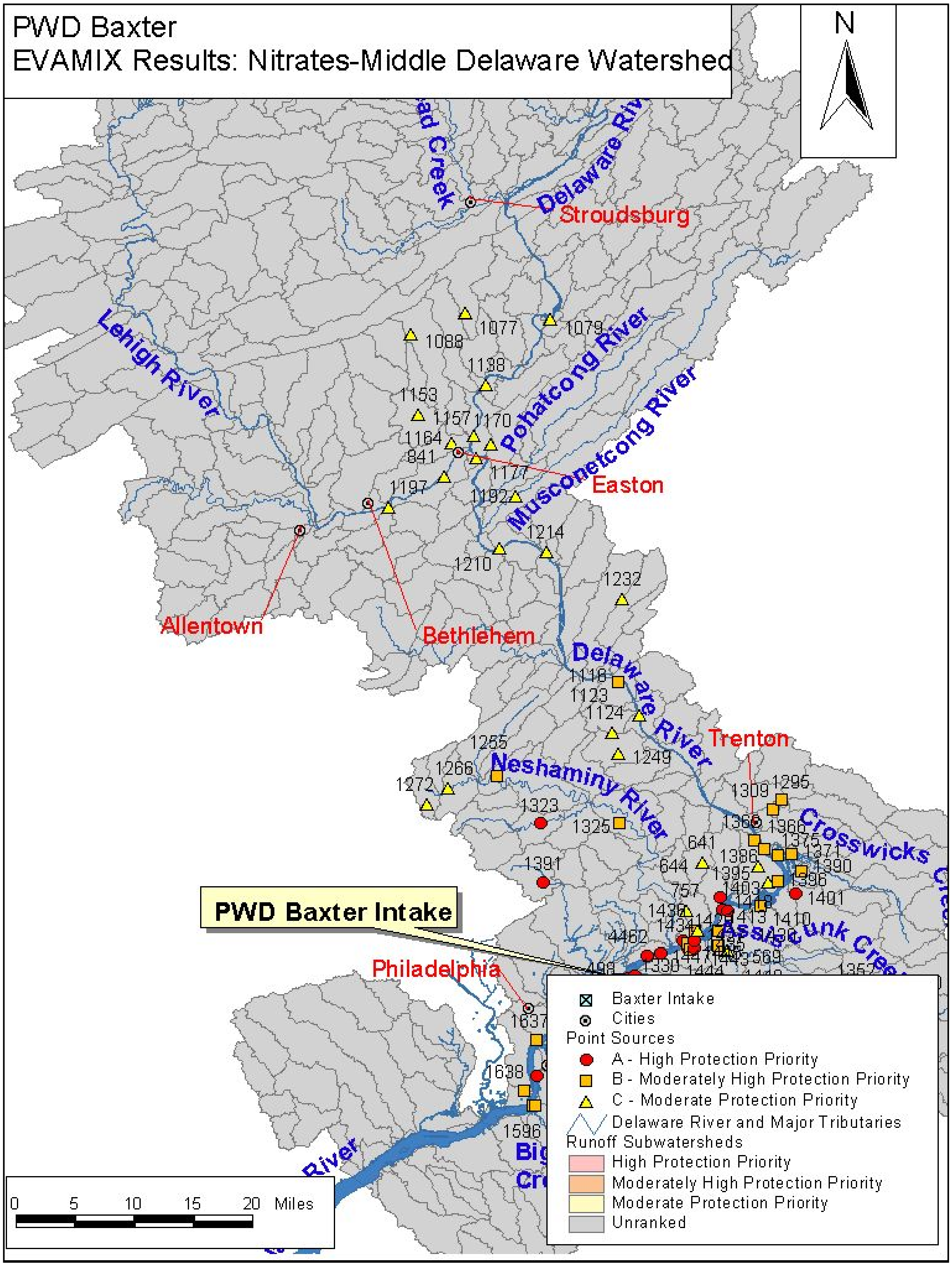
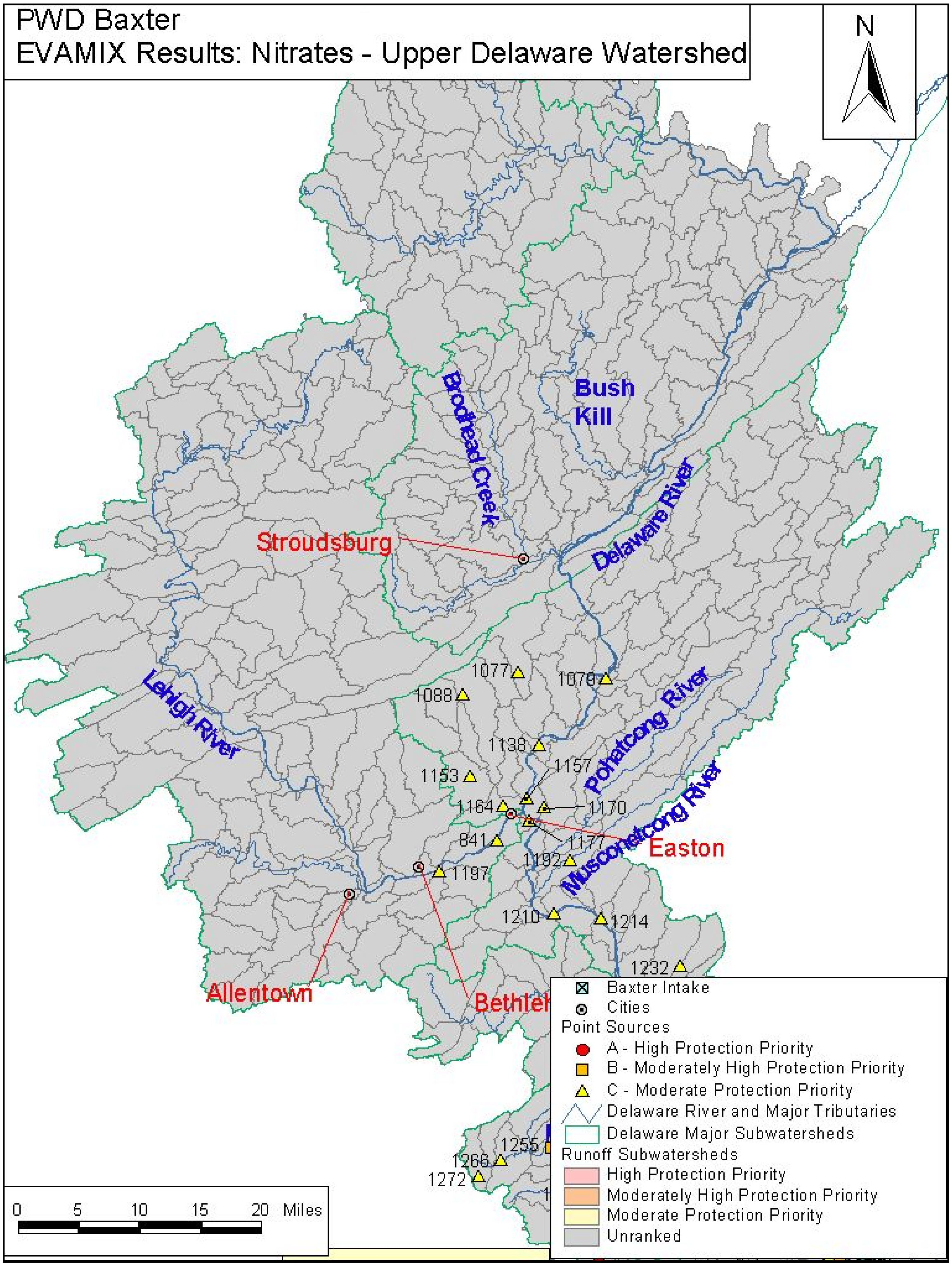


Figure 2.2.4-21 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for Nitrates in the Upper Delaware Watershed



Petroleum Hydrocarbons

The number of significant sources of petroleum hydrocarbons are shown in Table 2.2.4-8. Above ground storage tanks containing fuel, NPDES sites or stormwater runoff were identified as significant potential sources of petroleum hydrocarbon loading. Most of the high priority sites are either fuel storage facilities (with a low probability of release but potentially very high concentrations), NPDES sites with relatively low loadings, or stormwater runoff with lower concentrations but frequent occurrence. All of the potentially significant sources of AST identified were a geographic mixture of locations in the Zone A and Zone B. Fourteen non-point source runoff subwatersheds were identified as potentially significant sources of high protection priority and 11 as moderately high priorities. Figures 2.2.4-22 through 2.2.4-24 illustrate the priority point sources and subwatersheds for petroleum hydrocarbons in the Delaware River watershed. Most of the high priority subwatersheds are located in the upper portion of the watershed, including Lehigh and Musconetcong Creeks.

Table 2.2.4-8 Contaminant Category Ranking for Petroleum Hydrocarbons

Source ID	Source Name	Database Used	Subwatershed	Zone	Time of Travel	Relative Impact (%)	Priority
4654	GILBERT TERM	AST	Saucon Creek - 494	Zone B	17.1	21551.363	Highest-A
4565	US STEEL FAIRLESS WORKS	AST	Martins Creek - 616	Zone A	3.1	17236.847	Highest-A
4459	CROYDON GENERATING STA	AST	Delaware River - 666	Zone A	0.6	16706.483	Highest-A
5036	MEENAN OIL LP	AST	Delaware River - 597	Zone B	5.4	14570.286	Highest-A
1375	PSE&G MERCER GENERATING STA	NPDES	Delaware River - 927	Floodplain	3.7	9.539E-05	Highest-A
1214	CROWN PAPER CO	NPDES	Delaware River - 919	Floodplain	13.1	0.0037304	Highest-A
1513	SYBRON CHEMICALS INC	NPDES	RANCOCAS CR, N BR - 689	Zone B	4.0	0.027027	Highest-A
1390	CIRCUIT FOIL USA INC	NPDES	CROSSWICKS CR - 629	Zone B	4.0	0.0002544	Highest-A
1198	BETHLEHEM STEEL - BETHLEHEM	NPDES	LEHIGH R - 485	Zone B	21.4	1.1284555	Highest-A
90649	Delaware River-649	NP	Delaware River - 649	Zone A	1.3	0.1196412	Highest-A
90651	Unknown-651	NP	Unknown - 651	Zone A	3.3	0.1153142	Highest-A
5055	WARMINSTER BULK PLT	AST	Little Neshaminy Creek - 613	Zone B	4.2	6364.3745	Highest-A
90672	Barkers Brook-672	NP	Barkers Brook - 672	Zone B	3.5	0.1073159	Highest-A
90623	DOCTORS CR-623	NP	DOCTORS CR - 623	Zone B	4.4	0.1089153	Highest-A
90752	RANCOCAS CR-752	NP	RANCOCAS CR - 752	Zone B	4.4	0.1074457	Highest-A
90583	NESHAMINY R-583	NP	NESHAMINY R - 583	Zone B	5.1	0.1715621	Highest-A
90572	Delaware River-572	NP	Delaware River - 572	Zone B	5.9	0.0941263	Highest-A
1395	UNITED STATES STEEL GROUP-USX	NPDES	Delaware River - 649	Zone A	2.9	0.4340213	Highest-A
90496	Nishisakawick Creek-496	NP	Nishisakawick Creek - 496	Zone B	12.8	0.1288676	Highest-A
90484	Hakihokake Creek-484	NP	Hakihokake Creek - 484	Zone B	13.4	0.1083365	Highest-A
90459	MUSCONETCONG R-459	NP	MUSCONETCONG R - 459	Zone B	15.5	0.2466218	Highest-A
90525	Cooks Creek-525	NP	Cooks Creek - 525	Zone B	16.8	0.1143867	Highest-A
90443	Lopatcong Creek-443	NP	Lopatcong Creek - 443	Zone B	17.6	0.1184753	Highest-A
90394	POHATCONG R-394	NP	POHATCONG R - 394	Zone B	17.9	0.3220462	Highest-A

Source ID	Source Name	Database Used	Subwatershed	Zone	Time of Travel	Relative Impact (%)	Priority
90512	Saucon Creek-512	NP	Saucon Creek - 512	Zone B	17.9	0.093902	Highest-A
90453	Shoeneck Creek-453	NP	Shoeneck Creek - 453	Zone B	19.2	0.1341673	Moderately High-B
90444	Unknown-444	NP	Unknown - 444	Zone B	19.5	0.2137611	Moderately High-B
90415	Unknown-415	NP	Unknown - 415	Zone B	19.8	0.1508291	Moderately High-B
90393	Martins Creek-393	NP	Martins Creek - 393	Zone B	19.8	0.106943	Moderately High-B
90406	Unknown-406	NP	Unknown - 406	Zone B	19.8	0.0933621	Moderately High-B
90422	Buckhorn Creek-422	NP	Buckhorn Creek - 422	Zone B	20.3	0.0992126	Moderately High-B
90389	Oughoughton Creek-389	NP	Oughoughton Creek - 389	Zone B	20.6	0.1146208	Moderately High-B
90349	Martins Creek-349	NP	Martins Creek - 349	Zone B	20.8	0.1853983	Moderately High-B
90378	Waltz Creek-378	NP	Waltz Creek - 378	Zone B	20.8	0.1003107	Moderately High-B
90470	Monocacy Creek-470	NP	Monocacy Creek - 470	Zone B	21.4	0.160758	Moderately High-B
90371	PEQUEST R-371	NP	PEQUEST R - 371	Zone B	23.5	0.1322657	Moderately High-B
4446	COLMAR TERM	AST	West Branch Neshaminy Creek - 586	Zone B	9.0	3977.734	Moderately High-B
3666	TORRESDALE FUEL CO INC	AST	Delaware River - 690	Zone A	0.4	53.036454	Moderately High-B
4449	YELLOW FREIGHT SYS	AST	Delaware River - 666	Zone A	0.7	53.036454	Moderately High-B
4333	PENSKE TRUCK LEASING	AST	NESHAMINY R - 657	Zone A	1.5	53.036454	Moderately High-B
4396	EGGERT FUELS	AST	Mill Creek - 648	Zone A	1.6	53.036454	Moderately High-B
4403	DIAL	AST	Delaware River - 649	Zone A	1.8	63.643745	Moderately High-B
4576	SAFETY KLEEN CORP FAIRLESS HILLS BRANCH	AST	Queen Anne Creek - 627	Zone A	2.9	53.036454	Moderately High-B
4817	CHEMCENTRAL PHILA	AST	Delaware River - 649	Zone A	3.9	53.036454	Moderately High-B
4389	3M CO	AST	Mill Creek - 648	Zone B	2.4	530.36454	Moderately High-B
4856	SKILLMAN OIL	AST	Delaware River - 567	Floodplain	8.3	79.554681	Moderately High-B
4317	ATKINSON FREIGHT LINES CORP	AST	Delaware River - 666	Zone B	0.6	53.036454	Moderately High-B
4314	PENSKE TRUCK LEASING CO LP	AST	Delaware River - 666	Zone B	0.7	53.036454	Moderately High-B
4633	WILLOW GROVE TERM	AST	Robinhood Brook - 628	Zone B	2.8	278.44138	Moderately High-B
4870	WILLIAM W FABIAN & SON INC	AST	Newtown Creek - 600	Zone B	4.0	418.98799	Moderately High-B
4991	SINKLER INC	AST	Robinhood Brook - 633	Zone B	2.8	265.18227	Moderate-C
5050	DRYDEN OIL CO OF PA INC	AST	Little Neshaminy Creek - 613	Zone B	4.2	79.554681	Moderate-C
4962	DALE WOOD CO	AST	Delaware River - 808	Floodplain	15.0	265.18227	Moderate-C
4812	AMER TRANS FREIGHT	AST	Delaware River - 649	Zone B	4.3	53.036454	Moderate-C
4442	AEP COLMAR	AST	West Branch Neshaminy Creek - 586	Zone B	9.2	106.07291	Moderate-C
4130	NORTHAMPTON FARM BUR COOP	AST	Unknown - 444	Floodplain	19.8	53.036454	Moderate-C
4916	HAROLD MYERS	AST	Cabin Run - 558	Zone B	12.8	53.036454	Moderate-C

Source ID	Source Name	Database Used	Subwatershed	Zone	Time of Travel	Relative Impact (%)	Priority
4050	WIND GAP OIL STORAGE	AST	Unknown - 444	Zone B	22.2	556.88277	Moderate-C
4521	AERNI & HITZEL FUEL INC	AST	LEHIGH R - 474	Zone B	17.9	53.036454	Moderate-C
4063	UNION FUEL CO	AST	Shoeneck Creek - 462	Zone B	17.9	53.036454	Moderate-C
4074	DEITER BROS FUEL CO INC	AST	LEHIGH R - 934	Zone B	21.1	212.14582	Moderate-C
4601	FRITCH INC	AST	Unknown - 477	Zone B	20.6	79.554681	Moderate-C
4048	FOGELS FUEL SVC	AST	Shoeneck Creek - 453	Zone B	20.6	53.036454	Moderate-C
4289	MARTINS CREEK STEAM ELEC STA	AST	Delaware River - 399	Zone B	20.8	53.036454	Moderate-C
4342	LEHIGH HEAVY FORGE CORP	AST	LEHIGH R - 485	Zone B	21.4	78.228769	Moderate-C
4046	REIMER BROS	AST	Waltz Creek - 378	Zone B	22.2	159.10936	Moderate-C
3874	ALLENTOWN CTL OFC	AST	LEHIGH R - 934	Zone B	21.4	53.036454	Moderate-C
4128	SZILAGYI FUEL	AST	LEHIGH R - 485	Zone B	21.4	53.036454	Moderate-C
4092	WS REICHENBACH & SON INC	AST	LEHIGH R - 485	Zone B	21.4	53.036454	Moderate-C
4172	PENSKE TRUCK LEASING CO LP	AST	Unknown - 477	Zone B	21.6	53.036454	Moderate-C
4290	HOWER & SON	AST	Waltz Creek - 378	Zone B	21.9	53.036454	Moderate-C
4186	JOHN GOFFREDO & SONS INC	AST	Waltz Creek - 378	Zone B	21.9	53.036454	Moderate-C
4190	R R CORTAZZO	AST	Unknown - 444	Zone B	22.2	53.036454	Moderate-C
3849	TRANS BRIDGE LINES INC	AST	Monocacy Creek - 470	Zone B	22.4	53.036454	Moderate-C

Figure 2.2.4-22 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for Petroleum Hydrocarbons in the Lower Delaware River Watershed

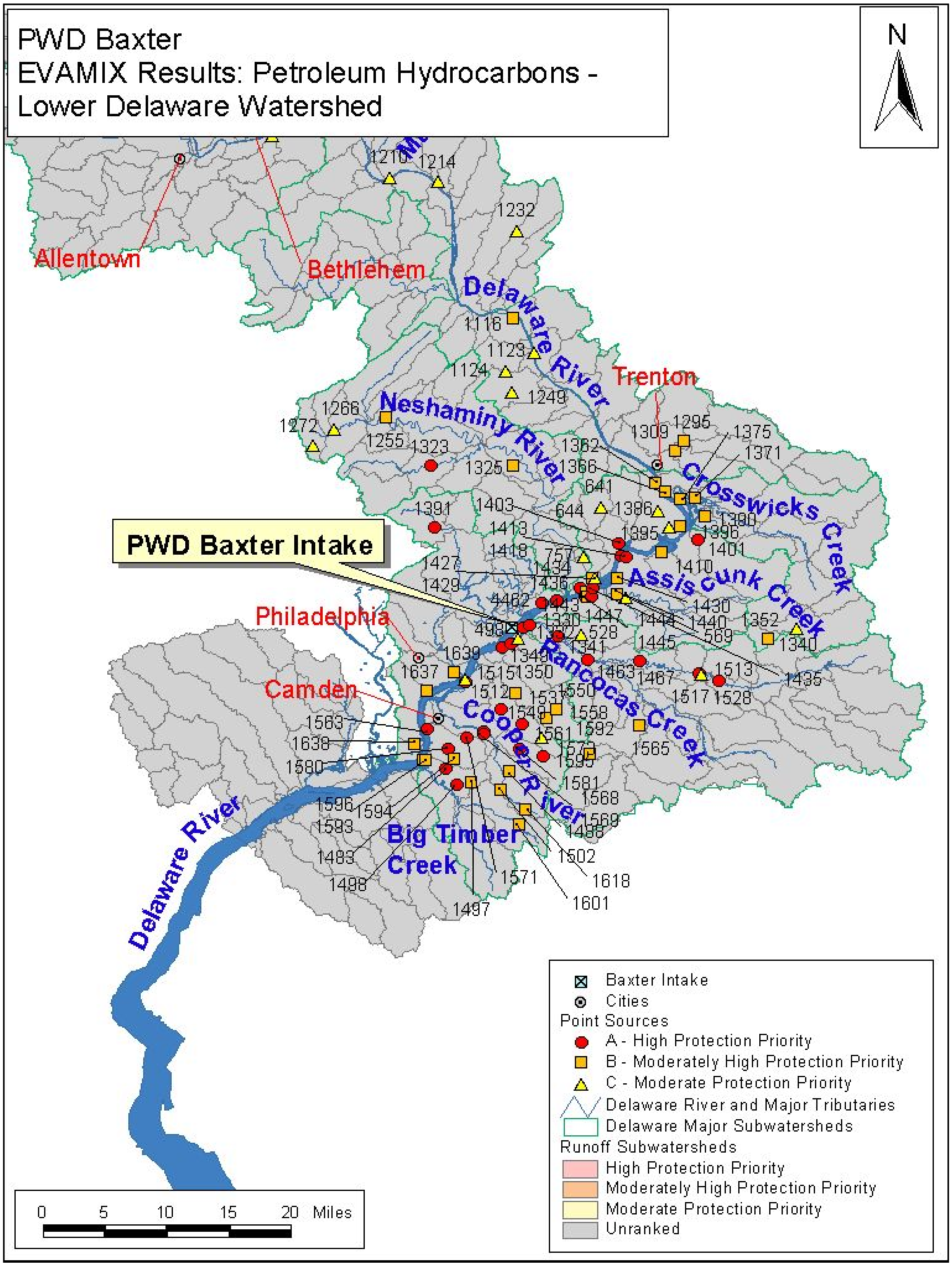


Figure 2.2.4-23 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for Petroleum Hydrocarbons in the Middle Delaware River Watershed

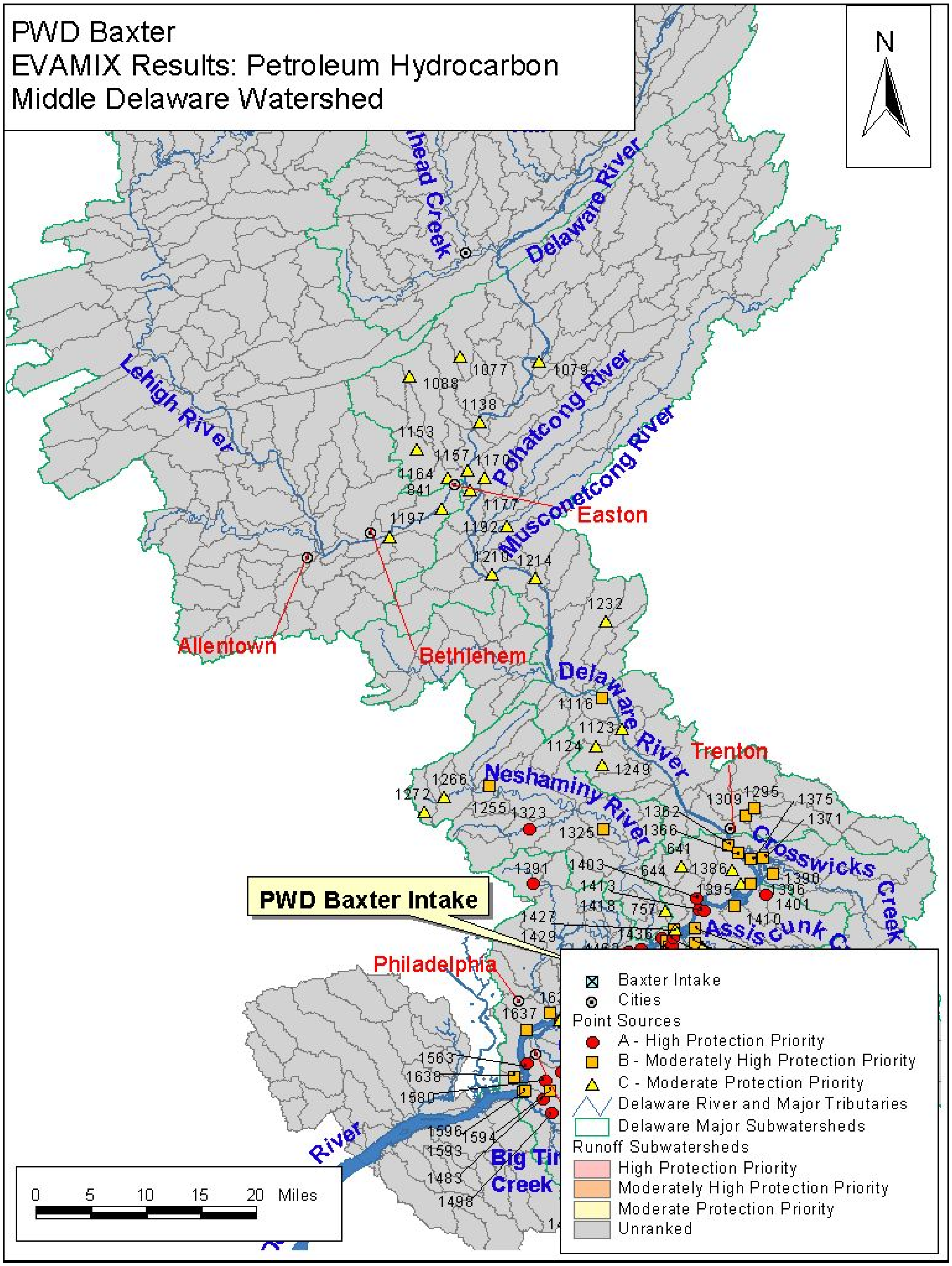
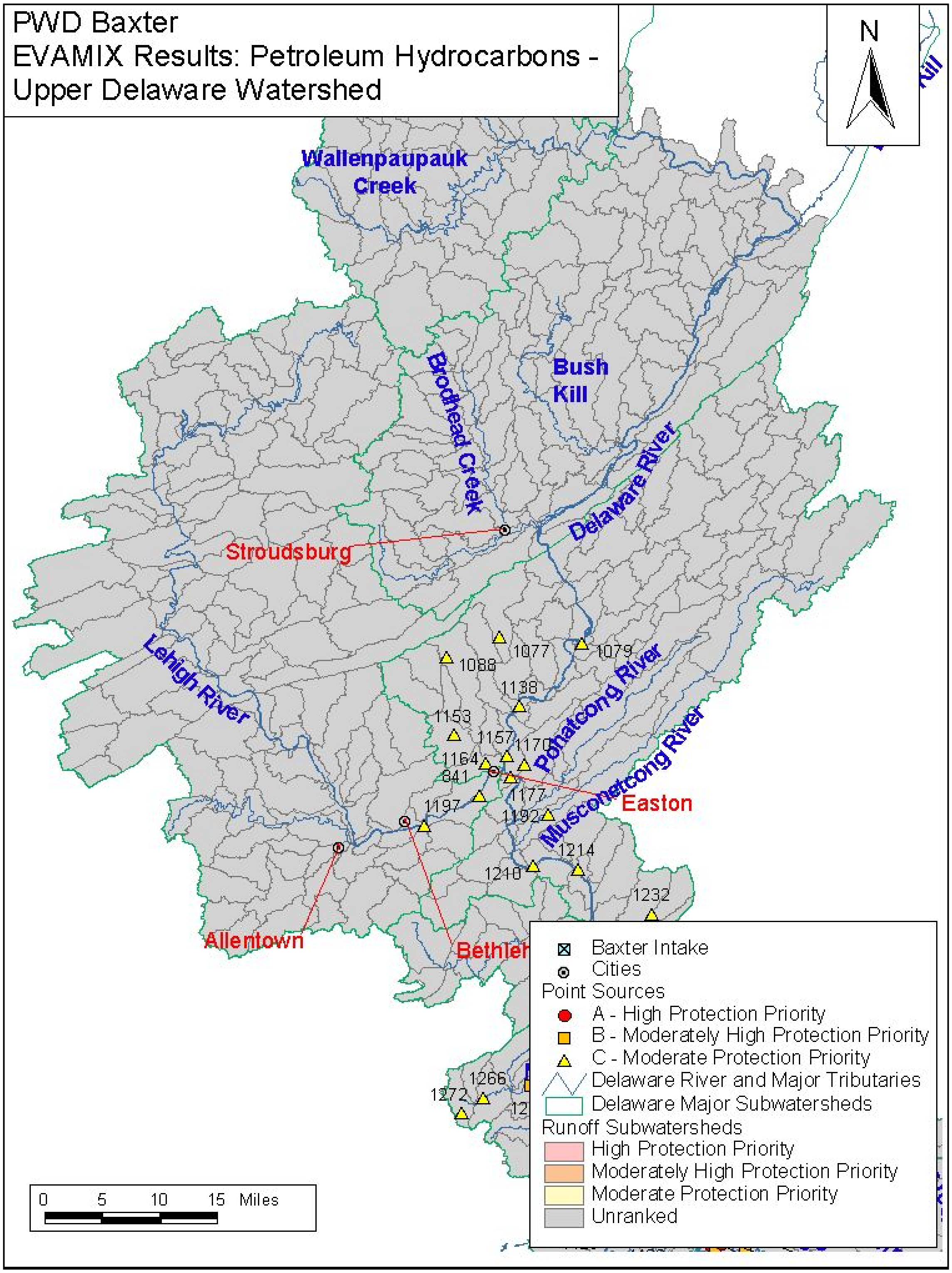


Figure 2.2.4-24 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for Petroleum Hydrocarbons in the Upper Delaware River Watershed



Phosphorus

Table 2.2.4-9 shows the ranking of sites for phosphorus loading. Like nitrates, the high protection priority category (category A) is dominated by NPDES dischargers, primarily wastewater treatment plants. Most of the loading from these sites appears to be relatively low, and is not likely to cause a cumulative impact that would cause significant water quality impairment at the intake. There is one AST site that is also included in the high category, primarily due to the high potential concentrations should a spill occur. Moderate priority sites are mainly NPDES and one TRI site. A large majority of the potentially significant sources were located in the drainage areas along the mainstem Delaware River. Figures 2.2.4-25 through 2.2.4-27 illustrate the priority point sources and subwatersheds for phosphorous in the lower and upper Delaware River Watersheds.

Table 2.2.4-9 Contaminant Category Ranking for Phosphorus

Source ID	Source Name	Database Used	Subwatershed	Zone	Time of Travel	Relative Impact (%)	Priority
4565	US STEEL FAIRLESS WORKS	AST	Martins Creek - 616	Zone A	3.1	23.369	Highest-A
637	RHONE-POULENC BASIC CHEMICALS DIV. OF RHONE-POULEN	TRI	Delaware River - 649	Zone B	3.9	4.667	Highest-A
1515	GEORGIA PACIFIC CORPORATION	NPDES	Delaware River - 931	Floodplain	1.1	0.001	Highest-A
1463	MT LAUREL TWP MUA	NPDES	RANCOCAS CR - 695	Zone A	1.5	0.011	Highest-A
1332	DELRAN SEWERAGE AUTHORITY	NPDES	Delaware River - 930	Floodplain	0.2	0.011	Highest-A
1444	COLORITE POLYMERS COMPANY	NPDES	Delaware River - 663	Floodplain	1.5	0.011	Highest-A
1443	BURLINGTON CITY STP	NPDES	Delaware River - 663	Zone A	1.5	0.011	Highest-A
1330	RIVERSIDE STP	NPDES	RANCOCAS CR - 680	Floodplain	0.2	0.011	Highest-A
1563	CAMDEN COUNTY M.U.A.	NPDES	Newton Creek - 753	Floodplain	2.4	0.001	Highest-A
1483	MT EPHRAIM BOROUGH OF	NPDES	BIG TIMBER CR - 769	Floodplain	3.3	0.001	Highest-A
1350	CINNAMINSON STP	NPDES	Delaware River - 930	Floodplain	0.0	0.011	Highest-A
1447	BEVERLY SEWERAGE AUTHORITY	NPDES	Delaware River - 929	Zone A	0.7	0.011	Highest-A
1391	UPPER MORELAND-HATBORO JNT SEW	NPDES	Robinhood Brook - 628	Zone A	2.8	0.001	Highest-A
1549	CHERRY HILL TOWNSHIP	NPDES	South Branch Pennsauken Creek - 724	Floodplain	2.4	0.001	Highest-A
1434	BRISTOL TWP WP CONTROL PLANT	NPDES	Delaware River - 661	Zone A	1.1	0.011	Highest-A
1581	CHERRY HILL TOWNSHIP	NPDES	North Branch Cooper River - 756	Zone A	3.8	0.001	Highest-A
1561	CHERRY HILL TOWNSHIP	NPDES	South Branch Pennsauken Creek - 724	Zone A	2.9	0.001	Highest-A
1401	BLACK'S CREEK WWTP	NPDES	Unknown - 651	Zone A	3.5	0.011	Highest-A
1413	FLORENCE TOWNSHIP STP	NPDES	Delaware River - 927	Zone A	2.0	0.011	Highest-A
1349	HOEGANAES CORPORATION	NPDES	Delaware River - 930	Floodplain	0.0	0.011	Highest-A
1323	WARMINSTER TWP. MUN. AUTH.	NPDES	Little Neshaminy Creek - 610	Zone B	4.8	0.287	Highest-A
1595	CHERRY HILL TOWNSHIP	NPDES	North Branch Cooper River - 756	Zone A	4.2	0.001	Highest-A
1341	WILLINGBORO WATER PCP	NPDES	RANCOCAS CR - 680	Zone A	0.7	0.011	Highest-A
1467	MOUNT HOLLY SEWERAGE AUTHORITY	NPDES	RANCOCAS CR, N BR - 698	Floodplain	2.6	0.011	Highest-A
1498	RUNNEMEDE SEWERAGE AUTHORITY	NPDES	BIG TIMBER CR - 769	Zone B	3.5	0.001	Highest-A
1528	PEMBERTON	NPDES	RANCOCAS CR, N BR - 725	Floodplain	4.6	0.011	Highest-A

Source ID	Source Name	Database Used	Subwatershed	Zone	Time of Travel	Relative Impact (%)	Priority
1435	PSE&G BURLINGTON GENERATING ST	NPDES	Delaware River - 661	Floodplain	1.3	0.011	Highest-A
1580	WEST COLLINGSWOOD HEIGHTS STP	NPDES	Newton Creek - 753	Zone A	3.1	0.001	Highest-A
1569	COLES MILLS STP	NPDES	COOPER R - 738	Zone A	3.1	0.001	Highest-A
1568	COOPER RIVER STP	NPDES	COOPER R - 738	Floodplain	2.9	0.001	Highest-A
1513	SYBRON CHEMICALS INC	NPDES	RANCOCAS CR, N BR - 689	Zone B	4.0	0.011	Highest-A
1571	COLLINGSWOOD BOROUGH OF	NPDES	Newton Creek - 753	Zone B	3.3	0.001	Highest-A
1418	GRIFFIN PIPE PRODUCTS CO	NPDES	Delaware River - 927	Zone B	2.0	0.011	Highest-A
1440	LA GORCE SQUARE PLANT	NPDES	ASSISCUNK CR - 662	Zone A	1.8	0.011	Moderately High-B
1594	AUDUBON BOROUGH STP	NPDES	Newton Creek - 753	Zone A	3.3	0.001	Moderately High-B
1445	BURLINGTON TWP MAIN STP	NPDES	Delaware River - 663	Zone A	1.5	0.011	Moderately High-B
1488	WOODCREST STP	NPDES	COOPER R - 760	Zone A	4.0	0.001	Moderately High-B
1371	HAMILTON TOWNSHIP WPCF	NPDES	CROSSWICKS CR - 629	Zone B	4.0	0.011	Moderately High-B
1558	RAMBLEWOOD STP	NPDES	PENNSAUKEN CR - 706	Zone A	2.6	0.001	Moderately High-B
1295	EWING-LAWRENCE SA	NPDES	Pond Run - 612	Zone B	5.4	0.011	Moderately High-B
1638	PHILADELPHIA CITY WATER DEPT -	NPDES	Delaware River - 711	Zone B	2.4	0.001	Moderately High-B
1430	HERCULES INCORPORATED	NPDES	ASSISCUNK CR - 662	Zone A	1.5	0.011	Moderately High-B
1639	PHILADELPHIA CITY WATER DEPT -	NPDES	Delaware River - 704	Zone B	1.3	0.001	Moderately High-B
1325	ASBURY PARK WTP	NPDES	NESHAMINY R - 601	Zone B	4.6	0.011	Moderately High-B
1502	SOMERDALE BORO STP	NPDES	COOPER R - 760	Zone A	4.0	0.001	Moderately High-B
1410	ROEBLING INDUSTRIES	NPDES	Crafts Creek - 655	Floodplain	2.8	0.011	Moderately High-B
1593	AMSPEC CHEMICAL CORP	NPDES	Delaware River - 932	Floodplain	2.9	0.001	Moderately High-B
1403	LOWER BUCKS COUNTY JOINT M.A.	NPDES	Delaware River - 649	Zone A	2.2	0.011	Moderately High-B
1375	PSE&G MERCER GENERATING STA	NPDES	Delaware River - 927	Floodplain	3.7	0.011	Moderately High-B
1565	MEDFORD TOWNSHIP STP	NPDES	Southwest Branch South Branch - 755	Zone B	3.7	0.011	Moderately High-B
1396	STEPAN CHEMICAL CO INC	NPDES	Delaware River - 649	Zone A	3.3	0.011	Moderately High-B
1366	TRENTON SEWER UTILITY	NPDES	Delaware River - 927	Zone B	3.9	0.011	Moderately High-B
1637	PECO ENERGY COMPANY-DELAWARE	NPDES	Delaware River - 704	Floodplain	1.6	0.001	Moderately High-B
1352	USATC & FORT DIX (WASTEWATER)	NPDES	RANCOCAS CR, N BR - 686	Zone B	5.9	0.011	Moderately High-B
1618	LINDENWOLD BOROUGH SEWAGE	NPDES	COOPER R - 760	Zone A	4.6	0.001	Moderately High-B
1255	CHALFONT-NEW BRITAIN TWP JOINT	NPDES	NESHAMINY R - 580	Zone B	7.9	0.011	Moderately High-B
1497	BARRINGTON SEWER UTILITY	NPDES	BIG TIMBER CR - 769	Zone B	3.7	0.001	Moderately High-B
1537	MOORESTOWN TOWNSHIP STP	NPDES	PENNSAUKEN CR - 706	Floodplain	2.0	0.001	Moderately High-B
1601	CLEMENTON SEWAGE AUTHORITY	NPDES	BIG TIMBER CR, N FK - 776	Zone B	5.1	0.001	Moderately High-B

Source ID	Source Name	Database Used	Subwatershed	Zone	Time of Travel	Relative Impact (%)	Priority
1390	CIRCUIT FOIL USA INC	NPDES	CROSSWICKS CR - 629	Zone B	4.0	0.011	Moderately High-B
1436	PUBLIC SERVICE ELECTRIC & GAS	NPDES	Delaware River - 663	Zone A	1.3	0.011	Moderately High-B
1592	ELMWOOD WWTP	NPDES	Southwest Branch South Branch - 759	Zone B	4.8	0.081	Moderately High-B
1362	MORRISVILLE BORO MUN AUTH-STP	NPDES	Delaware River - 649	Zone B	4.3	0.011	Moderately High-B
1116	MONMOUTH CO BAYSHORE OUTFALL	NPDES	Delaware River - 559	Zone B	9.1	0.011	Moderately High-B
1427	ROHM & HAAS COMPANY	NPDES	Mill Creek - 648	Zone A	1.6	0.011	Moderately High-B
1550	MAPLE SHADE TOWNSHIP STP	NPDES	PENNSAUKEN CR - 706	Zone B	2.9	0.004	Moderately High-B
1596	GLOUCESTER CITY TITANIUM CO	NPDES	Delaware River - 932	Zone B	2.9	0.001	Moderately High-B
1309	FEDERATED METALS	NPDES	Pond Run - 612	Zone B	5.1	0.011	Moderate-C
1573	WOODSTREAM STP	NPDES	South Branch Pennsauken Creek - 724	Floodplain	3.3	0.001	Moderate-C
1214	CROWN PAPER CO	NPDES	Delaware River - 919	Floodplain	13.1	0.011	Moderate-C
1123	LAMBERTVILLE SEWAGE AUTHORITY	NPDES	Delaware River - 923	Zone B	8.0	0.011	Moderate-C
1124	NORTHEAST MONMOUTH COUNTY RSA	NPDES	Pidcock Creek - 574	Zone B	8.8	0.011	Moderate-C
1517	PEMBERTON TOWNSHIP MUA STP	NPDES	RANCOCAS CR, N BR - 699	Floodplain	4.2	0.011	Moderate-C
1386	PRE FINISH METALS, INC.	NPDES	Delaware River - 649	Zone A	3.9	0.011	Moderate-C
1340	MCGUIRE AIR FORCE BASE STP	NPDES	CROSSWICKS CR - 668	Zone B	8.4	0.011	Moderate-C
1266	HATFIELD TWP MUN AUTH	NPDES	West Branch Neshaminy Creek - 586	Zone B	9.0	0.011	Moderate-C
1249	LONG BRANCH SEWERAGE AUTHORITY	NPDES	Pidcock Creek - 574	Zone B	8.8	0.011	Moderate-C
1210	GPU GENERATION INC	NPDES	Delaware River - 918	Zone B	14.4	0.011	Moderate-C
1232	MAGNESIUM ELEKTRON INC	NPDES	Plum Brook - 519	Zone B	11.5	0.011	Moderate-C
841	ASHLAND CHEMICAL INC.	TRI	LEHIGH R - 474	Floodplain	18.7	2.573	Moderate-C
1157	MALLINCKRODT BAKER INC	NPDES	Delaware River - 914	Floodplain	17.9	0.011	Moderate-C
1177	EASTON CITY	NPDES	Delaware River - 451	Zone B	17.4	0.011	Moderate-C
1512	GEORGIA PACIFIC CORPORATION	NPDES	Delaware River - 931	Floodplain	1.1	0.001	Moderate-C
1272	LANSDALE BORO	NPDES	West Branch Neshaminy Creek - 588	Zone B	9.4	0.011	Moderate-C
1170	INGERSOLL DRESSER PUMP CO	NPDES	Delaware River - 914	Zone B	17.1	0.011	Moderate-C
1192	FIBERMARK	NPDES	MUSCONETCONG R - 459	Zone B	16.6	0.011	Moderate-C
1429	BRISTOL BORO WAT & SEW AUTH	NPDES	Mill Creek - 648	Zone A	1.6	0.011	Moderate-C
1138	WITCO CORPORATION	NPDES	Delaware River - 913	Zone B	19.2	0.011	Moderate-C
1197	BETHLEHEM CITY	NPDES	LEHIGH R - 485	Floodplain	21.4	0.011	Moderate-C
1395	UNITED STATES STEEL GROUP-USX	NPDES	Delaware River - 649	Zone A	2.9	0.011	Moderate-C
624	ELF ATOCHEM N.A. INC.	TRI	Delaware River - 666	Zone A	0.6	0.202	Moderate-C
1164	HARCROS PIGMENTS INC	NPDES	Shoeneck Creek - 462	Zone B	18.4	0.011	Moderate-C
641	CORCO CHEMICAL CORP.	TRI	Queen Anne Creek - 627	Floodplain	2.9	0.193	Moderate-C
1079	HOFFMAN-LA ROCHE INC	NPDES	PEQUEST R - 405	Zone B	21.9	0.011	Moderate-C
948	ALUMINUM SHAPES INC.	TRI	Delaware River - 931	Zone B	1.1	0.009	Moderate-C
1077	BANGOR BORO AUTH	NPDES	Martins Creek - 349	Floodplain	21.4	0.011	Moderate-C

Source ID	Source Name	Database Used	Subwatershed	Zone	Time of Travel	Relative Impact (%)	Priority
1153	NAZARETH BORO MUN AUTH	NPDES	Shoeneck Creek - 453	Zone B	20.3	0.011	Moderate-C
931	OCCIDENTAL CHEMICAL CORP.	TRI	ASSISCUNK CR - 662	Zone A	2.2	0.134	Moderate-C
956	CIRCUIT FOIL USA INC. (FORMERLY YATES IND.)	TRI	Delaware River - 927	Zone B	3.1	0.073	Moderate-C
1088	WIND GAP MUN AUTH	NPDES	Unknown - 444	Floodplain	21.9	0.011	Moderate-C

Figure 2.2.4-25 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for Phosphorus in the Lower Delaware River Watershed

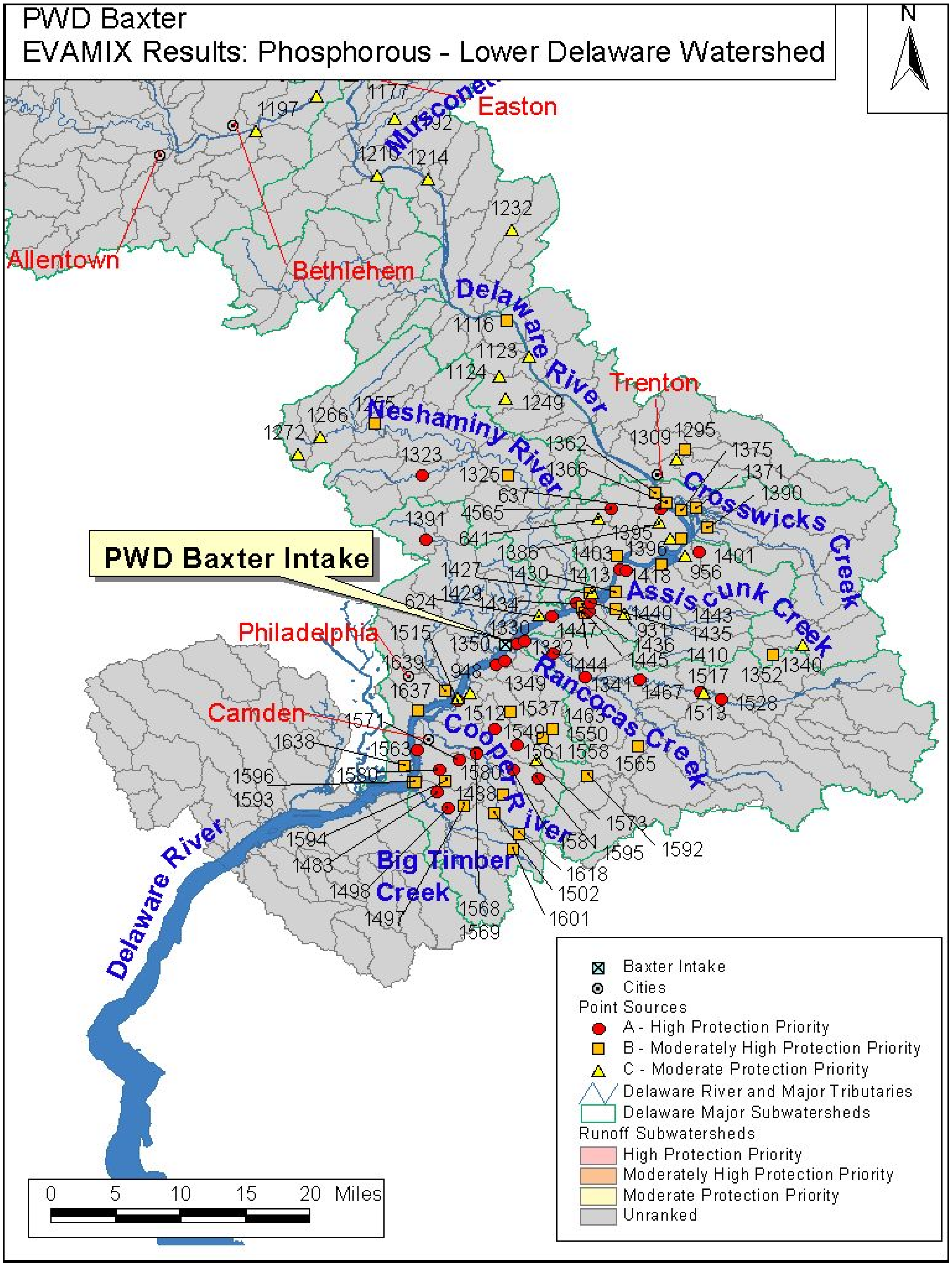


Figure 2.2.4-26 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for Phosphorus in the Middle Delaware River Watershed

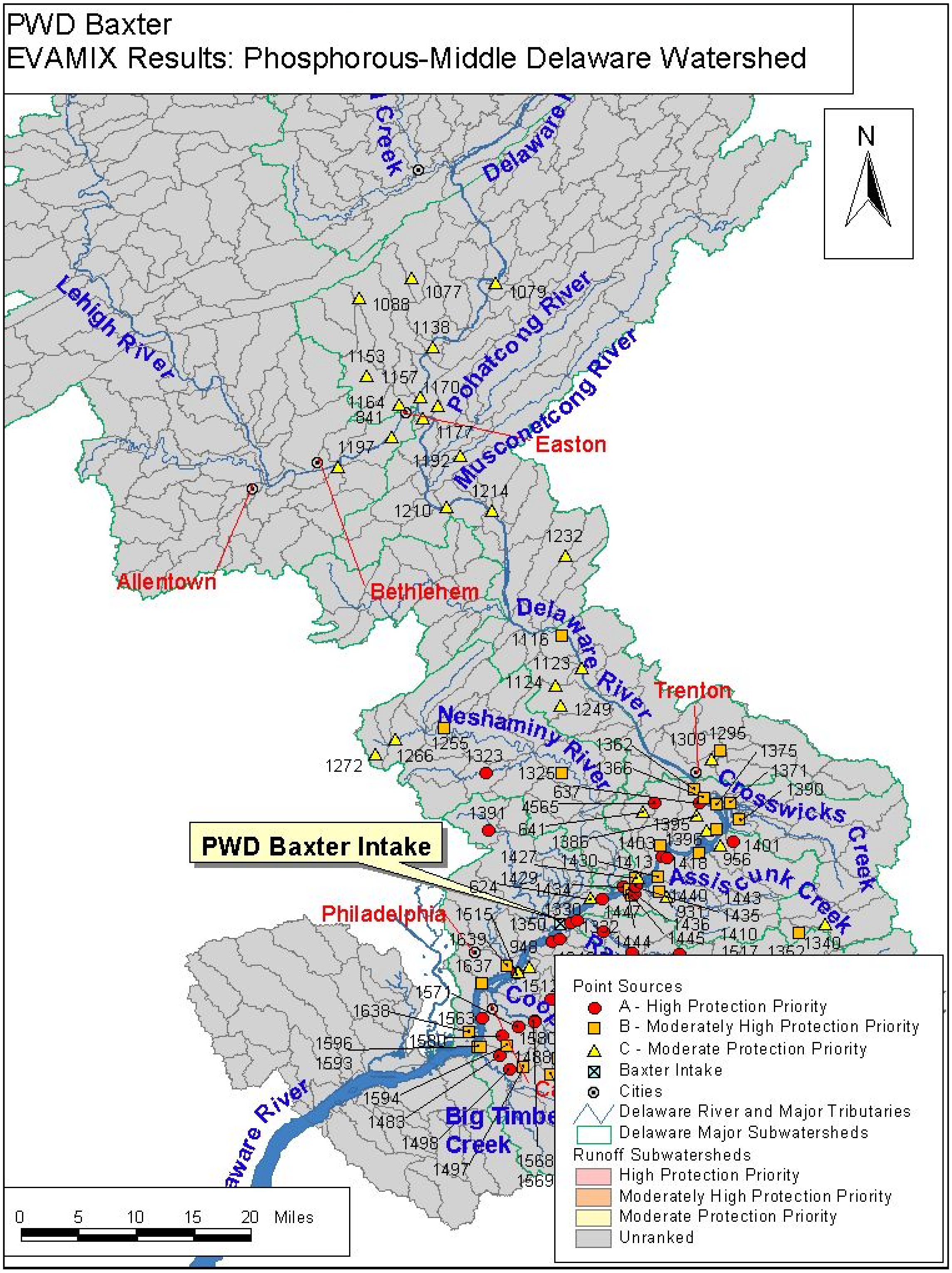
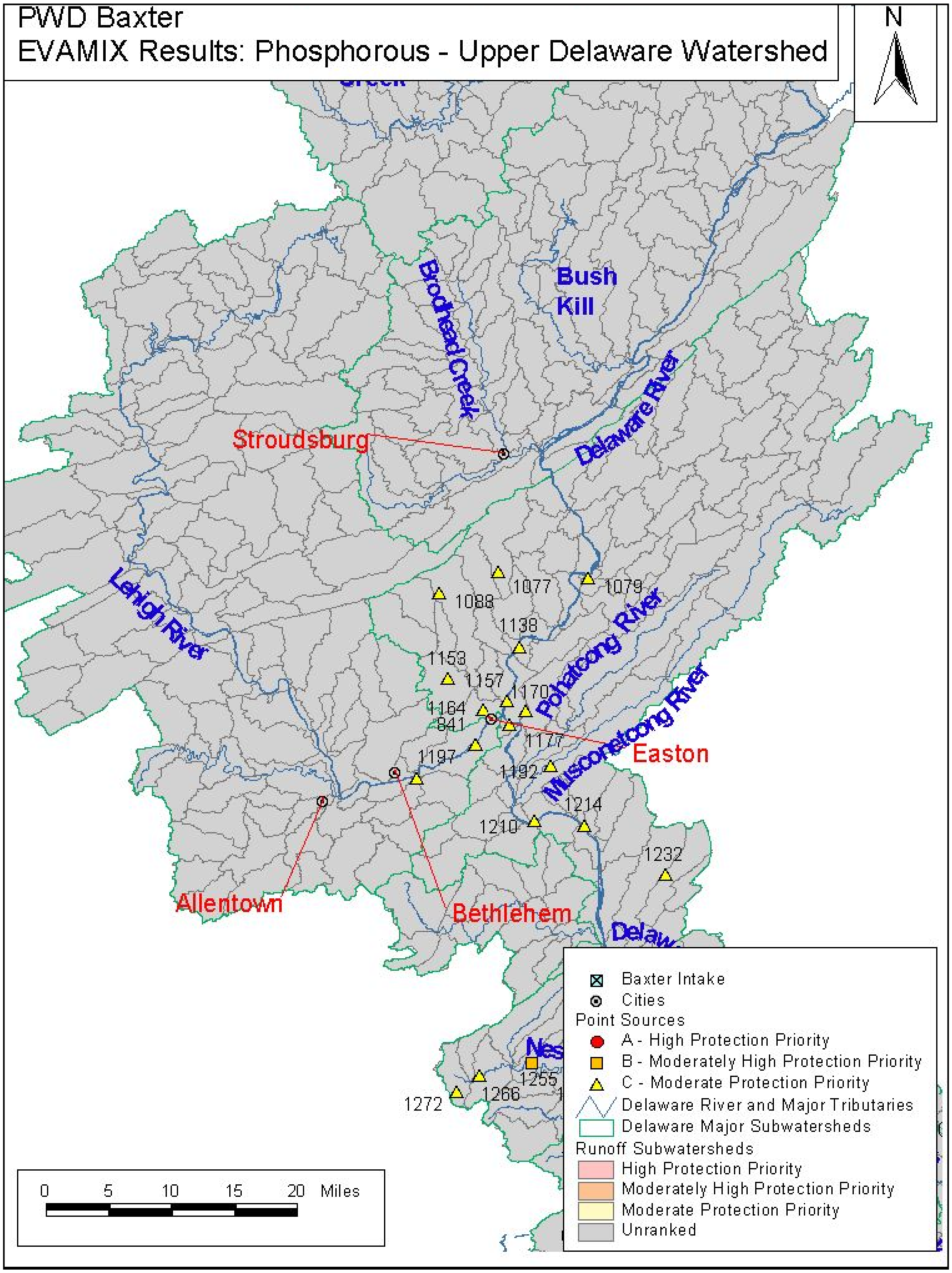


Figure 2.2.4-27 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for Phosphorus in the Upper Delaware River Watershed



Disinfection By-Product (Total Organic Carbon)

Table 2.2.4-10 provides the results of the ranking of potential sources of total organic carbon (TOC). In this case, all of the high protection priority sites (category A) are NPDES discharges from wastewater treatment plants and industries and one TRI facility. In general, nonpoint source locations appear to have a lower total load and impact on water quality than do the NPDES sites. Nonpoint sources are all found in the low priority category. Figures 2.2.4-28 through 2.2.4-30 illustrate the priority point sources and subwatersheds for total organic carbon in the lower and upper Delaware River watersheds.

Table 2.2.4-10 Contaminant Category Ranking for Total Organic Carbon (Disinfection By-product Surrogate)

Source ID	Source Name	Database Used	Subwatershed	Zone	Time of Travel	Relative Impact (%)	Priority
1515	GEORGIA PACIFIC CORPORATION	NPDES	Delaware River - 931	Floodplain	1.1	1.7500	Highest-A
909	WITCO CORP. BRAINARDS FACILITY	TRI	Delaware River - 914	Floodplain	18.4	1.3454	Highest-A
1325	ASBURY PARK WTP	NPDES	NESHAMINY R - 601	Zone B	4.6	0.6086	Highest-A
1395	UNITED STATES STEEL GROUP-USX	NPDES	Delaware River - 649	Zone A	2.9	0.7357	Highest-A
1350	CINNAMINSON STP	NPDES	Delaware River - 930	Floodplain	0.0	0.3801	Highest-A
1592	ELMWOOD WWTP	NPDES	Southwest Branch South Branch - 759	Zone B	4.8	0.2610	Highest-A
1403	LOWER BUCKS COUNTY JOINT M.A.	NPDES	Delaware River - 649	Zone A	2.2	0.1925	Highest-A
1197	BETHLEHEM CITY	NPDES	LEHIGH R - 485	Floodplain	21.4	0.2865	Highest-A
1463	MT LAUREL TWP MUA	NPDES	RANCOCAS CR - 695	Zone A	1.5	0.0822	Highest-A
1444	COLORITE POLYMERS COMPANY	NPDES	Delaware River - 663	Floodplain	1.5	0.0822	Highest-A
1443	BURLINGTON CITY STP	NPDES	Delaware River - 663	Zone A	1.5	0.0822	Highest-A
1332	DELRAN SEWERAGE AUTHORITY	NPDES	Delaware River - 930	Floodplain	0.2	0.0822	Highest-A
1330	RIVERSIDE STP	NPDES	RANCOCAS CR - 680	Floodplain	0.2	0.0822	Highest-A
1447	BEVERLY SEWERAGE AUTHORITY	NPDES	Delaware River - 929	Zone A	0.7	0.0822	Highest-A
1401	BLACK'S CREEK WWTP	NPDES	Unknown - 651	Zone A	3.5	0.0822	Highest-A
1528	PEMBERTON	NPDES	RANCOCAS CR, N BR - 725	Floodplain	4.6	0.0822	Highest-A
1413	FLORENCE TOWNSHIP STP	NPDES	Delaware River - 927	Zone A	2.0	0.0822	Highest-A
1467	MOUNT HOLLY SEWERAGE AUTHORITY	NPDES	RANCOCAS CR, N BR - 698	Floodplain	2.6	0.0822	Highest-A
1341	WILLINGBORO WATER PCP	NPDES	RANCOCAS CR - 680	Zone A	0.7	0.0822	Highest-A
1349	HOEGANAES CORPORATION	NPDES	Delaware River - 930	Floodplain	0.0	0.0822	Highest-A
1435	PSE&G BURLINGTON GENERATING ST	NPDES	Delaware River - 661	Floodplain	1.3	0.0822	Highest-A
1418	GRIFFIN PIPE PRODUCTS CO	NPDES	Delaware River - 927	Zone B	2.0	0.0822	Highest-A
1295	EWING-LAWRENCE SA	NPDES	Pond Run - 612	Zone B	5.4	0.0822	Highest-A
1371	HAMILTON TOWNSHIP WPCF	NPDES	CROSSWICKS CR - 629	Zone B	4.0	0.0822	Highest-A
1440	LA GORCE SQUARE PLANT	NPDES	ASSISCUNK CR - 662	Zone A	1.8	0.0822	Highest-A
1323	WARMINSTER TWP. MUN. AUTH.	NPDES	Little Neshaminy Creek - 610	Zone B	4.8	0.0822	Highest-A
1434	BRISTOL TWP WP CONTROL PLANT	NPDES	Delaware River - 661	Zone A	1.1	0.0480	Highest-A
1445	BURLINGTON TWP MAIN STP	NPDES	Delaware River - 663	Zone A	1.5	0.0822	Highest-A

Source ID	Source Name	Database Used	Subwatershed	Zone	Time of Travel	Relative Impact (%)	Priority
1483	MT EPHRAIM BOROUGH OF	NPDES	BIG TIMBER CR - 769	Floodplain	3.3	0.0082	Highest-A
1563	CAMDEN COUNTY M.U.A.	NPDES	Newton Creek - 753	Floodplain	2.4	0.0082	Highest-A
1410	ROEBLING INDUSTRIES	NPDES	Crafts Creek - 655	Floodplain	2.8	0.0822	Highest-A
1430	HERCULES INCORPORATED	NPDES	ASSISCUNK CR - 662	Zone A	1.5	0.0822	Highest-A
1255	CHALFONT-NEW BRITAIN TWP JOINT	NPDES	NESHAMINY R - 580	Zone B	7.9	0.0822	Highest-A
1375	PSE&G MERCER GENERATING STA	NPDES	Delaware River - 927	Floodplain	3.7	0.0822	Moderately High-B
1214	CROWN PAPER CO	NPDES	Delaware River - 919	Floodplain	13.1	0.0822	Moderately High-B
1116	MONMOUTH CO BAYSHORE OUTFALL	NPDES	Delaware River - 559	Zone B	9.1	0.0822	Moderately High-B
1565	MEDFORD TOWNSHIP STP	NPDES	Southwest Branch South Branch - 755	Zone B	3.7	0.0822	Moderately High-B
1352	USATC & FORT DIX (WASTEWATER)	NPDES	RANCOCAS CR, N BR - 686	Zone B	5.9	0.0822	Moderately High-B
1391	UPPER MORELAND-HATBORO JNT SEW	NPDES	Robinhood Brook - 628	Zone A	2.8	0.0082	Moderately High-B
1581	CHERRY HILL TOWNSHIP	NPDES	North Branch Cooper River - 756	Zone A	3.8	0.0082	Moderately High-B
1595	CHERRY HILL TOWNSHIP	NPDES	North Branch Cooper River - 756	Zone A	4.2	0.0082	Moderately High-B
1396	STEPAN CHEMICAL CO INC	NPDES	Delaware River - 649	Zone A	3.3	0.0822	Moderately High-B
1366	TRENTON SEWER UTILITY	NPDES	Delaware River - 927	Zone B	3.9	0.0822	Moderately High-B
1561	CHERRY HILL TOWNSHIP	NPDES	South Branch Pennsauken Creek - 724	Zone A	2.9	0.0082	Moderately High-B
1390	CIRCUIT FOIL USA INC	NPDES	CROSSWICKS CR - 629	Zone B	4.0	0.0822	Moderately High-B
1362	MORRISVILLE BORO MUN AUTH-STP	NPDES	Delaware River - 649	Zone B	4.3	0.0822	Moderately High-B
1124	NORTHEAST MONMOUTH COUNTY RSA	NPDES	Pidcock Creek - 574	Zone B	8.8	0.0822	Moderately High-B
1549	CHERRY HILL TOWNSHIP	NPDES	South Branch Pennsauken Creek - 724	Floodplain	2.4	0.0082	Moderately High-B
1123	LAMBERTVILLE SEWAGE AUTHORITY	NPDES	Delaware River - 923	Zone B	8.0	0.0822	Moderately High-B
1309	FEDERATED METALS	NPDES	Pond Run - 612	Zone B	5.1	0.0822	Moderately High-B
1498	RUNNEMEDE SEWERAGE AUTHORITY	NPDES	BIG TIMBER CR - 769	Zone B	3.5	0.0082	Moderately High-B
1436	PUBLIC SERVICE ELECTRIC & GAS	NPDES	Delaware River - 663	Zone A	1.3	0.0822	Moderately High-B
1427	ROHM & HAAS COMPANY	NPDES	Mill Creek - 648	Zone A	1.6	0.0822	Moderately High-B
1580	WEST COLLINGSWOOD HEIGHTS STP	NPDES	Newton Creek - 753	Zone A	3.1	0.0082	Moderately High-B
1569	COLES MILLS STP	NPDES	COOPER R - 738	Zone A	3.1	0.0082	Moderately High-B
1568	COOPER RIVER STP	NPDES	COOPER R - 738	Floodplain	2.9	0.0082	Moderately High-B
1513	SYBRON CHEMICALS INC	NPDES	RANCOCAS CR, N BR - 689	Zone B	4.0	0.0042	Moderately High-B
1571	COLLINGSWOOD BOROUGH OF	NPDES	Newton Creek - 753	Zone B	3.3	0.0082	Moderately High-B
1340	MCGUIRE AIR FORCE BASE STP	NPDES	CROSSWICKS CR - 668	Zone B	8.4	0.0822	Moderately High-B
1517	PEMBERTON TOWNSHIP MUA STP	NPDES	RANCOCAS CR, N BR - 699	Floodplain	4.2	0.0822	Moderately High-B
1594	AUDUBON BOROUGH STP	NPDES	Newton Creek - 753	Zone A	3.3	0.0082	Moderately

Source ID	Source Name	Database Used	Subwatershed	Zone	Time of Travel	Relative Impact (%)	Priority
							High-B
1488	WOODCREST STP	NPDES	COOPER R - 760	Zone A	4.0	0.0082	Moderately High-B
1210	GPU GENERATION INC	NPDES	Delaware River - 918	Zone B	14.4	0.0822	Moderately High-B
1386	PRE FINISH METALS, INC.	NPDES	Delaware River - 649	Zone A	3.9	0.0822	Moderately High-B
1558	RAMBLEWOOD STP	NPDES	PENNSAUKEN CR - 706	Zone A	2.6	0.0082	Moderately High-B
1550	MAPLE SHADE TOWNSHIP STP	NPDES	PENNSAUKEN CR - 706	Zone B	2.9	0.0525	Moderately High-B
1502	SOMERDALE BORO STP	NPDES	COOPER R - 760	Zone A	4.0	0.0082	Moderately High-B
1638	PHILADELPHIA CITY WATER DEPT -	NPDES	Delaware River - 711	Zone B	2.4	0.0082	Moderate-C
1266	HATFIELD TWP MUN AUTH	NPDES	West Branch Neshaminy Creek - 586	Zone B	9.0	0.0822	Moderate-C
1639	PHILADELPHIA CITY WATER DEPT -	NPDES	Delaware River - 704	Zone B	1.3	0.0082	Moderate-C
1593	AMSPEC CHEMICAL CORP	NPDES	Delaware River - 932	Floodplain	2.9	0.0082	Moderate-C
1249	LONG BRANCH SEWERAGE AUTHORITY	NPDES	Pidcock Creek - 574	Zone B	8.8	0.0822	Moderate-C
1157	MALLINCKRODT BAKER INC	NPDES	Delaware River - 914	Floodplain	17.9	0.0822	Moderate-C
1177	EASTON CITY	NPDES	Delaware River - 451	Zone B	17.4	0.0822	Moderate-C
1618	LINDENWOLD BOROUGH SEWAGE	NPDES	COOPER R - 760	Zone A	4.6	0.0082	Moderate-C
1601	CLEMENTON SEWAGE AUTHORITY	NPDES	BIG TIMBER CR, N FK - 776	Zone B	5.1	0.0082	Moderate-C
1497	BARRINGTON SEWER UTILITY	NPDES	BIG TIMBER CR - 769	Zone B	3.7	0.0082	Moderate-C
1637	PECO ENERGY COMPANY-DELAWARE	NPDES	Delaware River - 704	Floodplain	1.6	0.0082	Moderate-C
1170	INGERSOLL DRESSER PUMP CO	NPDES	Delaware River - 914	Zone B	17.1	0.0822	Moderate-C
1232	MAGNESIUM ELEKTRON INC	NPDES	Plum Brook - 519	Zone B	11.5	0.0822	Moderate-C
1537	MOORESTOWN TOWNSHIP STP	NPDES	PENNSAUKEN CR - 706	Floodplain	2.0	0.0082	Moderate-C
1596	GLOUCESTER CITY TITANIUM CO	NPDES	Delaware River - 932	Zone B	2.9	0.0082	Moderate-C
1138	WITCO CORPORATION	NPDES	Delaware River - 913	Zone B	19.2	0.0822	Moderate-C
1573	WOODSTREAM STP	NPDES	South Branch Pennsauken Creek - 724	Floodplain	3.3	0.0082	Moderate-C
1192	FIBERMARK	NPDES	MUSCONETCONG R - 459	Zone B	16.6	0.0822	Moderate-C
1272	LANSDALE BORO	NPDES	West Branch Neshaminy Creek - 588	Zone B	9.4	0.0822	Moderate-C
1079	HOFFMAN-LA ROCHE INC	NPDES	PEQUEST R - 405	Zone B	21.9	0.0822	Moderate-C
1164	HARCROS PIGMENTS INC	NPDES	Shoeneck Creek - 462	Zone B	18.4	0.0822	Moderate-C
1077	BANGOR BORO AUTH	NPDES	Martins Creek - 349	Floodplain	21.4	0.0822	Moderate-C
1153	NAZARETH BORO MUN AUTH	NPDES	Shoeneck Creek - 453	Zone B	20.3	0.0822	Moderate-C
1429	BRISTOL BORO WAT & SEW AUTH	NPDES	Mill Creek - 648	Zone A	1.6	0.0962	Moderate-C
1088	WIND GAP MUN AUTH	NPDES	Unknown - 444	Floodplain	21.9	0.0822	Moderate-C
1198	BETHLEHEM STEEL - BETHLEHEM	NPDES	LEHIGH R - 485	Zone B	21.4	0.0822	Moderate-C
607	WONDER CHEMICAL CORP.	TRI	Delaware River - 649	Zone A	3.9	0.1345	Moderate-C
90649	Delaware River-649	NP	Delaware River - 649	Zone A	1.3	0.0703	Moderate-C
1512	GEORGIA PACIFIC CORPORATION	NPDES	Delaware River - 931	Floodplain	1.1	0.0082	Moderate-C
90583	NESHAMINY R-583	NP	NESHAMINY R - 583	Zone B	5.1	0.1076	Moderate-C

Source ID	Source Name	Database Used	Subwatershed	Zone	Time of Travel	Relative Impact (%)	Priority
1263	FERMENTA ANIMAL HEALTH CO	NPDES	*C - 590	Zone B	6.4	0.0822	Moderate-C
90651	Unknown-651	NP	Unknown - 651	Zone A	3.3	0.0538	Moderate-C
1127	OXFORD TEXTILE INC	NPDES	Unknown - 412	Zone B	24.0	0.0157	Moderate-C

Figure 2.2.4-28 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for TOC in the Lower Delaware River Watershed

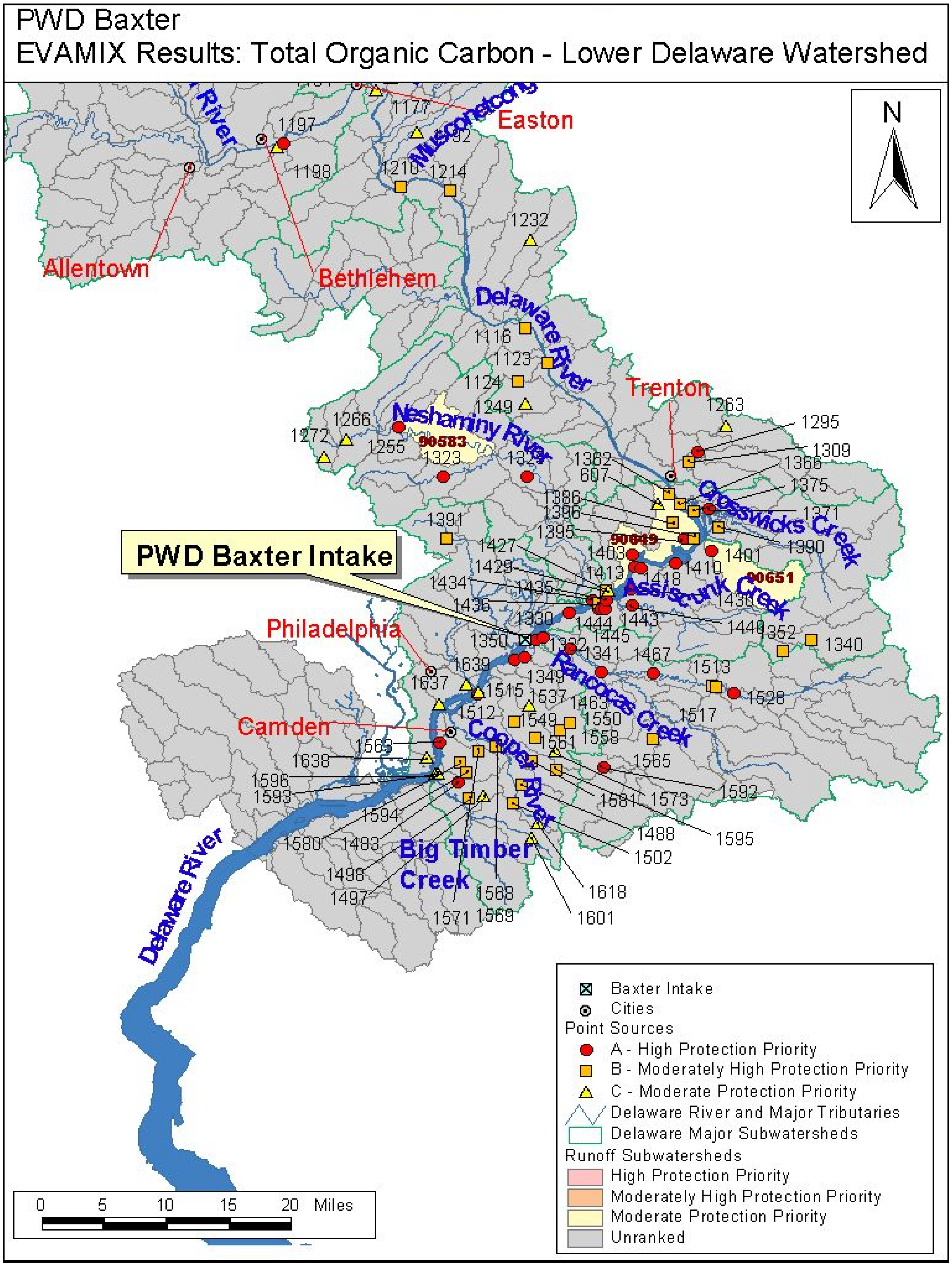


Figure 2.2.4-29 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for TOC in the Middle Delaware River Watershed

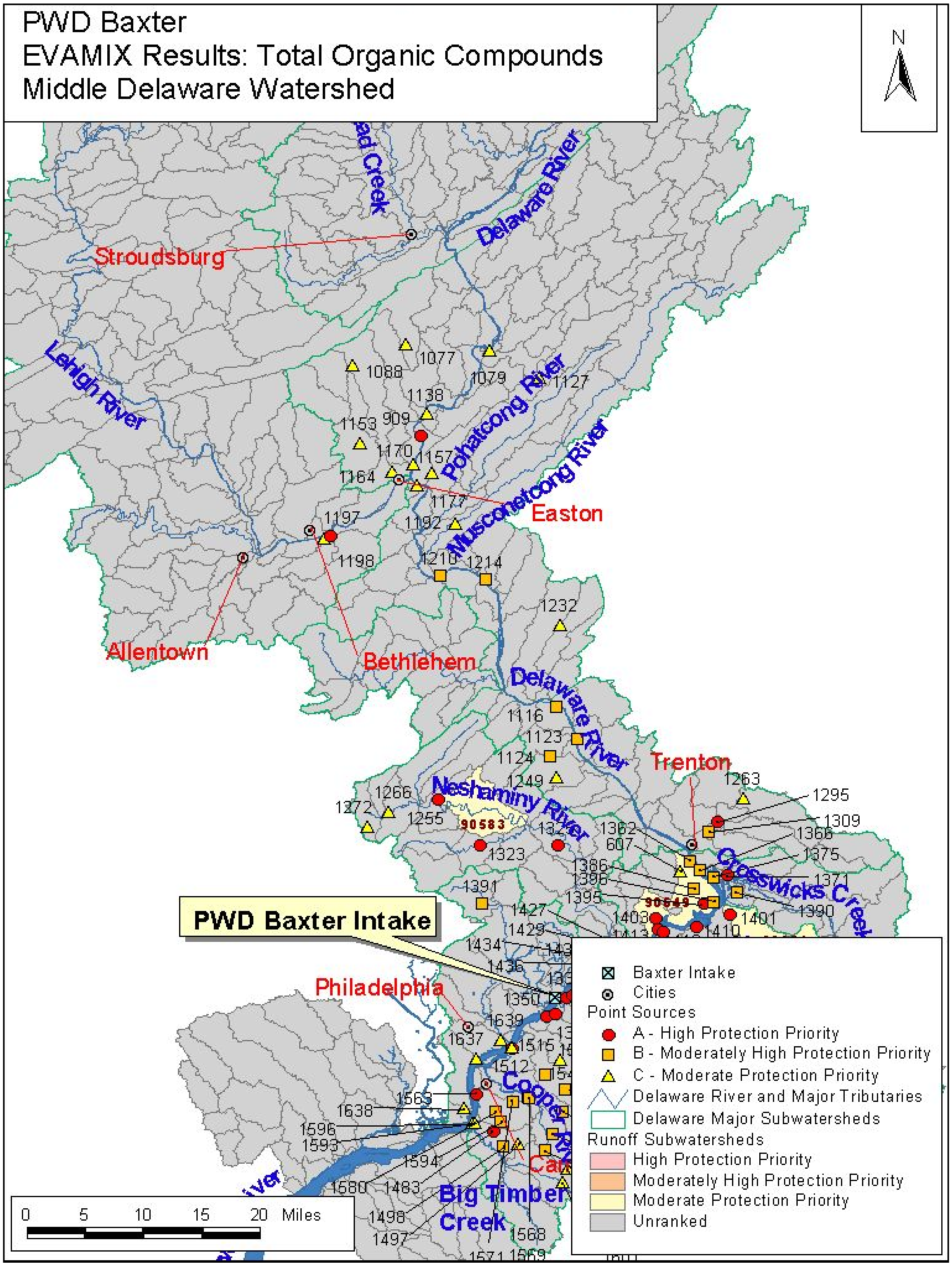
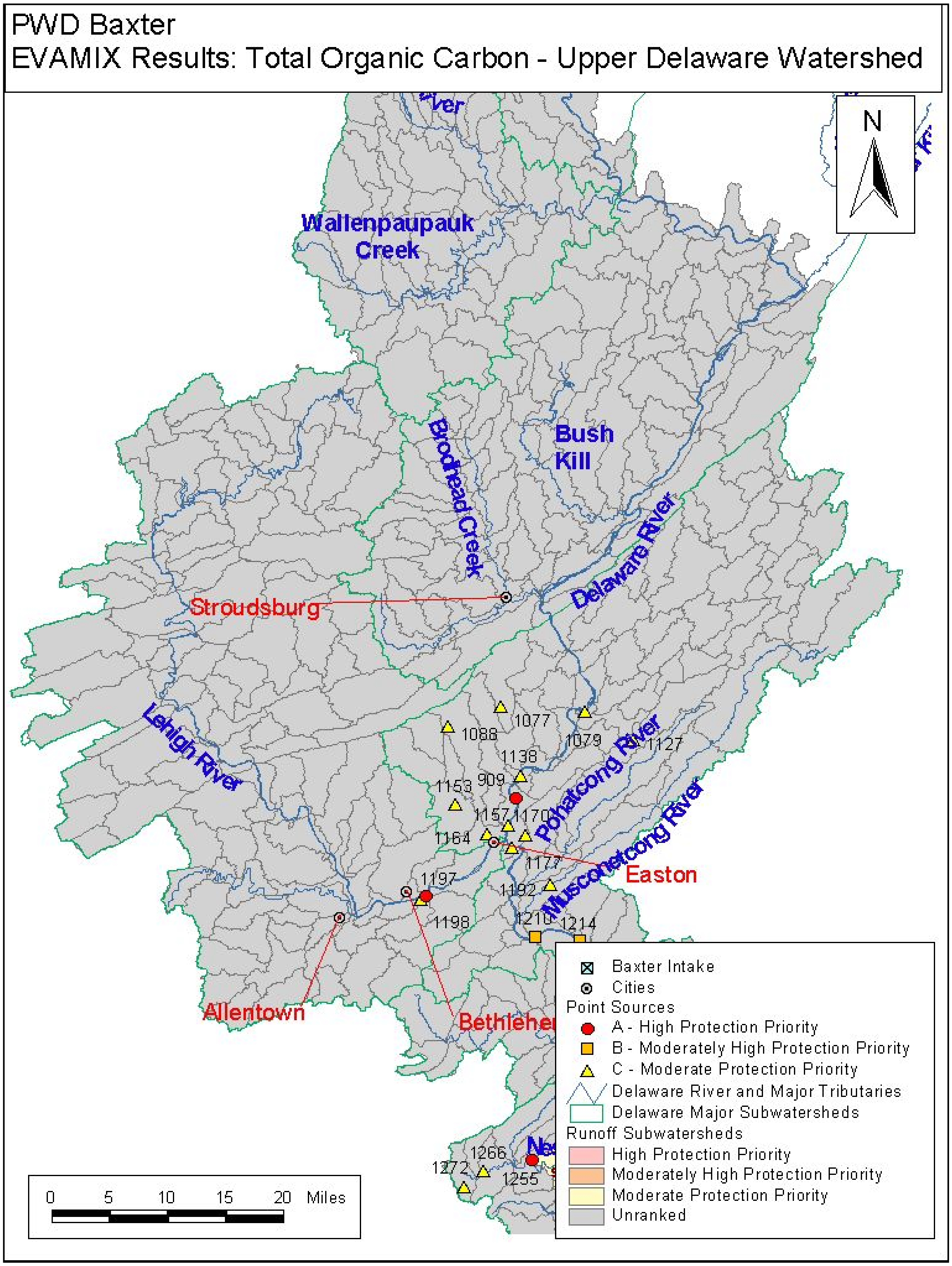


Figure 2.2.4-30 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for TOC in the Upper Delaware River Watershed



Turbidity (Total Suspended Solids)

Turbidity was analyzed using total suspended solids (TSS) as a surrogate. Table 2.2.4 – 11 provides the results of the final ranking of turbidity sources. Stormwater runoff and NPDES discharges were primarily identified as potentially significant sources of TSS. Only one AST site was identified as a high priority. The stormwater runoff (NPS sites) tends to show much higher loading with less frequency. The NPDES sites have lower rates of TSS loading, however, they are more constant discharges. Loading rates from non-point sources appear high enough to cause concern for cumulative impacts at the intake during storm events. Figures 2.2.4-31 through 2.2.4-33 illustrate the priority point sources and subwatersheds for total suspended solids in the lower and upper Delaware River watersheds.

Table 2.2.4-11 Contaminant Category Ranking for Total Suspended Solids

Source ID	Source Name	Database Used	Subwatershed	Zone	Time of Travel	Relative Impact (%)	Priority
90394	POHATCONG R-394	NP	POHATCONG R - 394	Zone B	17.9	2.3733	Highest-A
90583	NESHAMINY R-583	NP	NESHAMINY R - 583	Zone B	5.1	1.6627	Highest-A
90444	Unknown-444	NP	Unknown - 444	Zone B	19.5	1.7868	Highest-A
90459	MUSCONETCONG R-459	NP	MUSCONETCONG R - 459	Zone B	15.5	1.5915	Highest-A
90349	Martins Creek-349	NP	Martins Creek - 349	Zone B	20.8	1.5884	Highest-A
1124	NORTHEAST MONMOUTH COUNTY RSA	NPDES	Pidcock Creek - 574	Zone B	8.8	0.3632	Highest-A
1515	GEORGIA PACIFIC CORPORATION	NPDES	Delaware River - 931	Floodplain	1.1	0.0002	Highest-A
1483	MT EPHRAIM BOROUGH OF	NPDES	BIG TIMBER CR - 769	Floodplain	3.3	0.0003	Highest-A
1323	WARMINSTER TWP. MUN. AUTH.	NPDES	Little Neshaminy Creek - 610	Zone B	4.8	0.2008	Highest-A
1463	MT LAUREL TWP MUA	NPDES	RANCOCAS CR - 695	Zone A	1.5	0.0030	Highest-A
1563	CAMDEN COUNTY M.U.A.	NPDES	Newton Creek - 753	Floodplain	2.4	0.0003	Highest-A
1443	BURLINGTON CITY STP	NPDES	Delaware River - 663	Zone A	1.5	0.0030	Highest-A
1444	COLORITE POLYMERS COMPANY	NPDES	Delaware River - 663	Floodplain	1.5	0.0030	Highest-A
5113	AMER WTP	AST	Delaware River - 597	Zone B	5.6	1.3259	Highest-A
1581	CHERRY HILL TOWNSHIP	NPDES	North Branch Cooper River - 756	Zone A	3.8	0.0003	Highest-A
1332	DELRAN SEWERAGE AUTHORITY	NPDES	Delaware River - 930	Floodplain	0.2	0.0030	Highest-A
90649	Delaware River-649	NP	Delaware River - 649	Zone A	1.3	1.0168	Highest-A
90470	Monocacy Creek-470	NP	Monocacy Creek - 470	Zone B	21.4	1.3218	Highest-A
1391	UPPER MORELAND-HATBORO JNT SEW	NPDES	Robinhood Brook - 628	Zone A	2.8	0.0003	Highest-A
1401	BLACK'S CREEK WWTP	NPDES	Unknown - 651	Zone A	3.5	0.0030	Highest-A
1330	RIVERSIDE STP	NPDES	RANCOCAS CR - 680	Floodplain	0.2	0.0030	Highest-A
1561	CHERRY HILL TOWNSHIP	NPDES	South Branch Pennsauken Creek - 724	Zone A	2.9	0.0003	Highest-A
1549	CHERRY HILL TOWNSHIP	NPDES	South Branch Pennsauken Creek - 724	Floodplain	2.4	0.0003	Highest-A
1214	CROWN PAPER CO	NPDES	Delaware River - 919	Floodplain	13.1	0.0056	Highest-A
1325	ASBURY PARK WTP	NPDES	NESHAMINY R - 601	Zone B	4.6	0.1054	Highest-A
1350	CINNAMINSON STP	NPDES	Delaware River - 930	Floodplain	0.0	0.0341	Highest-A
90415	Unknown-415	NP	Unknown - 415	Zone B	19.8	1.2608	Highest-A

Source ID	Source Name	Database Used	Subwatershed	Zone	Time of Travel	Relative Impact (%)	Priority
1595	CHERRY HILL TOWNSHIP	NPDES	North Branch Cooper River - 756	Zone A	4.2	0.0003	Highest-A
1447	BEVERLY SEWERAGE AUTHORITY	NPDES	Delaware River - 929	Zone A	0.7	0.0030	Highest-A
1528	PEMBERTON	NPDES	RANCOCAS CR, N BR - 725	Floodplain	4.6	0.0030	Highest-A
1498	RUNNEMEDE SEWERAGE AUTHORITY	NPDES	BIG TIMBER CR - 769	Zone B	3.5	0.0003	Highest-A
1513	SYBRON CHEMICALS INC	NPDES	RANCOCAS CR, N BR - 689	Zone B	4.0	0.0021	Highest-A
1434	BRISTOL TWP WP CONTROL PLANT	NPDES	Delaware River - 661	Zone A	1.1	0.0073	Highest-A
1295	EWING-LAWRENCE SA	NPDES	Pond Run - 612	Zone B	5.4	0.0030	Moderately High-B
1255	CHALFONT-NEW BRITAIN TWP JOINT	NPDES	NESHAMINY R - 580	Zone B	7.9	0.0321	Moderately High-B
1413	FLORENCE TOWNSHIP STP	NPDES	Delaware River - 927	Zone A	2.0	0.0030	Moderately High-B
1580	WEST COLLINGSWOOD HEIGHTS STP	NPDES	Newton Creek - 753	Zone A	3.1	0.0003	Moderately High-B
1116	MONMOUTH CO BAYSHORE OUTFALL	NPDES	Delaware River - 559	Zone B	9.1	0.0030	Moderately High-B
1571	COLLINGSWOOD BOROUGH OF	NPDES	Newton Creek - 753	Zone B	3.3	0.0003	Moderately High-B
1467	MOUNT HOLLY SEWERAGE AUTHORITY	NPDES	RANCOCAS CR, N BR - 698	Floodplain	2.6	0.0030	Moderately High-B
1569	COLES MILLS STP	NPDES	COOPER R - 738	Zone A	3.1	0.0003	Moderately High-B
1371	HAMILTON TOWNSHIP WPCF	NPDES	CROSSWICKS CR - 629	Zone B	4.0	0.0030	Moderately High-B
1488	WOODCREST STP	NPDES	COOPER R - 760	Zone A	4.0	0.0003	Moderately High-B
1568	COOPER RIVER STP	NPDES	COOPER R - 738	Floodplain	2.9	0.0003	Moderately High-B
1594	AUDUBON BOROUGH STP	NPDES	Newton Creek - 753	Zone A	3.3	0.0003	Moderately High-B
1418	GRIFFIN PIPE PRODUCTS CO	NPDES	Delaware River - 927	Zone B	2.0	0.0030	Moderately High-B
90453	Shoeneck Creek-453	NP	Shoeneck Creek - 453	Zone B	19.2	1.1215	Moderately High-B
1210	GPU GENERATION INC	NPDES	Delaware River - 918	Zone B	14.4	0.0030	Moderately High-B
1341	WILLINGBORO WATER PCP	NPDES	RANCOCAS CR - 680	Zone A	0.7	0.0030	Moderately High-B
1502	SOMERDALE BORO STP	NPDES	COOPER R - 760	Zone A	4.0	0.0003	Moderately High-B
1435	PSE&G BURLINGTON GENERATING ST	NPDES	Delaware River - 661	Floodplain	1.3	0.0030	Moderately High-B
90617	Little Neshaminy Creek-617	NP	Little Neshaminy Creek - 617	Zone B	5.1	0.9317	Moderately High-B
1440	LA GORCE SQUARE PLANT	NPDES	ASSISCUNK CR - 662	Zone A	1.8	0.0030	Moderately High-B
1352	USATC & FORT DIX (WASTEWATER)	NPDES	RANCOCAS CR, N BR - 686	Zone B	5.9	0.0030	Moderately High-B
1558	RAMBLEWOOD STP	NPDES	PENNSAUKEN CR - 706	Zone A	2.6	0.0003	Moderately High-B
1349	HOEGANAES CORPORATION	NPDES	Delaware River - 930	Floodplain	0.0	0.0030	Moderately High-B
1638	PHILADELPHIA CITY WATER DEPT -	NPDES	Delaware River - 711	Zone B	2.4	0.0003	Moderately High-B
1197	BETHLEHEM CITY	NPDES	LEHIGH R - 485	Floodplain	21.4	0.0483	Moderately High-B
1157	MALLINCKRODT BAKER INC	NPDES	Delaware River - 914	Floodplain	17.9	0.0030	Moderately High-B
1123	LAMBERTVILLE SEWAGE AUTHORITY	NPDES	Delaware River - 923	Zone B	8.0	0.0030	Moderately High-B
1177	EASTON CITY	NPDES	Delaware River - 451	Zone B	17.4	0.0030	Moderately High-B
1445	BURLINGTON TWP MAIN STP	NPDES	Delaware River - 663	Zone A	1.5	0.0030	Moderately High-B
1592	ELMWOOD WWTP	NPDES	Southwest Branch South Branch - 759	Zone B	4.8	0.0739	Moderately High-B
1410	ROEBLING INDUSTRIES	NPDES	Crafts Creek - 655	Floodplain	2.8	0.0030	Moderately High-B
1403	LOWER BUCKS COUNTY JOINT M.A.	NPDES	Delaware River - 649	Zone A	2.2	0.0348	Moderately High-B
1601	CLEMENTON SEWAGE AUTHORITY	NPDES	BIG TIMBER CR, N FK - 776	Zone B	5.1	0.0003	Moderately High-B

Source ID	Source Name	Database Used	Subwatershed	Zone	Time of Travel	Relative Impact (%)	Priority
1593	AMSPEC CHEMICAL CORP	NPDES	Delaware River - 932	Floodplain	2.9	0.0003	Moderately High-B
1565	MEDFORD TOWNSHIP STP	NPDES	Southwest Branch South Branch - 755	Zone B	3.7	0.0030	Moderate-C
90606	Little Neshaminy Creek-606	NP	Little Neshaminy Creek - 606	Zone B	5.5	0.8733	Moderate-C
1375	PSE&G MERCER GENERATING STA	NPDES	Delaware River - 927	Floodplain	3.7	0.0030	Moderate-C
1366	TRENTON SEWER UTILITY	NPDES	Delaware River - 927	Zone B	3.9	0.0030	Moderate-C
1639	PHILADELPHIA CITY WATER DEPT -	NPDES	Delaware River - 704	Zone B	1.3	0.0003	Moderate-C
1430	HERCULES INCORPORATED	NPDES	ASSISCUNK CR - 662	Zone A	1.5	0.0030	Moderate-C
1618	LINDENWOLD BOROUGH SEWAGE	NPDES	COOPER R - 760	Zone A	4.6	0.0003	Moderate-C
1340	MCGUIRE AIR FORCE BASE STP	NPDES	CROSSWICKS CR - 668	Zone B	8.4	0.0030	Moderate-C
1170	INGERSOLL DRESSER PUMP CO	NPDES	Delaware River - 914	Zone B	17.1	0.0030	Moderate-C
1396	STEPAN CHEMICAL CO INC	NPDES	Delaware River - 649	Zone A	3.3	0.0030	Moderate-C
1497	BARRINGTON SEWER UTILITY	NPDES	BIG TIMBER CR - 769	Zone B	3.7	0.0003	Moderate-C
1138	WITCO CORPORATION	NPDES	Delaware River - 913	Zone B	19.2	0.0030	Moderate-C
1390	CIRCUIT FOIL USA INC	NPDES	CROSSWICKS CR - 629	Zone B	4.0	0.0000	Moderate-C
1362	MORRISVILLE BORO MUN AUTH-STP	NPDES	Delaware River - 649	Zone B	4.3	0.0030	Moderate-C
1309	FEDERATED METALS	NPDES	Pond Run - 612	Zone B	5.1	0.0030	Moderate-C
90389	Oughoughton Creek-389	NP	Oughoughton Creek - 389	Zone B	20.6	0.9820	Moderate-C
1637	PECO ENERGY COMPANY-DELAWARE	NPDES	Delaware River - 704	Floodplain	1.6	0.0003	Moderate-C
1537	MOORESTOWN TOWNSHIP STP	NPDES	PENNSAUKEN CR - 706	Floodplain	2.0	0.0003	Moderate-C
90601	NESHAMINY R-601	NP	NESHAMINY R - 601	Zone B	4.0	0.7623	Moderate-C
1079	HOFFMAN-LA ROCHE INC	NPDES	PEQUEST R - 405	Zone B	21.9	0.0118	Moderate-C
1573	WOODSTREAM STP	NPDES	South Branch Pennsauken Creek - 724	Floodplain	3.3	0.0003	Moderate-C
1550	MAPLE SHADE TOWNSHIP STP	NPDES	PENNSAUKEN CR - 706	Zone B	2.9	0.0065	Moderate-C
1266	HATFIELD TWP MUN AUTH	NPDES	West Branch Neshaminy Creek - 586	Zone B	9.0	0.0030	Moderate-C
1596	GLOUCESTER CITY TITANIUM CO	NPDES	Delaware River - 932	Zone B	2.9	0.0003	Moderate-C
1517	PEMBERTON TOWNSHIP MUA STP	NPDES	RANCOCAS CR, N BR - 699	Floodplain	4.2	0.0030	Moderate-C
1192	FIBERMARK	NPDES	MUSCONETCONG R - 459	Zone B	16.6	0.0030	Moderate-C
1436	PUBLIC SERVICE ELECTRIC & GAS	NPDES	Delaware River - 663	Zone A	1.3	0.0030	Moderate-C
1427	ROHM & HAAS COMPANY	NPDES	Mill Creek - 648	Zone A	1.6	0.0030	Moderate-C
90393	Martins Creek-393	NP	Martins Creek - 393	Zone B	19.8	0.9162	Moderate-C
1249	LONG BRANCH SEWERAGE AUTHORITY	NPDES	Pidcock Creek - 574	Zone B	8.8	0.0030	Moderate-C
90576	Mill Creek-576	NP	Mill Creek - 576	Zone B	5.5	0.7337	Moderate-C
1386	PRE FINISH METALS, INC.	NPDES	Delaware River - 649	Zone A	3.9	0.0030	Moderate-C
90610	Little Neshaminy Creek-610	NP	Little Neshaminy Creek - 610	Zone B	4.2	0.7108	Moderate-C

Figure 2.2.4-31 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for Total Suspended Solids in the Lower Delaware River Watershed

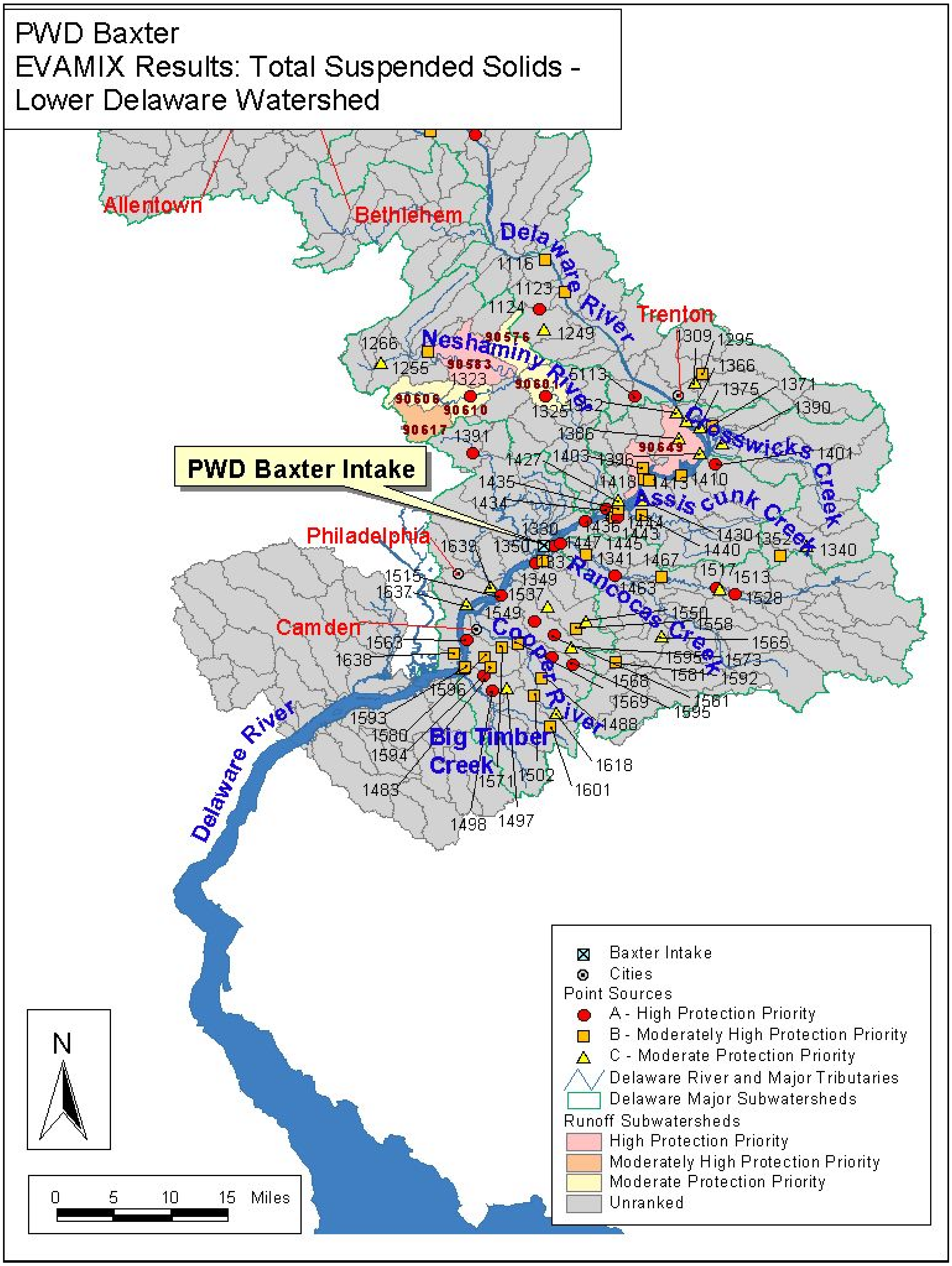


Figure 2.2.4-32 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for Total Suspended Solids in the Middle Delaware River Watershed

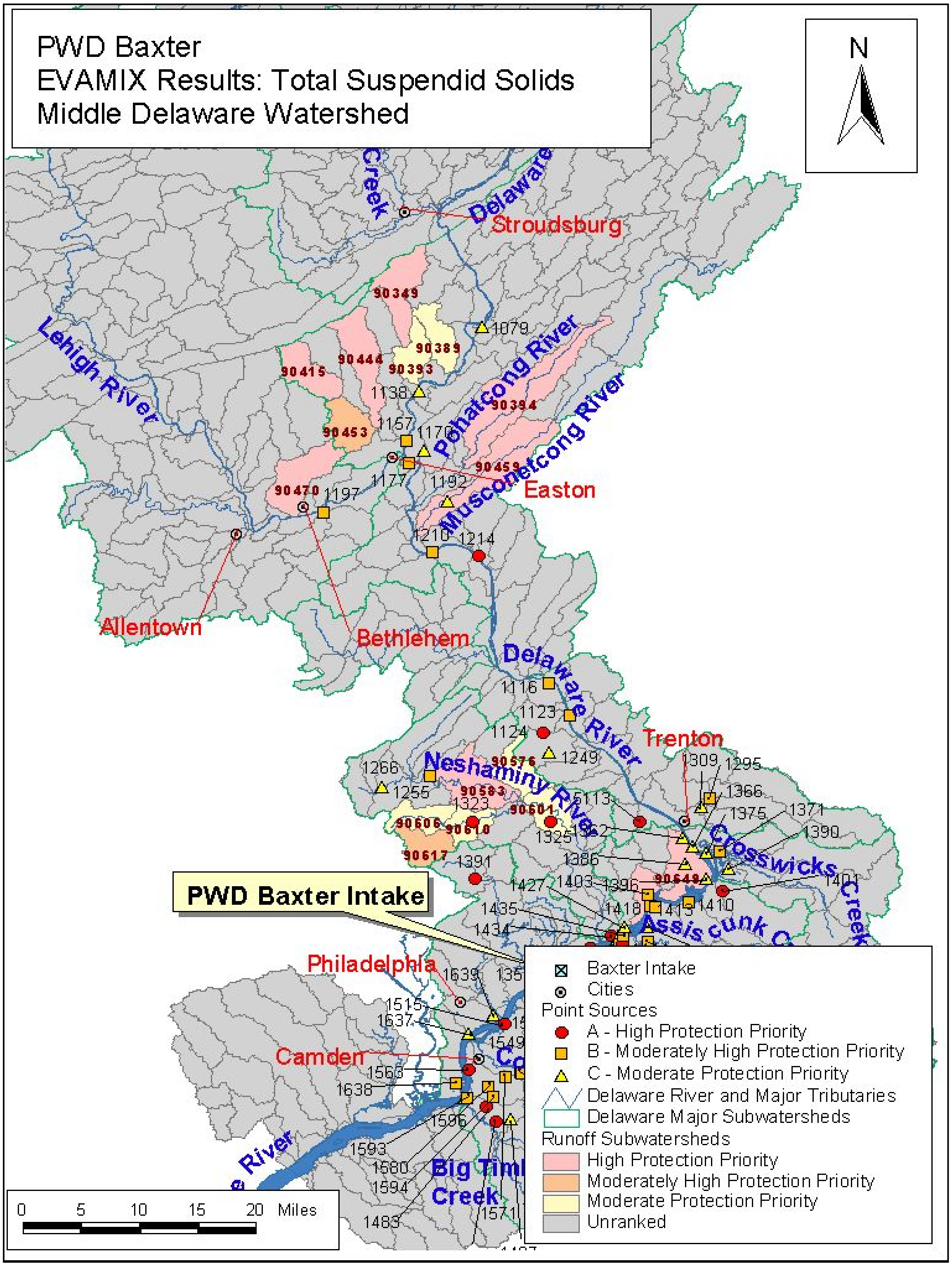
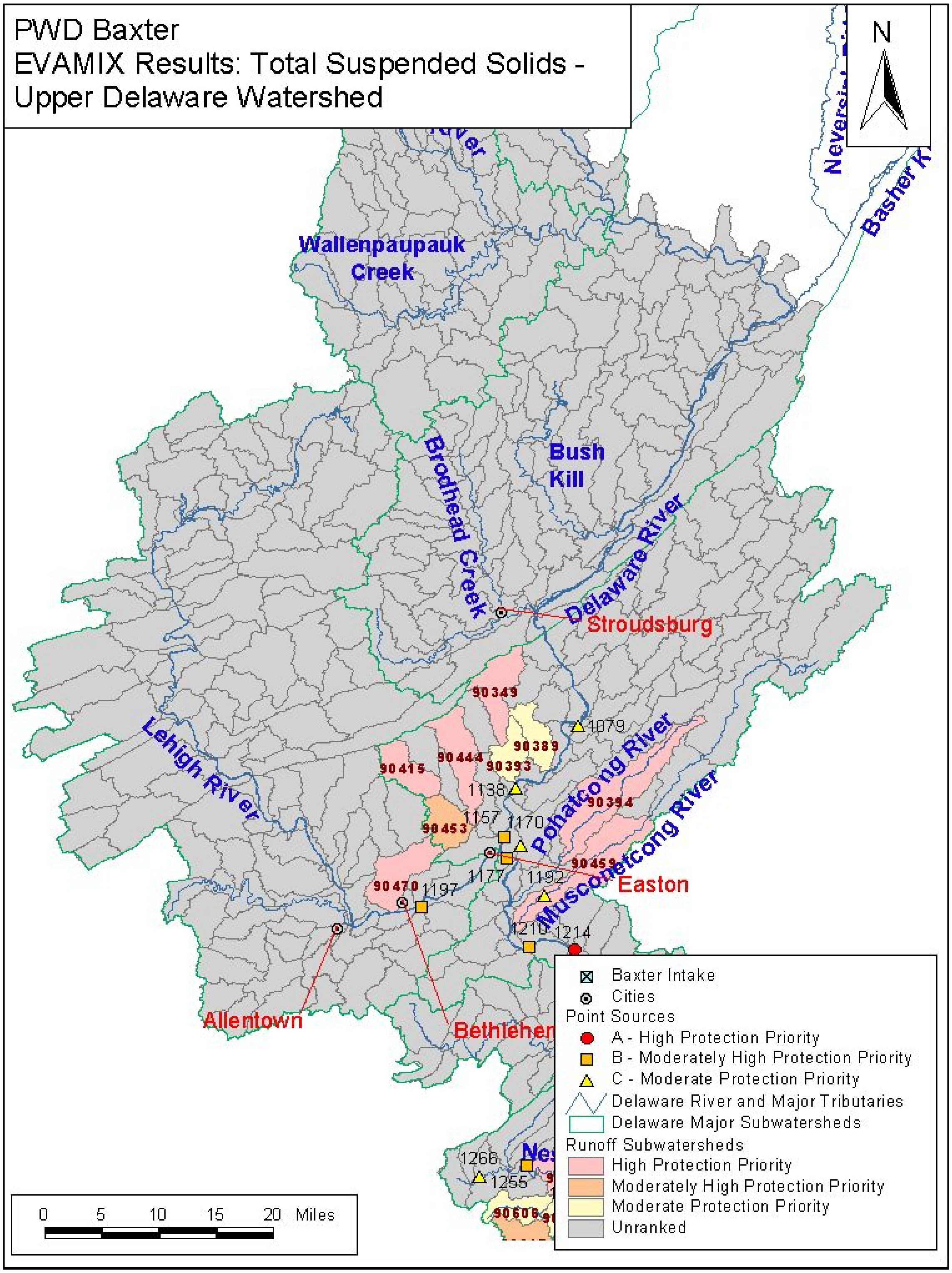


Figure 2.2.4-33 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for Total Suspended Solids in the Upper Delaware River Watershed



VOCs

Table 2.2.4-12 shows the results of the ranking of volatile organic compound (VOC) sites. In this case, the only significant potential sources of VOCs are storage tanks (ASTs), industrial sites from the TRI database, or wastewater treatment plants. The high protection priority category (category A) is a mixture of AST, RCRA, TRI, and NPDES sites. The moderately high and moderate protection priority categories are primarily AST, RCRA, and TRI sites. The NPDES sites appear to load VOCs at a low rate, and are not likely to cause water quality impairment at the intake. The AST and TRI sites would require a spill to cause water quality impairment, but resulting concentrations would be very high. RCRA sites were difficult to assess for potential loading. Figures 2.2.4-34 through 2.2.4-36 illustrate the priority point sources for volatile organic compounds in the lower and upper Delaware River watersheds.

Table 2.2.4-12 Contaminant Category Ranking for Volatile Organic Compounds

Source ID	Source Name	Database Used	Subwatershed	Zone	Time of Travel	Relative Impact (%)	Priority
4565	US STEEL FAIRLESS WORKS	AST	Martins Creek - 616	Zone A	3.1	64174.1091390	Highest-A
5091	WILLOW GROVE AIR FORCE RESERVE STA	AST	Little Neshaminy Creek - 617	Zone B	5.1	55688.2765256	Highest-A
4462	ROHM & HAAS CROYDON	AST	Delaware River - 666	Floodplain	0.6	39777.3403754	Highest-A
881	CRAIN IND. EASTON DIV.	TRI	LEHIGH R - 474	Zone B	18.2	24270.4800489	Highest-A
1515	GEORGIA PACIFIC CORPORATION	NPDES	Delaware River - 931	Floodplain	1.1	0.0056916	Highest-A
1350	CINNAMINSON STP	NPDES	Delaware River - 930	Floodplain	0.0	94.3671436	Highest-A
476	SAN JUAN INTL. INC.	TRI	Pond Run - 612	Zone B	5.4	13526.8903623	Highest-A
1513	SYBRON CHEMICALS INC	NPDES	RANCOCAS CR, N BR - 689	Zone B	4.0	0.0027027	Highest-A
1325	ASBURY PARK WTP	NPDES	NESHAMINY R - 601	Zone B	4.6	3.9205004	Highest-A
1550	MAPLE SHADE TOWNSHIP STP	NPDES	PENNSAUKEN CR - 706	Zone B	2.9	0.2256911	Highest-A
1390	CIRCUIT FOIL USA INC	NPDES	CROSSWICKS CR - 629	Zone B	4.0	0.0000000	Highest-A
1124	NORTHEAST MONMOUTH COUNTY RSA	NPDES	Pidcock Creek - 574	Zone B	8.8	0.0056598	Highest-A
4633	WILLOW GROVE TERM	AST	Robinhood Brook - 628	Zone B	2.8	16706.4829577	Highest-A
698	CRC IND. INC.	TRI	Little Neshaminy Creek - 613	Zone B	4.2	1553.9212787	Highest-A
1079	HOFFMAN-LA ROCHE INC	NPDES	PEQUEST R - 405	Zone B	21.9	0.0032114	Highest-A
5726	G R O W S INC LANDFILL	RCRA	Delaware River - 649	Floodplain	2.8	0.1193320	Highest-A
1127	OXFORD TEXTILE INC	NPDES	Unknown - 412	Zone B	24.0	0.0278378	Highest-A
931	OCCIDENTAL CHEMICAL CORP.	TRI	ASSISCUNK CR - 662	Zone A	2.2	800.4506997	Highest-A
5951	AMSPEC CHEMICAL CORP	RCRA	Delaware River - 932	Floodplain	2.9	0.0011933	Highest-A
624	ELF ATOCHEM N.A. INC.	TRI	Delaware River - 666	Zone A	0.6	89.8589735	Highest-A
599	CARTEX CORP.	TRI	Martins Creek - 616	Floodplain	3.3	81.2496859	Highest-A
543	OCCIDENTAL CHEMICAL CORP. BURLINGTON N. PLANT	TRI	Delaware River - 927	Zone A	2.0	246.4135945	Highest-A
534	HERCULES INC. BURLINGTON PLANT	TRI	Delaware River - 927	Zone A	2.0	106.5570651	Highest-A
4801	RHODIA INC	AST	Delaware River - 649	Zone A	3.9	10395.1449514	Highest-A
1395	UNITED STATES STEEL GROUP-USX	NPDES	Delaware River - 649	Zone A	2.9	0.8248631	Highest-A

Source ID	Source Name	Database Used	Subwatershed	Zone	Time of Travel	Relative Impact (%)	Priority
5452	YATES FOIL USA INC	RCRA	Delaware River - 927	Zone B	3.1	0.2121458	Highest-A
597	3M	TRI	Mill Creek - 648	Zone B	2.4	107.4226854	Highest-A
6482	COASTAL EAGLE POINT OIL CO	RCRA	BIG TIMBER CR - 769	Zone B	3.3	0.3314778	Highest-A
841	ASHLAND CHEMICAL INC.	TRI	LEHIGH R - 474	Floodplain	18.7	173.7606092	Highest-A
5940	RHODIA INC	RCRA	Delaware River - 649	Zone B	3.9	0.0058340	Highest-A
5839	MSC PRE FINISH METALS INC	RCRA	Delaware River - 649	Zone B	3.9	0.0010607	Highest-A
531	RHEIN CHEMIE CORP.	TRI	*C - 587	Zone B	5.4	315.1974130	Highest-A
955	CONGOLEUM CORP. AMTICO FLOORING DIV.	TRI	Branch of Pond Run - 609	Zone B	5.1	101.7136563	Highest-A
940	HOMASOTE CO.	TRI	Delaware River - 926	Zone B	5.6	165.2847119	Moderately High-B
923	U.S. NAVY NAVAL AIR WARFARE CENTER AIRCRAFT DIV.	TRI	Delaware River - 926	Zone B	5.6	110.7952045	Moderately High-B
566	CONGOLEUM CORP. PLANT 1	TRI	Pond Run - 603	Zone B	5.6	104.6196907	Moderately High-B
570	FINA OIL & CHEMICAL CO.	TRI	Pond Run - 603	Zone B	7.2	491.6163231	Moderately High-B
904	ROCHE VITAMINS & FINE CHEMICALS	TRI	PEQUEST R - 405	Zone B	21.9	576.4405752	Moderately High-B
912	BASF CORP.	TRI	Pophandusing Brook - 409	Zone B	22.2	545.2093146	Moderately High-B
625	ROHM & HAAS DELAWARE VALLEY INC.	TRI	Mill Creek - 648	Zone A	2.0	311.5104592	Moderately High-B
6057	ASHLAND CHEMICAL CO	RCRA	LEHIGH R - 474	Floodplain	18.7	0.0003646	Moderately High-B
4561	WONDER CHEM	AST	Delaware River - 649	Zone B	3.9	6894.7389984	Moderately High-B
4817	CHEMCENTRAL PHILA	AST	Delaware River - 649	Zone A	3.9	5303.6453834	Moderately High-B
5198	3M BRISTOL PACKAGING SYSTEMS PLANT	RCRA	Mill Creek - 648	Floodplain	1.8	0.0000001	Moderately High-B
5483	SITHE NJ HOLDINGS - GILBERT	RCRA	Delaware River - 918	Zone B	14.4	0.0795547	Moderately High-B
5368	SUPERPAC INC	RCRA	Mill Creek - 632	Floodplain	4.0	0.0000001	Moderately High-B
3674	SUNOCO 0002 6617	AST	Martins Creek - 616	Floodplain	2.8	3977.7340375	Moderately High-B
519	COASTAL EAGLE POINT OIL CO.	TRI	BIG TIMBER CR - 769	Zone B	3.3	1291.8568009	Moderately High-B
4828	BASIC CHEM SOLUTIONS	AST	Delaware River - 649	Zone A	3.9	4773.2808451	Moderately High-B
5036	MEENAN OIL LP	AST	Delaware River - 597	Zone B	5.4	6656.0749562	Moderately High-B
633	ALLIED-SIGNAL INC. FRANKFORD PLANT	TRI	Delaware River - 704	Zone B	1.3	478.5856464	Moderately High-B
792	TOWER PRODS. INC.	TRI	LEHIGH R - 933	Zone B	18.4	923.1245805	Moderately High-B
6198	FREDRICKS CO THE	RCRA	Rockledge Branch - 645	Floodplain	2.6	0.0000000	Moderately High-B
6448	J T BAKER CHEMICAL CO	RCRA	Delaware River - 914	Zone B	17.9	0.2651823	Moderately High-B
604	ALDAN RUBBER CO.	TRI	Delaware River - 704	Zone B	1.3	195.7101592	Moderately High-B
5865	PARAMOUNT PKG CORP	RCRA	West Branch Neshaminy Creek - 586	Floodplain	8.4	0.0000001	Moderately High-B
4312	SUNOCO 0014 3305	AST	Byberry Creek - 641	Zone B	1.3	3977.7340375	Moderately High-B
5028	TREVOSE GAS & CO	AST	Byberry Creek - 641	Zone B	1.3	3977.7340375	Moderately High-B

Source ID	Source Name	Database Used	Subwatershed	Zone	Time of Travel	Relative Impact (%)	Priority
5742	GRAVCO INC	RCRA	West Branch Neshaminy Creek - 586	Floodplain	8.4	0.0000001	Moderately High-B
4330	SUNOCO 0012 8959	AST	NESHAMINY R - 657	Zone B	1.8	3977.7340375	Moderately High-B
4389	3M CO	AST	Mill Creek - 648	Zone B	2.4	3977.7340375	Moderately High-B
4523	ELEMENTIS PIGMENTS INC	AST	Shoeneck Creek - 462	Zone B	18.4	9281.3794209	Moderately High-B
4725	EXXON RS 2 0336	AST	NESHAMINY R - 637	Zone B	2.6	3977.7340375	Moderately High-B
4315	WAWA FOOD MKT 277	AST	NESHAMINY R - 637	Zone B	2.8	3977.7340375	Moderately High-B
4898	7 ELEVEN 32639	AST	Queen Anne Creek - 627	Zone B	2.9	3977.7340375	Moderately High-B
4816	WHEELABRATOR FALLS INC	AST	Delaware River - 649	Zone B	3.9	3977.7340375	Moderately High-B
5058	CASTROL IND EAST	AST	Little Neshaminy Creek - 613	Zone B	4.2	3977.7340375	Moderately High-B
5049	CRC IND INC	AST	Little Neshaminy Creek - 613	Zone B	4.2	3977.7340375	Moderate-C
4904	WAWA 288	AST	Geddes Run - 561	Zone B	12.3	5303.6453834	Moderate-C
4130	NORTHAMPTON FARM BUR COOP	AST	Unknown - 444	Floodplain	19.8	5303.6453834	Moderate-C
4198	CRAIN IND	AST	LEHIGH R - 474	Zone B	18.2	6364.3744601	Moderate-C
6449	JAMES RIVER RIEGELSVILLE MILL	RCRA	MUSCONETCONG R - 459	Floodplain	16.0	0.0000001	Moderate-C
785	BETHLEHEM STRUCTURAL PRODS. CORP. COKE OPS.	TRI	Saucon Creek - 510	Zone B	17.4	169.4922362	Moderate-C
4128	SZILAGYI FUEL	AST	LEHIGH R - 485	Zone B	21.4	5303.6453834	Moderate-C
4177	HELLERTOWN STA	AST	Saucon Creek - 510	Zone B	17.6	3977.7340375	Moderate-C
3949	LOUBUC INC	AST	LEHIGH R - 936	Zone B	21.9	5303.6453834	Moderate-C
4190	R R CORTAZZO	AST	Unknown - 444	Zone B	22.2	5303.6453834	Moderate-C
4046	REIMER BROS	AST	Waltz Creek - 378	Zone B	22.2	5303.6453834	Moderate-C
4347	SQUARE ONE MINI MKT	AST	Unknown - 477	Zone B	20.8	4773.2808451	Moderate-C
767	BETHLEHEM STEEL CORP. STRUCTUAL PRODS. DIV.	TRI	LEHIGH R - 485	Zone B	21.4	169.9200798	Moderate-C
4112	G & JS PIT STOP II	AST	Shoeneck Creek - 445	Zone B	19.2	3977.7340375	Moderate-C
4279	AIR PROD & CHEM HANGER 2	AST	LEHIGH R - 935	Zone B	23.5	5303.6453834	Moderate-C
4164	B & C MINI MART	AST	Unknown - 420	Zone B	20.0	3977.7340375	Moderate-C
4601	FRITCH INC	AST	Unknown - 477	Zone B	20.6	3977.7340375	Moderate-C
5457	UNDERWATER TECHNICS INC	RCRA	Delaware River - 931	Floodplain	1.3	0.0004707	Moderate-C
5434	COLORITE POLYMERS	RCRA	Delaware River - 663	Floodplain	1.5	0.0530365	Moderate-C
5305	KEYSTONE LIGHTING USI LIGHTING	RCRA	Mill Creek - 648	Floodplain	1.8	0.0000000	Moderate-C
5329	LOWER BUCKS HOSP	RCRA	Mill Creek - 648	Floodplain	1.8	0.0000000	Moderate-C
3763	HESS 38406	AST	LEHIGH R - 936	Zone B	21.6	3977.7340375	Moderate-C
5439	GRIFFIN PIPE PRODUCTS	RCRA	Delaware River - 927	Floodplain	2.0	0.0013259	Moderate-C
4057	ALBRIGHTS SVC CTR	AST	Monocacy Creek - 470	Zone B	21.9	3977.7340375	Moderate-C
4052	SHOP QUIK 1	AST	Unknown - 444	Zone B	22.2	3977.7340375	Moderate-C
5440	HERCULES INC	RCRA	Delaware River - 927	Zone A	2.0	0.3646256	Moderate-C

Source ID	Source Name	Database Used	Subwatershed	Zone	Time of Travel	Relative Impact (%)	Priority
5667	FBF INC	RCRA	Mill Creek - 632	Floodplain	4.0	0.0000000	Moderate-C
5921	Q C INC	RCRA	Mill Creek - 632	Floodplain	4.0	0.0000000	Moderate-C
5438	ELECTRONIC PARTS SPECIALTY CO	RCRA	Unknown - 722	Zone A	2.9	0.0013259	Moderate-C
5694	PSE & G - MERCER GENERATING STA	RCRA	Delaware River - 927	Zone A	3.7	0.0477328	Moderate-C
5686	AMERICAN STANDARD INC	RCRA	Pond Run - 612	Zone B	5.6	0.0733627	Moderate-C
6452	PEARSALL CHEMICAL DIV WITCO	RCRA	Delaware River - 915	Zone B	17.1	0.0198887	Moderate-C
6070	BETHLEHEM STRUCTURAL PRODS CORP	RCRA	LEHIGH R - 485	Zone B	21.4	0.1856276	Moderate-C

Figure 2.2.4-34 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for VOCs in the Lower Delaware River Watershed

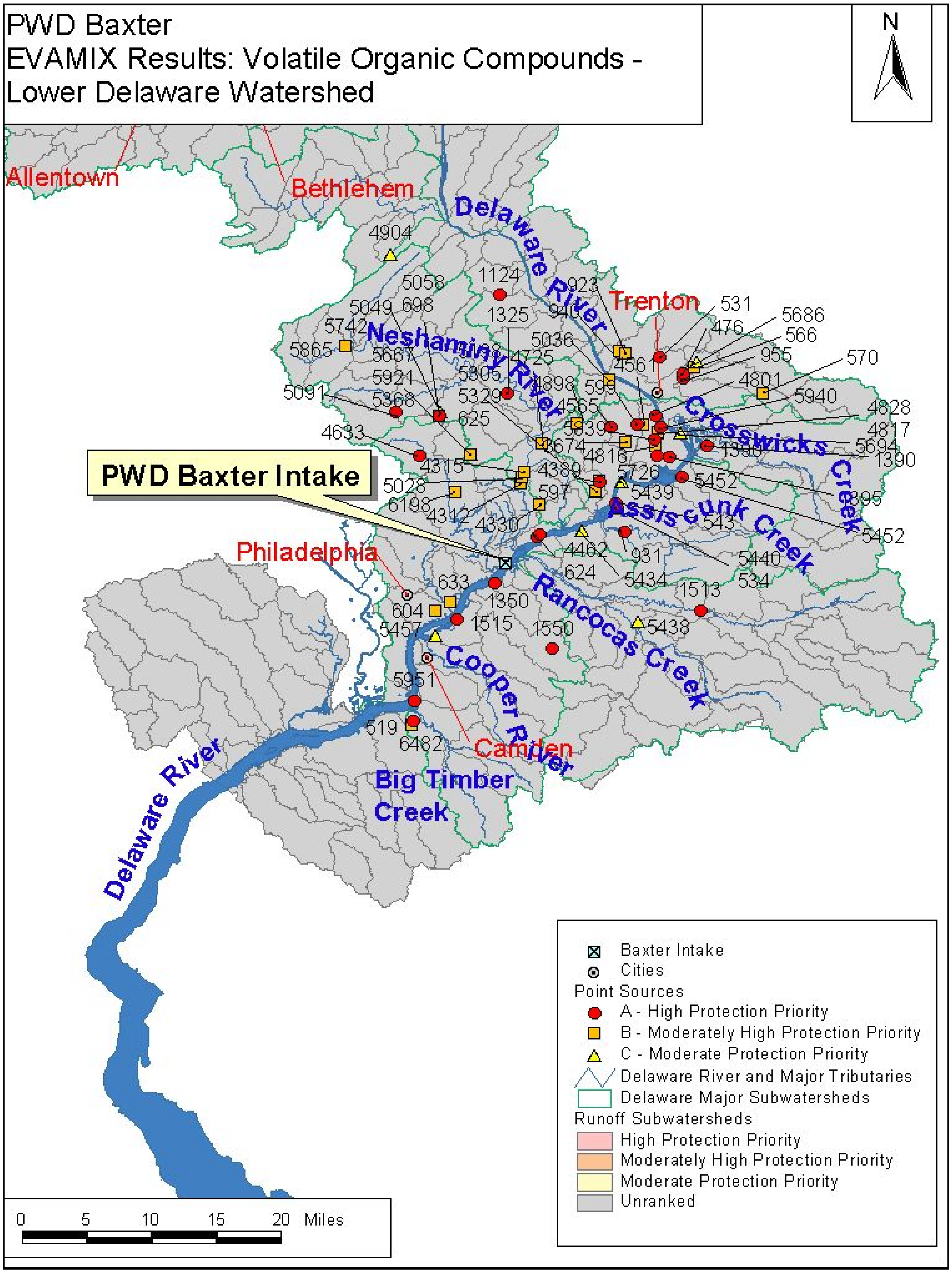


Figure 2.2.4-35 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for VOCs in the Middle Delaware River Watershed

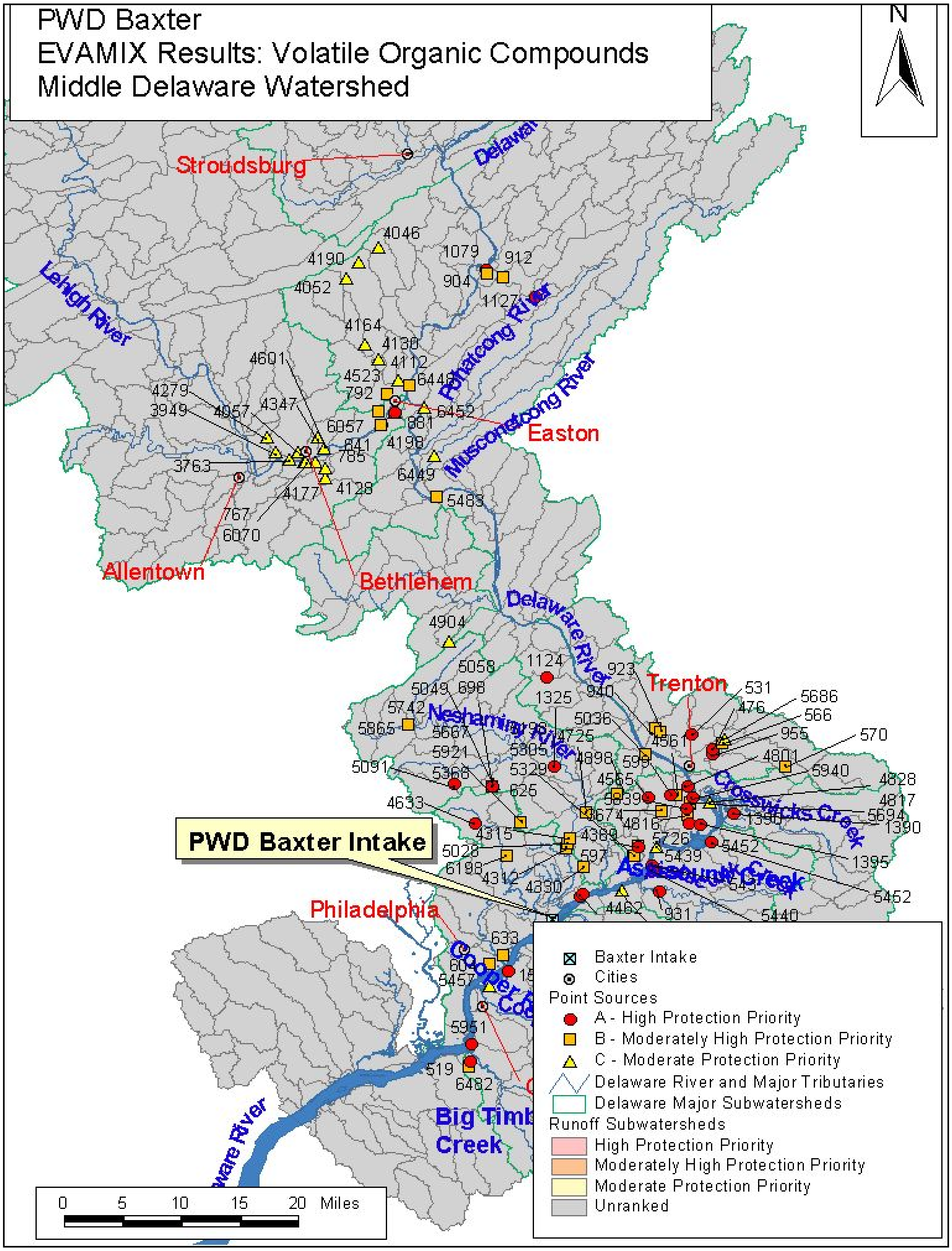
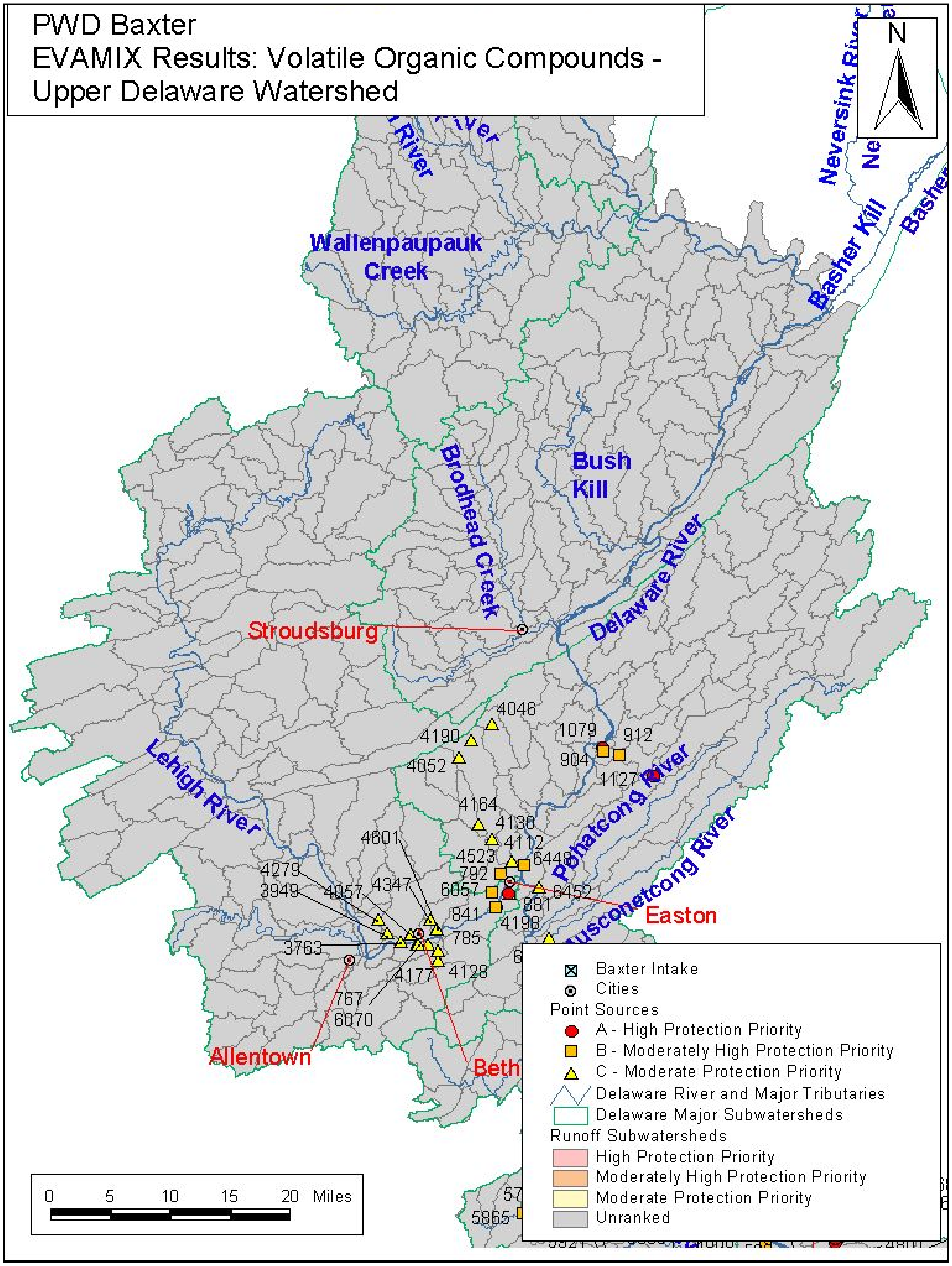


Figure 2.2.4-36 Priority Point Sources and Subwatersheds for PWD's Baxter Intake for VOCs in the Upper Delaware River Watershed



2.2.4.3 Narrative Results

Potentially Significant CERCLA Sources

There are 655 CERCLA sites in the watershed; 34 of these sites are on the National Priority List (NPL) for clean up by the USEPA. Approximately 543 of those CERCLA sites fall within the Zone A and B (5 to 25-hour times of travel) from the Baxter Intake during extreme high flow conditions. Only 116 of those 543 sites are within the Zone A (5-hour time of travel) from the Baxter Intake.

Of those 116 sites in Zone A, 63 are within the floodplain. It is very difficult to quantify the types and extent of contamination at a CERCLA site as well as the contaminant's ability to migrate and impact a surface water supply. Therefore, a simple screening process was developed to determine which CERCLA sites may be a potentially significant source of contamination to the water supply. Sites that were considered to be significant met one or several of the following characteristics:

- The site is a National Priority List Site and considered to be contaminated and of concern by the USEPA;
- The site is within Zone A of the Baxter Intake;
- The site is within the floodplain;
- The site is not currently being cleaned up by USEPA; and
- The site is identified by stakeholders as contaminated and of concern to the local community.

The priority ranking of the sites used the following criteria:

- A site met multiple criteria from above;
- A site was closer to the intake than another; and
- A site had a higher surface water migration score than another site or overall migration score according to rankings provided at www.scorecard.org.

Using these criteria, 34 NPL sites were identified within the watershed. Two of the NPL sites reside within the floodplain, 24 fall within the Zone A and B of PWD's Baxter Intake. NPL sites are considered to be significant due to their history of contamination and local environmental impacts that require cleanup by the USEPA. As shown in Table 2.2.4-13, Montgomery, Chester, Berks, and Bucks Counties are the top four counties in Pennsylvania when ranked by the number of NPL sites within them. Table 2.2.4-14 has a summary list of the most frequently detected chemicals at NPL sites in several counties within the Delaware River Watershed. As shown, the most common contaminants at these sites are volatile organic compounds and metal compounds.

Table 2.2.4-13 County Rankings in PA for Number of NPL Sites

Rank	County	Number of Superfund Sites
1	MONTGOMERY	16
2	CHESTER	12
3	BERKS	8
4	BUCKS	7
5	ADAMS	4
	ALLEGHENY	4
	LANCASTER	4
	LEHIGH	4
	MERCER	4
	MONROE	4
	YORK	4
6	DELAWARE	3
	SCHUYLKILL	3

Source www.scorecard.org

Table 2.2.4-14 Most Frequently Detected Chemicals at NPL Sites in Various Counties Draining into the Delaware River Watershed

Contaminant	County
TCE	Berks
Diethanolamine	Berks
1,1,1-Trichlorethane	Bucks
Zinc	Bucks
Trichlorethylene	Chester
Nickel Compounds	Chester
Vinyl Chloride	Lehigh
Copper	Lehigh
TCE	Montgomery
Copper	Montgomery
Methyl Isobutyl Ketone	Philadelphia
Nickel Compounds	Philadelphia
Mercury	Schuylkill
Barium Compounds	Schuylkill

Source www.scorecard.org

In addition to NPL sites there were another 69 CERCLA sites in the floodplain upstream of the Baxter Intake. These sites were examined for potential significance along with the other CERCLA sites identified by stakeholders as potentially significant sources of concern.

The final ranking of the NPL sites is provided in Table 2.2.4-15. The rankings identified four NPL sites that are considered to be potentially significant sources of contamination. All four of the sites were located within the Zone A (5 hour) travel time to the Baxter Intake. All other sites are located in Zone B (<25 hour) or C. The sites of protection priority C are sites that have been cleaned up, contained, or are being utilized by businesses again and should represent little threat to the environment.

There is no way to adequately quantify all of these sites for proper comparison in the overall EVAMIX prioritization rankings. However, based on the limited information available, it appears that the CERCLA sites would potentially rank very low compared to other potentially significant sources in the watershed from the combined ranking.

Spills and Accidents

The Delaware River Watershed is a major transportation corridor for railroads and trucking. In addition, there are several major petroleum pipelines located within the watershed. The volumes of chemicals transported by these means are quite significant. A tanker truck can normally hold about 5,000 gallons of a chemical. A railroad tanker car can normally hold about 14,000 gallons of a chemical. A pipeline, if it breaks and spills contaminants for an hour or more can spill between 1,000 to 10,000 gallons of a chemical depending on its size.

Hypothesizing that an accident were to spill the partial or entire contents of these sources into the river, estimates show that the impacts on downstream local water supplies could be severe, even up to 100 miles downriver of the spill. Assuming that a pipeline, railroad tanker car, or even tanker truck spilled benzene even 10 miles upriver from the water supply intake, only 10 gallons of benzene would need to make it to the river during a normal flow day for concentrations in the river to cause significant impacts on water quality. This would either require the water treatment plant to stop withdrawing water from the river or require special treatment of the water with carbon.

Table 2.2.4-15 Potentially Significant CERCLA Sources for the Baxter WTP Intake

Rank	Zone	Name	Chemicals	Floodplain	NPL Status
C	A	WELSBACH & GENERAL GAS MANTLE CONTAMINATION		No	Yes
C	A	FLORENCE LAND RECONTOURING LANDFILL		No	Yes
C	A	ROEBLING STEEL CO		No	Yes
C	A	SWOPE OIL & CHEMICAL CO		No	Yes

Under more extreme conditions, up to 100 gallons of benzene would need to be spilled for a similar impact. These estimates do not take into account the potential loss of benzene due to holding in pockets in the river or binding to sediments and other material as it flows downstream. Therefore, higher concentrations of 1,000 gallons of benzene spilled from an accident would most likely have a severe impact on water quality at the intake even if it were spilled during a rain event 100 miles upriver.

In terms of their overall priority compared to the other sources provided in the combined ranking, spills and accidents can have one of the greatest relative impacts on water quality and require some moderate level of protection priority. An early warning system on the Schuylkill River such as the system present on the Ohio River would help to prevent such severe impacts in the event of a spill.

Radionuclides
The presence of the Nuclear Generating Station in the region requires monitoring for the presence of radionuclides in the finished drinking water. To date, special monitoring has only detected Gross Beta radionuclides at levels far below the regulated limits in the finished water from Delaware River sources. All other types of radionuclides have not been detected.

Given that current water quality data does not suggest any radionuclide issues with these sources and the current controls and monitoring in place to protect against them, these sources would be considered a medium protection priority and would tend to fare lower than other sources identified in the combined ranking.

2.2.5 Qualitative Loading Analysis

Key Points
- **Quantitative contaminant loading analyses are difficult to implement as it is not possible to accurately characterize all of the factors affecting potential contaminant releases and transport.**
- **Qualitative contaminant loading analyses can provide order-of-magnitude assessments that will help to identify potentially significant major loads**
- **Non-point sources associated with stormwater runoff were identified as significant sources of fecal coliform, total suspended solids, and petroleum hydrocarbons.**

2.2.5.1 Method

Performing a quantitative pollutant loading analysis requires a substantial investment in data collection. For example, for sites that actually discharge wastewater to the river on a continuous or intermittent basis, accurate data on discharge rates and concentrations of contaminants in the discharge water are required. For sites that store chemicals, accurate data on the amount and type of chemical stored are required, and a series of assumptions must be made about the probability of leaks or spills occurring. The analysis must also account for natural sources of certain contaminants and a calibrated non-point source or runoff-loading model is needed to add stormwater-related pollutant loading to the calculations. For this reason, a quantitative contaminant loading analysis goes well beyond the scope of this study, and the data collected is not sufficiently accurate to allow a quantitative analysis to be performed.

Despite the limitations that the data impose, a more qualitative analysis of contaminant loading is still valuable, and can provide important insight into the relative magnitude of the impacts that the major contaminant sources might have on the water quality within the watershed. The approach to performing the analysis is summarized by the following steps.

Step 1: Loading Estimates

- For sites that have continuous or intermittent discharges, estimates of annual contaminant loading for each contaminant category are calculated by multiplying median discharge concentration by average annual discharge rate.

- For sites that simply store or use chemicals onsite, there is no logical way to estimate point loading because contaminants are only released through spills or leaks. An extreme estimate of potential loading can be made by assuming stored chemicals in the largest tank onsite are released through a catastrophic tank failure and are all spilled to the surface water.

- For non-point source pollutant loading, estimates for each contaminant category were provided by the SWMM model results on an annual basis.

Step 2: Loading Magnitude Comparisons
The loading estimates produced in step one are of widely varying accuracy. The SWMM model stormwater loads may be generally accurate, however, they are based on Event Mean Concentrations that may or may not be representative of local conditions within the watershed. The loading estimates for point source dischargers range from accurate for dischargers who regularly monitor their discharges and report results (usually the larger sources), to highly speculative where data had to be filled in for both concentration and discharge rate (many of the smaller dischargers). The loading estimates for sites that store or use chemicals are not based on data, and represent a speculation on potential leaking or spilling that probably overestimates loading by a considerable margin.

Despite the disparity in accuracy, the total annual loads can be contrasted with each other, and general conclusions about the magnitude of each type of source drawn. These estimates will also be compared to estimates of contaminant loads from natural or more regional sources (e.g. acid mine drainage) where information or data are available. The intent is not to calculate actual estimates of loading rates, but to better understand which sources are most likely to be major sources, and which appear to be minor sources.

Step 3: Reality Check
Because of the highly speculative nature of the loading estimates, annual average contaminant loads for each source are estimated and divided by annual average flow rates in the river. These concentrations are then diluted by the tidal effects of the lower Delaware River based on the tidal river model, and used to estimate an in-stream concentration. The calculated concentration can be compared to in-stream sampling data and conclusions drawn about the degree of overestimation or underestimation that the loading estimates appear to represent.

2.2.5.2 Results

Only a general, qualitative analysis of contaminant loading can be made with the sketchy data available for this analysis. A cumulative loading analysis goes well beyond the scope of this analysis and is not attempted here. The qualitative loading analysis is based on the loading estimates produced by the database in support of the evaluation of sites, and only provides an indication of the relative importance of each potential source.

Loading Estimates
Using the database, order of magnitude estimates of loads from each type of source can be made. These are discussed here in a general sense for the sites in the major databases.

Each source is rated according to the relative impact that the source might have on ambient river concentrations.

- Low: if the sites do not appear to contribute enough pollutant to even register as a portion of the ambient concentration. Generally, each of these sites if discharging or spilling to the river, would only change the concentration at the intake by less than 0.1%.

- Medium: if the sites could be contributing a low percentage of the actual ambient concentrations. Generally, each of these sites, if discharging or spilling to the river, would change the concentration at the intake 0.1 to 25%.

- High: if the sites could or are one of the major contributors of this contaminant. Generally, each of these sites, if discharging or spilling to the river, would change concentrations at the intake by more than 25%.

A distinction is made between sources that are contributing and those that could, but only if spills or leaks occur.

Table 2.2.5-1 provides a summary of the estimated combined contributions by the various source types under either normal or abnormal (such as the primary storage tank spilling all its contents) conditions. The table also provides comments on whether the indicated, cumulative sources appear to drive or influence water quality when compared to water quality data. "Yes" indicates that current water quality day corroborates the indicated source contributions. "Partial" indicates that current water quality data only partially corroborates the source contributions. "No" indicates that no real correspondence exists between the source contributions and water quality data.

Table 2.2.5-1 Qualitative Combined Contributions to River Water Quality

Contaminant	NPDES (dischargers)	NPS (runoff)	TRI (toxic facilities)	AST (storage tanks)	Matches with Reality?
Salts	Low	Low	Low	Low	Yes
Cryptosporidium	Low	Low	Low	Low	No
Fecal coliforms	Low	Medium	Low	Low	Yes
Nitrate	Low-Medium	Low	Medium*	Medium*	Yes
Metals	Medium-High	Low	High*	High*	Yes
Phosphorus	Medium	Medium	Medium*	Medium-High*	Partial
Petroleum Hydrocarbons	Low-Medium	Medium	Low	High*	Yes
Disinfection-by-Products	Medium	Low-Medium	Medium*	Low	Partial
Turbidity	Medium	Medium	Low	Medium*	Yes
Volatile Organic Compounds	Medium-High	Low	High*	High*	Yes

** Abnormal and highly unlikely situation would require the simultaneous release of contaminants from storage tanks.*

As shown, estimates for salts, fecal coliforms, nitrate, metals, petroleum hydrocarbons, turbidity, and volatile organic compounds appear to match well with current water quality data observations. However, the estimate for *cryptosporidium* does not match. Some categories, such as phosphorus and disinfection-by-products, only show partial matches. Source contributions for metals, such as lead and copper, do generally match water quality. However, source contributions do not correlate with iron and manganese intake levels, which are greatly influenced by acid mine drainage. Therefore, the qualitative loading analysis, which is based on conservative assumptions, only provides some very general indications about the impacts of various sources. This analysis requires further refinement as part of a true cumulative analysis for a TMDL in order to provide more accurate predictions.

Salts

NPDES (permitted dischargers): Low

Permanent discharges, but at very low concentrations.

NPS (stormwater runoff loading): Low

Stormwater runoff can be a source of salts during the winter, but does not appear to be a concern.

TRI (generators/handlers): Low

Sites could contribute minor amounts, but only do so through spill or leaks.

AST (above ground tanks): Low

A few potential sites could affect water quality, but only through a catastrophic spill.

Comparison of the loading results to actual seasonal trends in water quality data (section 2.1.5) shows that the results of both analyses indicate that NPS (stormwater) runoff is the main source of salts in the watershed. The qualitative loading results further indicate that the cumulative impact of these sources from developed areas is probably not significant, however, long term trends appear to suggest that the cumulative impacts could become more significant and the source of the increasing concentrations in the river.

Cryptosporidium

NPDES (permitted dischargers): Low

These are majority of the sources, however, the loading rate is relatively low, and does not result in significant concentrations in the ambient water under normal circumstances.

NPS (stormwater runoff loading): Low

Stormwater runoff can be a source of *Cryptosporidium* from certain land uses, and is probably responsible for almost all the background levels found in the river.

TRI (generators/handlers): Low

AST (above ground tanks): Low

Not a source. Comparison of the qualitative loading data with actual water quality data from research studies conducted by PWD, suggest that the elevated concentrations observed during storm events are most likely due to stormwater runoff from developed areas and pasture lands. However, during non-rainfall periods, it appears that NPDES discharges in particular from wastewater treatment plants are the main source of daily concentrations observed in the Delaware River. Therefore, efforts to reduce mean daily concentrations of *Cryptosporidium* in the river should focus on reducing the impacts from wastewater discharge, while efforts to reduce peak concentrations should focus on mitigating stormwater runoff from pastures and developed areas.

Fecal Coliform
NPDES (permitted dischargers): Low

These sites are one of only two sources, however, the loading rate is relatively low, and does not result in significant concentrations in the ambient water under normal circumstances.

NPS (stormwater runoff loading): Medium

Stormwater runoff is the primary source and is probably responsible for almost all the background levels found in the river. This is usually seen in the extreme variability of fecal counts responding to rainfall events.

TRI (generators/handlers): Low

Not a source

AST (above ground tanks): Low

Not a source

Comparison of the qualitative loading data with actual water quality data suggests that the elevated concentrations observed during storm events are most likely due to stormwater runoff from developed areas and pasture lands. However, during non-rainfall periods, it appears that coliforms can originate from a number of sources including wastewater discharges, leaking septic tanks, leaking sewers, “wildcat” or illegal sewage discharges, geese, and livestock.

Metals
NPDES (permitted dischargers): Medium-High

NPDES discharges may account for some of the metal concentration found at the intake. The amounts, cumulatively, could represent a low but significant percent of total metal loading for certain metals.

NPS (stormwater runoff loading): Low

Stormwater runoff can be a significant source of metals during storm events, with runoff often contributing copper, zinc, cadmium, and other metals at relatively low concentrations to the water.

TRI (generators/handlers): High (potential only)

Sites could contribute major amounts of metal to the river, but only do so through spill or leaks. The amounts stored, if spilled, could cause order of magnitude exceedences of the drinking water standards at the intake for short periods of time.

AST (above ground tanks): High (potential only)

Sites could contribute major amounts of metal to the river, but only do so through spill or leaks. The amounts stored, if spilled, could cause order of magnitude exceedences of the drinking water standards at the intake for short periods of time.

Though the qualitative analysis suggests that TRI and AST sites have the potential for the greatest cumulative impacts, it would require numerous simultaneous catastrophes in the watershed for this to occur. Based on analysis of long-term trends, it appears that concentrations of metals are increasing in the river. Also water quality data suggests most metals increase during storm events. The only metal that does not always increase during rain events is manganese. In section 1.4.6.1, it was shown that concentrations measured from acid mine drainage discharges can actually be responsible for everyday concentrations of iron and manganese observed in the Delaware River. Also, spatial analyses in section 2.1.5 also observed a decrease in metals concentrations with distance downriver. Therefore, though it is estimated qualitatively that NPDES discharges appear to have a medium impact on metal concentrations in the river, it is more likely that stormwater runoff and acid mine drainage are the driving factors cumulatively influencing water quality trends in the river.

Nitrates
NPDES (permitted dischargers): Low-Medium

Permitted discharges of wastewater contribute a steady load of nitrates to the river, but in general do not result in concentrations that approach the drinking water standard.

NPS (stormwater runoff loading): Low

Stormwater runoff can be a source of nitrate, especially runoff from agricultural lands. Overall loading, however, appears to be low.

TRI (generators/handlers): Medium (potential only)

Generally not a source, although a few sites appear to have the potential to be a temporary source if a spill were to occur.

AST (above ground tanks): Medium (potential only)

Generally not a source, although one site appears to have the potential to be a temporary source impacting concentrations through a spill or leak.

Analysis of observed nitrate concentrations in sections 2.1.5 show that nitrate and ammonia concentrations are decreasing in the river. Also, seasonal fluctuations in nitrate concentrations appear to be dominated by biological activity in the river. However, analysis of impairment data in section 2.1.5.4 suggests that nutrients are one of the top five leading causes of impairments in the tidal portion of the Delaware River Watershed in Pennyslvania. Upon further examination, these impairments may be more related to phosphorus than nitrate. Overall, the combined information suggests that improvements by wastewater discharge and reduced agricultural runoff have benefited the watershed, but the cumulative impacts of nitrate from both point and non-point sources combined may still play a significant role in determining stream health.

Petroleum Hydrocarbons
NPDES (permitted dischargers): Low-Medium

Generally not a source, although a number sites appear to contribute to concentrations. However, the loading rate is relatively low, and does not result in significant concentrations in the ambient water under normal circumstances.

NPS (stormwater runoff loading): Medium

Stormwater runoff is a source of petroleum hydrocarbons during storm events, particularly from urban areas. Measurable concentrations at the intake are likely to be the result from stormwater runoff.

TRI (generators/handlers): Low

Not a source

AST (above ground tanks): High (potential only)

This is only a source if spilled or leaked. The amounts stored at many sites, however, mean that a spill could have significant impact, with very high concentrations occurring following a spill.

As observed, petroleum hydrocarbons from non-point source runoff and aboveground storage tanks were considered to have the greatest potential qualitative impacts. Petroleum hydrocarbon impacts are typically observed from spills caused by accidents or releases. The impacts of hydrocarbons from stormwater runoff have not been observed in either water quality data or stream impairment descriptions to date. Therefore, the observed cumulative impact of various sources on hydrocarbons is low, but the observed impact from an individual source during an accident can be significant.

Phosphorus
NPDES (permitted dischargers): Medium

Wastewater discharges are a source of phosphorus, but at amounts that are not likely to have a large effect on ambient concentrations at the intake.

NPS (stormwater runoff loading): Medium

Stormwater runoff can be a source of phosphorus in runoff from residential and agricultural areas. Overall loading, however, appears to be relatively low.

TRI (generators/handlers): Medium (potential only)

Some sites could contribute significant amounts, but only do so through spill or leaks.

AST (above ground tanks): Medium-High (potential only)

In general, not a source, however one or two sites noted as storing phosphorus.

Analysis of observed orthophosphate concentrations in sections 2.1.5 and 1.4 show that orthophosphate concentrations are increasing in the river. Seasonally, orthophosphate concentrations also appear their greatest during spring when runoff and rainfall occurs. In addition, analysis of impairment data in section 2.1.5.4 suggests that nutrients are one of the top three leading causes of impairments in the lower half of the Schuylkill River Watershed. These impairments may be related mainly to phosphorus and not to nitrate. Overall, the combined information suggests that the cumulative release of phosphorus from non-point sources may be the most significant contribution for control.

Disinfection By-Product (Total Organic Carbon)
NPDES (permitted dischargers): Medium

Wastewater discharges are one of the major sources of TOC, and can be having a measurable impact on concentrations at the intake.

NPS (stormwater runoff loading): Low-Medium

Stormwater runoff can be a significant source of metals during storm events, at relatively low to medium concentrations to the water.

TRI (generators/handlers): Medium (potential only)

Sites could contribute significant amounts, but only do so through spill or leaks.

AST (above ground tanks): Low

Not a significant source

Total organic carbon can come from many sources including agriculture, decaying leaves and algae, and sewage discharge. However, the nature of the organic matter from those sources can be significantly different and have significantly different impacts on the formation of disinfection by-products when they react with chlorine. Water quality data in section 1.4 suggests that TOC has increased in the river over the past decade. Since the population in the watershed has not changed significantly in the past decade, it is doubtful that NPDES discharges are the influencing cumulative source related to this increase. However, during this period, developed land throughout the watershed has increased. These observations suggest that the combined impact from the many non-point sources in the watershed may be driving the increasing concentrations observed in the river.

Turbidity (Total Suspended Solids)
NPDES (permitted dischargers): Medium

Wastewater discharges are a major source of TSS, and probably have a measurable impact at the intake.

NPS (stormwater runoff loading): Medium

Stormwater runoff is the major source of TSS during storm events, and can cause large increases in concentration for periods of time during and after a storm.

TRI (generators/handlers): Low

Not a source

AST (above ground tanks): Medium (potential only)

Only a source if major spill occurs.

The qualitative analysis suggests that both NPDES discharges and non-point sources are the controlling sources of turbidity. Water quality data suggests that non-point source runoff tends to control turbidity due to its increased values during the wetter seasons. NPDES discharges may contribute to the daily non-rain event turbidity levels, but water quality data to date does not clearly suggest any impact on turbidity from dry weather discharges.

VOCs
NPDES (permitted dischargers): Medium-High

Generally not a significant source of VOCs, however can discharge measurable amounts.

NPS (stormwater runoff loading): Low

Not a significant source

TRI (generators/handlers): High (potential only)

Sites could contribute significant amounts, but only do so through spill or leaks. A spill would result in orders of magnitude increase above drinking water standards.

AST (above ground tanks): High (potential only)

Sites could contribute significant amounts, but only do so through spill or leaks. A spill would result in orders of magnitude increase above drinking water standards.

As observed, volatile organic compounds toxic release facilities and aboveground storage tanks were considered to have the greatest potential qualitative impacts. Analysis of the limited VOC data does not suggest any impacts from particular point sources or facilities. Past experiences tend to suggest that individual sources such as accidents and spills that release benzene or toluene are most likely to impact the water supply. Therefore, the observed cumulative impact and likelihood from various sources of VOCs is low, but the observed impact from an individual source during an accident can be significant.

2.2.6 Watershed Protection and Restoration Activities

In order to gain an understanding of the current levels of environmental stewardship and awareness within watersheds, a compilation of grants and restoration projects was completed. State, Federal and private grant sources identified the levels of funding that they provided through various programs to respective watersheds from 1995 to 2001.

These programs include the Pennsylvania Department of Environmental Protection's (PA-DEP) 319 Non-Point Source Program and the Growing Greener Program, the Pennsylvania Department of Conservation and Natural Resources (PA-DCNR) Rivers Conservation Plan Program, and Pennsylvania's Coastal Zone Management Program. Also included were Pennsylvania's Natural Resource and Conservation Service's (NRCS) Conservation Reserve Program (CRP), Wetlands Reserve Program (WRP), Watershed Protection and Flood Prevention Act (PL-566) Program, and the Environmental Quality Incentives Program (EQIP). Additional sources include monies from the New York State DEP, New York City DEP, and New Jersey DEP funds. In addition, private sources of funding were also compiled, including the William Penn Foundation, the Pew Charitable Trusts and The Pennsylvania League of Women's Voters. Additional sources of funding included federal funds via the Army Corps of Engineers (USACOE), the United States Environmental Protection Agency (EPA), the United States Fish and Wildlife Service (FWS), and the National Science Foundation (NSF).

Restoration activities within the lower portion of the Delaware River Watershed are generally within the Zone A limit of PWD's Baxter Intake. The lower portion of the Delaware River includes the following source water assessment study areas: Tidal PA-Philadelphia, Tidal PA Bucks, Neshaminy, Tohickon, NJ Mercer Direct, PA Bucks Direct, Crosswicks, Tidal NJ Upper, Rancocas, and Tidal NJ Lower. The combined grant funding for these study areas from 1995-2002 was $7,673,676.

The middle portion of the Delaware River Watershed is made up of the following source water assessment study areas: Lehigh and Middle Delaware. The combined funding level for the middle portion was $1,662,166.

The upper portion of the Delaware River Watershed is made up of the Upper Delaware, East Branch Delaware, Mongaup, and the Lackawaxen. The combined funding level for the upper portion was $9,781,960. Figure 2.2.6-1 summarizes the distribution of grant dollars by project type. Over 18% of the grant funds were allocated for restoration projects in the watershed.

Figure 2.2.6-1 Distribution of Tidal PA Philly Grants by Project Type

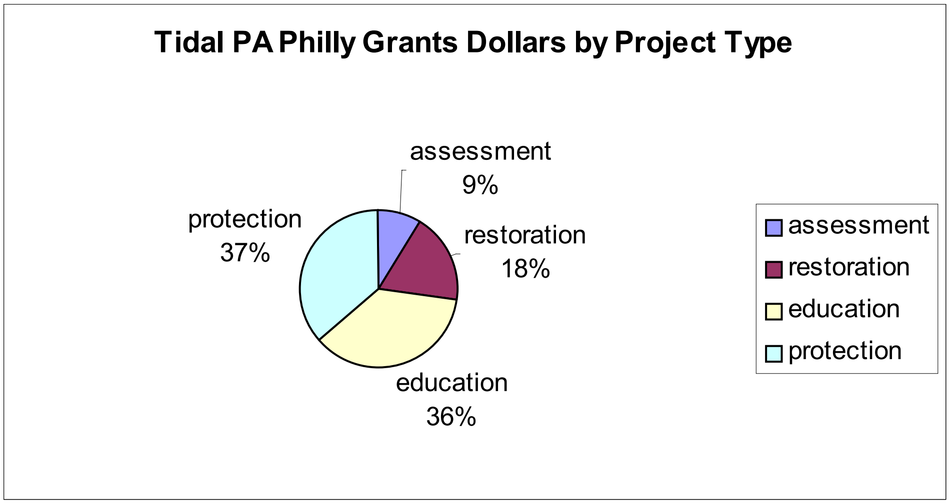


Table 2.2.6-1 lists the grants received within the Lower Delaware River Watershed from 1995-2001. The largest project funded was the Fairmount Water Works, receiving approximately 33% of the total funding for the watershed. The Fairmount Water Works will serve as the educational center for the region in terms of water resources and the connection between anthropogenic activities and environmental sustainability.

Table 2.2.6-1 Projects Receiving Grants in the Lower Delaware River Watershed (several SWAP Study areas)

Study Area	Grant	Awardee	Project Description	Year
Neshaminy	$250,000	Bucks County	Park Development for Peace Valley	2001
Neshaminy	$40,000	Bucks County	Churchville Reservoir Nature Center	2001
Neshaminy	$80,000	Heritage Conservancy	Rivers Conservation Plan - Lower Neshaminy	2001
Neshaminy	$200,000	Heritage Conservancy	90 acres preserved Durham Mine Bat Cave	2001
Neshaminy	$130,000	Heritage Conservancy	51 acres preserved of Quakertown Swamp	2001
Neshaminy	$63,850	Bucks County Audubon Society	Honey Hollow Watershed Conservation Plan	2001
Neshaminy	$60,000	Buckingham Township	Stormwater basin retrofit into wetland	2000
Neshaminy	$6,530	N.B. Neshaminy Creek Watershed Assc.	Start-up of a watershed association - Lake Galena	2000
Neshaminy	$112,535	American Littoral Society	Comprehensive watershed assessment	2000
Neshaminy	$60,000	Bucks County Conservation District	Warrington Lake & Neshaminy Creek Assessment	2001
Neshaminy		Doylestown Twp. Env. Advisory Council	Restoration at Bridge Point Park	2001
Neshaminy	$10,000	Horsham Township	Update comprehensive recreation & park plan	2001
Neshaminy	$60,000	Buckingham Township	Elementary School stormwater restoration & education	

Study Area	Grant	Awardee	Project Description	Year
Neshaminy	$6,530	N.B. Neshaminy Creek Watershed Assc.	Organizing a watershed group	
Neshaminy	$46,420	Pennridge Area Coordinating Committee	Watershed assessment	2000
Neshaminy	$50,000	Plumstead Township	Stormwater basin retrofit	2000
Neshaminy	$10,645	Senior Adult Activity Center of Lansdale	North Penn S.E.C. groundwater education	
NJ Mercer Direct	$564,900	Delaware River Basin Commission	2002 DRBC 106 Water Pollution Control Program	2002
NJ Mercer Direct	$95,000	Delaware River Basin Commission	PCBs Trackdown	2001
NJ Mercer Direct	$75,000	Delaware River Basin Commission	Municipal STP PCB Trackdown	2001
NJ Mercer Direct	$185,571	Delaware River Basin Commission	National Estuary Program	2001
PA Bucks Direct	$31,000	Upper Makefield Township	Develop township wide trail system	2001
PA Bucks Direct	$5,000	Upper Makefield Township	Riparian buffer along Jericho Creek	2001
PA Bucks Direct	$60,000	Delaware Riverkeeper	Paunacussing Creek Hydrogeomorphic survey	2001
PA Bucks Direct	$5,000	Upper Makefield Township	Riparian buffer restoration	2001
PA Bucks Direct	$60,000	Makefield Lakes Community Association	Community environmental education, restoration	2000
PA Bucks Direct	$48,000	Partnership for Land Use Management	Develop a NPS management plan for Paunnacussing Creek	2000
PA Bucks Direct	$4,875	Partnership for Land Use Management	Environmental awareness program	2000
PA Bucks Direct	$25,000	Delaware River Greenway Partnership	Streambank stabilization along Del Canal State Park	2000
PA Bucks Direct	$75,000	American Littoral Society	Educational materials for stream restoration monitoring	2001
Rancocas	$160,000	NJ DEP	Regional Geographic Initiative (RGI) Project	1998
Rancocas	$50,000	Partnership for the Delaware Estuary	Rancocas Delaware Estuary Program Watershed Initiative	2000
Tidal NJ Lower	$20,000	Partnership for the Delaware Estuary	Estuary Corporate Environmental Stewardship Program	2001
Tidal NJ Lower	$50,000	Partnership for the Delaware Estuary	Lower Tributaries Subwatershed Initiative	2000
Tidal NJ Lower	$34,560	Partnership for the Delaware Estuary	15 minute video and distribution about watersheds	2000
Tidal NJ Lower	$72,283	Partnership for the Delaware Estuary	Clean Water Partners Program	2001
Tidal PA Bucks	$1,200,000	Middletown Township	Otter Creek Watershed restoration phase II	2001
Tidal PA Bucks	$30,000	Bucks County Planning Commission	Otter Creek watershed assessment & protection plan	
Tidal PA Bucks	$60,000	American Littoral Society	Hydrogeomorphic survey of Paunacussing CR	2000
Tidal PA Bucks	$30,000	Bucks County Planning Commission	Watershed assessment, restoration & protection plan	
Tidal PA Philly	$75,000	Environmental Fund for Pennsylvania	Greenworks Project	2001
Tidal PA Philly	$190,000	Fairmount Park Commission	What's in Our Watershed?	2001

Study Area	Grant	Awardee	Project Description	Year
Tidal PA Philly	$15,867	Philadelphia City Sail Inc.	Environmental education program	2001
Tidal PA Philly	$65,000	Resources for Human Development Inc.	Protection Of Children From Environmental Threats	2000
Tidal PA Philly	$3,735	School District of Philadelphia	Environmental Education - Hunter Elementary	2001
Tidal PA Philly	$5,000	Temple University	Environmental Education - Delaware Canal State Park	2001
Tidal PA Philly	$698,500	The Academy of Natural Sciences	Urban Rivers Awareness	2001
Tidal PA Philly	$10,000	The Village Of Arts and Humanities	Teen Environmental Leadership Internship Program	2001
Tidal PA Philly	$15,000	The Village Of Arts and Humanities	Environmental Justice Small Grants - Camac	2001
Tidal PA Philly	$18,000	Milford Township	Develop Comprehensive recreation and park plan	2001
Tidal PA Philly	$175,000	Natural Lands Trust	Conservation easement along 100 acres	2001
Tidal PA Philly	$11,000	Horsham Township	Educational outreach program Kohler Park	2000
Tidal PA Philly	$30,000	Horsham Township	Stabilize streambanks and revegetate Kohler Park	2001
Tidal PA Philly	$99,968	Towamencin Township	Riparian buffers for NPS & stormwater BMP retrofits	2001
Tidal PA Philly	$350,000	Fairmount Park Commission	Acquire 16 acres of rail line property for trail	2001
Tidal PA Philly	$100,000	Philadelphia Water Department	Rivers-conservation plan for Tacony	2001
Tidal PA Philly	$3,000	Awbury Arboretum	Watershed education program	1999
Tidal PA Philly	$98,000	Upper Southampton Township	Southampton Creek watershed restoration	2000
Tidal PA Philly	$9,640	Upper Southampton Township	Creation of Southampton Creek Watershed Association	2000
Tidal PA Philly	$1,104,483	Fairmount Park Commission	Wetlands and tidal flats access & interpretation	2000
Tidal PA Philly	$150,000	Pennsylvania Environmental Council	Delaware River Basin Initiative	2001
Tidal PA Philly	$148,610	Philadelphia Earth Force	Earth Force Delaware Watershed Green Initiative	2001
Tidal PA Philly	$24,174	Environmental Fund for PA	Video Green Works: "The Value of Water"	2001
Tidal PA Philly	$60,000	Environmental Fund for PA	Video Green Works: "Life on the Delaware River"	2001
Tohickon	$12,000	Bridgeton-Nockamixon Tinicum	GIS Mapping of Tinicum Headwaters	2001
Tohickon	$20,000	Tinicum Township	Stream buffer and headwater protection	2001
Tohickon	$29,750	SE-PA RC&D Council	Livestock farm BMP	2000
Tohickon	$14,250	Bedminster Land Conservancy	Implementation of WQ monitoring for Deep Run	
Tohickon	$10,000	Heritage Conservancy	Quakertown Swamp Partnership	

2.2.7 Public Participation Process

Key Points

- **Public kick-off meetings, Technical Advisory Group meetings, media articles and a web site are some of the methods used to involve the public in the SWAP.**
- **An open Technical Advisory Group (TAG) has been established to facilitate communication among stakeholders and to gather information about the watershed.**
- **The TAG meets quarterly to assist the Source Water Assessment Partnership in the SWAP process.**
- **Thirty - four people attended the first of several public kick-off meetings being conducted to introduce the SWAP.**
- **SWAP project information is available through the project website, www.phillywater.org/delaware.**

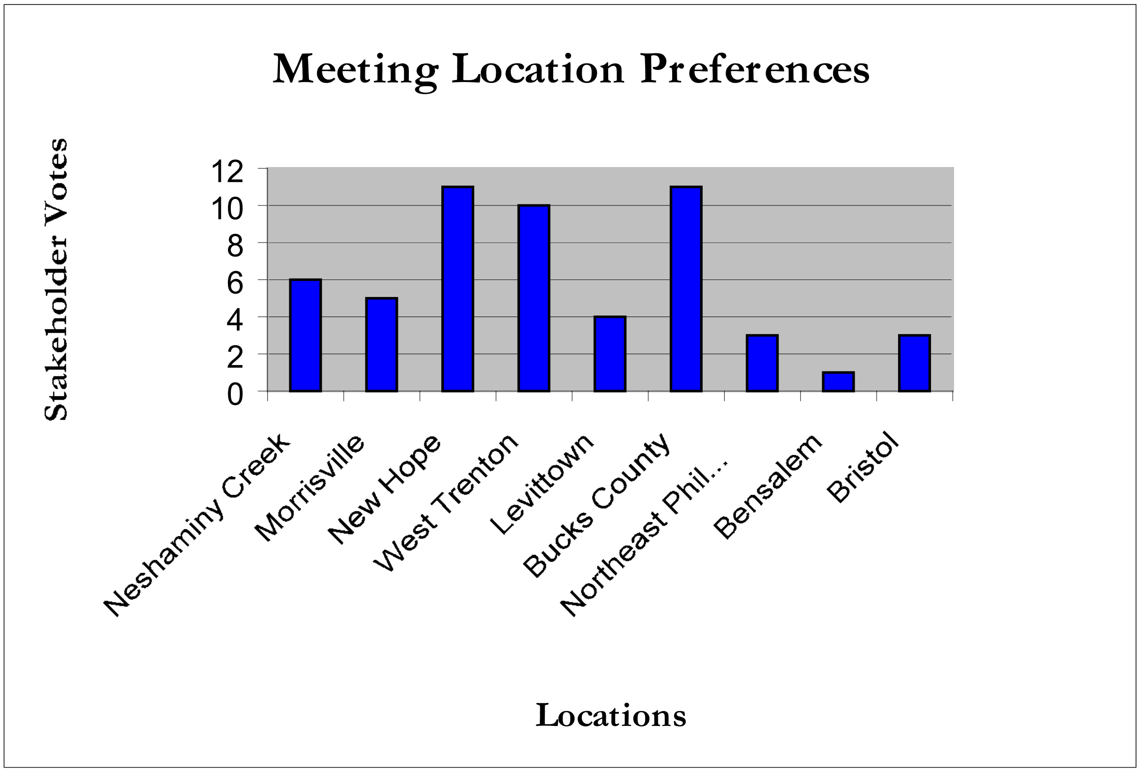
Several avenues will be available for stakeholder and public involvement throughout the Delaware Source Water Assessment Program. These include:

- Public kickoff meetings
- Public wrap-up meetings
- Technical advisory group meetings
- Legal notices
- Newspaper articles
- SWAP web site

This multi-faceted approach provides opportunities for the partnership to introduce the public and stakeholders to the source water assessment program and process, and for the partnership to obtain information and feedback from the public. In the past, these avenues appear to have been moderately successful at reaching interested public and stakeholders. One public meeting has resulted in 34 attendees, two advisory group meetings resulted in 23 attendees, 12 legal notices have been published, two newspaper articles have been published about the project, and the web site has been accessed 146 times to date. More public meetings discussing the ongoing assessment will take place in the near future

One of the important goals of gathering stakeholder input during the initial stages of the public participation process is to develop a framework for the meetings to ensure that they are optimally effective. According to the results of the first round of surveys distributed to gather stakeholder input, the best time for the stakeholders to meet is during the day (either morning or afternoon) and most would prefer to meet in the New Hope, West Trenton, or Bucks County areas. The following figure illustrates the amount of stakeholder votes each location received.

Figure 2.2.7-1 Meeting Location Preferences



2.2.7.1 Advisory Groups

To better facilitate communication among the Source Water Assessment Partnership and the regions of the Delaware River Watershed to be assessed, an open Technical Advisory Group (TAG) has been formed. This TAG was developed by the partnership as a way to closely interact with the stakeholders, and in turn, to gather integral information about each region of the Delaware River Watershed. All of the stakeholders have been invited by the partnership to participate. Meeting quarterly, it is the primary responsibility of the TAG to inject public interest into the SWA process. Other duties of this group include:

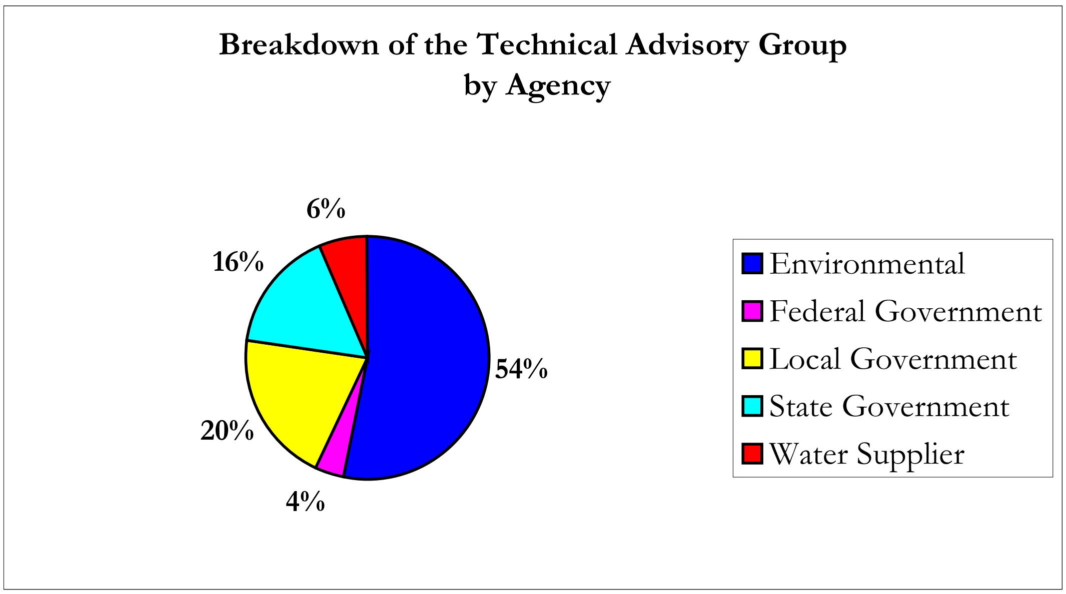
- Sharing information with stakeholders
- Verifying the information put forth by the partnership
- Providing input on the assessment techniques and criteria used by the partnership
- Offering general information regarding the areas local to each TAG
- Participating in public outreach and education
- Describing current protection activities

- Identifying "potential" sources of contamination and preservation
- Assisting in the development of summary reports

Technical Advisory Group Participants

Composed of watershed organizations, public interest groups, dischargers, suppliers, and local government agencies, the TAG offers a broad variety of perspectives and visions. The following graph is illustrative of the various types of agencies participating in the Technical Advisory Group (see Figure 2.2.7-2).

Figure 2.2.7-2 Technical Advisory Group Breakdown



The following is a summation of some of the TAG's participants:

It is the mission of the ***Department of Environmental Protection (DEP)*** to protect the air, land, and water of Pennsylvania from pollution, and to provide for the health and safety of its citizens through a cleaner environment. DEP works as a partner with individuals, organizations, governments, and businesses for the prevention of pollution and the restoration of natural resources. It achieves these goals via public service, protection, teamwork, communication, and pollution prevention. DEP is the state agency largely responsible for administering Pennsylvania's environmental laws and regulations. Its responsibilities include: reducing air pollution; making sure that drinking water is safe; protecting water quality in Pennsylvania rivers and streams; making sure waste is handled properly; managing the Commonwealth's recycling programs and helping citizens to prevent pollution and comply with the Commonwealth's environmental regulations. DEP is committed to general environmental education and encouraging effective public involvement in setting environmental policy.

PennFuture is an organization that takes pride in defending the environment. In achieving its mission of defending nature, PennFuture effectively resists those who attack the environment and rallies against those who fail to do their duty to protect it. By combating global warming, smog, acid rain, and illness, and by advocating the increase of desperately needed funding for farmland preservation, among other things, PennFuture is making great strides in assuring that polluters and their allies no longer decide the fate of the environment and the economy. Comments and concerns may be voiced to Brenna Herpmann at (800) 321-7775. PennFuture's mailing address is 212 Locust Street, Suite 410, Harrisburg, PA 17101.

In order to share the responsibility of managing the water resources of the Delaware River Basin, the ***Delaware River Basin Commission (DRBC)*** was formed by the signatory parties of the Delaware River Basin Compact (Delaware, New Jersey, New York, Pennsylvania, and the United States). Since its inception on October 27, 1961, the very day that Compact became law, DRBC has been a pacesetter in environmental protection. As mentioned in its mission statement, DRBC focuses mainly on protecting, enhancing, and developing the water resources of the Delaware River Basin for the benefit of present and future generations. In achieving their mission, DRBC has developed such programs as water pollution abatement, water supply allocation, regulatory review (permitting), water conservation initiatives, regional planning, drought management, and flood control. Questions, comments, and concerns may be forwarded to Jon Zangwill via e-mail, zangwill@drbc.state.nj.us or telephone, (609) 883-9500 x 307. DRBC's mailing address is 25 State Police Drive, West Trenton, NJ 08628.

Clean Water Action (CWA) is a national citizens' organization that works toward the following goals: affordable water, prevention of health-threatening pollution, creation of environmentally safe jobs and businesses, and the empowerment of people to make democracy work. In addition, CWA organizes grassroots groups, coalitions, and campaigns with the common interest of protecting health and quality of life, so that they may better promote environmental well-being within a community. The mailing address of the CWA National Office is 4455 Connecticut Avenue NW – Suite A300, Washington, DC 20008-2328 (Telephone: (202) 895-0420). The mailing address of the CWA Philadelphia Office is 1201 Chestnut Street, #602, Philadelphia, PA 19107. All inquires may be directed to Bob Wendelgass at the Philadelphia Office via e-mail, bwendelgass@cleanwater.org or telephone, (215) 640-8800.

It is the mission of the ***Pennsylvania Environmental Council (PEC)*** to improve the quality of life for all Pennsylvanians. In doing so, PEC enhances the Commonwealth's natural and man-made environments by integrating the advocacy, education, and implementation of both community and regional action programs. Director of Watersheds Programs, Ann Smith, will be accepting questions, concerns, and comments at (215) 563-0250. The mailing address of the PEC is 117 South 17th Street, Suite 2300, Philadelphia, PA 19103-5022.

Founded in 1989, The ***Delaware River Greenway Partnership*** (DRG) promotes awareness and protection of the river and other natural resources by encouraging both public and private stewardship of the Delaware River and the greenway that surrounds it. Among the DRG's current projects are: *Bridging Our Lower Delaware*, *Delaware River Heritage Trail*, and *Annual Education Reform*. The DRG also publishes a quarterly newsletter, the *Delaware River Greenway News*. The DRG can be contacted by telephone at (908) 996-0230.

The ***Bucks County Sierra Club*** is an organization that works to protect the county's land, air, and water resources by encouraging Bucks County residents to take an active role in making elected officials recognize the importance of these resources and prevent further damage to them.

The mission of the ***Bucks County Water and Sewer Authority*** is to provide quality service in an environmentally safe manner at an affordable rate, and to educate their current and future customers on water conservation. The authorities' ongoing goals include: maintenance of their commitment to affordable rates and excellent service levels, meeting or exceeding all environmental and public health standards, continual seeking and identification of cost saving procedures without the sacrifice of quality, and the education of customers, neighbors, and the communities' children in that water is a limited resource and should be treated as one of our most valuable commodities. The *Bucks County Water and Sewer Authority* was founded by the Bucks County Commissioners in 1962 to support local municipalities with the installation of water and sewer service. As a non-profit agency carrying out an enterprise role, no tax money is involved in the operation of this (or any) authority; all income is derived by billing the people who utilize their services. Consequently, those not making use of the service do not pay towards it; also known as "user pays." The good news is, as an "Authority", it only charges its customers the cost to operate the service.

The ***Stroud Research Center*** uses its advanced knowledge of stream and river ecosystems to provide solutions for water resource problems around the world. The center uses extensive education programs, conservation leadership, and its professional services to promote public understanding of freshwater ecology and to develop new ideas and hypotheses to improve the environment. Included in Stroud's mission statement are: the advancement of knowledge of stream and river ecosystems through interdisciplinary research, the development and communication of new ecological ideas, hypotheses or theories, the provision of solutions for water resource problems worldwide, and the promotion of public understanding of freshwater ecology through education programs, conservation leadership and professional service. The Stroud Center can be contacted via telephone at (610) 268-2153 or fax at (610) 268-0490. The mailing address for the center is 970 Spencer Road, Avondale, PA, 19311. Comments and concerns may also be voiced via e-mail at Webmaster@Stroudcenter.org.

Since it's beginning in 1969, the ***Catskill Center for Conservation and Development*** has worked as a non-profit organization to inform the public of issues concerning the conservation of the resources of their area. Public forums are used to encourage the public to get involved with these issues, and to help foster a deep appreciation for the environment in which they live. Centering on environmental protection and sustainable economic development has helped the organization to protect the cultural, historic, and natural resources of the Catskill Mountains. Merging both environmental protection and sustainable economic development, the organization is a campaigner for the region's vital main streets, valuable natural resources, artistic and historic assets, and working landscapes. They achieve this through four main program areas; *Natural Resources and Land Conservation, Education, Community Planning and Development, and Regional Culture and Arts.* The Catskill Center can be reached via telephone at (845) 586-2611. It is located in Arkville, New York.

Funded in 1959, ***Trout Unlimited's*** mission statement is "to conserve, protect and restore North America's trout and salmon fisheries and their watersheds." The organization accomplishes this mission through an extensive volunteer network. With 125, 000 volunteers in 500 chapters nationwide, the organization works directly through professionals who testify before congress and intervene in federal legal proceedings to ensure they are involved in conservation issues. The drive of the organization is to protect our rivers and fisheries for generations to come. Trout Unlimited can be reach by telephone at (703) 522-0200 and by fax at (703) 284-9400. The mailing address is 1500 Wilson Blvd., #310, Arlington, VA, 22209-2404. Questions and comments can also be sent via e-mail at trout@tu.org.

The ***Heritage Conservancy***, formerly known as the Bucks County Park Foundation, was founded in 1958 when concerns about the rapid loss of open space in Bucks County started to arise. Since that time, the conservancy has been dedicating its time and efforts to protecting the counties natural and historic heritage. By partnering with citizens, businesses, and government agencies, the conservancy has become a leader in land conservation and historic preservation. The organization achieves these environmental goals through a process of assessing potential sites, educating the public, and implementing actions to improve our natural habitats. The Heritage Conservancy can be contacted by phone at (215) 345-7020 and by fax at (215) 345-4328. The mailing address is 85 Old Dublin Pike, Doylestown, PA, 18901.

Created as a chapter of the National Audubon Society in 1969, the ***Bucks County Audubon Society*** has set out to create a sense of need for environmental change. Since their start, the BCAS has been protecting the environment, educating the public on ways to better conserve their natural resources, and promoting the wise use of land, water, and air. With over 2300 members, BCAS is one of the chief citizen membership groups representing environmental and ecological interests in Bucks County. The mailing address for the Bucks County Audubon Society is 6234 Upper York Road, New Hope, PA, 18938. BCAS can also be reached by phone at (215) 297-5880 or by fax at (215) 297-0835. All e-mail can be directed to bcas@bcas.org.

The ***New Jersey Audubon Society*** works to instill a sense of environmental conservation in New Jersey's citizens to protect the plants, animals, and natural resources of their state. Though not associated with The National Audubon Society, the NJAS has set forth to conserve the natural environment through education programs and information services, as well as to increase the public's knowledge of New Jersey's flora and fauna through extensive field work. As one of the oldest independent audubon societies, the NJAS has made every effort to protect threatened and endangered species and has also established and maintained wildlife sanctuaries and education centers. The mailing address for the NJAS is: New Jersey Audubon Society Headquarters, 9 Hardscrabble Road, PO Box 126, Bernardsville, NJ 07924. Questions and concerns can also be direct via telephone at (908) 204-8998 and through e-mail at hq@njaudubon.org.

The ***National Audubon Society of New York State*** works on local, state, and national levels to provide protection for birds, forests, wetlands, and wildlife. The statewide council advocates and educates the proper management of wildlife and their habitats to help improve the environment. The National Audubon Society of New York has, since its foundation, significantly increased its financial and staff commitments to centers and education. They are looking at the broadest possible range of opportunities to meet their goals of continued growth in the area, under the principle that realistic center growth must provide results that are fiscally advantageous, operationally practical and educationally sound. The society can be reached via telephone at (518) 869-9731, fax at (518) 869-0737, and by means of e-mail at nasnys@audubon.org. The mailing address is 200 Trillium Lane, Albany, NY 12203.

The ***New Jersey Farm Bureau*** represents the agricultural producers and enterprises of New Jersey. Their goal is to create positive public relations, influence laws and regulations, and to seek out activities and ventures that benefit the welfare of the producer members. In their mission, the New Jersey Farm Bureau states that their mission is to represent the agricultural producers and enterprises of New Jersey at all levels of government – local, county, state, federal, and international. The bureau's mailing address is 168 West State Street, Trenton, New Jersey, 08608. They can also be reached by phone at (609) 393-7163 and by fax at (609) 599-1209.

Pennsylvania-American Water Company is committed to providing quality water, services, and products to their customers while trying to maintain the environment in which we live. The company works hard to focus on personal solutions and to exceed the expectations of their clients in the services they provide. In their mission they state that they will "continually build ever-increasing value for their shareholders and their customers in the business of water resource management." The PAWC can be reached via their toll-free number at (800) 565-7292.

It is the mission of the ***Wildlands Conservancy*** to protect vital open spaces, watersheds, wildlife, and farmlands in Pennsylvania. The organization is dedicated to the preservation of rivers, land, and trails through public education programs. The efforts of this member-supported organization have produced over 31, 000 acres of permanently protected open spaces in eastern Pennsylvania. The Conservancy is also working to protect Pennsylvania's waterways and care for injured or orphaned wildlife. Questions and concerns can be voiced through phone at (610) 965-4397 or fax at (610) 965-7223. The mailing address for the conservancy is 3701 Orchid Place, Emmaus, PA 18049.

Established in 1996, the ***Partnership for the Delaware Estuary*** was created to coordinate the protection and enhancement of the Delaware River Estuary. The partnership has taken a leadership role in promoting the conservation of this natural resource to help contribute to the usefulness of the estuary for environmentally friendly recreational purposes. By increasing the publics awareness and understanding of this important natural resource, the partnership is encouraging enhancement and protection throughout the Delaware Estuary. Comments, questions and concerns can be directed to Kathy Klein via e-mail at partners@udel.edu. The Partnership for the Delaware Estuary may also be reached through its toll-free number at 1-800-445-4935.

New Jersey Futures was formed in 1987 to serve as the watchdog over the state's development and redevelopment plans. This nationally recognized promoter of open space protection has become a leader in the fight for smarter land use. NJF is also working with the state of New Jersey on a plan to become the nations first "sustainable state:" a plan that incorporates the balance of economic, environmental, and social goals of the state. The organization is working hard to develop a strong economy, and a healthy natural environment. The mailing address for NJF is New Jersey Future, 114 West State Street, Trenton, NJ, 08608. Questions and concerns can be voiced via e-mail to njfuture@njfuture.org. The organization can also be reached by telephone at (609) 393-1189 and by fax at (609) 393-1189.

Technical Advisory Group Meetings

Three TAG meetings were held as of April 2001. The following table outlines the date, location, and number of attendees at each meeting.

Table 2.2.7-1 Summary of Technical Advisory Group Meeting Dates and Locations

Meeting	Date	Location	Number of Attendees
1	May 16, 2001	Delaware River Basin Commission Offices West Trenton, NJ	14
2	November 8, 2001	Bucks County Water & Sewer Authority Offices Warrington, PA	9
3	May 14, 2002	Bucks County Water & Sewer Authority Offices Warrington, PA	
			Total Attendees 23

Summarization of Technical Advisory Group Meeting Minutes

These meetings are, in essence, forums for discussion during which local stakeholders are encouraged to voice their concerns and share their opinions of the project. The following is a summation of the minutes from the first two meetings:

MEETING 1

This meeting acted as an introduction to the Delaware River Watershed as well as to the Source Water Assessment Program. The meeting both summarized the Delaware River and its intrinsic values as well as reviewed the operation and challenges of a water treatment plant. The watershed of the Delaware River was said to be a home to over seven million people, composed of 1,450 industrial and municipal dischargers in which wastewater treatment accounts for 98% of the total discharge to the estuary. It was also stated that 17.5 million people rely on the estuary's surface water intakes for drinking water; most of the water being distributed throughout New York City. The estuary was cited as a source of heritage, history, culture and recreation for the region. In evaluating the operation and challenges of a water treatment plant, the Baxter WTP was broken down and analyzed. The plant was undergoing capitol construction; therefore, a review of its current and future conditions took place.

The specific aspects of the Delaware River Watershed as a source of drinking water supply are as follows:

- It is comprised of eight large surface water intakes.
- Over 600,000 MGD is withdrawn on average from the river and its tributaries (not allocated)
- It serves over 17.5 million people

The Source Water Assessment (SWA) was explained to be an iterative, continuous, and multi-phase process. The process aids in the identification of "potential" and/or existing sources of contamination, evaluates the vulnerability/susceptibility of the water supply to contaminant sources, and determines protection priorities and activities for the water supply. The ultimate goal of the SWA was specified as developing local sources of water protection initiatives involving both water suppliers and the public and educating the public about the source of their drinking water as well as its pertinent challenges.

Utilities and stakeholders were encouraged to become interested in the SWAs because the program was based on federal regulations mandated by Congress. Responding to requests by the public to know more about their water supply and how to protect it, Congress included provisions for a SWA within the Safe Drinking Water Act Reauthorization of 1996. It is the goal of Congress to have 50% of the United States population enveloped under Source Water Protection Plans by 2005.

The SWAs were said to benefit the stakeholders present at the meeting because stakeholders of the TAG would be directly involved by:

- Identifying sources of contamination and areas for protection
- Having their organization highlighted for interested persons to contact/join
- Determining potential linkages between their efforts and protection efforts
- Increasing potential funding opportunities for communities and watershed groups by incorporating projects into approved SWA plans

The point was made that source water advisory group participation is an integral piece in determining the success of the project. This group meets quarterly throughout the length of the project, provides public input into the process, and helps determine public outreach. A number of tasks that the stakeholders can do in order to assist in the source water assessments were also listed. These tasks, such as listing water source issues, providing pictures or tours of areas of concern, and providing input on ranking criteria were summarized. Final products and purposes of the project were also reviewed. The following table illustrates these specific final products.

Table 2.2.7-2 Final Products and Purposes

Product	Type	Audience
SWA Report	Technical	Water Supplier & Public Agencies
Summary Report	Educational/Motivational	Public
Maps/Coverages	Technical	Water Supplier & Public Agencies Watershed
Source Water Partnership	Educational/Motivational/Technical	All Stakeholders

It was also stated at the meeting that due to an inaccuracy in the federal databases, source issues must be "groundtruthed". In doing so, many things will be looked at including:

- Thousands of point sources and regulated facilities
- Dozens of wastewater plants
- Hundreds of farms
- Non-point source potential
- Numerous other sources typically identified

Another topic of consideration is source water protection issues. The following table outlines various issues as well as their possible sources:

Table 2.2.7-3 Source Water Protection Issues

Issues	Possible Sources
Pathogens-*Giardia/Cryptosporidium*	Sewage, livestock, & wildlife
Algal Blooms/Nutrients	Sewage, agriculture, lawncare, golf courses
Metals-Manganese	Acid mine drainage
Chloride & Sodium	Road salts/highways
Pesticides/Herbicides	Lawn care, right of ways, agriculture
MTBE/Bromide/DBP Precursors	Cars & recreational watercraft

Operation and challenges of a water treatment plant were also discussed at the meeting. Specifically, the challenges of optimized water treatment during capitol construction and increased regulatory requirements. The Baxter WTP was broken down in order to assess the challenges it faces. Its current condition and historical treatment were outlined in detail and the areas for improvement were identified. Baxter, scheduled to undergo capitol construction for seven months, finished in June 2001.

The meeting finished with a series of questions and answers in which the stakeholders were able to voice their concerns and comments as well as inquire about the assessment.

A schedule and timeline were presented. The deadlines for the draft reports, which begin in April 2002, are marked for completion by January 2003. The following figure displays the breakdowns of the assessment and the schedule.

Figure 2.2.7-3 Assessment Schedule

Intakes Assessed

Water Supply	Draft Reports
PWD – Baxter	April 2002
PSWC – Bristol	October 2002
Morrisville	October 2002
Lower Bucks JMA	October 2002

Non-tidal/Tributary Intakes

Water Supply	Draft Reports
PSWC – Neshaminy	July 2002
Middletown – Chubb Run	July 2002
PA American – Yardley	January 2003
Bucks County Water	January 2003

MEETING 2

Meeting two was broken up into three main sections. They were:

1. *Delaware River Source Water Assessments*
2. *Contaminant Source Inventory*
3. *Susceptibility Analysis*

Zone Delineation's for tidal and non-tidal areas were covered under the Delaware River SWAs. Determining the zone delineation for the intakes is a difficult task due to their considerably large size. The zone delineation was therefore broken down into several sections for simplification. These sections that compose the breakdown are:

- Intakes (the eight intakes were broken down into tidal and non-tidal influence and by intakes on tributaries)
- Zone definitions (Zones A, B, and C)
- Time of travel for tidal, non-tidal, and tributary intakes
- A further breakdown of tidal intakes
- Additional incorporation of tributaries in tidal zone, non-tidal river intakes, tributary delineation, and water quality data were also present in the analysis

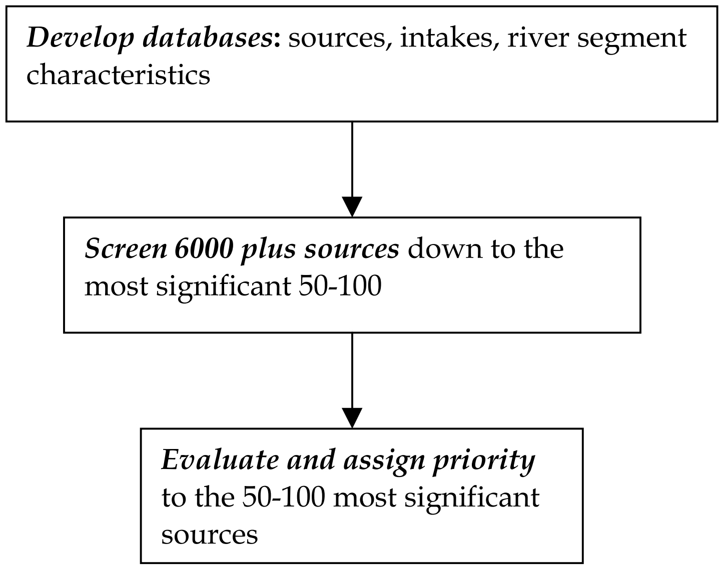
The next steps to take in the delineations were also discussed and include:

- Cleanup and refinement of the zones
- Beginning of data analysis
- Searching for electronic data or water quality studies to "groundtruth" suspected potential sources
- Working on stream impairment GIS and data for NJ

A contaminant inventory database compilation had been completed and was discussed at the meeting. Main web sites such as the "Right To Know Network" (RTK) and "Envirofacts" were utilized in the contaminant source compilation. Federal databases were accessed and data was downloaded. The data was downloaded by county, the data sites were then "clipped" in GIS to eliminate those outside of the watershed boundaries, missing "x-y" coordinates were filled in, facility data was cross-referenced, and quantity/contaminant data was populated.

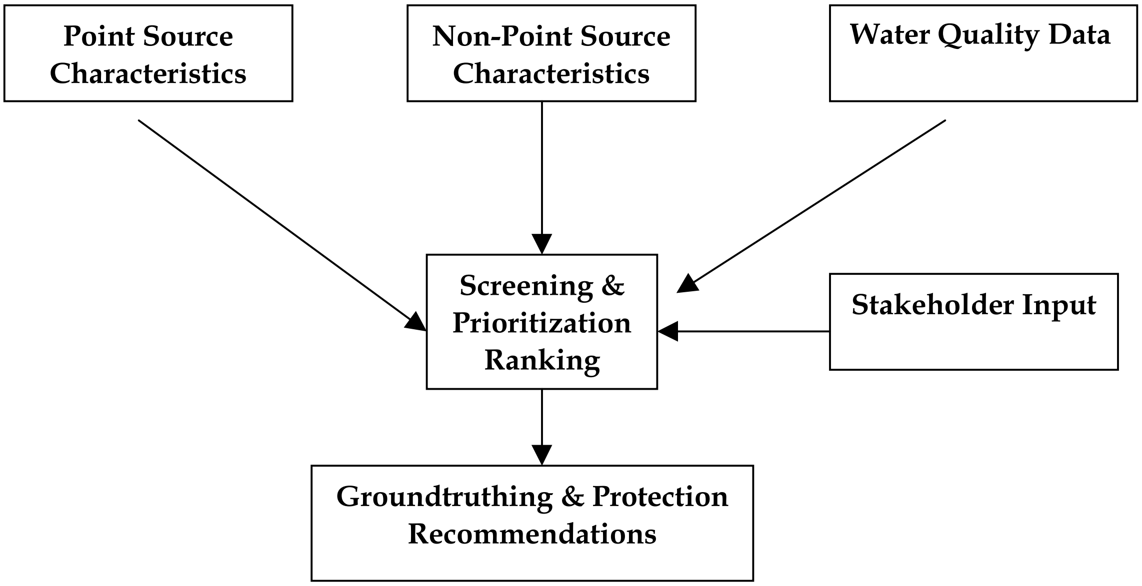
A susceptibility analysis overview was also presented at the meeting. The Delaware River Source Water Assessment proved to be a complex undertaking with the watershed covering 300 miles of river, as well as a 13,000 square mile watershed with more than 6,000 potential sources. The overall goal of the project is to understand which sources are most critical and which are less serious, understand present water quality concerns, focus energy on important sources, and result in a limited number of high priority sites. The general approach is comprised of three main steps, which are illustrated in the following figure (Figure 2.2.7-4):

Figure 2.2.7-4 Main Steps in the General Approach



This approach is based on and includes the approach of the Source Water Assessment and Protection Program of PADEP. It has been modified and formalized into the process that includes point sources, non-point sources, and "special categories" such as acid mine drainage, spills from railroads, and pipeline breaks. A technical approach or state approach was presented at the meeting and includes surface water and zone delineation, water quality analysis, a susceptibility analysis for the state which includes qualitative measures as well as available qualitative data. The Delaware River approach is inclusive of all the elements of the state approach but is more extensive. For example, the Delaware River approach is more quantitative than the state approach and is designed to handle thousands of potential sources. An illustration of the source water assessment simplified approach follows (see Figure 2.2.7-5). In this approach, stakeholder input is included in the "Screening and Prioritization Ranking" along with "Point and Non-Point Source Characteristics" and "Water Quality Data". After all four go through the "Screening and Prioritization Ranking", "Groundtruthing and Protection Recommendations" are then developed.

Figure 2.2.7-5 Source Water Assessment: Simplified Approach



A source priority ranking was completed utilizing the Evamix Evaluation Criteria Groups. The groups are comprised of:

- River Flow Related Criteria (2)
  - Location
  - Time of Travel
- User Related (1)
  - Potential Health Impact (combined ranking only)
- Intake Criteria (3)
  - Relative Impact (both intake and source related)
  - Removal Capacity (combined ranking only)
  - Impact on Treatment Operations (combined ranking only)
- Source Related (3)
  - Potential for Release/Presence of Controls
  - Potential Release Frequency
  - Violation Type/Frequency

Based on these, the stakeholders' criteria weightings are illustrated in the following table (Table 2.2.7-4):

Table 2.2.7-4 Stakeholder Criteria Weightings

Criteria	Min	Max	Average	Agreed
Relative Impact at Intake	5%	25%	13%	12
Time of Travel	2%	15%	7%	5
Existing Removal Capacity	3%	30%	13%	10
Impact on Treatment Operation	2%	30%	10%	10
Potential Health Impacts	10%	30%	20%	20
Potential for Release/Controls	3%	20%	10%	14
Potential Release Frequency	3%	20%	9%	14
Violation Type/Frequency	3%	20%	9%	10
Location	2%	20%	8%	5

The Delaware River approach employed four linked databases. In regards to the intake; location, stream segment, withdrawal data, and a list of contaminants where 50% MCL exceeded were included. In the stream segment were segment ID, position in stream, flow, and velocity. Lastly, the source included ID, location, stream segment, zone, quantity, concentration, contaminants, and likelihood of release.

Within the Delaware River approach it was necessary to assign pollutant categories. These categories are essential because the approach used cannot deal with thousands of sources, 42 intakes, and try to do this for all types of pollutants. The purpose of this approach is to assign one or more 10-pollutant categories to each source. This may be done using data from Federal or State Databases or through the use of SIC code and standard assumptions of pollutants related to SIC codes.

Advantages to the Evamix approach are that it helps to clearly define the alternatives under consideration, it requires a clear set of evaluation criteria, and it does not lose information because it accepts quantitative and qualitative data. Additionally, it organizes objective information into a clear set of scores, it segregates the subjective part of the evaluation into criteria weights, and it is flexible and simple in that it handles new data easily. Finally, the process is clear, defensible, and reproducible.

For this Delaware River approach, the Evamix results will be reviewed and "reality checked." Results for high-ranking sources will be added to other sources outside of the analysis (e.g., highway spills, pipelines, etc.). Furthermore, high-ranking sources will be flagged for follow-up data collection in a later phase to verify results.

The meeting again closed with questions and answers in which the stakeholders were able to present their concerns and provide input on the assessments.

2.2.7.2 Public Meetings

In an attempt to better educate the public about the importance of the Source Water Assessment Program (SWAP), several public meetings will be conducted throughout the study area; two for each intake. There have been no public meetings for the Baxter Intake thus far, however, a kick-off meeting is being scheduled for the Fall of 2002. The following general approach will be utilized in order to achieve the goal of generating public interest:

- Press releases will be produced by the Philadelphia Water Department and the local stakeholders, which will be sent to the local media and newspapers
- Legal notices will be sent to the local media and newspapers
- Advertisements will be published in the Pennsylvania Department of Environmental Protection (PADEP)'s *Update*

Hosted by local watershed organizations to promote a sense of credibility as well as to establish a connection with local residents, these meetings are, in essence, informational forums where members of the public are enabled to voice their concerns as well as share their visions for the project. Information about the assessments and the treatment plants for each intake is distributed along with a list of phone numbers to call to report violations. Tips on how to help improve source water quality ranging from better gardening practices to coordinating watershed groups is also included in the packet.

Standard meeting agendas have been developed and will be followed at each meeting. The agenda generally consists of an introduction, an explanation of the purpose of the meeting and an overview of Source Water Assessments, which includes a brief yet thorough description of the SWAP as well as the areas to be assessed, i.e., the SWAP study area's Bristol Intake. In addition, a discussion of contaminant source issues and water quality concerns is a keynote feature of the agenda. Finally, each meeting is concluded with an exercise in identification of potential contaminant sources, in which the attendees are asked to identify local sites that may impact the water supply. Examples are presented of what some of the source water assessment issues are and photos of these examples are shown to aid the public in identification. Questions, concerns, and comments are addressed as they are raised.

Prior to these kick-off meetings, several avenues are pursued in an attempt to notify the public. Letters produced by the Philadelphia Water Department, local stakeholders, and watershed groups specifying the location and directions, date, time and nature of the meetings are mailed to numerous stakeholders, including many of the businesses, government agencies, and environmental organizations located within or affected by the Delaware River Watershed. The information contained in these letters is also posted on the SWAP website, www.phillywater.org/delaware. In order to further generate public interest, various watershed groups and local stakeholders post flyers throughout their respective areas and send press releases to their local newspapers. Additionally, many of the local newspapers feature articles describing the nature of the meetings as well as the outcome, when applicable. Legal notices detailing the location, time, and date of each meeting are printed in the newspapers local to each area with which the SWAP is affiliated for the purpose of opening the meetings to everyone within the watershed.

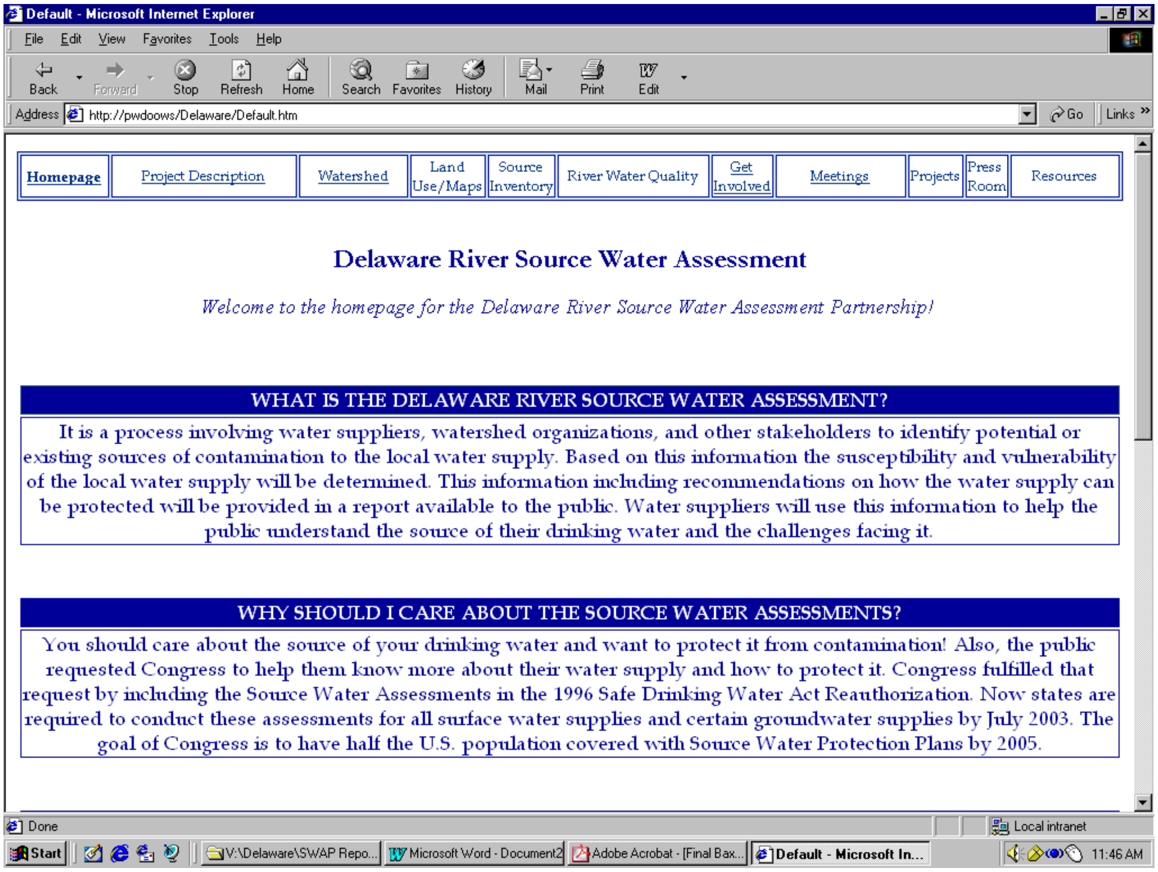
Newspaper articles will also be published in the Bristol Intake area by local newspapers that are highly distributed throughout the community talking about the source water assessments. The articles featured will clearly state the purpose of the meeting as well as the date and location of each of them. The function of the SWAP is described as well as its derivation. The articles invite the public to share their visions of the project and give the people an opportunity to contribute what they would like to see develop throughout the duration of the assessment. A contact number is also provided in the event that anyone might want to pursue more information on the Source Water Assessments.

2.2.7.3 Website

A website has been developed for the project (www.phillywater.org/delaware*)* to provide a location where information about the project can be easily accessed by the public and stakeholders (see Figure 2.2.7-6). Although, this is a task beyond the scope of the contract, it is considered a necessary form of information delivery. Most importantly, the website is considered the most efficient way of providing the advisory group meeting information, meeting handouts, and meeting minutes without producing a significant burden of production on staff, given that there are many stakeholders to whom information must be mailed on at least a quarterly basis.

The website has been set up to provide general information about the purpose of the SWAP as well as contact information. It also provides links to information about public meetings, advisory group meetings, meeting materials, general watershed information, limited maps, watershed organizations, and general water quality information. Another special feature is an on-line stakeholder survey that stakeholders can fill out to provide information about their water quality issues.

Figure 2.2.7-6 Delaware River SWAP Website (www.phillywater.org/delaware)



2.2.8 Baxter Intake Conclusions and Recommendations

The following section discusses the findings of the assessment, and provides recommendations for projects and initiatives that are general (for the entire watershed), regional, and intake specific. It also attempts to provide some specific examples of the best management practices that could be employed on some of the recommended projects.

Overall, the following activities were identified as having high priority for protection efforts to address:

- Sanitary sewer overflows of raw sewage from sewer collection systems, sewage lift stations, and manholes from upstream communities
- Discharges from municipal and industrial sources such as sewage treatment plants and chemical manufacturing facilities between Camden and Trenton
- Urban, residential, and agricultural runoff from various areas of the watershed, mostly located in tributaries such as the Pennypack Creek, Poquessing/Byberry Creek, Neshaminy Creek, and Rancocas Creek.
- Spill and accidents from cars, tanker trucks, railroad cars, pipelines, tire piles, and fires at industrial facilities near the river and its tributaries

Table 2.2.8-1 summarizes the protection priorities assigned to the various types of sources overall and for each contaminant category that could be quantified. As described above, runoff/non-point sources and municipal or industrial discharges had the greatest overall priority compared to other sources.

It is important to note that just because an activity is given a high priority that does not mean that any individual site is in violation of current environmental laws and regulations or impacts on the water quality at the facility. An activity with a high ranking means that it could possibly have a high potential to negatively impact the water supply quality under certain conditions.

Table 2.2.8.1 Summary of Protection Priority of Various Types of Potential Contaminant Sources

(A-C = significant protection priority, D-F = lower protection priority)

Contaminant Group	Permitted Municipal and Industrial Dischargers (NPDES)	Urban, Residential, and Agricultural Runoff	Industrial Facilities with Toxic Releases (TRI)	Hazardous Waste Facilities (RCRA)	AST (storage tanks)	CERCLA (landfills)	CSOs, SSOs, Defective Laterals	Acid Mine Drainage	Spills & Accidents
Overall (combined)	A-C*	B-C	C	C	C	C	A-C	C	A
Chloride	D-F	A-B	A-C*	D-F	A	D-F	D-F	D-F	A
Cryptosporidium	A-C*	B-C	D-F	D-F	D-F	D-F	A	D-F	A
Fecal Coliforms	A-C*	A-C	D-F	D-F	D-F	D-F	A	D-F	A
Metals	A-C*	D-F	A-C	C	C	C	N/A	A	A
Nitrate	A-C*	C	C	D-F	A	D-F	C	D-F	A
Petroleum Hydrocarbons	A-B	A-B*	D-F	D-F	A-C*	C	D-F	D-F	A
Phosphorus	A-C*	D-F	A-C	D-F	A	D-F	C	D-F	A
Disinfection By Products	A-C*	C	A-C	D-F	D-F	C	D-F	D-F	C
Turbidity	A-C	A-C*	D-F	D-F	D-F	D-F	D-F	D-F	C
Volatile Organic Compounds	A	D-F	A-C	A-C	A-C*	C	D-F	D-F	A
Herbicides/Pesticides	N/A	A	N/A	B-C	D-F	C	N/A	D-F	A
Radionuclides	A*	D-F	D-F	D-F	D-F	D-F	D-F	D-F	C

**dominant source type in listings*
Note: if only one source fell into a protection priority, that rank was given to the type of source for a given contaminant group
Just because an activity is given a high priority does not mean that any individual site is in violation of current environmental laws and regulations. An activity with a high ranking means that it could possibly have a high potential to negatively impact the quality of the water supply under certain conditions.

Geographically, most of the priority point sources for the Baxter Intake are located within priority non-point source watersheds. Therefore, it appears that, in general, protection and restoration efforts for non-point sources should be focused in similar areas as point sources.

Tables 2.2.8-2 and 2.2.8-3 provide summaries of the protection priorities for point and non-point sources in various watershed areas. Overall, the primary focus of PWD's protection efforts to protect and improve their water supply should include continued support of efforts for the ongoing improvements of the industrial and municipal discharges 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, and Rancocas Creek area as well as portions of the Muscentong, Pohatcong, and Lehigh Rivers. However other parts of the watershed may need special attention for contaminant specific issues that do not match with the general overall priority areas or sources.

Table 2.2.8-2 Summary of Protection Priority Ranking of Various Main Stem Delaware River Areas for Point and Non-point Sources

	Protection Priority			
River Segment	**A High**	**B Moderately High**	**C Moderate**	**D-F Low**
Camden - Philadelphia	P	P & N	P & N	
Philadelphia to Trenton	P	P & N	P & N	
Trenton to Easton	P	P	P & N	
Easton to Port Jervis	P	P	P & N	
Port Jervis to Headwaters				N & P

N – Non-point source runoff, P- Point sources

Table 2.2.8-3 Summary of Protection Priority Ranking of Various Tributaries for Point and Non-point Sources in Pennsylvania and New Jersey Streams

	Protection Priority			
Tributary / Watershed	**A High**	**B Moderately High**	**C Moderate**	**D-F Low**
Poquessing, Pennypack Creeks	P	N		
Tacony-Frankford Creek				N & P
Neshaminy Creek	P	N		
Tohickon Creek				N & P
Lehigh River			N & P	
Broadhead Creek				N & P
Bushkill Creek				N & P

New Jersey Streams

	Protection Priority			
Tributary / Watershed	**A High**	**B Moderately High**	**C Moderate**	**D-F Low**
Big Timber Creek	P	P	P	N
Cooper River	P	P	P	N
Rancocas Creek	P	P & N	P & N	
Assiscunk Creek			P	N
Crosswicks Creek		P		N
Musconetcong River		N	N	P
Pohatcong River			N & P	

2.2.8.1 General Recommendations

Based on the results of the susceptibility analysis, water quality data, and stream impairments, it is clear that the potential impacts from point source discharges need to be addressed from the discharges along the main stem of the Delaware River from Camden to Trenton. Efforts to reduce these impacts require:

- Enforcement of compliance requirements for industries and municipalities discharging wastewater into the protection priority corridor between Camden and Trenton;

- Development and support of watershed or local community/environmental organizations to restore and protect various segments of the protection priority corridor between Camden and Trenton and ;

- Ensure that TMDL process and requirements along the Delaware River include components to address drinking water impacts;

- Development of special state or federal legislation that provides funding and authority for water supply protection efforts in the protection priority corridor between Camden and Trenton .

- Include *Cryptosporidium* impacts in the permitting process for wastewater dischargers upstream of drinking water intakes.

In priority stormwater runoff areas such as the Pennypack Creek, Poquessing Byberry Creek, Rancocas Creek, Neshaminy Creek, and Lehigh River as well as streams near the PWD Baxter Intake the following activities are recommended for protection against non-point source runoff.

- Development of incentives for upstream communities to mitigate stormwater runoff;

- Education of township officials along the protection priority corridor about stormwater impacts;

- Preservation of existing greenspace along the Delaware River in the protection area;

- Acquisition of conservation easements or adjustment of zoning areas or local ordinances to reduce stormwater impacts from future development in priority runoff areas;

- Enforcement of the Phase II stormwater regulations for townships in priority runoff areas;

- Development of conservation easements, riparian buffers, and streambank fencing to mitigate impacts from agricultural activities.

Though the Poquessing and Pennypack Creeks were not determined to have the most potentially significant overall loadings or impacts on the PWD Baxter Intake compared to other watershed wide sources, water quality and stream impairment data suggest that it would be preduct to restore and protect the water quality in these areas. Therefore, the following actions are recommended for continued protection efforts in the Pennypack and Poquessing Creek Watersheds:

- Assessment, prioritization and mitigation of raw sewage discharges by defective laterals from stormwater collection systems from all townships, boroughs, and cities into these watersheds.

- Development of regulatory and financial incentives for enhanced wastewater discharge for pathogen removal and inactivation to address *Cryptosporidium* impacts;

- Development of incentives and controls for mitigation of stormwater runoff impacts. This includes requiring that current TMDL efforts in the watershed include specific components to address drinking water issues and concerns. This will provide an example of how the Safe Drinking Water Act and Clean Water Act should be integrated.

- Conduct an examination of current zonings and ordinances with the Bucks and Montgomery County Planning Commissions, Bucks and Montgomery County Conservation Districts, and local townships to determine ways they can be enhanced to address current and future stormwater impacts. Identify areas where innovative techniques and incentives can be used to mitigate stormwater impacts and assist in the development and implementation of these efforts.

- Support of existing greenways, riparian corridor areas, and future riparian corridor easement and acquisition being conducted by the various townships and Bucks and Montgomery County;

- Encourage and support the development of an Act 167 Stormwater Management Plan for the Pennypack and Poquessing/Byberry Creeks.

- Establish riparian buffers and streambank fencing in all agricultural areas of the Pennypack, Poquessing/Byberry, and Neshaminy Creek Watersheds.

The Philadelphia Suburban Water Company already works with numerous stakeholders to protect its water supply in the Neshaminy Creek. The Horsham Water Authority is also involved in source water protection initiatives to protect wellhead areas in the Pennypack Creek. Therefore, it is recommended that any protection efforts be coordinated with the Philadelphia Suburban Water Company and Horhsam Water Authority in the Pennypack and Neshaminy Creeks.

In addition to the previous specific geographic recommendations, the following general efforts are recommended:

- Emergency Response Planning activities should be focused on priority AST, TRI, and RCRA facilities since they have been shown to have the greatest relative impact on water quality. Efforts should also be initiated to collect more detailed data on these sites for reprioritization. Also, state authorities should be encouraged to implement a 2-hour notice requirement for downstream users from spills instead of allowing 24- hour requirement since most spills can make it to a number of intakes in less than a day under various conditions.

- Given the potential catastrophic impacts from spills and accidents, an early warning system similar to that on the Ohio River should be installed along the main stem Lower Delaware River to provide water suppliers warning and accurate real time data when spills and accidents occur. It is recommended that USGS should be involved in the implementation of the early warning system.

- Long-term protection efforts by PWD should be focused on enhancing wastewater discharges and mitigating stormwater runoff. These will have the greatest overall impacts on improving source water quality.

- Sources of pathogens appear to be the sources of greatest priority to PWD when examined in the overall rankings. Therefore, these sources should be addressed accordingly.

- Given the significant amount of activity in the watershed by various organizations, protection efforts should be coordinated in such a way as to support and enhance existing efforts in the watershed.

- A corporate environmental stewardship program should be developed to educate, provide incentives, and engage businesses in water supply protection and stormwater mitigation.

- A workshop should be sponsored by PADEP to educate golf courses about the benefits of joining the environmental certification program by the Audobon Society.

- Special mechanisms and funding should be developed to allow the distribution of monies to support or initiate specific initiatives outside the City of Philadelphia that will protect or restore the water supply. This may involve development of a quasi-governmental or non-profit organization that can raise funds and distribute them to various organizations conducting protection activities beneficial to PWD. This organization may also need the ability acquire conservation easements or land in sensitive areas to maintain protected areas.

- Efforts should be made to encourage PADEP and DRBC to address and prioritize the impacts of CSOs and untreated discharges of raw sewage upstream of drinking water intakes.

2.2.8.2 Regional Recommendations:

There are several regional recommendations based on the results of the study and stakeholder input. These include the following:

- Development of a mechanism or framework to address source water protection and non point source issues in the Lower Delaware River Basin area. The DRBC has a number of water resource and watershed/TMDL related committees, but they are not focused on source water protection concerns. Finding a way to include the priority areas and issues identified in the SWAPs into the existing DRBC framework for implementation and mitigation is critical.

- Adoption of model ordinances and zoning practices to reduce stormwater runoff impacts from residential and urban areas

- Aggressive acquisition of conservation easements for riparian buffer development and streambank fencing to mitigate the impacts of agricultural activities in sensitive areas of the watershed.

- Development of a coordinated regional protection plan that will be adopted by water suppliers, planning commissions, and municipalities for establishment and protection of sensitive and high priority protection areas to the multiple and overlapping water supply areas between Camden and Trenton.

- Enforcement of rigorous and regular revision and implementation of ACT 537 Sewage Facilities Management Plans in Montgomery and Bucks counties. In addition, the sewage facility related issues from the SWAs should be incorporated into the ACT 537 plan with emphasis on monitoring and measuring progress towards addressing identified problems.

2.2.8.3 Intake Specific Recommendations: Example Project List and Best Management Practices

There a numerous specific projects that can be implemented throughout the watershed to protect and improve water supplies. The following list of projects provides a project title and location, potential project partners, and a general description of the components that could be incorporated into the protection project.

It may not be possible to implement all of the projects listed due to numerous unforeseen and unknown issues. Therefore, this list should be used as a resource to brainstorm and provide techniques for other projects that may be just as effective and valuable for source water protection. Specific descriptions and pictures of technologies and techniques that have been used locally or nationally to address a specific issue are provided in section 2.2.8.4 so that the reader can envision the mentioned technologies.

Some specific projects or initiatives include:

1. Continued runoff control projects at the Fox Chase Farms.

2. Identification of conditions and sources of algal growth responsible for taste and odor issues.

3. Implementation of stormwater runoff controls in areas of the Pennypack Creek and Poquessing/Byberry Creek through ACT 167 Planning and obtain participation from the U.S. Army Corps of Engineers for a reconnaissance study of the watershed to address hydraulic and hydrodynamic factors influencing water quality.

4. Conduct reviews of compliance and permit information for high priority point-source discharges between Camden and Trenton. Field visits and dialogues with these sites should be developed.

5. Conduct reviews of compliance and permit information for high priority storage tanks between Camden and Trenton. Field visits and dialogues with these sites should be developed.

6. Implementation of runoff controls at horse riding stables in the Poquessing/Byberry Creek and Pennypack Creek Watershed

7. Explore alternative road salt technology initiatives in priority runoff areas near the PWD Baxter Intake.

8. Coordinated runoff protection projects with other water suppliers in the Pennypack and Neshaminy Creeks.

9. Application of innovative stormwater controls for redevelopment of waterfront properties in Philadelphia business & industrial parks

10. Implement best management practices at city and suburban golf courses.

11. Establish or encourage enrollment by priority point sources in a corporate environmental stewardship program

2.2.8.4 Data Needs

Based on the various analyses that were conducted to identify specific sources of contamination, their location, and other characteristics, the following data gaps and information needs were identified.

Study To Identify Causes, Conditions, And Sources Of Algae That Cause Taste And Odor Problems For Prediction And Mitigation Strategies

Several months a year water suppliers are impacted by nuisance algae that release chemical compounds that make the water taste and smell unpleasant to customers. This not only impacts water treatment costs, but can stigmatize a community and have economical impacts on businesses that rely on the water such as tourism and food and beverage manufacturing. Identification of the causes and sources of these taste and odor causing events and identification of the sources, their locations, and catalyzing conditions will allow for prediction of events for proper treatment as well as identify preventative measures to prevent conditions from occurring.

Study of Cryptosporidium Presence in Wastewater Effluents

The national guidance documents for the SWAPs and DEP's own SWAP process has very specific interests in identifying and ranking sources of *Cryptosporidium*. However, the information, data, and tools were not available at the local level for an accurate analysis of this information. Preliminary studies by the Philadelphia Water Department, Philadelphia Suburban Water Company, and the PADEP have detected *Cryptosporidium* frequently at elevated levels in raw and treated sewage. The potential contribution of the pathogen *Cryptosporidium* from wastewater discharges, unsewered communities, and illicit discharges upstream of drinking water supplies is necessary to understand the daily impacts they have on pathogen challenges to the water treatment plants downstream. This could lead to strategies to reduce routine levels or viability of *Cryptosporidium* from discharges and better protect water supplies. Over the past three years, the Water Environment Research Federation has been conducting a research method to accurately detect and quantify levels of *Cryptosporidium* in wastewater. This study is almost complete and it is recommended that local studies that are conducted use this new method.

Shared GIS Information

Compilation and housing of up-to-date GIS information for upstream municipalities including sewer and stormsewer infrastructure characteristics (sewersheds, outfalls), zoning areas, ACT 167 information, preserved or potentially preserved agricultural land, county and township park lands, lands with conservation easements. Better information on abandoned or historical industrial sites and brownfields is also needed. Suggested partners interested in housing this information include the Delaware River Basin Commission.

In addition, the development of watershed wide coverages of point sources and landuse for the Delaware River Basin would provide great strides in emergency planning and source water protection information. Currently each state maintains this information which limits its comparibility, detail, and usefulness and prevents any ability for a combined examination of information.

Selection Of Testing And Data Protocols For Accurate Comparison Of Stream Impairments Between States In The Delaware River Basin

Currently comparison of stream impairment data from one state to another in the basin is impossible. Different analytical protocols for data collection and systems for reporting prevent any discernable comparisons of causes and sources of impairment on a watershed wide or regional basis. Efforts should be made to develop at least some regional understanding of impairments on a standard basis.

Characterization Study Of Townships And Boroughs With Model Ordinances and BMP Implementation For Stormwater Runoff

An accurate characterization of the townships and boroughs in the watershed should be conducted to determine if municipalities have implemented ordinances, zoning, or various BMPs to control stormwater runoff. Given the upcoming Phase II stormwater permit process, this information should be tracked to determine how many, what kind, and to what extent municipalities are going to in order to control stormwater runoff. This can be compared against water quality changes over time.

2.2.8.5 Selection of Best Management Practices in Proposed Protection Projects

Selection of best management practices (BMPs) requires the careful weighting of various factors including capital and operational costs, land consumption, and effectiveness. This section describes the various costs and choices when selecting any BMPs.

There are two types of BMPs that can be employed to address stormwater runoff, structural and non-structural. Structural practices usually involve the construction of some control structure or device. Non-structural practices usually involve activities that include changing public behavior and land use practices through education, training, and legal requirements. A comprehensive list of these practices is provided below in Tables 2.2.8-4 and 2.2.8-5.

Table 2.2.8-4 Structural BMPs for Stormwater Control

Ponds
Dry extended detention ponds
Wet ponds
Infiltration practices
Infiltration basin
Infiltration trench
Porous pavement
Filtration practices
Bio-retention
Sand and organic filters
Vegetative practices
Stormwater wetland
Grassed swales
Grassed filter strip
Runoff pretreatment practices
Catch basins/Catch basin insert
In-line storage
Manufactured products for stormwater inlets

Table 2.2.8-5 Nonstructural BMPs for Stormwater Control

Experimental practices
Alum injection
On-lot Treatment
On-Lot treatment
Better site design
Buffer zones
Open space design
Urban forestry
Conservation easements
Infrastructure planning
Narrower residential streets
Eliminating curbs and gutters
Green parking
Alternative turnarounds
Alternative pavers
BMP inspection and maintenance
Ordinances for post-construction runoff
Zoning

Employment and selection of the various structural BMP techniques and technologies requires additional familiarity with the pros and cons of the technologies, site selection and design issues, operation and maintenance and costs. Tables 2.2.8-6 and 2.2.8-7 provide examples of estimates of capital and maintenance costs of various structural BMPs. Table 2.2.8-8 provides estimated land consumption for various structural BMPs. Table 2.2.8-9 provides a description of the various contaminants non-structural BMPs can address. Table 2.2.8-10 through 14 provide data on the effectiveness of pollutant removal by various BMPs. These tables are taken directly from EPA's website at **URL:** http://www.epa.gov/ost/stormwater/usw_d.pdf .

Table 2.2.8-6 Base Costs of Typical Applications of Stormwater BMPs

BMP Type	Typical Cost ($/BMP)	Application	Data Source
Retention Basin	$100,000	50-Acre Residential Site (Impervious Cover = 35%)	Adapted from Brown and Schueler (1997b)
Wetland	$125,000	50-Acre Residential Site (Impervious Cover = 35%)	Adapted from Brown and Schueler (1997b)
Infiltration Trench	$45,000	5-Acre Commercial Site (Impervious Cover = 65%)	Adapted from SWRPC (1991)
Infiltration Basin	$15,000	5-Acre Commercial Site (Impervious Cover = 65%)	Adapted from SWRPC (1991)
Sand Filter	$35,000-$70,000[2,3]	5-Acre Commercial Site (Impervious Cover = 65%)	Adapted from Brown and Schueler (1997b)
Bioretention	$60,000	5-Acre Commercial Site (Impervious Cover = 65%)	Adapted from Brown and Schueler (1997b)
Grass Swale	$3,500	5-Acre Residential Site (Impervious Cover = 35%)	Adapted from SWRPC (1991)
Filter Strip	$0-$9,000[3]	5-Acre Residential Site (Impervious Cover = 35%)	Adapted from SWRPC (1991)

1. Base costs do not include land costs.
2. Total capital costs can typically be determined by increasing these costs by approximately 30%.
3. A range is given to account for design variations.

Source: *http://www.epa.gov/ost/stormwater/usw_d.pdf*

Table 2.2.8-7 Operation and Maintenance Cost Estimates

BMP	Annual Maintenance Cost (% of Construction Cost)	Source(s)
Retention Basins and Constructed Wetlands	3%-6%	Wiegand et al, 1986 Schueler, 1987 SWRPC, 1991
Detention Basins[1]	<1%	Livingston et al, 1997; Brown and Schueler, 1997b
Constructed Wetlands[1]	2%	Livingston et al, 1997; Brown and Schueler, 1997b
Infiltration Trench	5%-20%	Schueler, 1987 SWRPC, 1991
Infiltration Basin[1]	1%-3%	Livingston et al, 1997; SWRPC, 1991
	5%-10%	Wiegand et al, 1986; Schueler, 1987; SWRPC, 1991
Sand Filters[1]	11%-13%	Livingston et al, 1997; Brown and Schueler, 1997b
Swales	5%-7%	SWRPC, 1991
Bioretention	5%-7%	(Assumes the same as swales)
Filter strips	$320/acre (maintained)	SWRPC, 1991

1. Livingston et al (1997) reported maintenance costs from the maintenance budgets of several cities, and percentages were derived from costs in other studies

Table 2.2.8-8 Land Consumption of Various BMPs

BMP Type	Land consumption (% of Impervious Area)
Retention Basin	2-3%
Constructed Wetland	3-5%
Infiltration Trench	2-3%
Infiltration Basin	2-3%
Porous Pavement	0%
Sand Filters	0%-3%
Bioretention	5%
Swales	10%-20%
Filter Strips	100%

Note: Represents the amount of land needed as a percent of the impervious area that drains to the practice to achieve effective treatment.
Source: Claytor and Schueler, 1996

Table 2.2.8-9 Non-Structural BMPs Suited to Controlling Various Pollutants: Pollutant Appropriate BMPs

	BMPS
Solids	Street Sweeping Land Use Modifications
Oxygen-Demanding Substances	Street Sweeping Education: Storm Drain Stenciling Land Use Modifications Education: Pet Scoop Ordinance Illicit Connections Eliminated
Nitrogen and Phosphorus	Street Sweeping Education: Pet Scoop Ordinance Land Use Modifications Proper Materials Handling Illicit Connections Eliminated Education: Lawn Care Materials Storage and Recycling
Pathogens	Illicit Connections Eliminated Land Use Modifications Education: Pet Scoop Ordinance
Petroleum Hydrocarbons	Street Sweeping Education: Storm Drain Stenciling Proper Materials Handling Illicit Connections Eliminated Materials Storage and Recycling Land Use Modifications
Metals	Street Sweeping Education: Storm Drain Stenciling Proper Materials Handling Illicit Connections Eliminated Materials Storage and Recycling Land Use Modifications
Synthetic Organics	Illicit Connections Eliminated Education: Storm Drain Stenciling Proper Materials Handling Education: Lawn Care Materials Storage and Recycling Land Use Modifications
Temperature	Land Use Modifications
pH	Illicit Connections Eliminated Proper Materials Handling Materials Storage and Recycling Land Use Modifications

Source: http://www.epa.gov/ost/stormwater/usw_d.pdf

Table 2.2.8-10 Structural BMP Expected Pollutant Removal Efficiency

BMP Type	Typical Pollutant Removal (percent)				
	Suspended Solids	Nitrogen	Phosphorus	Pathogens	Metals
Dry Detention Basins	30 - 65	15 - 45	15 - 45	< 30	15 - 45
Retention Basins	50 - 80	30 - 65	30 - 65	< 30	50 - 80
Constructed Wetlands	50 - 80	< 30	15 - 45	< 30	50 - 80
Infiltration Basins	50 - 80	50 - 80	50 - 80	65 - 100	50 - 80
Infiltration Trenches/ Dry Wells	50 - 80	50 - 80	15 - 45	65 - 100	50 - 80
Porous Pavement	65 - 100	65 - 100	30 - 65	65 - 100	65 - 100
Grassed Swales	30 - 65	15 - 45	15 - 45	< 30	15 - 45
Vegetated Filter Strips	50 - 80	50 - 80	50 - 80	< 30	30 - 65
Surface Sand Filters	50 - 80	< 30	50 - 80	< 30	50 - 80
Other Media Filters	65 - 100	15 - 45	< 30	< 30	50 - 80

Source: Adapted from US EPA, 1993c.

Table 2.2.8-11 Pollutant Removal by Infiltration Practices

Parameter	Median or Average Removal Efficiency (percent)	Number of Observations
Total Phosphorus	65	5
Ammonia-Nitrogen	83	3
Nitrate	82	3
Total Nitrogen	83	2
Suspended Solids	89	2
Organic Carbon	82	1
Lead	98	1
Zinc	99	1

Source: Brown and Schueler, 1997a

Table 2.2.8-12 Pollutant Removal by Retention Basins

Parameter	Median or Average Removal Efficiency (percent)	Range of Removals (percent)		Number of Observations
		Low	High	
Soluble Phosphorus	34	-12	90	20
Total Phosphorus	46	0	91	44
Ammonia-Nitrogen	23	-107	83	14
Nitrate	23	-85	97	27
Organic Nitrogen	23	2	34	6
Total Nitrogen	30	-12	85	24
Suspended Solids	70	-33	99	43
Bacteria	74	-6	99	10
Organic Carbon	35	-30	90	29
Cadmium	47	-25	54	5
Chromium	49	25	62	5
Copper	55	10	90	18
Lead	67	-97	95	34
Zinc	51	-38	96	32

Source: Brown and Schueler, 1997a

Table 2.2.8-13 Pollutant Removal Efficiency of Constructed Wetland Systems

Parameter	Median Removal Efficiency (percent)	Range of Removals (percent)		Number of Observations
		Low	High	
Soluble Phosphorus	23	-30	78	12
Ortho-Phosphate	28	-109	93	7
Total Phosphorus	46	-120	97	37
Ammonia-Nitrogen	33	-86	62	15
Nitrate	46	4	95	18
Organic Nitrogen	7	-36	39	7
Total Nitrogen	24	-20	83	11
Suspended Solids	76	-300	98	26
Bacteria	78	55	97	3
Organic Carbon	28	-31	93	15
Cadmium	69	-80	80	6
Chromium	73	38	98	3
Copper	39	2	84	10
Lead	63	23	94	17
Zinc	54	-74	90	16

Sources: Strecker at al (1992); Organic Carbon, Bacteria and Metals from Brown and Schueler, 1997a

Table 2.2.8-14 Pollutant Removal Efficiency of Open Channel Vegetated Systems

Parameter	Average or Median Removal Efficiency (percent)	Range of Removals (percent)		Number of Observations
		Low	High	
Soluble Phosphorus	11	-45	72	8
Total Phosphorus	15	-100	99	18
Ammonia-Nitrogen	3	-19	78	4
Nitrate	11	-100	99	13
Organic Nitrogen	39	11	86	3
Total Nitrogen	11	-100	99	10
Suspended Solids	66	-100	99	18
Bacteria	-25	-100	0	5
Organic Carbon	23	-100	99	11
Cadmium	49	20	80	6
Chromium	47	14	88	5
Copper	41	-35	89	15
Lead	50	-100	99	19
Zinc	49	-100	99	19

Source: Brown and Schueler, 1997a

Source: http://www.epa.gov/ost/stormwater/usw_d.pdf

2.2.8.6 Descriptions and Pictures of Technologies for Stormwater Control

Though many technologies are recommended for use of best management practices, not everyone can envision how they would look and operate. The following section provides descriptions and pictures of these technologies. More detailed information such as design criteria, pros and cons to construction and operation, technical fact sheets, effectiveness, and various diagrams are also provided on EPA's websites at the following URLs.

http://www.epa.gov/npdes/menuofbmps/post.htm

http://www.epa.gov/ost/stormwater/usw_c.pdf

The following descriptions have been taken from these websites to provide the reader with descriptions of the following BMP technologies and techniques:

- Infiltration trenches
- Bio-retention areas

- Stormwater wetlands
- Infiltration basins
- Wet ponds
- Dry extended detention ponds
- Grass filter strips
- Grass swales
- Green parking
- Porous pavement
- Sand and organic filters
- Catch basins and inserts
- Stormwater inlet products
- Log veins and coir fabric for streambank restoration

Bioretention Areas
Post-construction Stormwater Management in New Development and Redevelopment

Bioretention areas can be used in parking areas to collect and treat storm water (Source: University of Maryland, 2000)

Description

Bioretention areas are landscaping features adapted to provide on-site treatment of stormwater runoff. They are commonly located in parking lot islands or within small pockets of residential land uses. Surface runoff is directed into shallow, landscaped depressions. These depressions are designed to incorporate many of the pollutant removal mechanisms that operate in forested ecosystems. During storms, runoff forms ponds above the mulch and soil in the system. Runoff from larger storms is generally diverted past the facility to the storm drain system. The remaining runoff filters through the mulch and prepared soil mix. Typically, the filtered runoff is collected in a perforated underdrain and returned to the storm drain system.

Infiltration Basin
Post-construction Stormwater Management in New Development and Redevelopment

Infiltration basins are designed to collect storm water from impervious areas and provide pollutant removal benefits through detention and filtration

Description

An infiltration basin is a shallow impoundment which is designed to infiltrate stormwater into the ground water. This practice is believed to have a high pollutant removal efficiency and can also help recharge the ground water, thus restoring low flows to stream systems. Infiltration basins can be challenging to apply on many sites, however, because of soils requirements. In addition, some studies have shown relatively high failure rates compared with other management practices.

Stormwater Wetland
Post-construction Stormwater Management in New Development and Redevelopment

A storm water wetland detains storm water, removes pollutants, and provides habitat and aesthetic benefits (Source: The Bioengineering Group, Inc., no date)

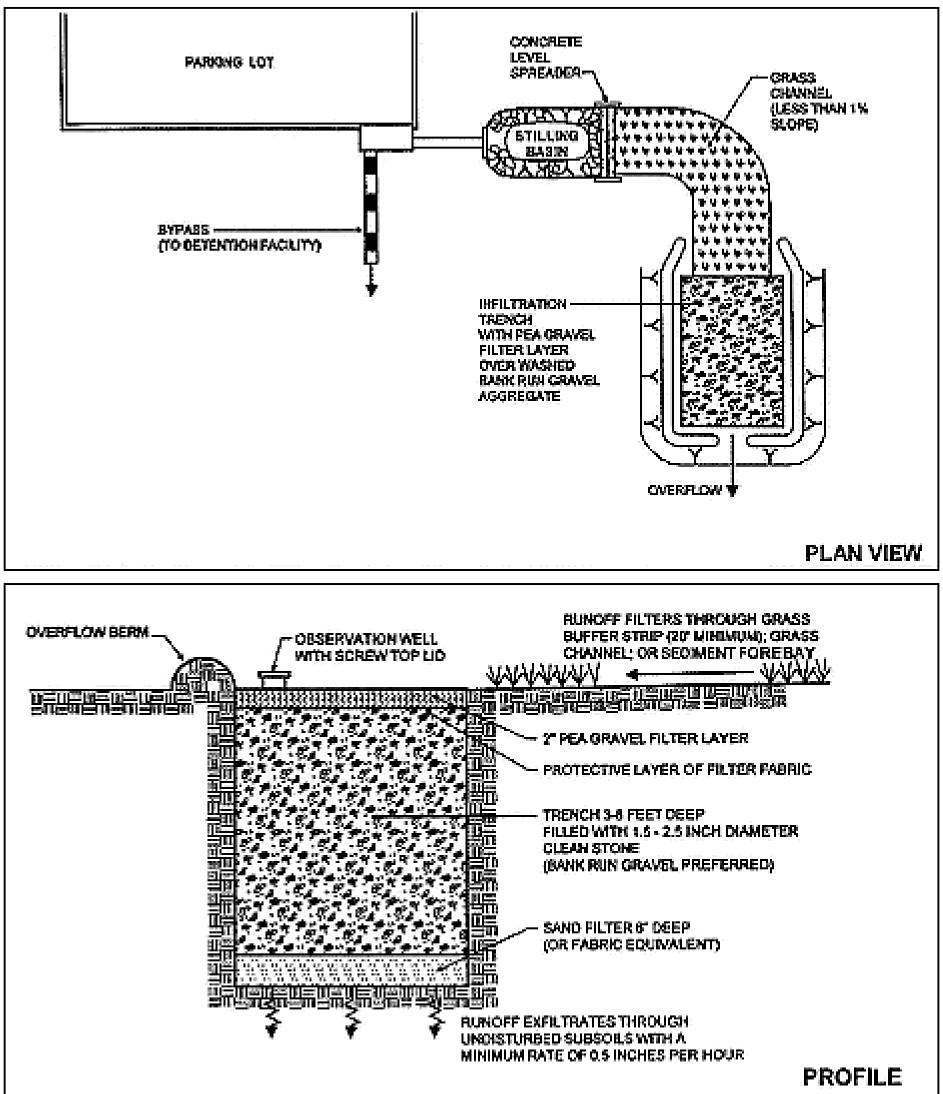
Description

Stormwater wetlands (a.k.a. constructed wetlands) are structural practices similar to wet ponds (see Wet Pond fact sheet) that incorporate wetland plants into the design. As stormwater runoff flows through the wetland, pollutant removal is achieved through settling and biological uptake within the practice. Wetlands are among the most effective stormwater practices in terms of pollutant removal and they also offer aesthetic value. Although natural wetlands can sometimes be used to treat stormwater runoff that has been properly pretreated, stormwater wetlands are fundamentally different from natural wetland systems. Stormwater wetlands are designed specifically for the purpose of treating stormwater runoff, and typically have less biodiversity than natural wetlands in terms of both plant and animal life. Several design variations of the stormwater wetland exist, each design differing in the relative amounts of shallow and deep water, and dry storage above the wetland.

A distinction should be made between using a constructed wetland for stormwater management and diverting stormwater into a natural wetland. The latter practice is not recommended because altering the hydrology of the existing wetland with additional stormwater can degrade the resource and result in plant die-off and the destruction of wildlife habitat. In all circumstances, natural wetlands should be protected from the adverse effects of development, including impacts from increased stormwater runoff. This is especially important because natural wetlands provide stormwater and flood control benefits on a regional scale.

Infiltration Trench
Post-construction Stormwater Management
in New Development and Redevelopment
Description

An infiltration trench (a.k.a. infiltration galley) is a rock-filled trench with no outlet that receives stormwater runoff. Stormwater runoff passes through some combination of pretreatment measures, such as a swale and detention basin, and into the trench. There, runoff is stored in the void space between the stones and infiltrates through the bottom and into the soil matrix. The primary pollutant removal mechanism of this practice is filtering through the soil.



A schematic of an infiltration trench (Source: MDE, 2000)

Grassed Filter Strip
Post-construction Stormwater Management
in New Development and Redevelopment

Grassed filter strips protect water quality by filtering pollutants before they reach the water (Source: USDA, 1997)

Description

Grassed filter strips (vegetated filter strips, filter strips, and grassed filters) are vegetated surfaces that are designed to treat sheet flow from adjacent surfaces. Filter strips function by slowing runoff velocities and filtering out sediment and other pollutants, and by providing some infiltration into underlying soils. Filter strips were originally used as an agricultural treatment practice, and have more recently evolved into an urban practice. With proper design and maintenance, filter strips can provide relatively high pollutant removal. One challenge associated with filter strips, however, is that it is difficult to maintain sheet flow, so the practice may be "short circuited" by concentrated flows, receiving little or no treatment.

Grassed Swales
Post-construction Stormwater Management
in New Development and Redevelopment

Grassed swales can be used along roadsides and parking lots to collect and treat storm water runoff

Description

The term swale (a.k.a. grassed channel, dry swale, wet swale, biofilter) refers to a series of vegetated, open channel management practices designed specifically to treat and attenuate stormwater runoff for a specified water quality volume. As stormwater runoff flows through these channels, it is treated through filtering by the vegetation in the channel, filtering through a subsoil matrix, and/or infiltration into the underlying soils. Variations of the grassed swale include the grassed channel, dry swale, and wet swale. The specific design features and methods of treatment differ in each of these designs, but all are improvements on the traditional drainage ditch. These designs incorporate modified geometry and other features for use of the swale as a treatment and conveyance practice.

Wet Ponds
Post-construction Stormwater Management
in New Development and Redevelopment


The primary functions of a wet pond are to detain storm water and facilitate pollutant removal through settling and biological uptake

Description

Wet ponds (a.k.a. stormwater ponds, retention ponds, wet extended detention ponds) are constructed basins that have a permanent pool of water throughout the year (or at least throughout the wet season). Ponds treat incoming stormwater runoff by settling and algal uptake. The primary removal mechanism is settling as stormwater runoff resides in this pool, and pollutant uptake, particularly of nutrients, also occurs through biological activity in the pond. Wet ponds are among the most cost-effective and widely used stormwater practices. While there are several different versions of the wet pond design, the most common modification is the extended detention wet pond, where storage is provided above the permanent pool in order to detain stormwater runoff in order to provide settling.

Dry Extended Detention Pond
Post-construction Stormwater Management
in New Development and Redevelopment


A dry extended detention pond is designed to temporarily detain runoff during storm events

Description

Dry extended detention ponds (a.k.a. dry ponds, extended detention basins, detention ponds, extended detention ponds) are basins whose outlets have been designed to detain the stormwater runoff from a water quality design storm for some minimum time (e.g., 24 hours) to allow particles and associated pollutants to settle. Unlike wet ponds, these facilities do not have a large permanent pool. However, they are often designed with small pools at the inlet and outlet of the basin. They can also be used to provide flood control by including additional flood detention storage.

Porous Pavement
Post-construction Stormwater Management in New Development and Redevelopment

A porous pavement parking lot (Source: Invisible Structures, no date)

Description

Porous pavement is a permeable pavement surface with an underlying stone reservoir to temporarily store surface runoff before it infiltrates into the subsoil. This porous surface replaces traditional pavement, allowing parking lot stormwater to infiltrate directly and receive water quality treatment. There are a few porous pavement options, including porous asphalt, pervious concrete, and grass pavers. Porous asphalt and pervious concrete appear to be the same as traditional pavement from the surface, but are manufactured without "fine" materials, and incorporate void spaces to allow infiltration. Grass pavers are concrete interlocking blocks or synthetic fibrous gridded systems with open areas designed to allow grass to grow within the void areas. Other alternative paving surfaces can help reduce the runoff from paved areas but do not incorporate the stone trench for temporary storage below the pavement (see Green Parking fact sheet). While porous pavement has the potential to be a highly effective treatment practice, maintenance has been a concern in past applications of the practice.

Green Parking
Post-construction Stormwater Management in New Development and Redevelopment

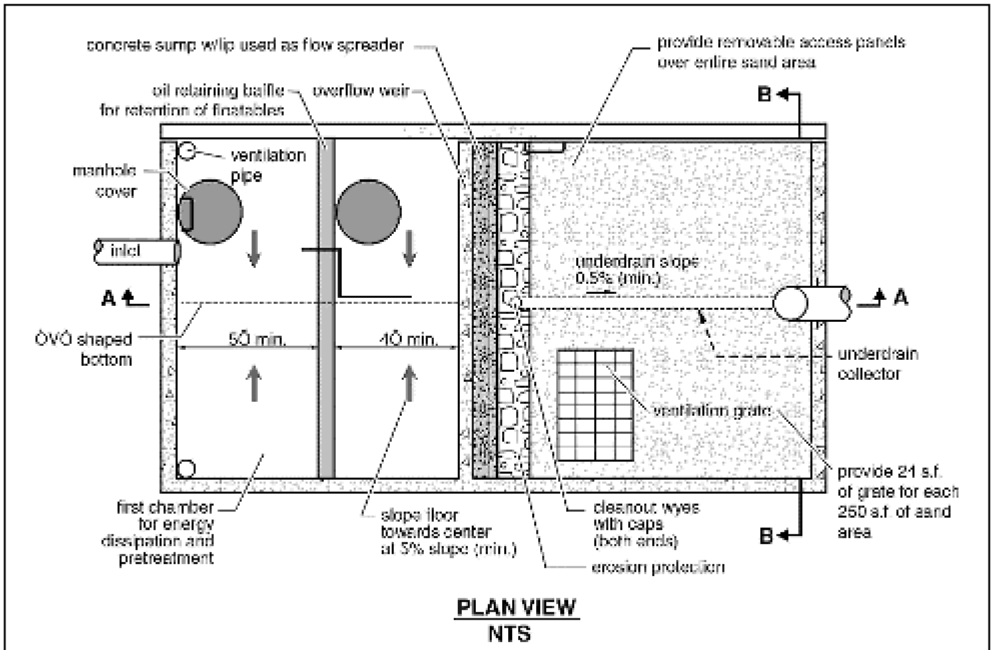
A green parking lot at the Orange Bowl in Miami, Florida (Source: Invisible Structures, no date)

Description

Green parking refers to several techniques applied together to reduce the contribution of parking lots to the total impervious cover in a lot. From a stormwater perspective, application of green parking techniques in the right combination can dramatically reduce impervious cover and, consequently, the amount of stormwater runoff. Green parking lot techniques include setting maximums for the number of parking lots created, minimizing the dimensions of parking lot spaces, utilizing alternative pavers in overflow parking areas, using bioretention areas to treat stormwater, encouraging shared parking, and providing economic incentives for structured parking.

Sand and Organic Filters
Post-construction Stormwater Management
in New Development and Redevelopment
Description

Sand filters are usually two-chambered stormwater practices; the first is a settling chamber, and the second is a filter bed filled with sand or another filtering media. As stormwater flows into the first chamber, large particles settle out, and then finer particles and other pollutants are removed as stormwater flows through the filtering medium. There are several modifications of the basic sand filter design, including the surface sand filter, underground sand filter, perimeter sand filter, organic media filter, and Multi-Chamber Treatment Train. All of these filtering practices operate on the same basic principle. Modifications to the traditional surface sand filter were made primarily to fit sand filters into more challenging design sites (e.g., underground and perimeter filters) or to improve pollutant removal (e.g., organic media filter).



Schematic of a sand filter (Source: King County, Washington, 2000)

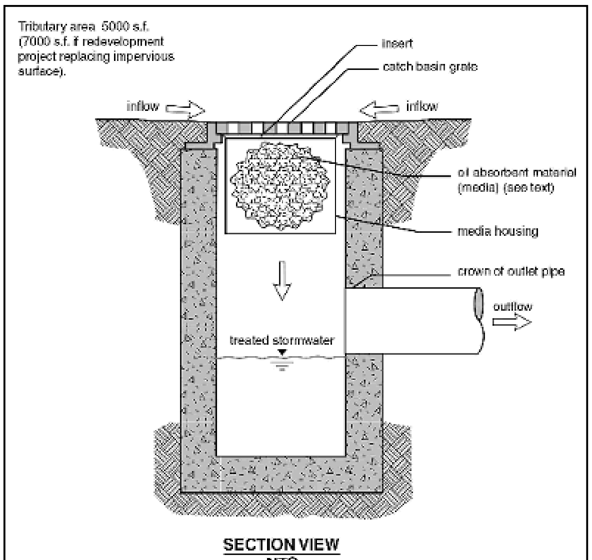
Catch Basins/Catch Basin Inserts
Post-construction Stormwater Management
in New Development and Redevelopment

A worker inserts a catch basin insert for oil and grease, trash, debris, and sediment removal from storm water as it enters the storm drainage system (Source: AbTech Industries, 2001)

Description

A catch basin (a.k.a. storm drain inlet, curb inlet) is an inlet to the storm drain system that typically includes a grate or curb inlet and a sump to capture sediment, debris, and associated pollutants. They are also used in combined sewer overflow (CSO) watersheds to capture floatables and settle some solids. Catch basins act as pretreatment for other treatment practices by capturing large sediments. The performance of catch basins at removing sediment and other pollutants depends on the design of the catch basin (e.g., the size of the sump) and maintenance procedures to retain the storage available in the sump to capture sediment. Catch basin efficiency can be improved using inserts, which can be designed to remove oil and grease, trash, debris, and sediment. Some inserts are designed to drop directly into existing catch basins, while others may require extensive retrofit construction.

Manufactured Products for Stormwater Inlets
Post-construction Stormwater Management
in New Development and Redevelopment



The typical design of a catch basin insert is a set of filters that are specifically chosen to address the pollutants expected at that site (Source: King County, Washington, 2000)

Description

A variety of products for stormwater inlets known as swirl separators, or hydrodynamic structures, have been widely applied in recent years. Swirl separators are modifications of the traditional oil-grit separator and include an internal component that creates a swirling motion as stormwater flows through a cylindrical chamber. The concept behind these designs is that sediments settle out as water moves in this swirling path. Additional compartments or chambers are sometimes present to trap oil and other floatables. There are several different types of proprietary separators, each of which incorporates slightly different design variations, such as off-line application. Another common manufactured product is the catch basin insert. These products are discussed briefly in the Catch Basin fact sheet.

Examples of Materials Used in a Streambank Restoration and Protection: Log veins redirect streamflow back to the center channel or slow side stream velocities protecting the streambank. The coir fabric stabilizes the streambank and allows new plantings such as tall warm seasoned grasses time to grow. Over time the coir fabric biodegrades back into the soil.

Conversion of Detention Ponds and Construction of Treatment Wetlands: A typical detention pond that is mowed has little water quality benefit and can be converted into something more beneficial. Treatment wetlands can be aesthetically pleasing and ecologically diverse. Both of the areas shown above are located in the Philadelphia Region.

2.2.9 PWD-Baxter Intake Public Summary

Introduction

As part of the requirements of the 1996 Safe Drinking Water Act Reauthorization, the Pennsylvania Department of Environmental Protection (PADEP) has been conducting assessments of all potentially significant sources of contamination to all public drinking water sources. The Philadelphia Water Department has prepared this Source Water Assessment Public Summary to provide information to support local and state efforts to protect the quality of the City of Philadelphia's drinking water sources. The information in this summary pertains to the water supply area for the Philadelphia Water Department's Baxter Water Treatment Plant. The water withdrawn for the Baxter Water Treatment Plant is treated and meets all state and federal regulations for safety and quality before being distributed to Northeast Philadelphia and Lower Bucks County. The assessment conducted for the Baxter Water Treatment Plant is of the "source" (river water) rather than "tap" (drinking) water. Information on "tap" (drinking) water quality is available from the Philadelphia Water Department's Annual Consumer Confidence Report that can be obtained by calling 215-685-6300 or visiting the website at www.phila.gov.

What is the Source of Your Drinking Water?

The source of water for the Philadelphia Water Department – Baxter Water Treatment Plant is surface water from the Delaware River. An average of 190 million gallons is withdrawn from the river per day. The water system serves approximately 750,000 customers in Northeast Philadelphia and Lower Bucks County. The water supply intake is located in Torresdale section of Philadelphia. Approximately 8,106 square miles of land covering portions of 3 states, 30 counties including large sections of Montgomery, and Lehigh, Bucks, and Mercer counties that drain into the river upstream from the intake. The land upstream of the intake is 70% forested/greenspace, 17% agricultural, and 10% developed. Approximately 4 million people live in the Delaware River Watershed.

Water Quality and Treatment Information

Water withdrawn from the Delaware River is coagulated, settled, filtered, and disinfected with chlorine prior to distribution to customers. Drinking water quality meets or exceeds all state or federal requirements. In addition, the Baxter Water Treatment Plant participates in the Partnership for Safe Water program. This program is an intensive voluntary program nationwide by water suppliers that strives for optimized water quality well beyond that required by state and federal agencies.

Evaluation of Significant Sources of Contamination

This assessment identifies and evaluates the possibility for contaminants to potentially enter the Schuylkill River upstream from the water intake prior to treatment. The contaminants addressed in this assessment include those regulated under the federal Safe Drinking Water Act as well as those PADEP has determined may present a concern to human health. These sources are then ranked to determine their protection priority to the water supplier. The protection priority is the level of importance and potential contamination a particular source represents for the water supply. A description of the protection priority assigned to various types of sources upstream from the Baxter Intake is provided in Table 2.2.9-1. Each type of source has a qualitative protection priority rating ranging from A to F. The "A" rating is considered a source of highest protection priority, while "F" is considered lowest protection priority. Sources with ratings between "A" and "C" are considered potentially significant sources for protection consideration. Sources with rating between "D" and "F" are considered to have less significance.

As indicated in Table 2.2.9-1, discharges of treated and untreated sewage upstream of the water intake were given the highest protection priority due to their potential to release pathogens and nutrients into the water supply. Polluted runoff from stormwater was also given a high protection priority due to the potential impacts of runoff from urban areas and agricultural lands that introduce pathogens, nutrients, and sediment into the water supply.

Ongoing Source Water Protection Activities

The Philadelphia Water Department (PWD) has an active source water protection program that works closely with state, federal, and local officials to address water quality issues. PWD also participates in various activities with upstream dischargers, businesses, communities, water suppliers, and watershed organizations that encourage communication, cooperation, education, protection, and restoration of the Schuylkill River and its tributaries.

Source Water Protection Needs

Overall, the primary focus of PWD's protection efforts to protect and improve their water supply should include continued support of efforts for the ongoing improvements of the industrial and municipal discharges the tidal areas of the Delaware River between Trenton and Philadelphia/Camden. Non-point source protection should be focused in the Pennypack, Poquessing/Byberry Creek, Rancocas Creek, and Neshaminy Creek area as well as portions of the Muscentong, Pohatcong, and Lehigh Rivers. However other parts of the watershed such as the Pennypack and Poquessing Creeks may need special attention for contaminant specific issues that do not match with the general overall priority areas or sources.

Long-term protection efforts should be focused on enhancing wastewater discharges and mitigating stormwater runoff from urban and residential areas. These will have the greatest overall impacts on improving source water quality and the Delaware River.

How to Obtain More Information

This Source Water Assessment Public Summary was completed in June 2002. Individuals interested in learning more about this water system and watershed can contact the Philadelphia Water Department at 215-685-6300 or access information from the internet at www.phila.gov/departments/water or www.phillywater/Delaware.org.

Table 2.2.9-1 Summary of Protection Priorities for Various Upstream Sources

Source	Protection Priority	Description	Priority Area(s)	Contaminants
Treated Sewage	A – C (Moderate – High)	Wastewater discharges from wastewater treatment plants	Camden to Trenton	Pathogens, bacteria, viruses, *Cryptosporidium*, nutrients, sediment, organic chemicals
Untreated Sewage	A (High)	Combined and sanitary sewer overflows/discharges	Camden to Trenton	Pathogens, bacteria, viruses, *Cryptosporidium*, nutrients
Urban/Residential Runoff	A – C (Moderate – High)	Stormwater runoff from roads, parking lots, roofs	Pennypack Creek Poquessing Creek Byberry Creek Neshaminy Creek	Pathogens, bacteria, viruses, *Cryptosporidium*, nutrients, metals, sediment
Agricultural Runoff	A – C (Moderate – High)	Stormwater runoff from croplands, pastures, livestock	Neshaminy Creek Pohatpocong River Musconetcong River Lehigh RIver	Pathogens, bacteria, viruses, *Cryptosporidium*, nutrients, sediment
Acid Mine Drainage	C (Moderate)	Discharge from abandoned coal mining areas	Lehigh River	Metals
Industrial Facilities	C (Moderate)	Facilities that store or use hazardous chemicals	Camden to Trenton	Metals, nutrients, organic chemicals
Above Ground Storage Tanks	C (Moderate)	If storage tank spilled into river	Camden to Trenton	Petroleum hydrocarbons, metals, phosphorus
Landfills	C (Moderate)	Leaching of contaminants into streams	Camden to Trenton	Petroleum hydrocarbons, metals
Spills and Accidents	A – C (Moderate – High)	Car, truck, train, or pipeline accident spilling benzene	Watershed wide	Petroleum hydrocarbons, organic chemicals

Note: *Petroleum hydrocarbons include chemicals found in oils and greases. Organic chemicals include chemicals found in solvents, degreasers, varnishes, paints, gasoline, plastics, insect and weed killers.*

How Do I Get Involved in Protecting the River and My Water Supply?

There are many ways you can help protect the river and your water supply. You can join a local watershed organization, join a citizens advisory committee, or write your state and local representatives or congressmen about your views and opinions on issues. Instead of joining organizations, you can also lend a hand when these various organizations conduct trash cleanup, stream restoration, tree planting activities, stenciling storm drains, or conducting stream monitoring. Even the smallest of things can help protect your stream, river, or water supply. Just simply calling the proper authorities when you see illegal dumping, dead fish, or other polluting activities can make a big difference (see Table 2.2.9-2). Below are a list of numbers to call for various situations and a list of websites to find more information about local watershed and environmental organizations in the area (see Table 2.2.9-3).

Table 2.2.9-2 Who to Call to Report Various Situations

Situation	Who To Call	Phone
Dead Fish	Fish & Boat Commission PADEP	717-626-0228 800-541-2050
Illegal Dumping & Related Pollution Activities	PADEP Environmental Police Unit	800-541-2050 215-685-6300
Sewage Spills	PADEP PWD	800-541-2050 215-685-6300
Oil & Gas Spills / Accidents	PADEP PWD	800-541-2050 215-685-6300
Soil Erosion and Runoff from Construction or Farming	PADEP Bucks Co. Conservation District	610-832-6131 215-345-7577

Table 2.2.9-3 Getting Involved: Places to go for More Information About Local Organizations

Information About	*Phone Number*	Website Address
Philadelphia Area Watershed Organizations	215-685-6300	www.phillywater.org/delaware
Friends of Pennypack Park	(215) 934-7275	jryanpark9@aol.com
Fairmount Park Friends Groups		
Delaware Riverkeeper	(215) 369-1188	www.delawareriverkeeper.org
Neshaminy Creek Watershed	(215) 598-7791	myersrich@juno.com
Friends of Tacony Creek Park	215-745-8903	
Poquessing Creek	(215)-972-6275	friendsofpoquessing.org/
Cobbs Creek Environmental Education Center	(215) 471-2223	www.cobbscreek.org
Darby Creek Watershed Association	(610) 789-1814	
Pennypack Ecological Restoration Trust	(215) 657-0930	www.libertynet.org/pert
Chester Ridley Crum Watershed Organization		www.ctic.purdue.edu/crcwa/home.html
Trout Unlimited – Bucks Co.	(215) 453-7689	http://members.aol.com/troutubuck