CHAPTER 5

WATER RESOURCES

Introduction

The Delaware Direct Watershed constitutes approximately 1% of a larger drainage area known as the Delaware River Basin, shown in Figure 5.1. It is important to keep this distinction in mind when discussing the water resources of the Delaware Direct Watershed. This relatively small urban drainage area is a piece of a much larger puzzle, and the quality of its water resources is influenced by conditions both upstream and across the river in New Jersey.

The Delaware River Basin

The Delaware River originates on the western slopes of New York's Catskill Mountains as two separate branches that meet at Point Mountain in Hancock, NY. From Point Mountain to the mouth of the Delaware Bay, the 330-mile Delaware River winds its way south along the interior of the Eastern coast of the United States (Figure 5.1). From Hancock, NY, the river flows southeast for 78 miles through rural regions along the New York-Pennsylvania border to Port Jervis in the Shawangunk (Catskill) Mountains. It then heads southwest along the border between Pennsylvania and New Jersey, through the Appalachian Mountains and the 42 miles of the Minisink Valley and the Delaware Water Gap in the Kittatinny Mountains (also known as Blue Mountain in Pennsylvania). Turning southeast again at Easton, PA, where it is met by the Lehigh River (its second largest tributary), the Delaware then flows approximately 80 miles to the tidal waters of Trenton, NJ. Approximately 30 miles downstream of Trenton, the river passes Philadelphia—the fifth-largest metropolitan region in the nation—and the mouth of the Schuylkill River, its largest tributary. The river continues past the city of Wilmington, DE, and widens and enters the Delaware Bay. With Cape May, NJ, on its eastern shore and Cape Henlopen, DE on the west, the river completes its course and empties into the Atlantic Ocean.[1]

The drainage area (or watershed) often referred to as the Delaware River Basin covers an area of more than 13,000 square miles and encompasses four states, 42 counties and 838 municipalities in the mid-Atlantic region of the country. More than 15 million people (approximately 5% of the nation's population) rely on the waters of the Delaware River Basin for drinking, agriculture and industrial use.[2] This River Conservation Plan focuses on the water resources of the Delaware Direct Watershed in Philadelphia. For more information on the entire Delaware River Basin, view the State of the Basin Report, published by the Delaware River Basin Commission (DRBC).

[1] Delaware River Basin Commission, State of the Delaware River Basin Report, 2008
[2] Delaware River Basin Commission, Basin Facts, 5 Feb. 2011<http://www.state.nj.us/drbc/thedrb.htm>

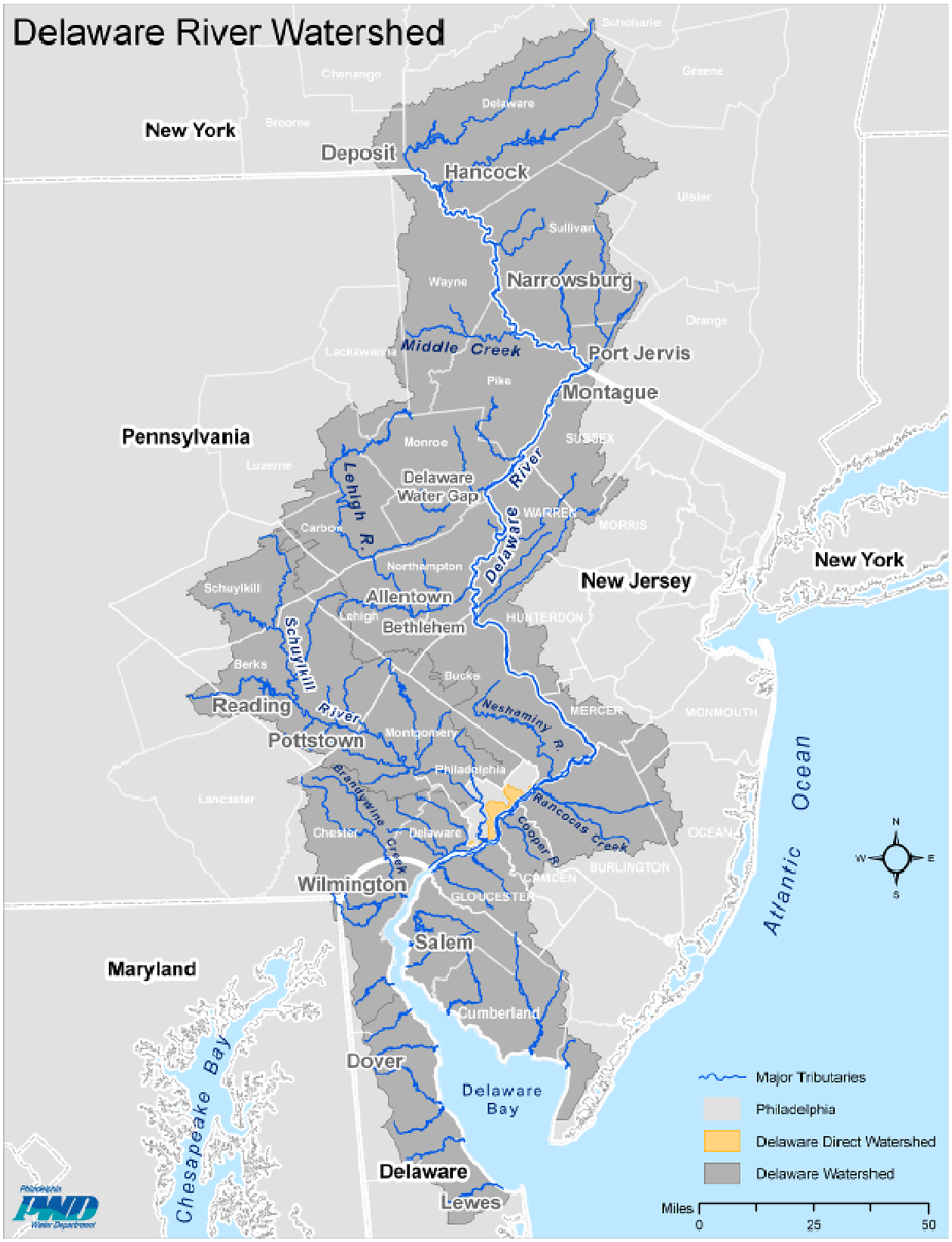

Figure 5.1: The Delaware Direct Watershed within the Delaware River Basin

5.1 – Tributaries

The water resources in the Delaware Direct Watershed have undergone significant transformation from their original, natural state. Urbanization from settlement to development and redevelopment has created a man-made drainage area. An area that was once covered by free-flowing streams, open spaces and tidal marshlands is now a densely populated and paved city atop a network of engineered sewers. This urbanization process eliminated most of the naturally occurring freshwater lakes, ponds, wetlands and tributary streams to the Delaware River within the City of Philadelphia. For more information on wetlands and an update on the life they support in the Delaware Direct Watershed, refer to Chapter 6.

Tributaries
Due to Philadelphia's development over the last 200 years, many of the Delaware River's original tributaries—smaller streams and creeks that fed into the Delaware—were forced underground and became part of the current sewer system. This endeavor took decades to complete, even for small streams. According to historic maps and PWD data, the direct drainage to the Delaware River prior to urbanization included an estimated 67 linear miles of tributaries.

PWD studies historical records, maps and other archival material to better understand the natural hydrology of Philadelphia's past and plan for its future. These efforts have resulted in the ongoing development of a Geographic Information System (GIS) map of these original tributaries. Figure 5-2 approximates the locations of the historic streams in Philadelphia. More information about the historic tributaries of Philadelphia can be found in Chapter 7 of this document and online at phillyh2o.org.

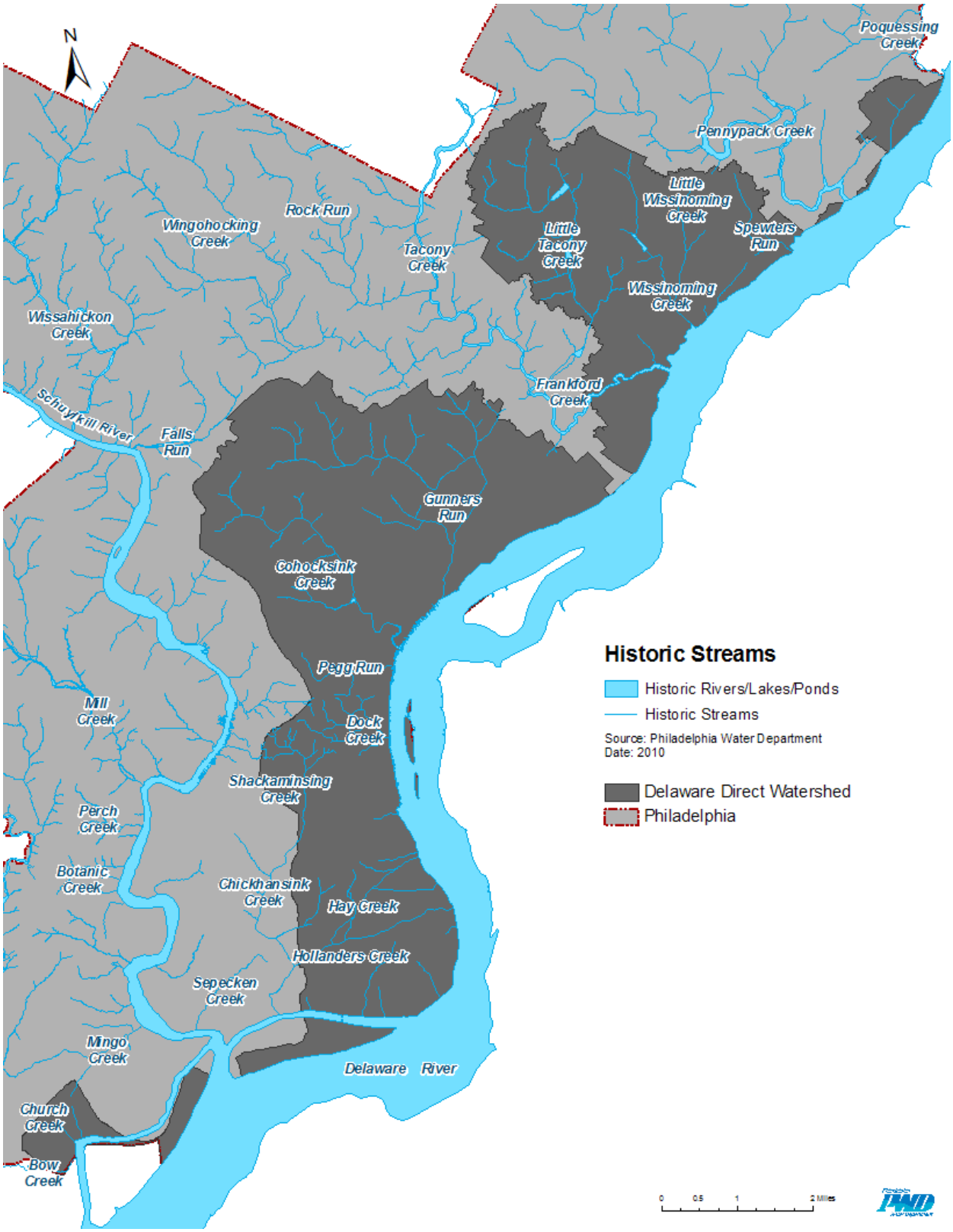

Figure 5.2 - Historic Streams in the Delaware Direct Watershed

Water Quality Management

The objective of the Clean Water Act (CWA) is to "restore and maintain the physical chemical and biological integrity of the Nation's waters."(CWA ref). Some parts of the Clean Water Act are carried out not by the Federal government, but by individual states and authorized tribes, territories and interstate water management agencies. Two of the most important functions are assessing waters to see whether they are healthy (Section 305[b]) and listing waters that appear to be impaired (Section 303[d]).

Because the Delaware River and its tributaries constitute an interstate waterway (passing through New York, Pennsylvania, New Jersey and Delaware), its water quality is not regulated by any individual state authority. Rather, water quality is managed specifically for the Delaware Estuary (i.e., the tidal portion of the river, which stretches from the mouth of the Delaware Bay to Trenton) by the Delaware River Basin Commission (DRBC).

The DRBC has established Interstate water management zones and accompanying designated uses for each segment of the river. These designated uses are categories of ways in which the Delaware River is used by or provides value to people, such as support of aquatic life, recreation, public water supply and fish consumption. Water quality standards are developed to provide appropriate water quality conditions to meet uses occurring in (or desired for) the zone. DRBC interstate water management zones thus have different water quality standards.[3] For example, it would be inappropriate to have water quality standards intended to support Public Water Supply use in saline zones, or temperature criteria protective of trout and other cold water fish in warmwater areas. Designated uses for the Delaware Direct watershed, which is located in DRBC interstate zone 3, tend to be less stringent than other zones, recognizing the long history of urban water pollution in this area. For more information on water quality in the Delaware River, refer to the DRBC State of the Basin Report and Partnership for the Delaware Estuary State of the Estuary Report.

The DRBC assesses the Delaware River every two years, utilizing "boat run" water quality sampling data collected approximately monthly at several stations along the river as well as continuous monitoring equipment at selected USGS gaging stations. Results of the assessment are reported to the US EPA in a water quality assessment report. Zone 3, encompassing the Delaware Direct watershed, was listed in the most recent 2010 assessment as not meeting its designated use for aquatic life due to violations of dissolved oxygen (DO), pH, alkalinity and temperature water quality standards. This listing occurred due to DRBC's interpretation of current US EPA policy (one observed violation and one confirmation) and marked a change from the 2008 assessment where a less stringent method of interpreting the standard was used and zone 3 was listed as supporting aquatic life use.[4]Zone 3 was also listed as not meeting its designated use for fish consumption due to the presence of elevated levels of polychlorinated biphenyls (PCBs, a class of persistent organic toxic chemicals once used widely in industrial applications such as transformers). More information is available in the DRBC 2010 Delaware River and Bay Integrated List Water Quality Assessment

[3] Delaware River Basin Commission, Administrative Manual - Part III: Water Quality Regulations, 2008
[4] Delaware River Basin Commission, 2010 Delaware River and Bay Integrated List, 2010

5.2 – Floodplains & Localized Flooding

Floodplains are lands adjacent to a stream or river subject to natural flooding. Only a small area of the Delaware Direct Watershed lies within the 100- and 500-year floodplains—that is, the land expected to be flooded once every 100 or 500 years. Although the riverfront areas are at low elevations, there is little to no reported occurrences of the Delaware River overflowing its banks. The highly developed shoreline includes bulkheads and other man-made structures to protect the City from flooding. Figure 5.3 depicts FEMA flood zones in the Delaware Direct Watershed.

The Philadelphia region, like other areas in the Delaware River Basin, has recently experienced storms of great intensity at great frequencies. Certain neighborhoods within the Delaware Direct Watershed have experienced localized flooding as a result of the sewer system lacking the capacity to drain stormwater runoff from intense, proximate rainfall events. These neighborhoods include Northern Liberties, Washington Square West and areas of South Philadelphia. PWD has initiated a large-scale storm flood relief project to reduce property damage from flooding and basement backups. PWD's efforts include work on multiple fronts—from continuous sewer inspection and maintenance to better stormwater management—to understand the causes of flooding and implement tools to alleviate damage to flood-prone properties.

The Philadelphia Water Department (PWD) has agreed to assist water customers with flooding conditions in basements due to heavy rainstorms through the Basement Protection Program (BPP). The eligibility guidelines and application materials for this optional program are available by calling 215-685-6069. A program information sheet can be downloaded from http://www.phila.gov/water/pdfs/BPP_info_flyer.pdf

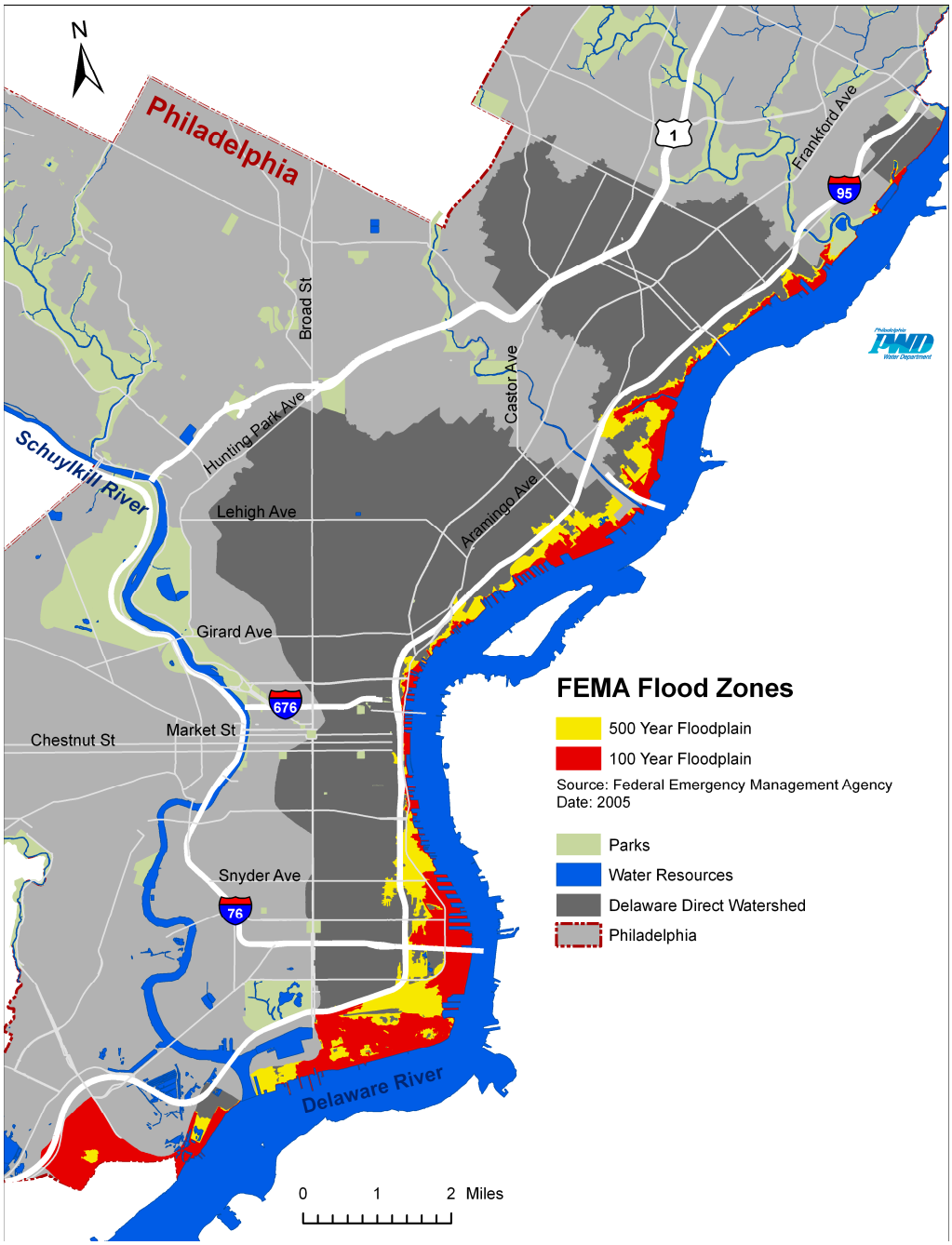

Figure 5.3: FEMA Flood Zones in the Delaware Direct Watershed

5.3 – Water Quality

Rivers, lakes and oceans are not sterile bodies of water. Not only do they contain naturally occurring organisms and bacteria, they can also be contaminated by outside sources. Water quality in a river is affected by many factors, including weather, climate, industrial and sewage discharges, and accidental spills. The hydrologic impacts from the conversion over time of Philadelphia's landscape from woodlands and marshes to a

densely populated impervious urban area coupled with the alteration of surface tributary streams to sewer drainage pipes present other layers of factors affecting water quality.

Philadelphia's Sewer System

The Philadelphia Water Department has the distinction as the oldest municipal water department in the United States. Its massive sewer system network includes 1,600 miles of combined sewers, 1,200 miles of separate sanitary and storm sewer lines, 150 miles of intercepting sewers, 169 combined sewer regulating chambers, 85,600 manholes, and 75,000 stormwater inlets. Development of this extensive infrastructure system occurred over an entire century and significantly contributed to the development patterns of the city.

During the Colonial era, stormwater was managed simply through natural runoff to the nearest stream. The city's first sewers, built around 1740, were constructed to convey only stormwater. Human waste was collected in privy wells and most commercial wastes were simply dumped directly into an adjacent stream. After the city began to supply water to citizens in 1801, fixtures such as bathtubs and water closets came into wider use and the wastewater produced by each household greatly increased.

In the early 1860s both human and commercial wastes were allowed into the City's sewers along with stormwater, creating the "combined sewers" still utilized in much of Philadelphia. Sewers at that time simply emptied into the nearest stream or river, many of which became open sewers themselves. By the second half of the 19th century, as epidemics such as typhoid fever killed thousands, providing proper sewage disposal and stormwater management became a subject of great concern. Therefore, when city engineers drew up preliminary drainage maps in the 1880s, many of the city's smaller streams were planned for conversion into sewers, often in advance of development (Levine, 2002).

The practice of culverting streams was undertaken for a number of reasons. First, standard sewage disposal directed branch sewers to streams. Therefore, culverting streams was viewed as a positive step toward protecting public health. Second, because relying on gravity flow was the simplest and cheapest approach to sewage and stormwater disposal, placing sewers in the natural stream valleys afforded engineers the gravity flow they needed while minimizing the need for extensive excavation. Third, culverting streams and filling in the stream valleys facilitated real estate development and reduced other city obligations. For instance, the cost of building a bridge at each stream crossing was avoided and the regular grid pattern that facilitated land subdivision was easily extended across the city (Levine, 2002).

After the Commonwealth of Pennsylvania passed a law prohibiting municipalities from building new sewers that would discharge untreated sewage directly into streams, Philadelphia published a comprehensive report in 1914 detailing planned improvements to sewage collection and treatment. The plan called for miles of intercepting sewers designed to keep sewage out of the rivers and carry it to three proposed treatment plants.

However, this extensive system took over 50 years to complete. Today's system, with many upgrades and additions, still conforms to the outlines of the 1914 plan.

The interceptor sewers and sewage treatment plants were not built to handle the significantly increased volumes during major storms but instead were designed to overflow into rivers and streams to prevent street and basement flooding, and event called a combined sewer overflow (CSO). Indeed, building an infrastructure that could convey and treat the total amount of stormwater that rushes into combined sewers during every storm would have been (and still remains) cost prohibitive. Combined sewer systems and overflows are not unique to Philadelphia and are in fact common in many older cities across the country.

Today, the Delaware Direct Watershed is home to more than a half-million people, and 68% of the area is covered by impervious surfaces causing significant amounts of stormwater runoff. These factors exacerbate the problem of CSOs. More than 80% of the land in the Delaware Direct Watershed drains to a combined sewer system, with just a small portion of land directly draining to the river itself, either through overland flow or separate storm sewers.

Separate sewer systems contain two different pipes for stormwater and sanitary sewage. Wastewater from homes, businesses, and industry is transported directly to treatment plants. The stormwater sewer pipe carries water collected from street inlets, building downspouts, and other storm sewer lines to the receiving river and is discharged through a stormwater outfall. Figure 5.4 shows the types of sewers and CSO outfalls in the study area.

While water quality in the City's rivers and streams has vastly improved over the past thirty years due to Clean Water Act regulations on "point sources" of pollution, Philadelphia's waterways still do not meet designated use standards. Today, the most significant remaining impacts to the health of the City's rivers and streams result from stormwater runoff, or "non-point source pollution," and combined sewer overflows.

Point and Non-Point Sources of Water Pollution

Point sources, defined as pollution released directly into waterways, can bring both industrial and municipal waste to the Delaware River. Common point source pollution creators include industrial factories, storage tank leaks, boats, combined sewer overflows and commercial animal farms.

Unlike pollution from industry, CSOs and sewage treatment plants, non-point source pollution (NPS) comes from many different sources. Non-point source pollution includes stormwater runoff from urban, suburban, and agricultural areas. Stormwater runoff becomes polluted as it flows across the landscape, picking up contaminants such as sediment, nutrients from fertilizers, chemicals from pesticides, herbicides, bacteria, metals, gasoline, and motor oil.

Discharges from both combined and separate sewers not only contaminate our waterways, making it unsafe and difficult to recreate alongside the creeks, but the volume

and the intensity of the stormwater wreaks havoc on the waterways themselves - causing streams to flood, banks to erode, and fish and insect communities to be displaced.

The volume of stormwater increases as a watershed becomes more populated and developed. The water quality threat from stormwater creates a need for stormwater best management practices and more sustainable land development practices, such as low-impact development, that help mitigate the negative impacts of development.

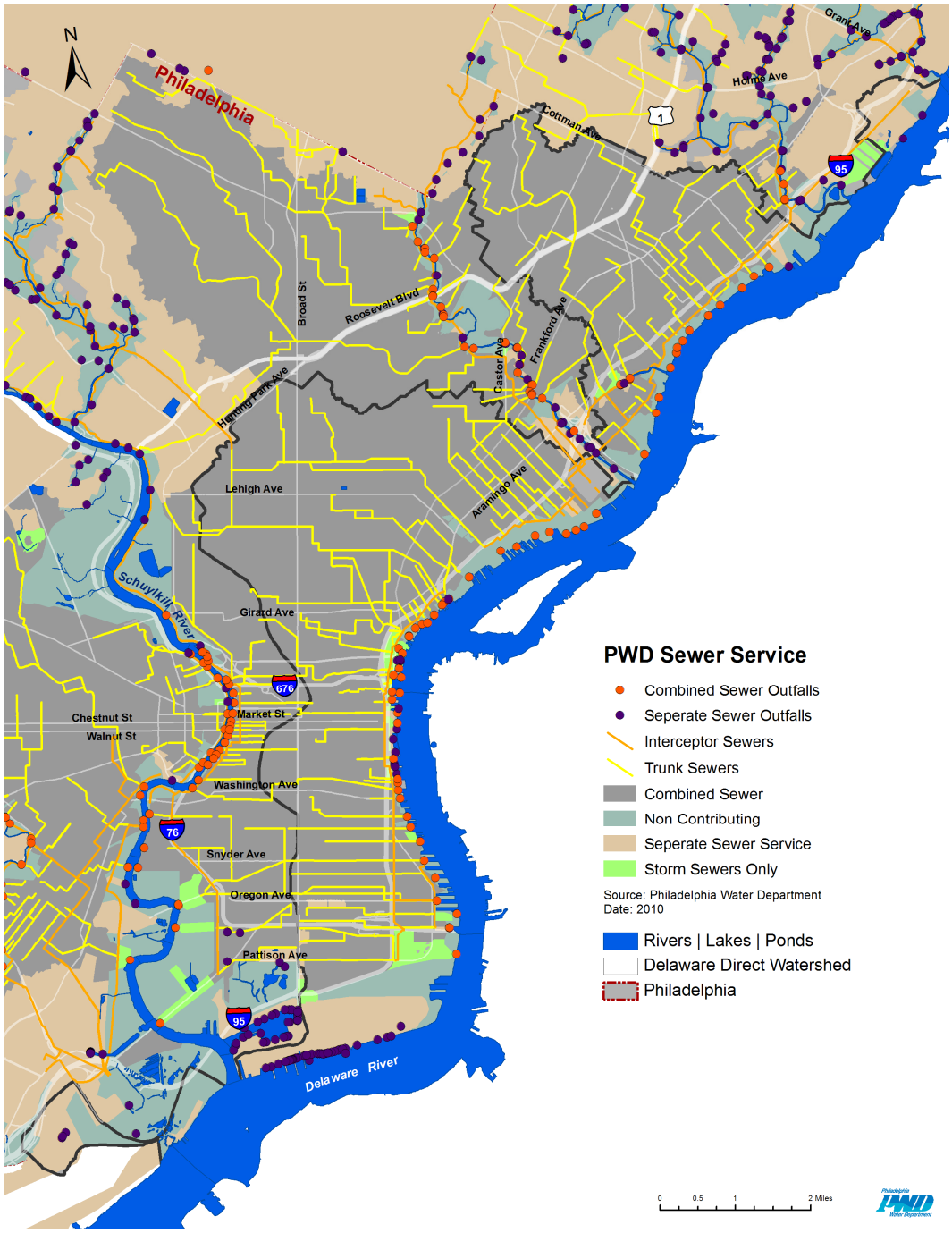

Figure 5.4 - CSO Outfalls in the Delaware Direct Watershed

Combined Sewer Overflow Long-Term Control Plan
There are 54 outfalls where CSOs can occur along the Philadelphia side of the Delaware River. Philadelphia's Combined Sewer Overflow Public Notification System, otherwise known as CSOcast, is an online tool to alert the public of possible overflows from Philadelphia's combined sewer system. For details on the CSO Long Term Control Plan Update in relation to the Delaware River and other receiving waterways, please refer to Philadelphia's CSO Long Term Control Plan Update (Green City, Clean Waters).

While there are large demands on the combined sewer system, there are also great opportunities for positive transformation. Philadelphia's approach to attainment and maintenance of the designated and beneficial uses of these waters is guided by planning, developing and implementing technically viable, cost-effective improvements and operational changes. To this end, PWD is investing in necessary capital projects to increase the system's ability to store and treat combined sewer and stormwater flows.

Conventional approaches to reducing combined sewer overflows rely on underground infrastructure investments to detain the excess volume of sewage combined with stormwater and pump it back into the sewer network when treatment capacity is available after the rain event. Guided by "Green City, Clean Waters," Philadelphia has adopted a comprehensive watershed restoration approach that promotes control of stormwater at the source through low-impact development and green stormwater infrastructure practices on the land. Green stormwater infrastructure includes a range of soil-water-plant systems that mimic nature by intercepting stormwater, infiltrating a portion of it into the ground, evaporating a portion of it into the air, and in some cases releasing a portion of it slowly back into the sewer system. Comprehensive and long-term implementation of these stormwater practices will be achieved through three primary mechanisms:

- Stormwater regulations on development activities
- Customer stormwater billing and crediting, primarily based on the amount of unmanaged impervious surface
- City-led investments in green stormwater infrastructure projects

These green infrastructure investments will be coupled with strategic investments in the existing conventional infrastructure system, such as upgrades and expansions at the waste water treatment plants.

Water Resource Monitoring Program
The Philadelphia Water Department and the United States Geological Survey (USGS) have been working cooperatively on PWD's Water Resource Monitoring Program to continuously monitor all of the watersheds in the Philadelphia area. The measurements in the monitoring program include: water temperature, pH, dissolved oxygen and conductance for the one Delaware River station near the Benjamin Franklin Bridge. Color-coding of each parameter allows for an easy reading of water quality. Up-to-date measurements can be found online at Philadelphia Water Resources Monitoring Program.

As discussed above, the Delaware Direct represents only 1% of the entire Delaware River Basin, and there is the potential for other sources of pollution to enter into the large watershed upstream of Philadelphia. PWD analyzes data obtained from other agencies' monitoring efforts to better understand and study water quality in the river.

5.4 – Water Supply

Public Drinking Water Sources
The Delaware River is an important water supply for the City of Philadelphia. All drinking water in Philadelphia is withdrawn by the Philadelphia Water Department (PWD) from surface water sources located on the Delaware and Schuylkill Rivers. PWD services the entire City of Philadelphia and a small portion of the surrounding municipalities with approximately 250 million gallons of drinking water on a daily basis, with the Delaware contributing about one-half of the water supply. PWD's Baxter drinking water treatment plant is located on the Delaware River, in the Torresdale neighborhood of Philadelphia.

Source Water Protection Program
Although a dramatic improvement in water quality has been achieved for the City's two major rivers since the passage of the federal Clean Water Act in the early 1970s, more work remains in order to protect drinking water sources from pollution. PWD's Source Water Protection Program embodies the department's multi-barrier approach to ensuring the safety and quality of Philadelphia's drinking water. The Source Water Protection Program staff works closely with the department's treatment plant managers and operators to anticipate and respond to emergencies and challenges to conventional treatment techniques. The program has developed a thorough understanding of the City's water supply characteristics, including ambient water quality conditions, major sources of actual and potential contamination, water availability, flow patterns and management practices in the upstream areas of the Delaware River Basin.

The success of the Source Water Protection Program's organized and comprehensive approach is evident in the integrity of the Delaware and Schuylkill Rivers as drinking water supplies. In order for the program to continue to meet its high standards, PWD employs a wide range of tools, including research projects, regional partnerships, outreach and education, advanced technologies, and on-the-ground implementation and monitoring to achieve source water goals.

Completed in 2002, the Delaware Source Water Assessment was created in response to the 1996 Safe Drinking Water Act Amendments, which called for the assessment of all source water supplies across the United States to identify potential sources of contamination. PWD, along with its project partners, conducted a watershed-based, multi-phase assessment that identified and prioritized potential and existing sources of contamination and evaluated the vulnerability of the water supply to these contaminant sources. The Source Water Protection Plan establishes a set of priority actions to address

threats to the water supply identified during the assessment phase. The plans' recommended action items are based on a holistic watershed approach that recognizes the interconnectedness between source water protection concerns, upstream land and water use, and the need to maintain a healthy aquatic ecosystem. New research, technologies, analysis and assessment methods are important tools in protecting the drinking water quality.

The Source Water Assessments and Protection Plans are fundamental elements of PWD's Source Water Protection Program. However, the program encompasses a much wider range of projects related to research, on-the-ground implementation, partnership workgroups and in-city initiatives. Since its inception, the Source Water Protection Program has implemented numerous local and watershed-wide BMPs, developed partnerships to address regional water quality and quantity concerns, created an advanced water quality early warning system to support drinking water treatment operations along with an associated system for recreational water quality advisories, and conducted research, monitoring and analyses for a broad range of issues related to drinking water treatment support and regulatory compliance. PWD's partnerships have proved imperative to implementation of source water protection projects that are located beyond Philadelphia's jurisdictional boundaries.

Marcellus Shale Natural Gas Drilling

Natural gas drilling—because it is a new technology in the Delaware River Basin with still evolving regulations around all aspects of water quality protection—has the full attention of the Philadelphia Water Department (PWD). At this point in time, PWD believes that the current regulatory framework, if enforced, is adequate to protect our water supply from immediate threats. PWD is watching, monitoring and evaluating upstream activities. If something appears to be imminently dangerous to our water supply, alarms will be raised.

The long-term impacts from drilling on the water quality of the Delaware Basin are not well understood. In particular, the impacts of wastewater discharge on drinking water quality—even under the improved regulations under the state's wastewater treatment requirements—are not known. With this in mind, PWD has communicated and is in continual discussion with the Environmental Protection Agency (EPA), the PA Department of Environmental Protection (PADEP), and the Delaware River Basin Commission (DRBC) concerning water supply concerns relating to Marcellus Shale drilling. PWD has shared with its regulating partners that it expects complete respect by the natural gas industry of current and future regulations designed to protect our water resources and public health.