SOURCE WATER ASSESSMENT AND PROTECTION REPORT

City of Baltimore Bureau of Water & Wastewater
Department of Public Works

Prepared by:
Susquehanna River Basin Commission
Watershed Assessment and Protection Program

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Source Water Assessment and Protection Plan

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I. EXECUTIVE SUMMARY

The U.S. Environmental Protection Agency (USEPA) established a new requirement under Section 1453 of the 1996 Safe Drinking Water Act. The Act requires each state to develop a Source Water Assessment Program (SWAP) to evaluate the drinking water sources that serve public water systems. The city of Baltimore (City) operates one drinking water intake on the Susquehanna River. This SWAP report: (1) delineates the entire watershed area for the surface-water source; (2) identifies the significant potential sources of contamination; and (3) determines the susceptibility of the public water source to contamination. The goal of the SWAP report is to guide local, state, and federal agencies, and private landowners to develop partnerships for the protection of source water supplies.

The methods used for the assessment are outlined in Maryland Department of the Environment's (MDE) approved SWAP Plan, submitted for the USEPA in February 1999. The SWAP reports utilize pre-existing data for determination of raw water source susceptibility. The data used for this report includes data sources from local, state, and federal agencies.

Contaminants of concern to the water supply include turbidity and sediment, microbial, disinfection byproducts, inorganic compounds, organic compounds, and radionuclides. The sources for these contaminants are largely associated with agricultural land use within the Lower Susquehanna Subbasin, and to a lesser degree urban/residential development. Runoff from agricultural land contributes significant amounts of sediment, microbial contaminants and nutrients to the raw water source through overland runoff. Sediment in particular can contribute other harmful constituents as well, such as pesticides and other organic contaminants that commonly attach to sediment particles. With an increase in concentrated animal operations and sewage effluent, microbial contaminants pose an increased threat as well. Additionally, increased amounts of organic material from all these sources can lead to the formation of harmful disinfection byproducts during the treatment process. Although radioactive constituents are generally well below harmful levels, the existence of several nuclear power generating plants with outfalls along the Susquehanna River, upstream of Baltimore's intake, indicates a significant potential for radionuclide contamination.

Source water protection efforts can be improved by increasing communication and utilizing partnerships between local, state, and federal agencies, as well as the emergency response community. Partnerships can provide the mechanism to affect significant changes through a collective voice. Regular monitoring for bacteria and total organic carbons should be conducted, and additional monitoring should be considered based on the potential threats to the raw water source outlined in this report.

II. INTRODUCTION

A. Surface Water Source

1. Description

The City treats water received from the Susquehanna River, typically during periods of drought. The Susquehanna River Basin spans three states (New York, Pennsylvania, and Maryland), draining approximately 27,500 square miles, or 43 percent of the Chesapeake Bay's drainage area (Figure 1). The population within the basin is approximately 4.1 million people.

The Susquehanna River flows 444 miles from its headwaters at Otsego Lake near Cooperstown, N.Y. to Havre de Grace, Md. where it meets the Chesapeake Bay. The river flows approximately 20 miles per day on average during summer. The average flow of the Susquehanna River is 34,450 cubic feet per second (cfs). The highest recorded flow was during June of 1972, when flows reached 1,020,000 cfs at Harrisburg, Pennsylvania. The lowest recorded flow was during the 1930 drought, when flows dropped to 1,700 cfs. Table 1 shows annual water discharge for 2001, as well as long-term annual mean flows, for selected sites located on the Susquehanna River.

Table 1. Annual Water Discharge, Calendar Year 2001

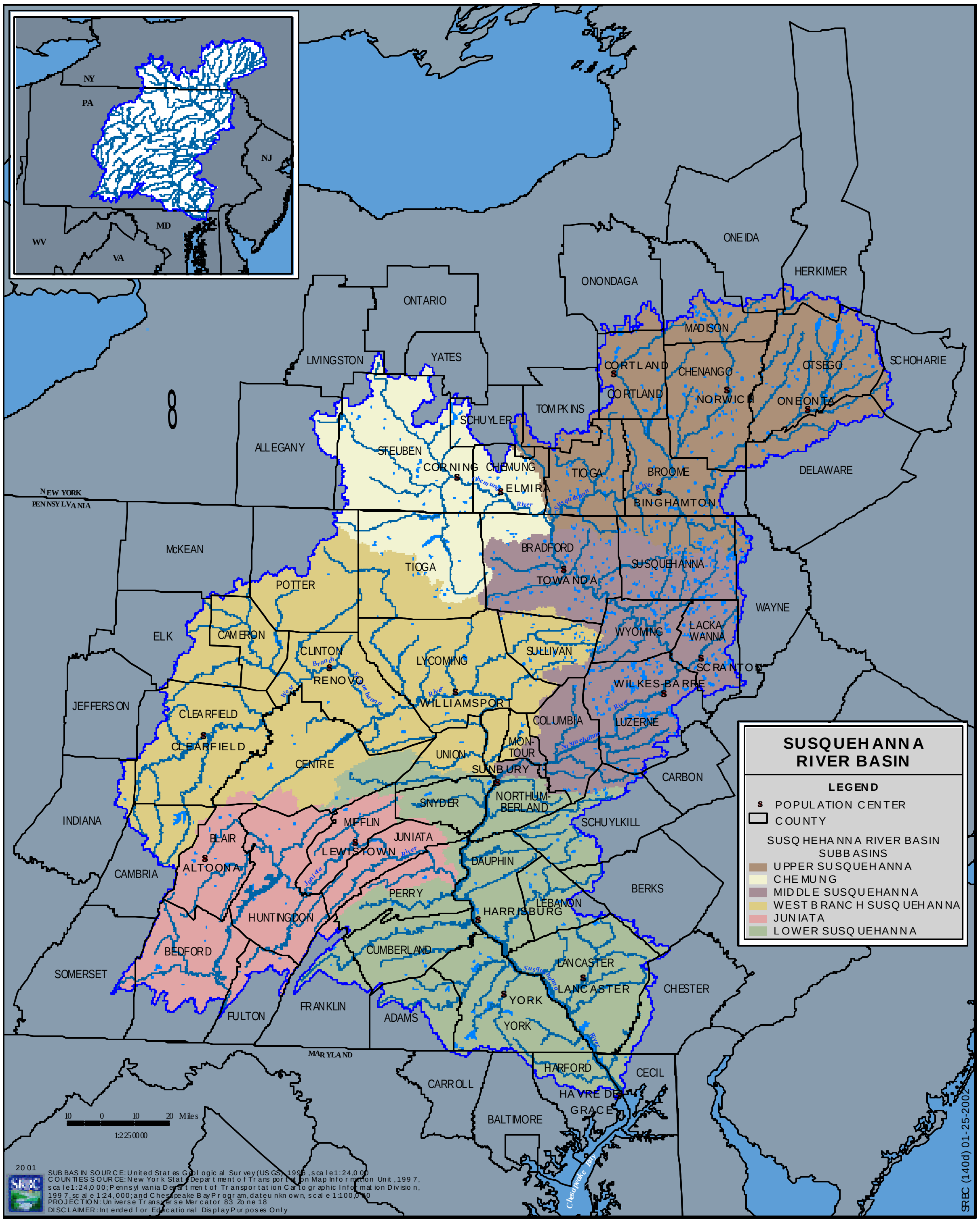
Site Short Name	Years of Record	Long-term Annual Mean cfs[1]	2001	
			Mean cfs	Percent of Long-Term Mean
Towanda	88	10,617	7,727	72.8
Danville	97	15,224	11,067	72.7
Lewisburg	62	10,809	6,749	62.4
Newport	102	4,305	2,499	58.0
Marietta	70	37,038	24,378	65.8
Conestoga	17	634	367	57.9

[1] Cubic feet per second

2. Political jurisdictions

All three states in the Susquehanna River Basin have county level governments. In New York and Pennsylvania, political boundaries are further subdivided into urban and township units. Unlike the Maryland county system, most of the land use control is delegated down to the township and municipal level.

Nineteen major population centers are located throughout the basin (Figure 1). At the headwaters in N.Y., Cortland, Norwich, Oneonta, and Corning represent the more populated areas. South of these cities, Elmira, and Binghamton also are heavily populated areas in the Upper Susquehanna Subbasin.



SUBBASIN SOURCE: United States Geological Survey (USGS), 1996, scale 1:24,000
COUNTIES SOURCE: New York State Department of Transportation Map Information Unit, 1997, scale 1:24,000; Pennsylvania Department of Transportation Cartographic Information Division, 1997, scale 1:24,000; and Chesapeake Bay Program, date unknown, scale 1:100,000
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Figure 1. Location Map for the Susquehanna River Basin

In northern Pennsylvania, Towanda, Scranton, and Wilkes-Barre are population centers located in the Middle Susquehanna Subbasin. The West Branch of the Susquehanna River represents the most sparsely populated area of the basin, and is comprised of a significant amount of state-owned lands. Clearfield, Renovo, and Williamsport are the largest population centers. Sunbury, Pa., is located at the confluence of the West Branch Susquehanna River and the mainstem of the Susquehanna River. It also hosts the uppermost dam on the mainstem of the Susquehanna River in Pennsylvania. The portion of the basin downstream of Sunbury comprises the Lower Susquehanna Subbasin, which is the primary focus of this assessment.

The last major subbasin contributing to the lower Susquehanna is the Juniata Subbasin. The cities of Altoona and Lewistown are located within this subbasin. Raystown Lake, one of the largest impoundments in the Susquehanna basin, is located within the Juniata Subbasin.

Representing the most densely populated region in the Susquehanna River Basin, the metropolitan areas of Harrisburg, York, and Lancaster are located in southcentral Pennsylvania, within the Lower Susquehanna Subbasin. The Lower Susquehanna Subbasin empties into the Chesapeake Bay at Havre de Grace, Md.

3. Topography and Climate

The Susquehanna River Basin is very diverse with respect to topography and climatic conditions. Within the basin, there are three predominant physiographic provinces (Figure 2). The characteristics of each of these provinces largely control factors such as weather patterns and ambient water quality conditions. The physiographic provinces in downstream order include the Appalachian Plateau, Valley and Ridge, and Piedmont. A small portion of the Blue Ridge Province extends into the southern extent of the basin. The highest elevations lie in New York and northern Pennsylvania. Elevations significantly decrease towards Sunbury, Pa., and then continue to decrease more gradually towards the mouth of the river at Havre de Grace, Md.

The predominant physiographic province in the basin is the Appalachian Plateaus Province, which comprises about 40 percent of the Susquehanna River Basin. The province boundary trends southwest to northeast across the upper portions of the Susquehanna River Basin. Most of the province is characterized by flat-lying bedrock geology, primarily sedimentary rock. The western portion of the province in Pennsylvania contains bituminous coal reserves that have been mined extensively in the past, and continue to be mined today. Weather patterns are primarily influenced by systems moving from the Midwest United States, and “lake-effect” systems moving across northwestern Pennsylvania from Canada.

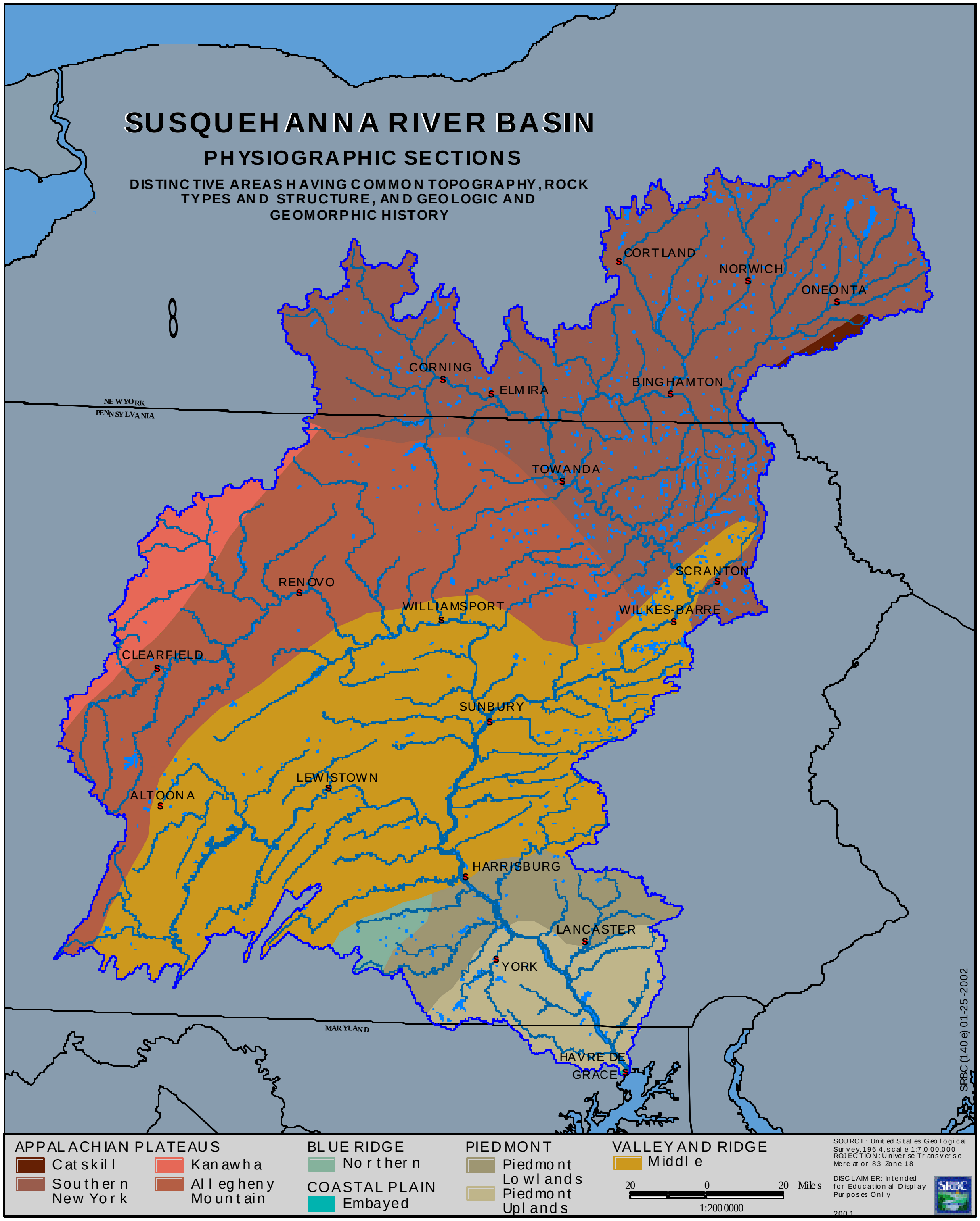


Figure 2. Physiographic Provinces in the Susquehanna River Basin

The Valley and Ridge Province, which also trends northwest southeast across the basin, is characterized by steeply folded and faulted geology. The geologic materials are predominantly inter-bedded sedimentary sandstones, shale, and limestone. The eastern portion of the province has significant anthracite coal reserves, which was mined extensively in the past, and continues to be mined today. Surface water quality in the higher elevation areas is influenced more by precipitation quality than local environmental factors, although degraded water quality and erosion is common in the abandoned-mine areas. The topography of the ridges and slopes creates rapid, direct runoff to streams, with short contact time with materials. Another portion of the province of significant influence is the Great Valley Section, composed primarily of limestone. Within this area, local environmental factors have a greater influence on the water quality. Commonly referred to as karst terrain, this section of the province extends across Franklin, Cumberland, Dauphin, and Lebanon Counties in the Lower Susquehanna Subbasin. The Great Valley Section bounds some of the most productive agricultural areas within the river basin, as well as some of the most densely populated areas. Erosion in the Great Valley Section tends to occur at higher rates compared to anywhere else in the Valley and Ridge Province. Climatic conditions for the Valley and Ridge Province are generally transitional between the Appalachian and Piedmont Provinces and are largely controlled by the northwest-southeast trending Appalachian Mountains of the Valley and Ridge Province.

The Piedmont Physiographic Province is the southernmost province in the Susquehanna River Basin. It represents a significant change in the geology of the basin, characterized predominantly by metamorphic and igneous rock. The topography of the Piedmont Province is generally low rolling hills and broad valleys. Based on the friable nature of the geologic material, the derived soils are subject to a significant amount of erosion. The increase in erosion is typically associated with the Uplands Section of the Piedmont Province, located in the southern portions of York and Lancaster Counties. Climatic conditions tend to be fairly mild and are largely controlled by weather systems moving into the region from the southern and coastal areas. The typical air temperature ranges from about 46 to 55 degrees.

As mentioned before, climatic conditions vary somewhat throughout the Susquehanna basin. Mean annual precipitation ranges from about 38 inches to 48 inches. Most of the precipitation is in the form of rain, although the northern portions of the basin can receive significant amounts of snowfall. Table 2 shows a summary of precipitation for selected areas of the basin.

Table 2. **Summary for Annual Precipitation for Selected Areas in the Susquehanna River Basin, Calendar Year 2001**

Area	**Season**	**Average Long-Term Precipitation**	**Calendar Year 2001 Precipitation**
		inches	**inches**
Susquehanna River above Towanda, Pa. (Chemung and Upper Susquehanna Subbasins)	January-March	7.96	6.95
	April-June	9.98	8.82
	July-September	10.22	10.48
	October-December	8.70	6.15
	Yearly Total	**36.86**	**32.41**
Susquehanna River above Danville, Pa. (Middle Susquehanna Subbasin)	January-March	7.90	6.78
	April-June	10.07	8.68
	July-September	10.36	10.36
	October-December	8.72	6.03
	Yearly Total	**37.05**	**31.85**
West Branch Susquehanna River above Lewisburg, Pa. (West Branch Susquehanna Subbasin)	January-March	8.90	5.75
	April-June	11.38	9.08
	July-September	11.53	10.19
	October-December	9.38	5.6
	Yearly Total	**41.19**	**30.62**
Juniata River above Newport, Pa. (Juniata Subbasin)	January-March	8.84	4.67
	April-June	10.95	7.12
	July-September	10.83	4.73
	October-December	9.07	3.42
	Yearly Total	**39.70**	**19.93**
Susquehanna River above Marietta, Pa. (Within Lower Susquehanna Subbasin)	January-March	8.51	6.94
	April-June	10.66	8.92
	July-September	10.75	9.40
	October-December	9.01	5.37
	Yearly Total	**38.93**	**30.63**
Conestoga River above Conestoga, Pa. (Within Lower Susquehanna Subbasin)	January-March	8.58	7.08
	April-June	10.80	6.52
	July-September	11.78	6.59
	October-December	9.35	2.49
	Yearly Total	**40.51**	**22.68**

B. Development of the Water Supply

1. History of the system

Founded in 1797 the City is located along the north bank of the Patapsco River above the confluence with the Chesapeake Bay in Maryland (see location map). After several failed attempts by the Baltimore Township to establish a public water system during the 1700's, the Baltimore Water Company was formed in 1804, just seven years after the City was established by an act of the Maryland General Assembly. The Jones Falls supply was established between 1858 and 1862 after the City's purchase of the Baltimore Water Company in 1854. The original system has since evolved due to a series of large projects throughout the late-1800s and 1900s, in order to match growing population and public needs. Projects that formed what is today's system include:

- Construction of the Gunpowder Falls Dam, creating the City's first permanent water source (1881).

- Construction of Montebello 1 & 2 Filtration Plants (1915 & 1928).
- Formation of the Loch Raven Dam and Reservoir (1915).
- Construction of the Pretty Boy Dam (1932).
- Creation of the Liberty Dam/Reservoir and Ashburton Filtration Plant (1956).
- Implementation of the Deer Creek Pumping Station for withdrawal from the Susquehanna River (1966).

In addition to these projects, several major tunnels and conduits were installed throughout the 1900s in order to transport water and join the system.

2. System description

Presently, the City's water system is one of the largest in the nation, providing drinking water to over 1.8 million people in an area of approximately 560 square miles, including the City, parts of Baltimore, Howard, and Anne Arundel Counties. The central system distributes this water through 4,500 miles of mains, 22 pumping stations, and 26 storage facilities to homes and businesses in five designated pressure zones. Each of these five zones is supplied with water from one of the three treatment plants: Montebello 1, Montebello 2, and Ashburton. Functioning collectively, the Montebello Plants supply the first three zones with contribution from the Ashburton Plant on zones Two and Three. Zones Four and Five are supplied entirely by the Ashburton Plant. Operating solely on surface water intakes, including water from three impoundments (Liberty, Loch Raven, and Prettyboy) and the Susquehanna River, these four sources contribute to the three treatment plants, capable of producing up to 405 million gallons of drinking water per day.

Contributing over half of water supplied (up to 240 million gallons per day [mgd]), the Montebello Plants treat water from either the Loch Raven Reservoir or the Susquehanna River or blended water from those sources. The raw water source of Loch Raven Reservoir is Gunpowder Falls, and its watershed area encompasses northern Baltimore County and small parts of western Harford County and northeastern Carroll County, as well as Southern York County, Pennsylvania. The Prettyboy Reservoir maintains a nominal release into the river channel for the benefit of the downstream trout. When needed to maintain the elevation at the downstream Loch Raven Reservoir, this flow to the Gunpowder Falls is augmented. Water from the Susquehanna River is pumped through Deer Creek pumping station and is available to conserve reservoir storage during drought. The intake is located north of Aberdeen, near the Pennsylvania State line, and raw water is transported 38 miles via the Susquehanna conduit. In 2002, the Susquehanna intake has been used extensively in order to maintain system production throughout the current drought, contributing approximately 150 mgd. According to the Baltimore City Water Quality Report, there have been provisions made in the construction of the Deer Park Facility to augment the current Susquehanna Supply maximum withdrawal capacity of about 150 million gallons per day to planned future capacity of 200 million gallons per day. Water from the Liberty Reservoir originates in the North Branch of the Patapsco River, and it is gravity-fed to the Ashburton Plant, comprising the remaining water supplied to the City (up to 165 mgd).

3. Treatment strategy

The three-filtration plants treat raw water similarly, incorporating pre-chlorination, coagulation, flocculation, sedimentation, filtration, fluoridation, post-chlorination, and corrosion control treatment. As raw water flows into each plant, it is treated with chlorine to initially disinfect the water. Alum is then added in rapid mix chambers to coagulate small particles in the water. After this, the water flows from serpentine mixing basins to flocculators for particle formation. These particles settle out of the water in large sedimentation basins, from which the now clear top layer of water flows through sand and gravel filters. The filtered water is directed into clearwells, where fluoride, chlorine (as needed), and lime (to raise pH) are added before entering the distribution system.

III. RESULT OF SITE VISITS

A. Intake Description

The City's Susquehanna intake is located in the Conowingo Pool, just upstream of the dam. The intake is located at an elevation of 69 meters above seal level. Water is gravity fed through the City's 108-inch pipe, known as "The Big Inch", to the Deer Creek pump station. The water is then pumped over a ridge and then to the Montebello Filtration Plants where, at the discretion of facility managers, this water may be mixed with the Loch Raven supply prior to treatment or introduced exclusively to one or both plants.

B. Operator Concerns

The Susquehanna River Basin Commission (SRBC) staff met with representatives of the City's Department of Public Works in December 2001, at the Ashburton Treatment Facility. The meeting focused on operators' concerns with respect to the water quality of the Susquehanna River. The primary water quality interests were related to point-source discharges and virus/bacteria/protozoa transport. The operators expressed an interest in knowing total loads emanating from point sources such as wastewater treatment plants (WWTP) and industrial facilities, as well as the percentage of flow that these discharges contribute to the river upon reaching the intake. It was also expressed that permit compliance information would be very helpful.

Spill events were also a concern, both related to transportation corridors and industrial facilities. In particular, there are several power plants operating in the immediate vicinity of the Conowingo Pool. Events occurring at these facilities could have a significant impact on the City's supply.

IV. WATERSHED CHARACTERIZATION

A. Source Water Assessment Area

Delineation of the watershed for the purposes of this assessment included the area contributing water to the City's Susquehanna intake. For the purposes of this assessment, a general contaminant review was developed for the entire Susquehanna River Basin. Given the vast size of the basin, the assessment focused with greater detail on the Lower Susquehanna Subbasin. The Lower Susquehanna Subbasin extends from the confluence of the West Branch and Susquehanna River at Sunbury, Pa., to the mouth of the river at Havre De Grace, Md. The City's water supply intake is located within the Conowingo Pool, approximately 12 miles upstream of the mouth of the river and approximately 118 miles downstream from Sunbury, Pa. The delineation area for this assessment is shown in Figure 3.

1. Breakdown of subbasins

The Susquehanna River Basin can be broken down into six major subbasins: Upper Susquehanna; Chemung; West Branch Susquehanna; Middle Susquehanna; Juniata; and Lower Susquehanna (Figure 4). These subbasins can be further divided into major watersheds within each major subbasin. A listing of these watersheds can be reviewed in Appendix 1.

Watershed delineations from several sources were used in the assessment. Watershed delineations in New York were based on the Department of Environmental Conservation's 11-digit hydrologic unit codes (HUC). Pennsylvania's watershed boundaries were delineated using a combination of the state's 11-digit HUC codes, as well as delineations from the State Water Plan. The watersheds in Maryland are similar to the state's 11-digit HUC codes, obtained from the USEPA Chesapeake Bay Program.

There are 19 subwatersheds within the Lower Susquehanna Subbasin. Primary focus was given to this subbasin, since it has greatest influence on water quality conditions at the City's water supply intake.

B. General Subbasin Characteristics

1. Major subbasins

The northernmost subbasin is the Upper Susquehanna Subbasin. This subbasin encompasses 4,944 square miles in New York. The Susquehanna River begins at Ostego Lake in Cooperstown, N.Y. and flows south into Pennsylvania and back into New York at Great Bend, Pa. The river flows west and joins the Chemung River in Sayre, Pa. Most of this subbasin is forested and steeply sloped, with some agricultural areas. There is a small amount of development in the subbasin.

The Chemung Subbasin comprises 2,604 square miles of the Susquehanna River Basin. The subbasin includes the Tioga River and Coshocton River watersheds, which join to form the Chemung River before flowing into Pennsylvania. The topography is typical for glaciated terrain. The subbasin is composed of rolling to flat-topped uplands with steep valleys where the main rivers flow. Much of this subbasin is forested.

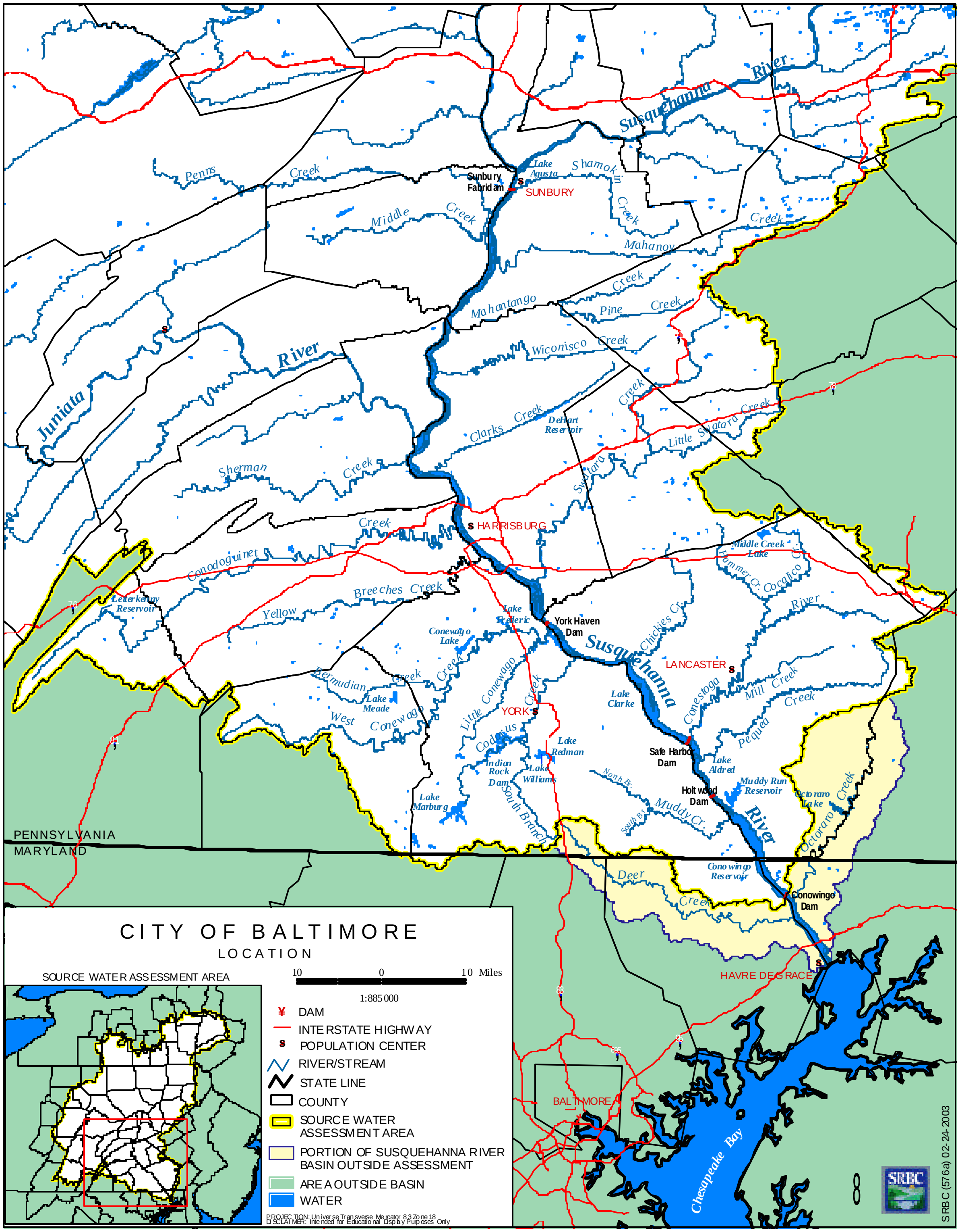
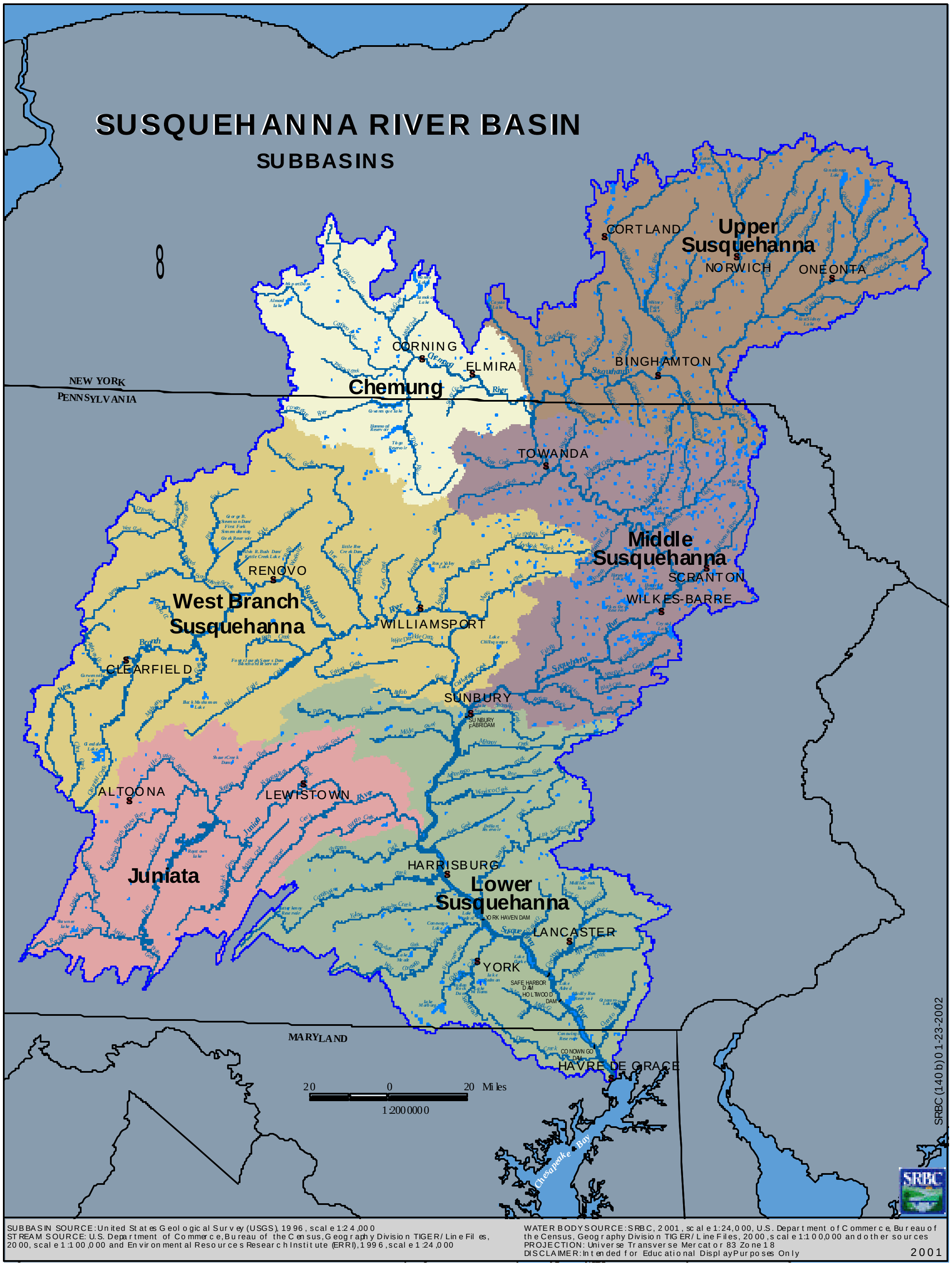


Figure 3. Source Assessment Delineation for the Baltimore Assessment



SUBBASIN SOURCE: United States Geological Survey (USGS), 1996, scale 1:24,000
STREAM SOURCE: U.S. Department of Commerce, Bureau of the Census, Geography Division TIGER/Line Files, 2000, scale 1:100,000 and Environmental Resources Research Institute (ERRI), 1996, scale 1:24,000

WATER BODY SOURCE: SRBC, 2001, scale 1:24,000, U.S. Department of Commerce, Bureau of the Census, Geography Division TIGER/Line Files, 2000, scale 1:100,000 and other sources
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Figure 4. Major Subbasins in the Susquehanna River Basin

The Middle Susquehanna Subbasin flows southeast through high plateaus separated by steep valleys. It comprises 3,755 square miles of the entire basin. The Susquehanna River joins the Lackawanna River before turning to flow southwest towards Sunbury. Much of this area is known as Wyoming Valley and extends from Carbondale to Nanticoke, Pa. This is a coal-mining region that has become more urbanized.

The West Branch Susquehanna Subbasin originates in the rolling hills of the Allegheny Mountains and is 6,992 square miles. The West Branch flows northeast passing the Allegheny High Plateaus section. At Renovo, Pa., the West Branch flows southeast to meet its confluence with the Susquehanna River. This area is predominantly forested, although extensive coal mining has occurred in the western parts of the subbasin.

The Juniata River is a major tributary to the Susquehanna River, draining approximately 3,406 square miles. This Juniata Subbasin is contained entirely within the Ridge and Valley Province, which has parallel mountains with long, narrow valleys. Although predominantly forested, agriculture is a major land use in the subbasin. The carbonate valleys in this subbasin possess highly productive soils. Agricultural runoff is a major source of stream impairment in the subbasin.

The Lower Susquehanna Subbasin is the most developed subbasin comprising 5,809 square miles, of which 275 lie in Maryland. The northern part of the subbasin contains sedimentary ridges that trend southwest to northeast. The river flows through the remaining Valley and Ridge Province with the mainstem of the Susquehanna River widening as it flows through the central portion of the basin. The southern portion of the subbasin is comprised of metamorphosed sediments that are folded and faulted. The steep river slope and narrow valley of the Lower Susquehanna Gorge creates a suitable environment for hydroelectric power generation. Agriculture is very prominent in this subbasin. In addition, some of the largest urban centers are located in this subbasin. The Lower Susquehanna Subbasin empties into the Chesapeake Bay in Havre de Grace, Md. providing greater than 50 percent of the freshwater inflow to the bay.

2. Time-of-travel information

Time-of-travel information is important when considering impacts of contamination on a drinking water source. For the Susquehanna River in New York and Pennsylvania, no dye studies for estimating time-of-travel information have been conducted since the 1960s. A series of dye studies were performed by the SRBC in the lower Susquehanna River in 2001-2002; however, the studies focused on sections of the river below the City's intake. For the purpose of this assessment, a USGS estimation method was used to summarize time-of-travel information.

The USGS recently developed regression equations for determining time-of-travel estimates in Pennsylvania (Reed and Stuckey, 2002). Streamflow data obtained from USGS gauges were used to calculate the time-of-travel estimates from selected points within the Susquehanna River Basin to the Conowingo Dam at Md. State Route One (Table 3). The flows used in the equations were the 80th, 50th, and 20th percentile exceedance flows for each gauge. Figure 5 shows the locations used to calculate the time-of-travel information. Based on the estimates, the data shows that there is a significant difference in travel times when comparing different flow percentiles.

Table 3. Time-of-Travel Information from Selected Locations in the Susquehanna River Basin

USGS Gauge	Flow (percentile exceedance) Low = 80th Medium = 50th High = 20th	Velocity (ft/sec)	Reach Length (mi)	Time-of-Travel (days)	Time –of-Travel (hrs)
Chemung, NY	Low	0.74	284.5	18.85	452.50
	Medium	1.18		12.60	302.22
	High	2.20		6.75	162.10
Waverly, NY	Low	1.08	277.0	17.86	428.64
	Medium	1.91		11.85	284.54
	High	2.59		6.47	155.39
Towanda, PA	Low	0.83	259.0	16.76	402.24
	Medium	1.27		11.28	270.72
	High	2.52		6.05	145.20
Danville, PA	Low	0.98	122.0	6.66	159.84
	Medium	1.40		4.68	112.32
	High	2.42		2.72	65.28
Lewisburg, PA	Low	0.87	117.5	6.48	155.52
	Medium	1.27		4.55	109.20
	High	2.43		2.61	62.64
Sunbury, PA	Low	1.08	108.0	5.80	139.20
	Medium	1.53		4.08	97.92
	High	2.69		2.37	56.88
Newport, PA	Low	0.88	83.0	4.73	113.52
	Medium	1.09		3.52	84.48
	High	1.90		2.06	49.44
Harrisburg, PA	Low	1.17	55.5	2.83	67.92
	Medium	1.73		1.98	47.52
	High	3.17		1.18	28.32
Marietta, PA	Low	1.22	30.0	1.50	36.00
	Medium	1.69		1.08	25.92
	High	2.65		0.69	16.56

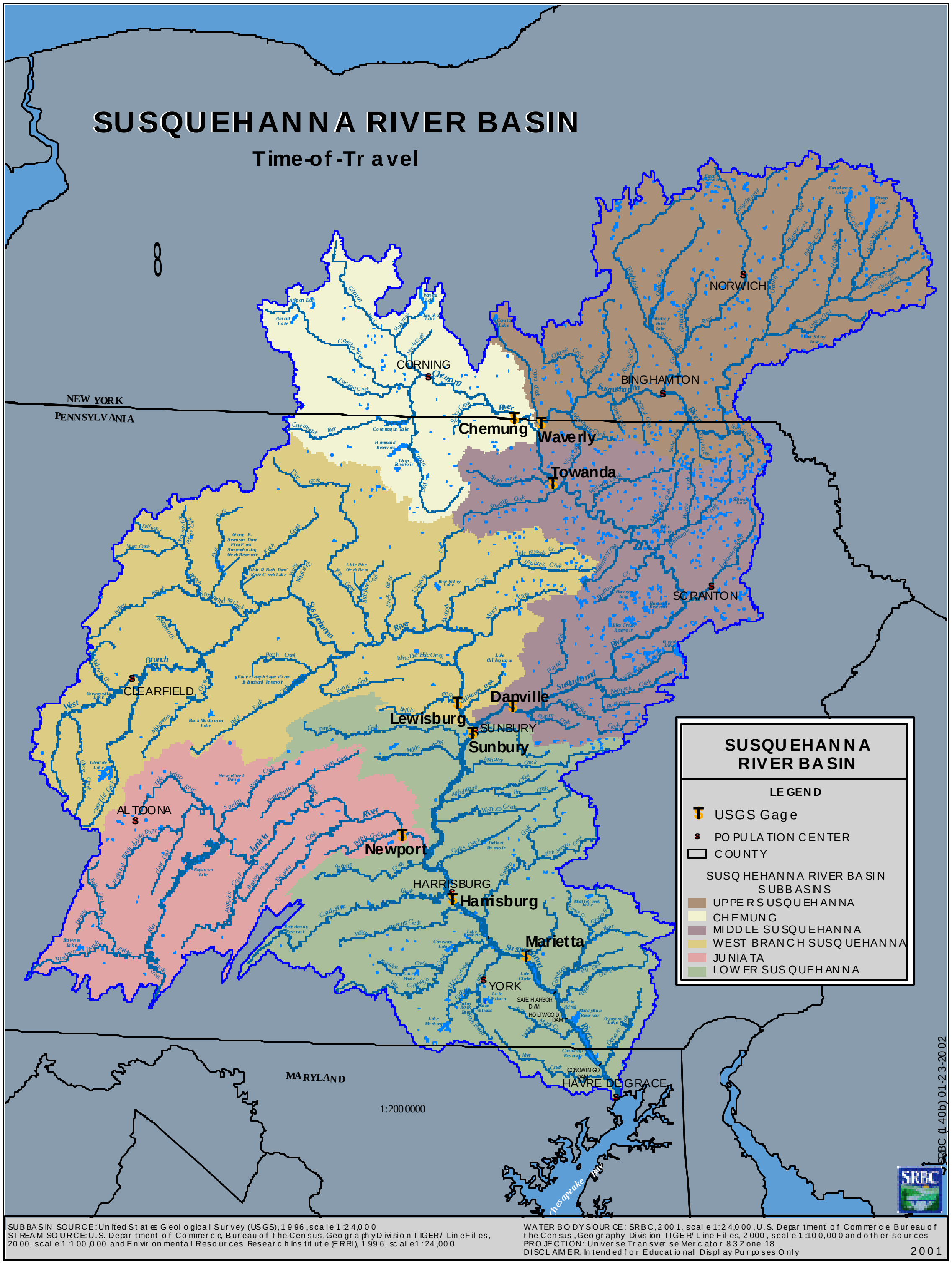

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Figure 5. Locations Used for Time-of-Travel Estimates

C. Land Use Characteristics

1. Local

The City's intake is located in the Conowingo Pool, straddling the border between Pennsylvania and Maryland. Approximately two-thirds of the pool is in Pennsylvania. The impounding dam, owned by Exelon Energy's subsidiary Susquehanna Electric Company, reaches depths of 90 feet. The power station itself first commenced operations in 1928. A large percentage of the property surrounding the pool is owned by Exelon Energy's various power plants. Pool elevations are largely governed by power plant use, but also adhere to federal minimum pass-by requirements. A majority of the remaining property is state-owned lands associated with boating, fishing, and camping activities. These recreational activities are also incorporated into the pool elevation management plan.

Upstream of the Conowingo Pool, land ownership along the mainstem of the Susquehanna River ranges from private, commercial, to public lands. Table 4 shows land use statistics for the portion of the assessment area in Maryland. The pie chart and map, Figures 6 and 7, respectively, also show land use for the portion of the assessment area in Maryland. The 2000 land use dataset was acquired from the Maryland Department of Planning.

Table 4. Land Use for the Baltimore Assessment area in Maryland.

Land Use	Percent	Square Miles
Low Density Residential	10.54	6.98
Medium Density Residential	0.47	0.31
High Density Residential	0.11	0.07
Commercial	0.56	0.37
Industrial	< 0.1	0.01
Institutional	0.37	0.25
Open Urban Land	< 0.1	0.003
Extractive	< 0.1	0.03
Cropland	40.09	26.56
Pasture	3.98	2.64
Orchards	< 0.1	0.06
Deciduous Forest	33.38	22.12
Evergreen Forest	0.54	0.36
Mixed Forest	1.28	0.85
Brush	0.60	0.83
Water	7.49	4.96
Bare Ground	< 0.1	0.03
Feeding Operations	< 0.1	0.05
Agricultural Building	0.34	0.22
Total	**100**	**66.71**

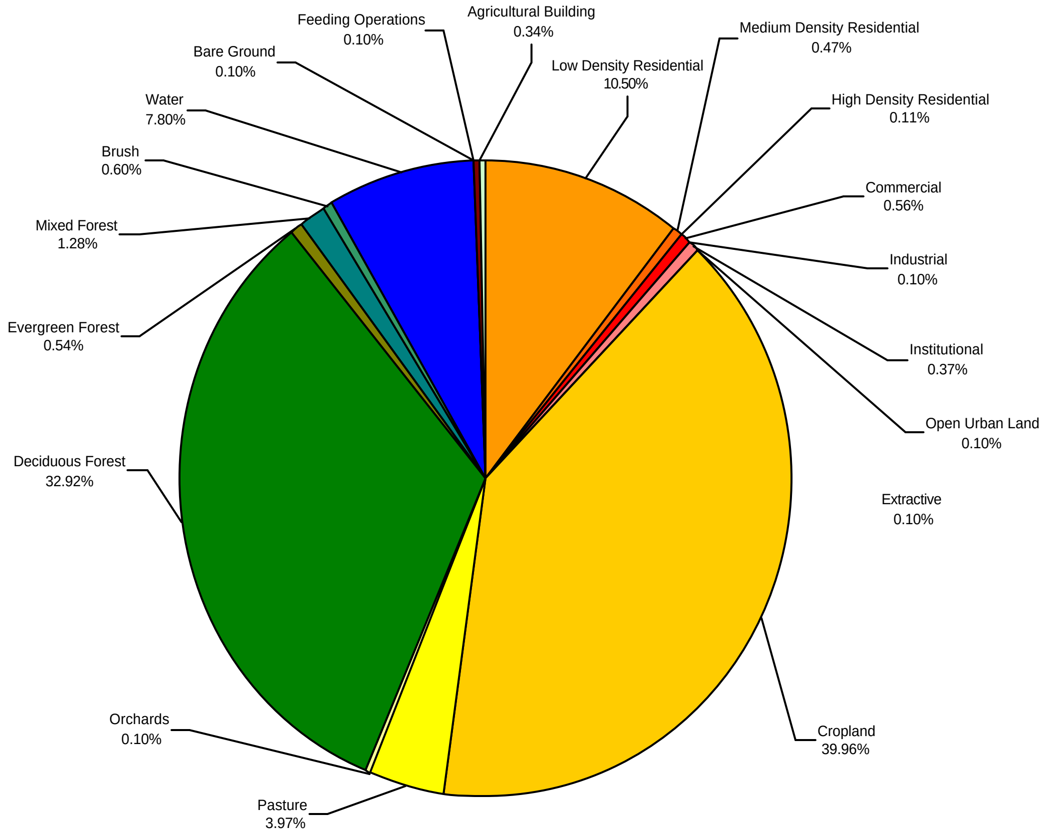

Figure 6. Land Use for the Maryland Portion of the Assessment Area

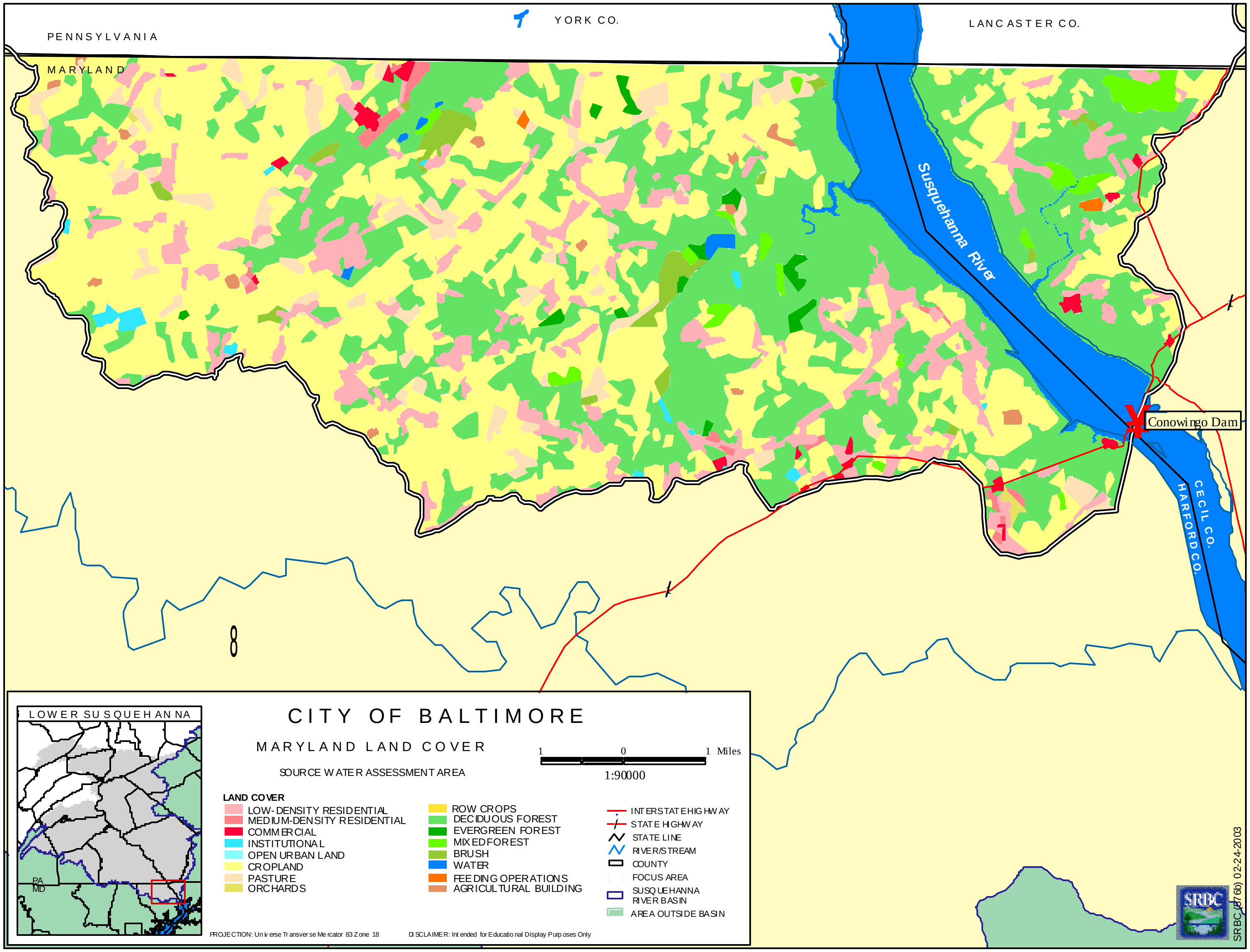

Figure 7. Map of Land Use for the Maryland Portion of the Assessment Area

2. Analysis of land use types for the Susquehanna basin

Land use types in the Susquehanna River Basin are shown in Table 5, Figure 8, and the land cover map (Appendix 4). The information was derived from USEPA Multi-Resolution Land Cover (MRLC) 1993 Landsat Thematic Mapper data, developed by the USGS Earth Resources Observation Systems Data Center (Vogelmann, 1993). The MRLC data was reclassified to improve data quality and released again in 1997. The basin as a whole is predominantly forested. This is true for all the major subbasins, with the exception of the Lower Susquehanna Subbasin. The lower Susquehanna is predominantly agricultural, and also has the highest percentage of developed lands in the basin.

Table 5. Land Use for Major Subbasins in the Susquehanna River Basin

Land Use	Upper	Chemung	Middle	West Branch	Juniata	Lower	Entire River Basin
Water	1%	1%	2%	< 1%	1%	2%	1%
Low Intensity Developed	1%	1%	2%	1%	1%	3%	1%
High Intensity Residential	< 1%	< 1%	1%	< 1%	< 1%	1%	< 1%
High Intensity Commercial/Industrial	< 1%	< 1%	1%	< 1%	< 1%	1%	< 1%
Hay/Pasture	14%	9%	7%	4%	7%	18%	10%
Row Crops	12%	22%	20%	12%	20%	32%	19%
Other Grass (lawns, city parks, golf courses)	< 1%	1%	< 1%	< 1%	< 1%	< 1%	< 1%
Evergreen Forest	5%	3%	7%	7%	4%	3%	5%
Mixed Forest	28%	17%	9%	11%	6%	3%	12%
Deciduous Forest	37%	47%	50%	63%	59%	36%	49%
Woody Wetland	1%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%
Emergent Herbaceous Wetland	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%
Bare; quarries, strip mines, and pits	< 1%	< 1%	1%	1%	< 1%	1%	1%
Bare; transitional	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%

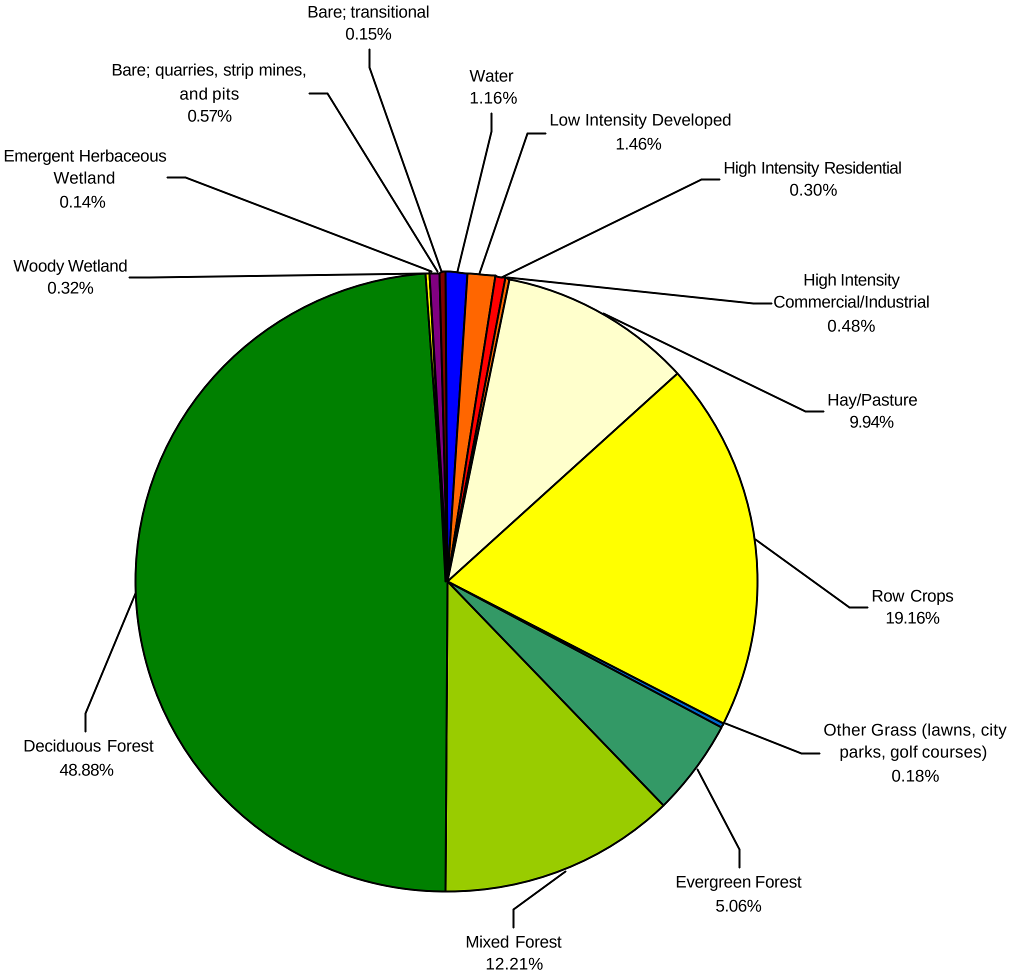

Figure 8. Land Use for the Susquehanna River Basin

3. Subbasin characteristics and general trends

The following section discusses general land use characteristics and trends for each subbasin. As seen in both Table 5 and the land cover map (Appendix 4), land use varies between the major subbasins in the assessment area. Land cover data for the entire Susquehanna River Basin only covers data collected in the early 1990s. The 2000 Multi-Resolution Land Characteristics (MRLC) update has not been released as of the date of this assessment report. However, U.S.

Census Bureau data collected on populations surveyed in 1990 and 2000 were used to assist with the general trends observed in each of the subbasins.

In the Upper Susquehanna Subbasin, much of the land is steeply sloped with hills and ridges dominated by forested land. Agricultural land occupies the lower lying areas possessing more productive soil types. The major population centers in the subbasin are Binghamton, Johnson City, Endicott, Cortland, and Oneonta, N.Y. Small villages exist throughout the subbasin. Census data indicates that the population in the subbasin has decreased slightly during 1990 to 2000.

The Chemung Subbasin is composed of terrain that is typical of glaciated watersheds. Forested land occupies the steep hillsides, while flat hilltops and valleys are used for agriculture. Agricultural activity is almost evenly split between cropland and pasture grazing. The major population centers in the subbasin are Elmira, Corning, and Hornell, N.Y. Populations within the subbasin did not significantly change between the 1990 and 2000 census.

The Middle Susquehanna Subbasin terrain has many high plateaus that are separated by steep valleys. This subbasin is a highly urbanized coal-mining region. Much of the mining region is abandoned lands; however, remining activity has been increasing with technological advances in extraction methods. The major population centers are Scranton, Wilkes-Barre, Carbondale, and Sunbury, Pa. The Scranton/Wilkes-Barre corridor represents a very intensely urbanized area, extending over 20 miles in the Lackawanna Valley.

The West Branch Susquehanna Subbasin is predominantly covered by forested land with low rolling hills. Mining, urban, and agricultural areas are dispersed throughout the subbasin. The major population centers are State College, Lock Haven, Williamsport, Clearfield, and Lewisburg, Pa. Census data indicates the population has increased by approximately 5 percent in the subbasin over the last decade. Most of this increase is focused in the Nittany Valley, surrounding the State College area. Development has increased rapidly in the area with the addition of housing at the expense of traditionally agricultural areas.

The Juniata Subbasin is composed of terrain with mountains and long, narrow valleys. Agriculture is common in the valley portions of the subbasin where soils are more productive, while the steep mountains are primarily forested. The subbasin is predominantly rural. The major population centers in the subbasin are Altoona, Hollidaysburg, Bedford, Lewistown, Huntingdon, and Mount Union, Pa. The subbasin is facing increasing development pressure with the addition and improvement of several travel corridors. Interstate 99 is currently being built to connect Interstate Routes 76/70 and 80, which run parallel to each other in an east-west direction across Pennsylvania. State Route 322, which travels northwest into the subbasin from Harrisburg, was recently expanded to accommodate four lanes of traffic. With this expansion, the increased accessibility to the Harrisburg Metropolitan Area has spurred development in the eastern portions of the basin.

With respect to land use distribution, the Lower Susquehanna Subbasin contrasts greatly in comparison to the other subbasins. Fifty percent of the subbasin is dedicated to agricultural activities. Several counties in the subbasin possess some of the most productive soils in the state of Pennsylvania, with a significant amount of effort being placed on preserving current agricultural activities. Urban and residential development accounts for almost 5 percent. Although the percent development does not seem significantly different than some of the other subbasins, the 2000 update for land cover for this region is expected to show dramatic increases. Census data indicates that population growth in the metropolitan areas within the subbasin has increased over 10 percent. Additionally, there is a significant amount of growth occurring in Pennsylvania, along the southern portions of Adams and York Counties, as a result of expansion around the City. The predominant trend in land use within the subbasin is the conversion of cropland and pastures to residential and commercial development.

D. Subwatersheds of Concern

Water quality varies between the major subbasins due to a number of characteristics associated with land use, soils, and geology. Under the Clean Water Act, states are required to assess streams and lakes within their jurisdiction and list waterbodies that do not meet water quality standards. The lists are called the Section 303(d) List, and are published every two years on even numbered years. The following section summarizes major influences on water quality within each of the major subbasins and identifies watersheds of concern, based on SRBC subbasin surveys and state 303(d) lists (Appendix 2).

Overall, the Upper Susquehanna Subbasin has excellent water quality conditions. Most sample sites were found to be supporting healthy water quality, biological conditions, and habitat. Some areas for concern include Tioughnioga River Watershed, Salt Lick Creek, and Nanticoke Creek, which had slightly impaired sample sites. The water quality impairments that do exist tend to be associated with atmospheric deposition, particularly acid rain and mercury from air pollution.

The Chemung Subbasin has five major watersheds. Much of the Tioga River Watershed is severely impacted by acid mine drainage (AMD). Biological conditions are greatly impaired on most of the mainstem. The Cowanesque River Watershed has slight impairments due to excessive nutrients from wastewater discharges and agricultural runoff. Overall, the Canisteo River Watershed is fairly healthy. There is a small area with urban influences. The Cohocton River Watershed has poor water quality due to the agricultural activities throughout the watershed.

A subbasin survey was completed for the Middle Susquehanna Subbasin in 2001. The survey found the watersheds of the upper half of the basin, such as Towanda Creek, Tunkhannock Creek, and Meshoppen Creek to be fairly healthy. None of the watersheds are considered to be extremely degraded in water quality, biology, or habitat. The watersheds in the lower half of the basin, which include the Lackawanna River, Nescopeck Creek, and Catawissa Creek, are greatly affected by AMD and urban influences. Smaller tributaries such as Solomons, Nanticoke, and Newport Creeks are strongly impacted by urban influences and AMD and provide very poor quality water to the Susquehanna River. Most of the sample sites on the mainstem in the middle Susquehanna either had water quality of low or nonexistent acidity and high organic carbon concentrations; or had high levels of nutrients and AMD inputs. The AMD and nutrient effected sites were generally located between Wilkes-Barre and Sunbury. Few sites had an increase in ammonia and decrease in sulfate due to major point-source inputs.

The West Branch Susquehanna Subbasin is largely affected by AMD. Over 100 miles of the West Branch Susquehanna River between the towns of Clearfield and Lock Haven have no aquatic life due to AMD. The pH in this section of river is as low as 3.2 at the town of Karthaus. Another 100 miles of the river varies in degree of degradation due to AMD. Water quality ranges from fair to good, and some life is found in the biological communities. The lower 50 miles of the West Branch is the only section of the river that is free from the effects of AMD. The tributaries to the West Branch Susquehanna River have a tremendous impact on its water quality. Clearfield Creek negatively impacts the West Branch due to its large flow and its degraded water quality. Alder Run is another tributary with a negative impact on the West Branch. Water quality is poor and the biological conditions are stressed. Moshannon Creek contributes highly acidic water and the greatest acid load of all of the tributaries to the West Branch. The Sinnemahoning Creek is the largest tributary to the West Branch. One of its branches is severely degraded by AMD. Chest Creek discharges beneficial water into the upper West Branch; however the West Branch does not receive a major contribution of beneficial water quality until Bald Eagle Creek at Lock Haven. From Lock Haven down, the river begins to show signs of improving water quality.

Water quality conditions in the Juniata Subbasin are fairly good. However, there are some watersheds such as the Frankstown Branch, the Beaverdam Branch, and the Kishacoquillas Creek that contribute poor water quality to the Juniata River. A section of the Frankstown Branch is impaired by a point-source discharger**.** The Beaverdam Branch has poor water quality due to AMD, point sources, and runoff from the Altoona/Hollidaysburg area. Several sections of the Kishacoquillas Creek are impaired due to agricultural impacts. The lower section of the Kishacoquillas Creek is moderately impaired due to urban runoff during storm events or point-source discharges.

In the lower Susquehanna River Basin, the major sources of contamination are agricultural runoff, AMD, urban runoff, municipal and industrial waste discharges, atmospheric deposition, and septic discharges. Nutrients and siltation from agricultural runoff and streambank erosion have been identified as pollutants causing designated use impairments throughout the subbasin. In many places, little to no riparian buffer zone exists along pastures and croplands. Livestock also have unlimited access to streambanks in many parts of the subbasin. Fertilizer and animal manure contribute to agricultural related contamination. The Chickies Creek and Conestoga River, both in Lancaster County, have the highest and second highest animal-loading indices, respectively, in Pennsylvania. AMD contributes sediment and metals to surface waters, particularly in the northern portions of the subbasin. Urban runoff and municipal and industrial discharges contribute high concentrations of nutrients, heavy metals, organic contaminants, and other materials to surface waters. On-lot septic systems contribute nutrients to the basin. Degradation of surface water also is caused by atmospheric deposition and natural conditions. Precipitation in Pennsylvania has low pH, which can affect poorly buffered headwater streams. Emissions of sulfur and nitrogen oxides have resulted in some of the most acidic precipitation in the nation.

V. WATER QUALITY DATA

Different sources of water quality data were reviewed for the Susquehanna River Basin. Data were collected and reviewed from water suppliers' monthly operating reports, SRBC data, Pennsylvania Department of Environmental Protection (Pa. DEP), MDE data, Maryland Department of Natural Resources (MD DNR) data, and USGS data.

A. Review and Discussion of Existing Plant Data

The City conducts over 100,000 finished water quality analyses a year, covering 90 different contaminants. The contaminant classes sampled for include microbial contaminants, turbidity, inorganic compounds, fluoride, lead, copper, arsenic, volatile organic compounds (VOCs), synthetic organic compounds (SOCs), and radioactive contaminants. Although not a direct measure of source water quality, finished water quality analyses can be used to indicate what contaminants might pose problems based on their occurrence in drinking water. It is also important to note that the City analyzes finished water quality for samples representing blended water from several sources, not exclusively the Susquehanna River source. A copy of finished water quality data can be obtained from the City.

Raw Water Quality

In addition to sampling raw water quality from the Conowingo Pool, the City measures a number of parameters from the Susquehanna River water supply prior to blending with the Loch Raven source water at the filtration plants. Over 20 parameters were reviewed from monthly samples collected for April 2002 through December 2002.

Basic water quality parameters were measured monthly, as well as several inorganic contaminants, which include nitrate, phosphate, and several metals and trace elements. For most parameters, no notable concentrations were detected in the Susquehanna raw water source. For the period of April 2002 to December 2002, measured turbidity ranged from 2.33 NTU to 48.7 NTU, with an average value of 10.7 NTU. The average nitrate concentration was less than 1 mg/l, with the highest concentration a little more than 2 mg/l. Sulfates ranged from 2.76 mg/l to 78.4 mg/l. All of these concentrations are typical for the lower Susquehanna River, as observed from data collected by SRBC and other agencies from 1986 to 2001. Although sulfate concentrations appear to vary significantly, the long-term median values for several lower Susquehanna River sampling sites are between 30 and 50 mg/l over the past 15 years.

Finished Water Quality

Disinfection byproducts are sampled within the distribution system of the plant. Data provided by MDE indicated that total trihalomethanes (THM) ranged from 0.027 to 0.087 mg/l during 2002, with an annual average of 0.060 mg/l. Total haloacetic acids ranged from 0 to 0.057 mg/l, with an annual average of 0.023 mg/l. The MCLs for total THMs and total haloacetic acids is 0.08 mg/l and 0.06 mg/l, respectively, with compliance determined from the running annual average. Disinfection byproducts information from 2002 for Baltimore is shown in Table 6. The data shows that there were no MCL exceedances based on the annual average concentrations for either total THMs or total haloacetic acids, although total THMs concentrations did exceed the 50 percent level of the MCL. The data represents samples taken from the distribution system for both Baltimore City and Hartford County. The data does not represent water exclusively from the Susquehanna River, but samples taken during use of the river as a source, as well as from portions of the distribution system that the Montebello Plant serves. In the case of Harford County, the county has an agreement with Baltimore to receive up to 10 mgd, in order to supplement their water supply. The data shown in Table 6 represents the period of time during which the county was using Baltimore source water to supplement their water supply. As shown in the table, there were certain byproducts detected above the 50 percent level of the MCL.

Table 6. Disinfection Byproduct Detected in the Distribution System during 2002

Contaminant	2002 Concentrations for Baltimore's Montebello Plant (mg/l)		2002 Concentrations for Harford's Abingdon Plant (mg/l)	
	Peak	Average	Peak	Average
Chloroform	0.075	0.049	0.129	0.066
Bromoform	<0.001	<0.001	0.005	<0.001
Bromodichloromethane	0.016	0.010	0.027	0.017
Dibromochloromethane	0.001	0.004	0.009	0.004
Monochloroacetic Acid	0.012	0.002	0.019	0.004
Monobromoacetic Acid	0.003	<0.001	0.002	<0.001
Dichloroacetic Acid	0.028	0.009	0.057	0.029
Trichloroacetic Acid	0.026	0.011	0.066	0.031
Dibromoacetic Acid	0.001	<0.001	0.002	<0.001
Bromochloroacetic Acid	0.039	0.009	--	--

Conditions in the Conowingo Pool

There are very few studies that have focused specifically on the water quality of the Conowingo Pool. One study conducted for the City in the early 1980s focused predominantly on Susquehanna River water quality, and not on conditions specific to the pool itself (Malcolm Pirnie, 1980). From April 1959 through May 1960, the Chesapeake Bay Institute conducted a detailed physical and chemical limnology study of conditions within the Conowingo Pool. The study focused on characterizing: (1) flow characteristics behind the dam; (2) seasonal and spatial variations in water temperatures; (3) seasonal and spatial variations in dissolved oxygen (DO)/pH, and (4) organic production by aquatic vegetation and the resulting oxygen balance.

The study determined the dominant downstream flow regime to be present on the west side of the pool. The flow pattern follows what was once the natural river channel, prior to inundation. Since releases at the dam are now confined to the west side as well, a significant change in the flow regime is unlikely. The flows along the eastern portion of the pool, closer to the dam, commonly form an eddy current. The eddy current returns flow upstream along the eastern shore for a distance before reentering the downstream current on the west side, forming a circular flow pattern. The study did not cite specific distance measurements concerning how far upstream of the dam the eddy current is present. With respect to the magnitude flow, the eddy current is present even during high flows, although it is more closely confined to the dam face and eastern shore. With respect to depth, underflow currents typically travel the length of the reservoir in less than 25 percent of the time it would normally take flows near surface. During low flows, the situation reverses.

During the winter months, temperatures and DO are fairly uniform. However, during the spring and summer both parameters become stratified and decrease with depth. Temperatures typically range from 23 to 28 degrees Celsius from bottom to surface, respectively. DO ranges can vary from 0 to 8 mg/l from bottom to surface, respectively. The under-saturated DO values are mostly confined to the deeper portions of the reservoir within the immediate vicinity of the dam. The decrease in DO typically causes aquatic plant die-off, producing higher total organic carbon (TOC) levels. Conditions generally remain stratified until temperature changes in the fall cause the pool to turn over and eliminate the stratification.

Residence times can vary significantly for the Conowingo Pool, obviously depending on flows. Typical residence time determined by the study for a high flow scenario was less than 24 hours. During such flows, temperature, oxygen, and pH are fairly homogeneous. During a low-flow scenario, residence times are typically 2 to 4 days, with approximately the top 40 feet of the water column dominating the flow patterns, characterized by higher flow velocities. The lower layers typically have reduced velocities. During severely low flows, this surface flow regime becomes even more dominant, and residence times can reach 5 to 6 days. The resulting drop in DO levels can cause taste and odor problems for drinking water supplies, due to increases in nutrient input to the reservoir and the resulting algal problems.

B. Review and Discussion of Current or Completed Studies in Watershed

Nutrients and Sediment

The SRBC Publication No. 225 *Nutrients and Suspended Sediment Transported in the Susquehanna River Basin, 2001 and Trends 1985 through 2001* collected nutrient data at three sites on the Susquehanna River and three sites on major tributaries. The locations include the Susquehanna River at Towanda, Danville, and Marietta; the West Branch Susquehanna at Lewisburg; the Juniata River at Newport; and the Conestoga River at Conestoga. The study tracked seasonal variations for total nitrogen, total phosphorus and suspended sediment (Table 7). Total nitrogen had the highest loads in the spring followed by winter, fall, and summer. Suspended sediment loads and total phosphorus loads show similar seasonal variation at the sites on the Susquehanna River. The Conestoga River Watershed had the greatest yields in pounds per acre per year of total nitrogen, total phosphorus, and suspended sediment for all seasons. The long-term yields of total nitrogen increased in the Susquehanna River in a downstream order from Towanda to Marietta. The increase is possibly due to a larger amount of agricultural lands and sewage treatment plants in the lower Susquehanna. Overall, the Susquehanna River system is phosphorus limited. Long-term yields for total phosphorus at the sites on the Susquehanna River do not show a uniform seasonal pattern. Suspended sediment long term yields decreased in downstream order except during the summer at Marietta. Overall, there were significant improving trends at all six stations for total nitrogen, total phosphorus and suspended sediment.

The USGS Lower Susquehanna National Water Quality Assessment (NAWQA) Study, conducted from 1992 to 1995, found that nitrate concentrations exceeded the USEPA MCL (10 mg/l) in streams located in agricultural areas that are underlain by limestone. These areas have a strong correlation between the manure applications rate and nitrate concentrations. The study also found that streams located in agricultural areas that are underlain by sandstone, shale, and crystalline bedrock contribute large amounts of nitrate. Animal manure used as fertilizer for agriculture was determined to be the main source of nitrogen to the Susquehanna River. Manure application had a strong correlation with nitrate levels in the streams. The study found that there were higher concentrations in streams than in ground water in limestone urban areas. Tributaries like Mill Creek, Lancaster Co., that are in limestone areas had nitrate levels around 10 mg/l. There were some seasonal fluctuations in these concentrations. Nitrate concentrations were less than 2 mg/l in the Susquehanna River at Harrisburg. Nitrate concentrations in limestone areas are generally higher during the spring. Overall, nitrate was found in 98 percent of the samples. Ninety-two percent of the samples detected nitrate in concentrations above 0.3 mg/l. Streams with these levels of nitrates encourage excessive algae growth.

The Susquehanna River transports about 25 percent of the sediment, 40 percent of the phosphorus, and nearly 66 percent of the nutrient load to the Chesapeake Bay. Three hydroelectric dams on the lower Susquehanna River form the reservoir system, which consists of Lake Clarke, Lake Aldred and the Conowingo Reservoir. Since their construction in the early 1900s these reservoirs have been filling with sediment and nutrients. Lake Clarke and Lake Aldred, the upper two reservoirs, have reached their capacity to store sediment and no longer trap sediments and nutrients. The Conowingo Reservoir currently traps 2 percent of the total nitrogen load, 40 percent of the total phosphorus load and 70 percent of the suspended-sediment load. Concentrations of total nitrogen collected from bottom sediments averaged about 3,600 milligram/kilogram (mg/kg) in the area of the reservoir within 1-mile upstream of the Conowingo Dam. The average concentration for total phosphorus in this area was about 850 mg/kg.

There is about 29,000 acre-ft of sediment storage capacity left in the reservoir. There is no storage capacity left in the Conowingo Reservoir from its upper end to about 28,000 feet upstream of the Conowingo Dam. Once the reservoir system reaches capacity, and if conditions remain constant, there will be a 2 percent average yearly increase in total nitrogen, a 70 percent average yearly increase in total phosphorus, and a 250 percent average yearly increase in suspended sediment entering the Chesapeake Bay. Such conditions could result in elevated turbidity levels, an increase in algal-related problems, or increased risk of microbial contamination.

Table 7. Seasonal Mean Water Discharges and Loads of Nutrients and Suspended Sediment, Calendar Year 2001

Station	Season	Mean Water Discharge	Total Ammonia as N	Total-Organic Nitrogen as N	Total Nitrite Plus Nitrate as N	Total Nitrogen as N	Dissolved Ortho-phosphate as P	Dissolved Phosphorus as P	Total Phosphorus as P	Dissolved Ammonia as N	Suspended Sediment	Dissolve Nitrogen as N	Dissolved Nitrite Plus Nitrate as N	Dissolved Organic Nitrogen as N	Total Organic Carbon
		cfs	thousands of pounds												
Towanda	Winter	9,929	259.1	2,045	3,901	6,211	255.9	228.2	402.5	327.5	170,359	6,112	3,959	1,807	13,865
	Spring	15,781	384.6	4,415	4,642	9,297	358.7	348.8	1,099.0	410.2	1,102,616	8,193	4,660	3,299	26,876
	Summer	1,978	22.3	573	428	953	92.4	67.2	108.9	26.0	13,055	839	429	427	3,598
	Fall	3,356	79.8	777	1,148	1,999	244.6	152.5	189.0	122.4	21,195	1,980	1,155	694	5,173
Danville	Winter	14,781	406.3	3,054	6,997	10,301	361.8	277.2	585.3	561.4	208,795	10,180	7,107	2,616	18,629
	Spring	20,990	433.0	5,719	7,417	13,212	407.1	366.7	1,289.3	525.1	877,762	11,899	7,459	4,175	32,927
	Summer	3,462	28.5	1,100	800	1,738	74.0	66.4	155.8	36.4	22,120	1,454	803	752	6,161
	Fall	5,223	110.2	1,404	2,096	3,474	226.6	162.8	276.2	167.9	38,226	3,361	2,122	1,173	7,775
Lewisburg	Winter	9,062	332.0	1,635	2,810	4,578	107.7	115.2	277.9	271.3	86,194	4,300	2,812	1,258	8,285
	Spring	10,014	241.0	1,827	2,569	4,462	106.9	104.3	298.3	192.3	107,395	3,993	2,555	1,324	9,992
	Summer	2,476	30.1	539	659	1,183	44.6	39.9	80.0	31.2	13,270	1,048	649	389	3,111
	Fall	5,529	103.0	1,205	1,685	2,973	122.4	120.7	245.2	147.8	46,311	2,676	1,672	880	6,368
Newport	Winter	4,054	46.9	920	2,494	3,524	154.6	132.7	221.4	61.8	80,589	3,352	2,515	755	5,676
	Spring	4,202	49.1	1105	2,283	3,432	184.8	152.7	305.6	71.1	149,541	3,140	2,294	812	6,501
	Summer	883	8.0	283	364	588	46.1	45.1	71.4	12.4	9,730	531	365	211	1,640
	Fall	912	7.8	255	462	695	47.5	49.4	65.5	12.3	5,873	662	467	214	1,539
Marietta	Winter	33,127	829.7	8,599	18,225	27,089	1,452.3	966.3	1,813.1	935.4	786,776	24,951	18,280	5,914	43,722
	Spring	42,905	780.7	13,965	18,856	30,894	2,329.9	1,374.4	3,402.7	850.3	1,948,548	27,395	18,800	8,729	67,466
	Summer	8,382	82.4	3,396	2,742	5,248	463.9	311.9	552.0	106.2	150,945	4,697	2,777	2,273	16,153
	Fall	13,490	312.0	5,081	6,776	11,315	1,136.6	625.8	1,006.3	362.4	285,069	10,364	6,865	3,439	22,488
Conestoga	Winter	635	30.2	487	2,104	2,587	49.7	52.6	122.6	31.5	42,775	2,438	2,092	295	1,456
	Spring	521	19.0	342	1,715	2,003	53.5	46.3	111.8	19.5	35,897	1,896	1,706	193	1,170
	Summer	200	4.4	116	635	737	38.9	30.6	50.2	4.5	6,754	696	636	68	488
	Fall	120	1.7	78	410	502	18.7	18.4	20.8	2.1	630	478	412	54	264

Volatile Organic Compounds

The NAWQA study found that VOCs were more frequently detected in groundwater of urban areas than in agricultural areas. This is likely due to the numerous sources of VOCs found in urban areas. These sources include spills, improper disposal, runoff from pavement, leaks from underground storage tanks, atmospheric deposition, and leaking sewer lines. This study indicated that contaminated groundwater flows from springs into streams. The detection levels of VOCs in wells ranged from 0.2 to 1.0 ug/l. These levels were detected in 23 of the 60 compounds sampled. However, there were no significant concentrations detected in surface waters within the lower Susquehanna.

Synthetic Organic Compounds

Pesticide concentrations in the lower Susquehanna rarely exceeded the drinking water standards. Overall, the concentrations of individual pesticides were quite low. Forty-seven insecticides and herbicides were tested for. Only 22 of over 500 samples detected pesticides at levels greater than 0.002 mg/l. Herbicides that are widely used on corn were the most commonly detected pesticides. These herbicides include atrazine, metolachlor, simazine, prometon, alachlor, and cyanazine. The two most commonly used agricultural pesticides in the lower Susquehanna River Basin are metolachlor and atrazine. Generally, the detection of pesticides was related to bedrock type, pesticide leaching potential, and pesticide use. Storm runoff in the spring during the major application period was found to be a major contributor of high concentrations of pesticides to streams. During the major application period, concentrations of atrazine detected in Mill Creek ranged from 0.1 mg/l to 0.2 mg/l. The pesticides detected in the Susquehanna River at Harrisburg were similar to those found in streams in agricultural areas throughout the lower Susquehanna River Basin. Pesticide concentrations found at this site were usually less than 1ug/l. Atrazine concentrations ranged from 0.00001 to 0.001 mg/l. Metolachlor concentrations ranged from 0.000007 to 0.002 mg/l. The MCL for atrazine is 0.003 mg/l, for simazine is 0.004 mg/l, and for alachlor is 0.002 mg/l.

A more recent NAWQA study took place nationwide during 1999 and 2000. This study looked for the occurrence of pharmaceuticals, hormones, and other organic wastewater contaminants in streams. Five of the sampling sites were located in the lower Susquehanna River Basin. These sites were located in the East Mahantango Creek at Klingerstown, Schuylkill County; Conodoguinet Creek at Hogestown, Cumberland County; Bachman Run at Annville, Lebanon County; Chickies Creek at Marietta, Lancaster County; and Mill Creek at Lyndon, Lancaster County.

In the lower Susquehanna River Basin, 18 antibiotic compounds were sampled for at the five sites. Each site had concentrations of the antibiotics that were generally below the detectable limits. Erythromycin (sampled at Chickies Creek) was the only compound found in the lower Susquehanna at a detectable limit (0.00005 mg/l). Lincomycin and erythromycin were the only antibiotics found in the basin that were frequently detected nationwide. Steroid and hormone compound data were only collected in Chickies Creek. Cholesterol, used as a plant/animal steroid, was found at a level of 0.0023 mg/l. Coprostanol, a fecal steroid, had a concentration of 0.00014 mg/l. Estriol, a reproductive hormone, was the only other compound with a concentration (0.000019 mg/l) above the detectable limit. Forty-five compounds considered as wastewater-related were sampled for at the Chickies Creek site. Twenty of these compounds were frequently detected in streams nationwide. Four of the compounds sampled at Chickies Creek had concentrations at a detectable limit. Ethanol, used as a blending component in gasoline, had a concentration of 0.0002 mg/l. Naphthalene, a polycyclic aromatic hydrocarbon (PAH), was detected at 0.00005 mg/l. The health advisory level for this contaminant is 0.02 mg/l. Triclosan, an antimicrobial disinfectant, had a concentration of 0.00006 mg/l. Tri (chloroethyl) phosphate, a fire retardant was found at a level of 0.00006 mg/l.

The USGS and George Mason University (Koplin and others, 2002) studied organic contaminants sampled at the Conowingo Dam between March 4 and December 12, 1994. Some common contaminants that were detected included pesticides (atrazine, metolachlor, cyanazine, and malathion), insecticides (chlordane), total PCBs, and total PAHs. Both point and nonpoint source, are associated with contributing these contaminants to the environment.

Sample concentrations were measured in filtered water and filtered particles. The samples were filtered with Whatman glass fiber filters. For a list of common filtered water concentrations see Table 8. Although there were detections for many of the compounds sampled, all were well below any established MCLs.

Table 8. Organic Contaminants Detected at Conowingo Dam, 1994

Contaminant	Mean Concentration (ng/l)	Concentration Range (ng/l)	MCL (ng/l)
Pesticides			
Malathion	105	<2.9-279	NA
Cyanazine	84.5	<0.9-184	NA
Atrazine	81.5	26-241	3000
Metolachlor	61.2	16-195	NA
Insecticides			
Chlordane	0.19	<0.0009-0.65	2000
Total PCB	1.7	0.5-5.3	500
Total PAH	99.6	25-240	NA

Malathion was found in the river water in high concentrations, but was infrequently detected. There was a peak in the discharge between March and May due to combined runoff from snowmelt and rainfall. Concentrations of organo nutrient/phosphorus pesticides showed a seasonal link to agriculture activities. PCBs and chlordanes concentrations were linked to seasonal runoff. PBC concentrations were greatest during the spring due to increased runoff from precipitation and snowmelt. Chlordane concentrations showed an increase during the spring and the month of August when river flows were high.

Microbial

USEPA Information Collection Rule (ICR) studies occurred in several major raw water intakes throughout the Lower Susquehanna Subbasin from July 1997 – December 1998, including the York Water Company, the Lancaster Metropolitan Authority, and the Chester Water Authority. These locations represent total coliform and *E. Coli* levels for Codorus Creek downstream of its South Branch, the Susquehanna River upstream of the Conestoga River, and the Conestoga River upstream of Mill Creek. This data was utilized in order to determine general coliform influences from several major tributaries to the Lower Susquehanna Subbasin, which may indicate tributaries of concern for the immediate area.

The ICR data reviewed indicates that although the mainstem Susquehanna River currently meets state standards, selected major tributaries in the Lower Susquehanna Subbasin may contribute significantly to total coliform, fecal coliform, Giardia, and Cryptosporidium levels. The Susquehanna River, Conestoga River, and Codorus Creek studies all indicated the presence of Giardia: ranging from 0-412 cysts/100L. Conestoga River and Codorus Creek studies recorded the presence of Cryptosporidium: ranging from 0-77 oocysts/100L. As well, total coliform levels were significant, reaching 20,000 MPN/100ml in Codorus Creek, 9,000 MPN/100ml in the Susquehanna River, and 8,500 MPN/100ml in the Conestoga River. Fecal coliform levels also were elevated: in the Conestoga River, levels reached 2,800 MPN/100ml, while the Susquehanna site they reached 2,200 MPN/100ml. No major trends were determined based on the ICR data (USEPA ICR Report www.epa.gov/enviro/html/icr/utility/report).

Facility IDs: PA1230004961028200912
PA7670100961004144429
PA7360058960919140351

Radionuclides
Present both naturally and as a result of human activity, low concentrations of radionuclides are typically found when sampling air, soil, or water. However, potential contamination of drinking water sources by increased levels of radionuclides exists due to human activities such as the mining of radioactive substances, production of nuclear power, use and/or production of nuclear weapons, and practice of nuclear medicine. The most significant sources of radionuclides in the lower Susquehanna are nuclear power plants and residual piles of surfaced elements from mining operations.

In order to ensure public safety from exposure to radioactive particles, the USEPA has set MCLs for radium (5 picocuries per liter - pCi/l), gross alpha particles (15 pCi/l), beta particles (50 pCi/l), tritium (20,000 pCi/l), and uranium (30 ug/l). Public water systems are required to test annually for radioactive contaminants. According to the City's 2001 CCR, sampling was conducted for 4 quarters every fourth year by the MDE. Sampling occurred for beta/photon emitters, alpha emitters, and combined radium (Ra-226/-228), indicating that the City's water is well below maximum levels for alpha emitters and combined radium. Beta/photon emitters also were below maximum levels, but were slightly elevated (3.0 +/- 2.0 pCi/l). The City attributed this to the decay of natural and manmade deposits.

Furthermore, upstream surface water data supplied by AmerGen (TMI) and MDE was reviewed. TMI data incorporates several locations (upstream control sites and downstream indicator sites) sampled monthly from January to December of 2001. MDE data represents weekly sampling from the Susquehanna River at Conowingo from January 2000 – September 2002. Concentrations of tritium (H-3), iodine-131 (I-131), and gross beta particles were reviewed for both datasets. (MDE samples additionally for xenon-133 (Xe-133), and TMI for numerous gamma-emitting isotopes.)

TMI samples along the Susquehanna River near Steelton for control measurements. Downstream indicator measurements of outfalls are taken along the Susquehanna River near TMI (west shore), Columbia, and Wrightsville. Tritium levels at the upstream control location ranged from <143-<183 pCi/l, averaging over the 12 month collection period at approximately 168 pCi/l. Levels at the indicator location (downstream of the outfall) typically ranged from <159 to approximately 3,300 pCi/l, spiking once in January 2001 at 30,129 ± 495 pCi/l. The median for this period was 1,657 pCi/l. Not including the January event, the yearly average over the remaining 11 months was approximately 1,300 pCi/l. It should be noted, that some of the samples from this location were grab samples, due to freezing temperatures and/or sampler malfunction. Columbia data indicated only one instance of slightly elevated tritium levels (437 pCi/l). Wrightsville data stayed within control levels for tritium.

Both Columbia and Wrightsville sites were sampled for gross beta particle levels and I-131. I-131 levels oscillated infrequently and very slightly, deviating from control values (<0.4 pCi/l) by no more than 0.2 pCi/l. Gross beta results were similar. Control values (1.5-2.4 pCi/l) were seldom exceeded at Columbia, and although exceeded frequently at Wrightsville, the variation in concentration was small (max. record 3.7 pCi/l).

MDE data from the Susquehanna River at Conowingo also indicates stable levels of I-131 and gross beta particles. However, gross beta particle values for MDE data exceeded those of TMI, the low value being 1.0 pCi/l in January of 2000, and the high value in August and September of 2002 at 6.0 pCi/l. Tritium concentrations remained <300 pCi/l throughout the study period.

C. Review and Discussion of Outside Sources of Data and Findings

USEPA STOrage and RETrieval (STORET) Data

STORET data has been collected at many sites on the Susquehanna River. Lower Susquehanna River data collected by the Pa. DEP, SRBC, and MD DNR were reviewed. The data were collected from the Susquehanna River at Columbia and Wrightsville, Pa., and also from Cecil County, Md., near Lapidum. The data collection period ranged from 1978 to 1995.

Low DO in a stream can be indicative of poor water quality. The measured DO values typically ranged from 4 to 14 mg/l, with the lowest values typically measured during the summer months. Nitrate values at ranged from approximately 0.53-2.79 mg/l. Nitrite values ranged from 0.003-0.154 mg/l. All the data exhibited a general trend where nitrate/nitrite levels increased during the winter months.

Copper and lead found in streams may result from plumbing corrosion and natural erosion. USEPA sets action levels for copper and lead at 1.3 mg/l and 0.015 mg/l, respectively in finished water. Pa. DEP data indicated that the concentrations of both metals were typically below detection limits.

The National Secondary Drinking Water Regulations provide guidelines for regulating nontoxic contaminants. Total aluminum, chloride, iron, manganese, and sulfate in drinking water have recommended maximum values under these guidelines. The recommended maximum concentration of aluminum in drinking water is 0.05-0.2 mg/l and is influenced by the water treatment process, with little if any association with the source water quality under most circumstances. The recommended maximum concentration for each compound is shown in Table 9.

Table 9. Summary of STORET Data

Contaminant	Pa. DEP Data	SRBC Data	MD DNR	US EPA Limits
				Recommended Maximum Values
Total Aluminum	0.0264-2.235 mg/l	0.150-1.350 mg/l	N/A	0.05-0.2 mg/l
Chloride	8-30 mg/l	10-92 mg/l	N/A	250 mg/l
Iron	0.0264-2.235 mg/l	0.00298-3.060 mg/l	N/A	0.3 mg/l
Manganese	<0.001-0.405 mg/l	0.010-0.420 mg/l	N/A	0.05mg/l
Sulfate	19-92 mg/l	23-61 mg/l	N/A	250 mg/l
				MCL
Copper	<0.001-0.0093 mg/l	N/A	N/A	1.3 mg/l
Lead	<0.001-0.00252 mg/l	N/A	N/A	0.015 mg/l
Nitrite	<0.02 mg/l	0.01-0.03 mg/l	0.003-0.154 mg/l	1 mg/l
Nitrate	0.56-1.93 mg/l	0.81-2.99 mg/l	0.53-2.79 mg/l	10 mg/l

Data from Fish Tissue

The Pa. DEP and Pennsylvania Fish and Boat Commission regularly sample fish tissue for contaminants. Levels of a specific PCB compounds were detected in fish tissue at all sites sampled north of Sunbury, Pa., with the exception of one site at Sayre, Pa. Of the six PCB compounds analyzed, only one compound was typically above detectable limits. Pesticides and trace elements also were detected at varying levels in fish tissues. The metals detected include arsenic, mercury, copper, lead, chromium and cadmium. In 2000, mercury was detected at 0.063 micrograms per gram (ug/g); copper was detected at 0.326 ug/g; lead was detected at <0.025 ug/g; chromium was detected at 0.385 ug/g; and cadmium was detected at 0.008 ug/g. In 1988, arsenic was detected at 0.2 milligrams per kilogram of wet weight.

VI. SIGNIFICANT SOURCES OF CONTAMINATION

A. Nonpoint Source Concerns

Unlike point sources, nonpoint sources are unable to be isolated to a specific discharge point. Runoff from agricultural activities and roads, improper stormwater drainage, erosion along streambanks or from uncontrolled construction, and on-lot septic systems are all examples of nonpoint sources. Nonpoint sources in this assessment were identified using several geographic information system (GIS) datasets. These data sets included land use, animal indices, stream assessment information, and field observations.

Although difficult to quantify, nonpoint sources are significant contributors to water quality degradation in the Susquehanna River Basin. Several hundred miles of streams are listed on Maryland, New York, and Pennsylvania's 303(d) List of Impaired Waters (Appendix 2). The sources and causes range significantly. In the Susquehanna River Basin, the leading sources of contamination in order of significance are agricultural runoff, AMD, and runoff associated with urban/residential areas and storm sewers (Table 10). The leading cause of water quality impairment from nonpoint sources is sediment, coming from all three major sources. Additionally, agricultural runoff contributes to a majority of the problems associated with excessive nutrients and organic enrichment. AMD is the primary source for metals and low pH, although urban runoff is believed to contribute some metals as well. Urban runoff is a source for numerous contaminants, based on the range of activities present. Appendix 3 indicates which watersheds have approved Total Maximum Daily Loads established, and lists the pollutants addressed.

Table 10. Summary of Stream Assessments in the Susquehanna Basin

Category	Entire Susquehanna Basin (in stream miles)	Lower Susquehanna Subbasin (in stream miles)
Stream Assessment Status		
Assessed	27,000	7,500
Impaired	4,100	2,000
Unassessed	9,200	1,900
Three Leading Impairment Sources		
Agriculture	1,900	1,200
Acid Mine Drainage	1,300	200
Urban/Residential	60	50

The Susquehanna River Basin north of Sunbury, Pa. is predominantly forested with some agricultural land use and a few urban centers. Water quality conditions in the Upper Susquehanna Subbasin are fairly good, with little agriculture and development. The only potential for significant contamination exists from urban/stormwater runoff in the Elmira and Binghamton, N.Y. areas. Agricultural practices in the Chemung Subbasin have caused an increase in nutrients and sediments, and to a lesser extent, AMD has caused problems with metals and sediment. The single most problematic area in the northern portion of the assessment area is the large urban area located in the Wyoming Valley, within the Middle Susquehanna

Subbasin (Wilkes Barre/Scranton, Pa.). The tributaries in the Wyoming Valley contribute a large amount of sewage, trash, and urban runoff to the Susquehanna River. The Middle Susquehanna Subbasin also has severe problems associated with AMD. Combined with the West Branch Susquehanna Subbasin, these two subbasins contribute the majority of the problems associated with AMD in the Susquehanna basin. AMD causes low pH, high levels of metals, and acidity. However, the effects of AMD are largely mitigated by dilution downstream of the subbasin.

As stated in previous sections, the Lower Susquehanna Subbasin is the southernmost subbasin and most influential regarding Maryland's source water quality. Unlike all the other subbasins, it is dominantly agricultural land, with most of the activity occurring within Lancaster and York Counties, Pa. (Figure 1). It represents the most productive area in the Susquehanna River Basin. Hence, the leading cause for water quality problems is associated with agricultural runoff, specifically siltation and nutrients.

Siltation is fairly severe in portions of the lower Susquehanna, degrading to source water quality, as well as recreational use and fish habitat. The small particles clog waterways and decrease water clarity. Sediment also can carry contaminants such as pesticides into streams. The major contributors of siltation in the lower Susquehanna are predominantly unmanaged crop and pasture fields, and to a lesser extent urban/stormwater runoff, and unmanaged construction.

The problems associated with excessive nutrients are also prevalent in the lower Susquehanna. Sources of phosphorus include human sewage, urban/residential runoff, agricultural run-off from crops, sewage from animal feedlots, pulp and paper industry, vegetable and fruit processing, chemical and fertilizer manufacturing, and detergents. Aside from the negative health effects from elevated nutrients such as nitrate, elevated nutrient loads (nitrogen and phosphorus) can lead to increased algal productivity (Novotny and Olem, 1994). The addition of large quantities of phosphorus to waterways accelerates algae and plant growth by enhancing eutrophication and depleting the waterbody of oxygen. Increases in algal productivity also can have adverse effects on water supplies, such as potentially clogging a filter or affecting taste and odor. Any increase in total organic carbon also increases the excretion of toxins and the probability for the formation of harmful disinfection byproducts during treatment.

Agricultural practices also can increase the loads of fecal coliforms, cryptosporidium, and giardia in waterways, particularly where the animal populations are high. These microbial contaminants can result in severe gastrointestinal illnesses. Increases in the number of industrial farms, or concentrated animal feeing operations, have increased the potential for contamination of source water in the Lower Susquehanna Subbasin. To determine relative inputs, animal biomass indices were calculated for the subbasin using 1998 zip code data with animal population numbers, and USEPA estimates for daily manure loadings by animal type. The calculations were then distributed on a per acre basis of animal biomass. The index map identifies high animal densities throughout Lancaster County (Figure 9). The highest densities are represented in the Chickies Creek watershed, followed in decreasing order by Pequea Creek, Conestoga River, and Octoraro Creek watersheds. Due to the proximity and concentration of livestock sources in the Lower Susquehanna to the intake, potential for source contamination is high. Contaminants of high concern include: nutrients, siltation/turbidity, and bacteria/protozoa (total coliforms, Giardia, Cryptosporidium, etc.).

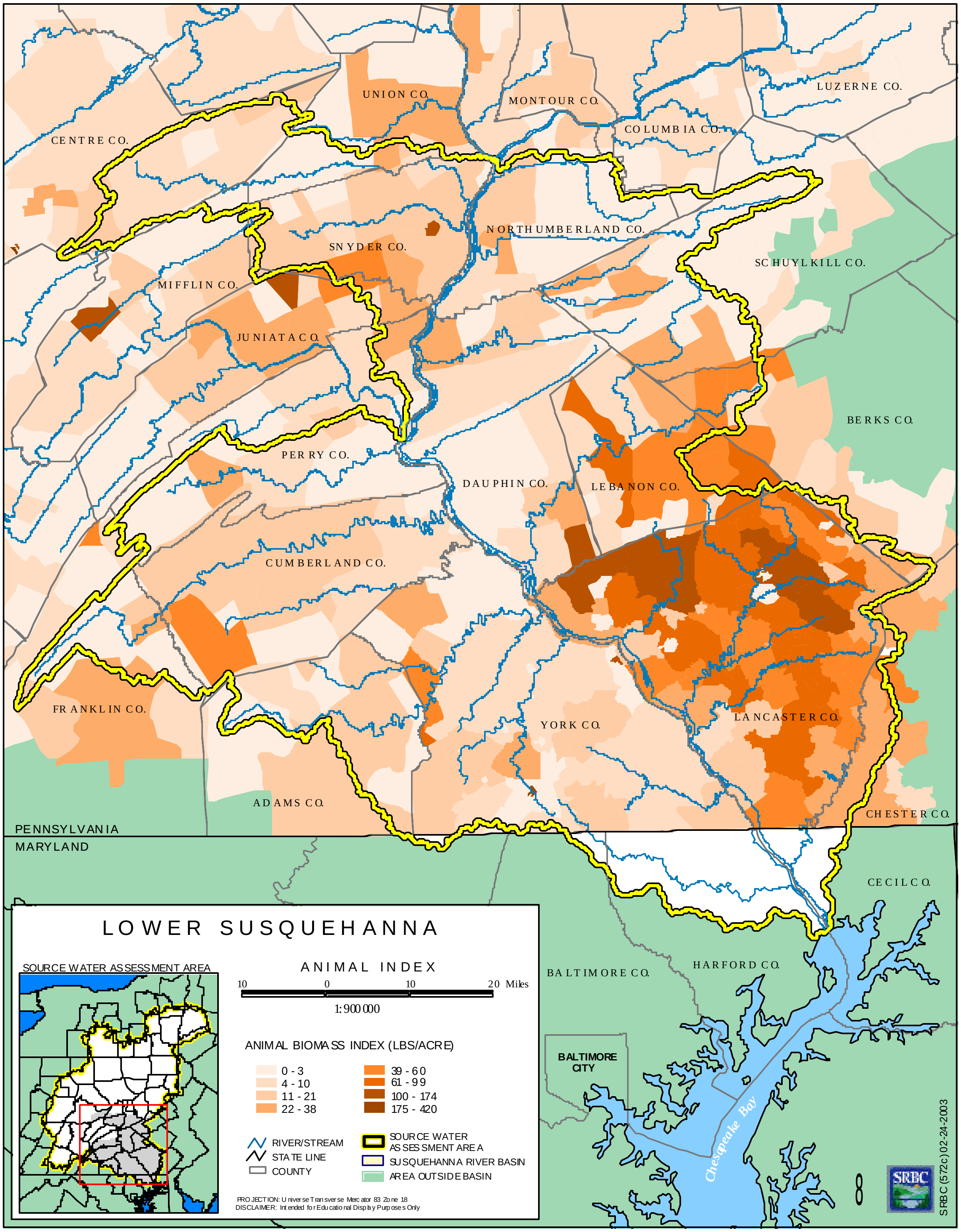

Figure 9. **Animal Biomass Index for the Pennsylvania Portion of the Lower Susquehanna Subbasin**

Although their occurrence is not as frequent as the previously mentioned contaminants, herbicide/pesticide usage also has been documented to contribute contaminants to waterways from runoff associated with agricultural activities. Aside from agricultural sources, residential use of lawn fertilizers/pesticides, as well as increases in the number of golf courses, is responsible for an increase in the contribution of these types of contaminants as development increases in the Lower Susquehanna Subbasin.

Within the Lower Susquehanna Subbasin, there are three major metropolitan areas (Harrisburg, Lancaster, and York). Development has been rapidly expanding for both residential and commercial areas. Runoff from these developed areas can lead to increased problems with VOCs, SOCs, metals, and turbidity. Runoff containing road de-icing chemicals is also becoming an increasing problem during the winter months. On such occasions, the presence of several bridges in the lower subbasin, with minimal drainage controls, has caused some water suppliers to experience problems with chlorine demand during treatment due to ammonia levels present in road de-icers.

B. Point Discharge Concerns

Point-source pollutants generally refer to instream discharges that have a discrete, identifiable outfall, regulated by the state and federal government. Point sources are commonly called "end of pipe" discharges. Examples of point sources include sewage treatment plants and industrial wastewater discharges. For this assessment, point sources were identified using GIS datasets provided by the USEPA, Pa. DEP, and MDE. For permits located within the Lower Susquehanna Subbasin, discharge monitoring reports were reviewed and water quality violations were noted.

There are approximately 1,152 permitted discharge sites in the entire Susquehanna River Basin covered under the USEPA's National Pollutant Discharge Elimination System (NPDES). Of that total, there are 115 sites located in New York, 1,024 in Pennsylvania, and 13 in Maryland. Within the Lower Susquehanna River Basin there are about 372 NPDES discharges upstream of Baltimore's intake. Of these dischargers, 245 (66 percent) are municipal and 111 (29 percent) are industrial. Sixteen sites (5 percent) are a combination municipal/industrial. Within the Maryland portion of the assessment area, there are 2 municipal and 2 industrial discharges. The NPDES map (Appendix 4) in the appendix shows the sites within Baltimore's assessment area for the Lower Susquehanna Subbasin. A majority of the municipal sources discharge contaminants such as nutrients, while the industrial sources discharge a full range of contaminants (metals, VOCs, SOCs, etc.). It is important to note that mine and quarry operations do not always have NPDES permits for discharges, based on differences in the way the sites are managed and regulated.

The USGS NAWQA Program summarized nutrient levels in the lower Susquehanna River Basin between 1975 and 1990. Based on volume, the two primary contaminants of concern associated with point-source discharges in the Lower Susquehanna Subbasin are nitrogen and phosphorus. With respect to point source contribution, about 60 percent of the nitrogen comes from municipal discharges, while almost 90 percent of the phosphorus load comes from industrial sources such as food processing facilities and pharmaceutical laboratories (Risser and Siwiec, 1996). Overall, point-source nitrogen loads exceed phosphorus loads in the Susquehanna River and its tributaries. The study determined that the Codorus Creek, the Juniata River, and the Conestoga River receive the majority of the nitrogen and phosphorus loads from municipal dischargers, with nitrogen loads significantly higher than phosphorus loads.

Overall, estimated nutrient loads from point sources are significantly lower than loads emanating from nonpoint sources. Another USGS study (Sprague and others, 2000) found that approximately 10 percent and 27 percent of the total load for nitrogen and phosphorus, respectively, originate from point sources within the Susquehanna basin.

Based on permits reviewed for this assessment, flows from municipal and industrial discharges in the Lower Susquehanna Subbasin are estimated to comprise less than 5 percent of the mean annual flow for the Susquehanna River, as measured at Marietta, Pa. Average flows from municipal and industrial discharges are estimated to be 110 mgd and 50 mgd, respectively. These estimates did not include flows associated with non-contact cooling water.

Several power plants comprise the majority of the flow contribution to the Susquehanna from point-source discharges in the Lower Susquehanna Subbasin. Table 11 shows the facilities and their associated flows. Water used for non-contact cooling processes in 2001 comprised almost 20 percent of the flow in the lower Susquehanna River as measured at Marietta, Pa., during the same time period (approximately 15,000 mgd).

Table 11. Power Facilities Located in the Lower Susquehanna Subbasin

Permit Number	Permit Name	Design Flow (mgd)	Average Flow (mgd)	Average Flow for Non-contact Cooling (mgd)
Non-contact Cooling				
PA0008281	PP&L Brunner Island	744.5	580	580
PA0009733	Exelon Energy Company – Peach Bottom	2,199.8	1,960	1,960
PA0009920	AmerGen Energy Company - TMI	83.4	20	20
PA0008451	Sunbury Generation LLC	330.0	260	260
Power Generation				
PA0009741	Exelon Energy Company – Muddy Run	N/A	6.40	--
PA0008435	PP&L Holtwood	N/A	0.17	--
PA0044628	York Haven Power Company	N/A	0.28	--
PA0032379	Safe Harbor Water Power Corporation	N/A	0.03	--
MD0002518	Susquehanna Energy Company (SEC)	N/A	5,000	--
Total Flows		**3,357.7**	**7,826.88**	**2,820**

C. Transportation Related Concerns

Transportation crossings on the Susquehanna River mainstem are another concern due to the possibility of spills. There are approximately 51 road and railroad crossings over the Susquehanna River in Pennsylvania. Most of these crossings are U.S. Routes or State Routes that are classified as a primary highway. Fifteen crossings are by rail. The majority of pipeline and utility crossings are found within the Lower Susquehanna Subbasin. Below Sunbury there are 19 road/train crossings, 10 pipeline crossings and 35 utility crossings.

The heaviest bridge traffic occurs in the Harrisburg area, with three major interstates and two railroad crossings. Spills involving oil, fertilizers, and other hazardous materials have occurred within the past five years, although the impact has been minimal due to rapid spill response and cleanup, as well as dilution in the river itself.

Pennsylvania State Route 30 in Lancaster, and Route 372 near Holtwood, are the last major road crossings before Baltimore's intake. Although there have been no significant spills in recent years, water suppliers downstream of bridges have experienced treatment problems in the winter due to the use of road de-icers. The particular compound used increases chlorine demand and poses a problem for coagulation treatment.

Pipeline crossings in the Lower Susquehanna Subbasin are a mix of refined petroleum and natural gas. No known pipeline breaches resulting in releases to the river were identified from literature review. Table 12 shows pipeline crossings in the Susquehanna basin in order of closest proximity to Baltimore's intakes.

Table 12. Pipelines Crossing the Susquehanna River Upstream of Baltimore's Intake

Pipeline Name/Company	River Crossing	Commodity
Williams Gas Co. Pipeline - Transco	Lower Lanc./York Co., Pa.	Natural gas
Texas Eastern Transmission Corp.	Wrightsville/Columbia, Pa.	Natural gas
Sun Pipeline Co.	Highspire/New Cumberland, Pa.	Refined Products. Liquefied Petroleum Gas, Crude Oils
Buckeye Pipeline	Highspire/New Cumberland, Pa.	Refined Petroleum Product
Texas Eastern Products Pipeline Co.	Highspire/New Cumberland, Pa.	Liquefied Petroleum Gas
Buckeye Pipeline	Marysville/Harrisburg, Pa.	Refined Petroleum Product
Texas Eastern Transmission Corp.	Speeceville/Perry Co. , Pa.	Natural gas
Buckeye Pipeline	Duncannon, Pa.	Refined Petroleum Product
Sun Pipeline Co.	Northumberland Co., Pa.	Refined Products. Liquefied Petroleum Gas, Crude Oils
Sun Pipeline Co.	Berwick, Pa.	Refined Products. Liquefied Petroleum Gas, Crude Oils
Williams Gas Co. Pipeline - Transco	Berwick, Pa.	Natural gas
Williams Gas Co. Pipeline - Transco	Wyoming, Pa.	Natural gas
Exxon Pipeline Co.	Pittston, Pa.	Refined Petroleum Product
Sun Pipeline Co.	Ransom, Pa.	Refined Products. Liquefied Petroleum Gas, Crude Oils
Tennessee Gas Pipeline Co.	Wyalusing, Pa.	Natural gas

D. Land Use Planning Concerns

Maryland

The populations in Cecil and Harford Counties, Md. have increased over the past decade. From 1990 to 2000, the population in both counties increased by about 20 percent. As mentioned in the previous discussions on land use, little more than 12 percent of the assessment area in Maryland is significantly developed. So a majority of the county's planning efforts are focused on agricultural activities. Land use changes in the county over the past 10 years has been predominantly through the conversion of agricultural lands to developed lands, although forested to developed land use conversion is common as well in some areas.

As of 1999, Harford County had 27,500 acres of permanent agricultural easements. Harford County's agricultural land preservation program allows landowners to preserve farmland for future generations. Cecil County also has some agricultural easements. With respect to conservation practices, the County Soil Conservation Districts have assisted farmers with the installation of riparian buffers on crop and pasturelands, through programs such as the Conservation Reserve Enhancement Program. Additionally, the retirement of steep croplands within 1,000 feet of waterbodies is being promoted, as is the construction of wetlands in croplands.

The Environmental Quality Incentive Program supports a wide range of conservation practices including grassed waterways, nutrient management, manure storage, and other practices. This program has active participation, as does the Maryland Cost Share Program that assists with stream crossings for livestock, watering troughs, and riparian buffers.

Pennsylvania

Several of the heavily agricultural counties in the Pennsylvania portion of the assessment area also employ many of the same types of conservation programs as Maryland. Many watershed groups and county conservations districts are planning and implementing restoration projects for various watersheds with both state and federal grant assistance. With agricultural land use exceeding 60 percent, both Lancaster and York Counties have very active farm preservation programs. Last year, close to 60 farms, encompassing 60,000 acres of farmland, were preserved in the two counties under the conservation easement program.

In addition to the conservation easement program, there are numerous other efforts working towards the goal of reducing nonpoint agricultural runoff. Within the lower counties, there are over 30 active USEPA 319 Nonpoint Source Control projects active in York and Lancaster Counties. Pennsylvania's Growing Greener Grant Program has funded dozens more. A sample list of activities ongoing in the two counties includes streambank restoration, fencing, wetland construction, installation of manure treatment systems, best management practices (BMPs) effectiveness studies, and numerous educational activities. In recent years, there also has been special focus on such tributaries of concern as Codorus Creek, Pequea Creek, Chickies Creek, Octoraro Creek, and the Conestoga River. River conservation plans are underway or completed for several of these waterbodies. One of the largest contributors of nutrients to the Susquehanna River, the Conestoga, is currently the focus of a pilot nutrient trading project. It is hoped that this project will determine the best way to manage and reduce nutrient inputs from both nonpoint and point sources.

Aside from agricultural issues, the Lower Susquehanna Subbasin in Pennsylvania is experiencing an increase in water quality problems associated with development. The second biggest source of contamination in the southernmost counties is related to development issues. Specific examples of sources include urban runoff, storm sewers, construction, runoff from residential areas, and road runoff. Development pressure is increasing due to growth in both the southcentral Pennsylvania corridor (York, Lancaster, and Harrisburg), as well as expansion of the Baltimore commuter communities to southern Adams and York Counties.

Currently, there are only a handful of stormwater management plans developed for watersheds in the Lower Susquehanna Subbasin. These plans were developed under Pennsylvania's Act 167 Stormwater Management Program. The development of an Act 167 Plan is voluntary, so few are approved and operational at present. In York and Lancaster Counties, approximately 50 miles of stream impaired by urban/residential sources are covered under an Act 167 Plan. With the implementation of USEPA's NPDES Phase II Program, stormwater and urban runoff controls should improve with mandatory BMP construction. However, there are still several communities in the lower subbasin that will not be covered under the program. Full implementation of the program also will not take effect for several years, and program effectiveness will not be measurable until a numbers of years beyond that.

VII. SUSCEPTIBILITY ANALYSIS (FOR EACH CONTAMINANT CLASS)

Each class of contaminants that were detected in the water will be analyzed based on the potential for contaminating the water supply. The analysis will identify suspected sources of contaminants, evaluate the natural conditions in the watershed that may decrease or increase the likelihood of a contaminant entering the reservoir, and evaluate the impacts that future changes may have on the susceptibility of the reservoir.

A. Evaluation of Available Water Quality Data

The USEPA requires testing of finished water at all public water supply treatment plants. As stated earlier, the plant analyses indicated no problems with any particular contaminant class, with the exception of chlorination byproducts.

B. Review of Potential Sources of Contamination

After review of all the data, several contaminant classes could potentially pose a threat to Susquehanna source water quality. Most of the problems associated with daily use of the intake during the summer months seem to be related to nuisance algal blooms, which contribute to treatment problems and adverse odor and taste problems. Additionally, in the absence of significant algal mass, it has been seen that actinomycete bacteria, which produces 2-methylisoborneol and geosmin, very potent odor producing compounds, have been detected during periods of odor problems at the Conowingo Pool.

The expansion of animal operations and flows associated with wastewater treatment plants in the Lower Susquehanna Subbasin pose an ever-increasing threat of microbial contamination. In addition, inorganic contaminants such as nitrate and trace metals are introduced from the same types of sources. Development pressure in York and Lancaster Counties also will increase the likelihood for the introduction of VOCs, SOCs, and trace metals into streams. In order of significance, the following paragraphs highlight the perceived threats to source water quality regarding use of the City's Susquehanna intake.

Microbial Contaminants

Coliforms and protozoa originate throughout the lower Susquehanna River Basin by several means. Agricultural manure application, concentrated feeding operations, and general management practices may contribute significantly to the amount of fecal material that enters surface waters through runoff. Human waste is also a feasible source of contamination through permitted point-source discharges of wastewater treatment plants, onsite septic systems, or the unpredictable overflow of sewer systems during storm events.

While total and fecal coliform counts indicate that microbial contamination near the intake is within water quality criteria concerning state designated use for acceptable densities (MDE 488-3), periodic influx of increased coliform density and large densities upstream may indicate potential contaminant sources of concern. The results could be a product of seasonal changes, involving storm events that contribute to an increase in surface runoff, or variable point source discharges of significance. The collection of frequent upstream raw water coliform data may increase understanding of microbial susceptibility for the City's Susquehanna intake.

Awareness of upstream management practices, or upstream water quality conditions, also may increase the ability of the City to protect the overall quality of the Susquehanna intake against microbial contaminants.

The agricultural land in Lancaster County, Pa., probably contributes the most significant amount of fecal coliforms and other microbial contaminants to the water supply, as illustrated by the index map (Figure 11). Periods of heavy rainfall increase turbidity, as well. This increase in turbidity is likely to increase the coliforms moving down the river. Coliform data collected by MDE from 2000 to 2002 also indicated that higher levels of coliforms were more likely to be found during the winter months, due to improper manure storage and increased runoff from frozen agricultural lands. .

Disinfection Byproducts

Disinfection of drinking water is one of the major public health advances in the 20th century. In the past, typhoid and cholera epidemics were common throughout the United States. Disinfection was the major reason for the reduction in these epidemics, and it is an essential part of drinking water treatment today. However, while disinfectants are effective in controlling many microorganisms, chlorine compound disinfectants react with natural organic and inorganic matter in source water and distribution systems to form potentially harmful disinfection byproducts (DBPs).

Many of these DBPs have been shown to cause cancer and reproductive and developmental effects in laboratory animals. Chlorine can combine with natural organic or inorganic materials in the raw water to create a group of related contaminants called trihalomethanes (THMs). THMs are known to cause liver, kidney, or central nervous system problems in animals used for testing. Repeated exposure to elevated levels of THMs or haloacetic acids, another group of contaminants associated with chlorine’s reaction with natural organic material, over a long period of time could increase a person's risk of cancer.

The formation of DBPs is a concern for the City, based on the nature of the source. Surface water sources are more likely to contain the organic materials that combine with chlorine to form DBPs. In addition, the Conowingo Pool has some similarities to a lake under certain flow conditions, thus increasing the effects of eutrophication. As discussed in previous sections, the level of nutrient and sediment input into the Conowingo Pool can compound the problem. Nutrients such as phosphorus increase the rates of production of aquatic biomass, while organic matter attached to sediment can increase TOC. Low-flow conditions in the river, particularly in the summer months, can increase the effects of any of the aforementioned processes.

Other factors controlling the formation of DBPs include source water pH and temperature. Biological activity discussed in the previous paragraph can cause small changes in pH. However, temperatures can fluctuate significantly not only with the change of seasons, but both laterally and vertically in Conowingo Pool depending on the river flows.

Nitrates

Sources of nitrate in the Lower Susquehanna Subbasin are numerous. Fertilizer/manure runoff, leaching from septic tanks, wastewater effluent, atmospheric deposition, and erosion of natural deposits all has the potential for contributing nitrate to the water supply. Nitrates have been detected in finished water; however, no samples have been close to the 50 percent MCL trigger.

Since so much land use within the basin is agricultural, nitrate will continue to enter the water supply. It is unlikely that nitrates will increase in the future based on long-term decreasing trends in loads observed in the more heavily agricultural watersheds in the lower Susquehanna Subbasin. With regards to point-source discharges, it is believed that any increase in the numbers of facilities will be offset by improvements in removal technologies. Presently, only 2 percent of the nitrogen load is trapped by the Conowingo Reservoir, so any change in storage capacity associated with the dam is probably insignificant from the water system's perspective.

Volatile Organic Compounds and Synthetic Organic Compounds

The only VOCs detected were those typically resulting from DBPs of drinking water chlorination (discussed separately in previous page). However, the level of activity in the vicinity of Conowingo Pool warrants some concern for VOC contamination. Maryland State Route 1 runs across the dam just downstream of the intake, and Pennsylvania Route 372 crosses not far upstream. There exists the possibility of a spill traveling upstream or commingling with downstream waters under certain flow conditions, based on the eddy currents discussed in previous sections. Although there are no major roads running along the pool, the secondary roads may pose more of hazard due to their poor condition. In addition, Norfolk Southern operates an active railway that runs the length of the pool along the eastern shore.

And although SOCs have been detected at the treatment plant, all the analyses indicate that concentrations were below 50 percent of the MCL. USGS studies have indicated herbicides such as atrazine, cyanazine, alachlor, and simazine have been detected above MCLs in tributaries; however, the dilution occurring in the mainstem of the Susquehanna appears to mitigate the impact of SOC contamination. The same can be said for the other organic contaminants. However, increasing use of such compounds in the environment has the potential to cause future problems.

Trace Metals

Based on the extensive testing performed by the City, levels of trace metals appear to pose a minimal threat to drinking water contamination. The field data reviewed also suggests that the occurrence of trace metals in the mainstem of the Susquehanna River is well below drinking water standards. Although the Susquehanna Basin has significant problems with AMD in the middle region of the basin, the effects are mitigated by the volume of flow present in the mainstem of the river.

Radionuclides

Although radioactive monitoring values remain quite constant and low concentrations are the norm, the existence of several nuclear power generating plants with outfalls along the Susquehanna River upstream of Baltimore's intakes indicates a significant potential for radionuclide contamination. Based solely on close proximity to the intake, the Peach Bottom should be considered a potential source of contamination. The accident at the Three Mile Island facility in 1979 is an example that the possibility does exist.

Contaminants used to clean water intake and cooling tower structures can also pose a unique problem for water supply intakes downstream of nuclear facilities. Pesticides are often used to control organisms, such as zebra mussels, from attaching to the structures. Regular cleaning of the same structures can also introduce halogenated disinfectants, commonly chlorine based, which can lead to DBP formation.

VIII. RECOMMENDATION FOR SOURCE WATER PROTECTION PLAN

The assessment report for Baltimore's Susquehanna intake was developed to provide the city with the information it needs to best protect its raw source. Although the vast size of the assessment area creates a daunting task in terms of source protection, there are feasible steps that can be taken to improve the use of the source. With the information contained in this report, the City is in a position to better understand the water supply area, track potential contaminant sources, identify critical protection areas, and evaluate the potential for future problems. It is hoped that the information will assist the City's management of resources associated with source water protection activities. Some recommendations are presented in the following sections.

A. Increase Communication

The City does not own or control properties abutting the Conowingo Pool nor does it own, control or manage properties upstream of the intake facility. However, many comprehensive planning, restoration, and protection efforts are currently underway in the Lower Susquehanna Subbasin. Source water protection efforts could be improved with minimal resources by increasing the level of communication with other water suppliers, local/state/federal agencies, and the emergency response community. Efforts could be focused on priority issues identified within this assessment report.

The immediate protection priority for the Susquehanna source is the Conowingo Pool itself. Based on the size of the assessment area, it is not feasible to expect the City to effectively work on controlling water quality conditions in the pool. However, knowing when and why certain conditions may exist could help with management of the source. The City's present and continued participation in studies/activities directly related to water quality conditions in the Conowingo Pool will have the most direct effect on intake operations.

The SRBC and Pa. DEP are currently developing the framework for an early warning communication network for the Susquehanna River and major tributaries. The goal of the system is to provide water suppliers and the emergency response community the means for exchanging water quality information for the purpose of protecting the public health and improving treatment strategies. The City is encouraged to participate in activities related to this project.

In addition, the U.S. Army Corp of Engineers (USACE) Section 22 Lower Susquehanna Comprehensive Water Resources Study is currently underway. The USACE has partnered with Pa. DEP, SRBC, and the Capital Region Water Board (CRWB), to develop a management plan for the water resources in southcentral Pennsylvania. The study may provide additional information for the understanding of the assessment area.

In regards to planning information, the City could establish a protocol for regularly obtaining updates on state and county planning initiatives relating to source water quality issues such as:

- Stormwater management planning;
- Agricultural runoff prevention programs; and
- Land use planning initiatives.

Emergency action plans also should be developed or updated concerning potential threats to source water integrity in the vicinity of Conowingo Pool. Establishing a point of contact for transportation-related accidents associated with Maryland State Route 1 on Conowingo Dam, and the Norfolk Southern Railway running parallel to the Conowingo Pool's east shore, could improve the management of intake operations during accidents. Additionally, the number of power generation facilities in the Conowingo Pool poses a unique threat if an accident occurs at a facility.

B. Public Awareness and Outreach

A public meeting presenting the results of this source water assessment was held on March 5, 2003, in Havre de Grace. Over 15 people attended the meeting, including 2 individuals from the City and 6 individuals representing local, state, and federal agencies. Several local citizens were also in attendance.

A summary of this assessment should be included in future Consumer Confidence Reports. Full reports will be available at public libraries, town/city offices, or by contacting the Water Supply Program of MDE. The City maintains a well organized, informative website that details drinking water quality for the system (http://www.ci.baltimore.md.us/government/dpw/water.html). These efforts should be continued. The addition of summary information from this assessment report would assist the public in understanding conditions affecting the quality of their drinking water source

Increased education and coordination can enhance support for source water protection activities. Based on this concept, the SRBC conducted a workshop in 1999 focusing on the formation of community partnerships to foster or enhance source water protection efforts (SRBC, 1999). The goal was to bring together a diverse group of representatives from government, industry, academia, and citizen groups for the purpose of developing a source water protection plan for Swatara Creek Watershed. The groups were asked to present ideas for developing and implementing the steps needed for source water protection, with the emphasis on utilizing effective partnerships. The basic steps identified were: (1) establish a steering committee; (2) delineate the protection area; (3) identify the sources of contamination; (4) determine the methods to be utilized; and (5) implement the plan of action.

The model outlined at the workshop has proven to be an effective catalyst for source water protection efforts. Results that can be linked to the success of the workshop include:

- The establishment of the Swatara Creek Watershed Association as an example of the importance of citizen involvement in source protection efforts;
- The Swatara becoming a pilot watershed for Pa. DEP's new Environmental Futures Planning Initiative; and
- The development of the USACE Lower Susquehanna Comprehensive Water Resources Study, working in partnership with the SRBC, Pa. DEP, and a regional water suppliers board.

A similar model could be followed by potential stakeholders in the Maryland portion of the basin as well. The formation of community partnerships can facilitate reaching a consensus on the steps needed to solve complex water quality issues. It also provides the necessary support needed to acquire funds to perform the necessary work.

C. Monitoring

As demand for use of the Susquehanna River increases, the City would greatly benefit from an increase in the frequency of water quality sampling at the intake location. The City does collect samples periodically. However, based on the physical and chemical limnology of the river and the pool, water quality conditions can vary significantly with depth, changes in temperature, and magnitude of flows. Real-time monitors for pH, turbidity, and TOC could assist with treatment strategy, and serve as a surrogate indicator for several types of contamination.

Other monitoring suggestions include:

- Continue to monitor current list of constituents.
- Participate in a cooperative relationship with other agencies, or water suppliers, in sampling efforts in the lower Susquehanna River.
- Develop a monitoring plan to assess trends in microbial concentrations at the intake, in order to assist with improving susceptibility characterization.
- Conduct monitoring for parameters relating to nuisance problems associated with algal material (algal organisms, chlorophyll-a, etc.)
- Develop a monitoring plan to assess other parameters of importance outlined in this report (VOC/SOCs, emerging contaminants, etc.).
- Continuous monitoring of TOC, to assist with the management of DBPs resulting from chlorination.

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Appendix 1. Major Watersheds within the Six Susquehanna Subbasins

Major watersheds in the Upper Susquehanna Basin

Cayuta Creek Watershed	Oaks Creek Watershed
Catatonk Creek Watershed	Otego Creek Watershed
Owego Creek Watershed	Cherry Valley Creek Watershed
Nanticoke Creek Watershed	Schenevus Creek Watershed
Wappasening Creek Watershed	Charlotte Creek Watershed
Apalachin Creek Watershed	Ouleout Creek Watershed
Choconut Creek Watershed	Snake Creek Watershed
Tioughnioga River Watershed	Saltlick Creek Watershed
Otselic River Watershed	Starrucca Creek Watershed
Chenango River Watershed	Susquehanna River
Unadilla River Watershed	

Major Watersheds in Chemung Basin

Canisteo River Watershed	Tioga River Watershed
Cowanesque River Watershed	Seeley Creek Watershed
Cohocton River Watershed	Chemung River Watershed

Major Watersheds in the West Branch Susquehanna Basin

Sinnemahoning Creek Watershed	Anderson Creek Watershed
Kettle Creek Watershed	Chest Creek Watershed
Young Woman's Creek Watershed	Clearfield Creek Watershed
Pine Creek Watershed	Moshannon Creek Watershed
Larry's Creek Watershed	Beech Creek Watershed
Lycoming Creek Watershed	Bald Eagle Creek Watershed
Loyalsock Creek Watershed	Fishing Creek Watershed
Muncy Creek Watershed	Buffalo Creek Watershed
Mosquito Creek Watershed	White Deer Hole Creek Watershed
West Branch Susquehanna River Watershed	Chillisquaque Creek Watershed

Major Watersheds in the Middle Susquehanna Basin

Sugar Creek Watershed	Bowman Creek Watershed
Towanda Creek Watershed	Lackawanna River Watershed
Wysox Creek Watershed	Susquehanna River Watershed
Wyalusing Creek Watershed	Fishing Creek Watershed
Meshoppen Creek Watershed	Nescopeck Creek Watershed
Tunkhannock Creek Watershed	Catawissa Creek Watershed
Mehoopany Creek Watershed	Roaring Creek Watershed

Major Watersheds in the Juniata River Basin

Raystown Branch Juniata River Watershed	Kishacoquillas Creek Watershed
Frankstown Branch Juniata River Watershed	Tuscarora Creek Watershed
Little Juniata River Watershed	Juniata River Watershed
Shaver Creek Watershed	Buffalo Creek Watershed
Standing Stone Creek Watershed	

Major Watersheds in the Lower Susquehanna Basin

Penns Creek Watershed	Yellow Breeches Watershed
Middle Creek Watershed	West Conewago Creek Watershed
Shamokin Creek Watershed	Chickies Creek Watershed
Mahanoy Creek Watershed	Conestoga River Watershed
Mahantango Creek Watershed	Codorus Creek Watershed
Wiconisco Creek Watershed	Muddy Creek Watershed
Susquehanna River Watershed	Pequea Creek Watershed
Sherman Creek Watershed	Octoraro Creek Watershed
Swatara Creek Watershed	Deer Creek Watershed
Conodoguinet Creek Watershed	

Appendix 2. Impairments of Major Streams in the Susquehanna River Basin

Subbasin/ State (ID)	Watershed Name	Source of Impairment	Cause of Impairment
Lower Susquehanna			
MD(02120202)	Deer Creek	Unknown	Biological
MD(02120203)	Octoraro Creek	Unknown	Biological
MD(02120205)	Muddy Creek (Broad Creek)	Unknown	Biological
MD(02120201)	Susquehanna River	Unknown	Biological
		Non-point, Natural	Metals
		Non-point, Natural	Nutrients
		Non-point, Natural	Sediments
		Undefined	Toxics
MD(02120204)	Susquehanna River (Conowingo Dam)	Undefined	Bacteria
		Unknown	Biological
		Atmospheric Deposition	Metals
		Non-point, Natural	Nutrients
		Non-point, Natural	Sediments
PA(7I)	Deer Creek	Agriculture	Nutrients
		Agriculture	Suspended Solids
PA(7K)	Octoraro Creek	Agriculture	Nutrients
		Agriculture	Siltation
		Agriculture	Organic Enrichment/Low DO
PA	Susquehanna River	Agriculture	Nutrients
		Agriculture	Siltation
		Agriculture	Organic Enrichment/Low DO
		Grazing Related Agriculture	Nutrients
		Grazing Related Agriculture	Siltation
		Urban Runoff/Storm Sewers	Siltation
		Road Runoff	Water/Flow Variability
		Road Runoff	Siltation
		Channelization	Water/Flow Variability
		Other	Cause Unknown
		Habitat Modification	Other Habitat Alterations
PA(7I)	Muddy Creek	On Site Wastewater	Taste and Odor
		On Site Wastewater	Organic Enrichment/Low DO
		Petroleum Activities	Oil and Grease
PA(7K)	Pequea Creek	Grazing Related Agriculture	Nutrients
		Grazing Related Agriculture	Siltation
		Crop Related Agriculture	Siltation
		Agriculture	Organic Enrichment/Low DO
PA(7J)	Conestoga River	Agricultural	Nutrients
		Agricultural	Siltation
		Crop Related Agriculture	Nutrients
		Crop Related Agriculture	Siltation
		Grazing Related Agriculture	Nutrients
		Grazing Related Agriculture	Siltation
		Urban Runoff/Storm Sewers	Cause Unknown
		Urban Runoff/Storm Sewers	Nutrients
		Urban Runoff/Storm Sewers	Siltation
		Urban Runoff/Storm Sewers	Suspended Solids
		Small Residential Runoff	Nutrients
		Small Residential Runoff	Siltation
		Road Runoff	Siltation
		Golf Courses	Nutrients
		Municipal Point Source	Chlorine
		Surface Mining	Siltation
		Upstream Impoundment	Siltation

Subbasin/ State (ID)	Watershed Name	Source of Impairment	Cause of Impairment
		Channelization	Siltation
		Channelization	Flow Alterations
		Removal of Vegetation	Siltation
		Other	Organic Enrichment/Low DO
		Land Development	Siltation
		Erosion from Derelict Land	Cause Unknown
		Erosion from Derelict Land	Siltation
PA(7G)	Chickies Creek	Agriculture	Siltation
		Agriculture	Nutrients
		Urban Runoff/Storm Sewers	Flow Alterations
		Urban Runoff/Storm Sewers	Metals
		Urban Runoff/Storm Sewers	Cause Unknown
		Other	Other Habitat Alterations
PA(7H)	Codorus Creek	Agriculture	Siltation
		Agriculture	Nutrients
		Agriculture	Flow Alterations
		Agriculture	Suspended Solids
		Urban Runoff/Storm Sewers	Flow Alterations
		Urban Runoff/Storm Sewers	Siltation
		Channelization	Other Habitat Alterations
		Industrial Point Source	Suspended Solids
		Industrial Point Source	Organic Enrichment/Low DO
		Industrial Point Source	Thermal Modifications
		Industrial Point Source	Color
		Habitat Modification	Other Habitat Alterations
		Municipal Point Source	Nutrients
PA(7F)	West Conewago Creek	Agriculture	Suspended Solids
		Other	Suspended Solids
PA(7D)	Swatara Creek	Agriculture	Nutrients
		Agriculture	Siltation
		Agriculture	Organic Enrichment/Low DO
		Crop Related Agriculture	Nutrients
		Crop Related Agriculture	Siltation
		Abandoned Mine Drainage	Metals
		Abandoned Mine Drainage	Suspended Solids
		Abandoned Mine Drainage	pH
		Construction	Siltation
		Road Runoff	Siltation
		Urban Runoff/Storm Sewers	Siltation
		Urban Runoff/Storm Sewers	Suspended Solids
		Municipal Point Source	Nutrients
		On Site Wastewater	Organic Enrichment/Low DO
		Natural Sources	Water/Flow Variability
		Other	Siltation
PA(7E)	Yellow Breeches Creek	Agriculture	Nutrients
		Agriculture	Siltation
		Agriculture	Organic Enrichment/Low DO
		Agriculture	Other Habitat Alterations
		Construction	Siltation
		Construction	Organic Enrichment/Low DO
		Construction	Other Habitat Alterations
		Urban Runoff/Storm Sewers	Siltation
		Urban Runoff/Storm Sewers	Cause Unknown
		Hydromodification	Water/Flow Variability
		Habitat Modification	Other Habitat Alterations
		Source Unknown	Siltation
		Source Unknown	Flow Alterations
		Atmospheric Deposition	pH

Subbasin/ State (ID)	Watershed Name	Source of Impairment	Cause of Impairment
PA(7B)	Conodoguinet Creek	Agriculture	Pesticides
		Agriculture	Nutrients
		Agriculture	Suspended Solids
		Habitat Modification	Flow Alterations
		Construction	Siltation
		Land Disposal	Cause Unknown
		Land Disposal	Priority Organics
		Other	Organic Enrichment/Low DO
		Other	Siltation
		Other	Nutrients
		Source Unknown	Cause Unknown
PA(7A)	Sherman Creek	Removal of Vegetation	Siltation
		Crop Related Agriculture	Siltation
		Grazing Related Agriculture	Nutrients
		Grazing Related Agriculture	Siltation
		Atmospheric Deposition	Metals
PA(6C)	Wiconisco Creek	Agriculture	Siltation
		Agriculture	Nutrients
		Crop Related Agriculture	Siltation
		Grazing Related Agriculture	Siltation
		Removal of Vegetation	Siltation
		Small Residential Runoff	Nutrients
		Abandoned Mine Drainage	pH
		Abandoned Mine Drainage	Metals
		Abandoned Mine Drainage	Siltation
PA(6C)	Mahantango Creek	Agriculture	Siltation
		Silvaculture	Siltation
		Road Runoff	Siltation
		Removal of Vegetation	Siltation
PA(6B)	Mahanoy Creek	Grazing Related Agriculture	Organic Enrichment/Low DO
		Grazing Related Agriculture	Siltation
		Crop Related Agriculture	Siltation
		Agriculture	Siltation
		Abandoned Mine Drainage	Metals
		Abandoned Mine Drainage	pH
		Abandoned Mine Drainage	Water/Flow Variability
		Abandoned Mine Drainage	Siltation
		Atmospheric Deposition	pH
PA(6A)	Middle Creek	Atmospheric Deposition	pH
		Grazing Related Agriculture	Siltation
		Grazing Related Agriculture	Nutrients
PA(6A)	Penns Creek	Grazing Related Agriculture	Siltation
		Crop Related Agriculture	Siltation
		Animal Feeding Agriculture	Nutrients
		Animal Feeding Agriculture	Siltation
PA(6B)	Shamokin Creek	Grazing Related Agriculture	Organic Enrichment/Low DO
		Grazing Related Agriculture	Siltation
		Agriculture	Organic Enrichment/Low DO
		Agriculture	Siltation
Juniata			
PA	Juniata River	Crop Related Agriculture	Siltation
PA(12B)	Buffalo Creek	Crop Related Agriculture	Siltation
PA(12B)	Tuscarora Creek	Agriculture	Siltation
		Grazing Related Agriculture	Nutrients
		Grazing Related Agriculture	Siltation
PA(12A)	Kishacoquillas Creek	Agriculture	Nutrients
		Agriculture	Siltation
		Agriculture	Water/Flow Variability
		Agriculture	Flow Alterations

Subbasin/ State (ID)	Watershed Name	Source of Impairment	Cause of Impairment
		Urban Runoff/Storm Sewers	Siltation
		Urban Runoff/Storm Sewers	Flow Alterations
		Urban Runoff/Storm Sewers	Other Habitat Alterations
		Hydromodification	Siltation
		Hydromodification	Water/Flow Variability
PA(12C)	Aughwick Creek	Crop Related Agriculture	Nutrients
		Crop Related Agriculture	Nutrients
		Grazing Related Agriculture	Siltation
PA(11D)	Raystown Branch	Abandoned Mine Drainage	Metals
		Abandoned Mine Drainage	pH
PA(11B)	Standing Stone Creek	No Listings	
PA(11B)	Shaver Creek	No Listings	
PA(11A)	Frankstown Branch	Industrial Point Source	Suspended Solids
		Industrial Point Source	Priority Organics
		Industrial Point Source	Cause Unknown
		Road Runoff	Siltation
		Urban Runoff/Storm Sewers	Cause Unknown
		Abandoned Mine Drainage	Metals
		Abandoned Mine Drainage	pH
		Abandoned Mine Drainage	Siltation
		Combined Sewer Overflow	Organic Enrichment/Low DO
PA(11A)	Little Juniata River	Urban Runoff/Storm Sewers	Cause Unknown
		Municipal Point Source	Organic Enrichment/Low DO
West Branch Susquehanna			
PA	West Branch Susquehanna River	Abandoned Mine Drainage	Metals
		Abandoned Mine Drainage	pH
		Road Runoff	Siltation
		Upstream Impoundment	Siltation
		Upstream Impoundment	Nutrients
		Industrial Point Source	Organic Enrichment/Low DO
		Industrial Point Source	Thermal Modification
		Urban Runoff/Storm Sewers	Filling and Draining
		Urban Runoff/Storm Sewers	Siltation
		Urban Runoff/Storm Sewers	Cause Unknown
		Agriculture	Siltation
		Flow Regulation/Modification	Water/Flow Variability
		Small Residential Runoff	Cause Unknown
		Other	Siltation
PA(10D)	Chillisquaque Creek	Industrial Point Source	Other Habitat Alterations
		Agriculture	Siltation
		Agriculture	Organic Enrichment/Low DO
		On Site Wastewater	Nutrients
		On Site Wastewater	Organic Enrichment/Low DO
		Hydromodification	Other Habitat Alterations
		Hydromodification	Flow Alterations
PA(10C)	Buffalo Creek	Atmospheric Deposition	pH
		Small Residential Runoff	Nutrients
		Grazing Related Agriculture	Nutrients
		Grazing Related Agriculture	Siltation
PA(10C)	White Deer Hole Creek	No Listings	
PA(10D)	Muncy Creek	Source Unknown	Cause Unknown
PA(10B)	Loyalsock Creek	Abandoned Mine Drainage	Metals
		Abandoned Mine Drainage	pH
PA(10A)	Lycoming Creek	No Listings	
PA(10A)	Larry's Creek	No Listings	
PA(9A)	Pine Creek	Abandoned Mine Drainage	pH
		Abandoned Mine Drainage	Metals

Subbasin/ State (ID)	Watershed Name	Source of Impairment	Cause of Impairment
		Urban Runoff/Storm Sewers	Siltation
		Urban Runoff/Storm Sewers	Water/Flow Variability
		Upstream Impoundment	Organic Enrichment/Low DO
		Channelization	Flow Alterations
PA(9C)	Fishing Creek	Urban Runoff/Storm Sewers	Siltation
		Crop Related Agriculture	Siltation
		On Site Wastewater	Nutrients
		Source Unknown	Unknown Toxicity
		Grazing Related Agriculture	Siltation
PA(9C)	Bald Eagle Creek	Grazing Related Agriculture	Siltation
		Grazing Related Agriculture	Organic Enrichment/Low DO
		Removal of Vegetation	Siltation
		Industrial Point Source	Metals
PA(9C)	Beech Creek	Abandoned Mine Drainage	pH
		Abandoned Mine Drainage	Metals
PA(9B)	Young Woman's Creek	No Listings	
PA(9B)	Kettle Creek	Abandoned Mine Drainage	pH
		Abandoned Mine Drainage	Metals
		Abandoned Mine Drainage	Siltation
PA(8A)	Sinnemahoning Creek	Abandoned Mine Drainage	pH
		Abandoned Mine Drainage	Metals
		Abandoned Mine Drainage	Other Habitat Alterations
		Road Runoff	Siltation
		Draining or Filling	Siltation
PA(8A)	Mosquito Creek	Abandoned Mine Drainage	Metals
PA(8D)	Moshannon Creek	Abandoned Mine Drainage	Metals
		Abandoned Mine Drainage	pH
		Abandoned Mine Drainage	Siltation
		On Site Wastewater	Nutrients
		Small Residential Runoff	Siltation
PA(8C)	Clearfield Creek	Abandoned Mine Drainage	pH
		Abandoned Mine Drainage	Metals
		Golf Courses	Water/Flow Variability
PA(8B)	Anderson Creek	Abandoned Mine Drainage	Metals
		Abandoned Mine Drainage	pH
		Grazing Related Agriculture	Siltation
PA(8B)	Chest Creek	Agriculture	Siltation
		Removal of Vegetation	Other Habitat Alterations
Middle Susquehanna			
PA	Susquehanna River	No Listings	
PA(5E)	Roaring Creek	No Listings	
PA(5E)	Catawissa Creek	Abandoned Mine Drainage	Metals
		Abandoned Mine Drainage	pH
PA (5C)	Fishing Creek	Atmospheric Deposition	Metals
		Atmospheric Deposition	pH
		Road Runoff	Siltation
		Removal of Vegetation	Siltation
		Agriculture	Siltation
PA(5D)	Nescopeck Creek	Abandoned Mine Drainage	Metals
		Abandoned Mine Drainage	pH
PA(5A)	Lackawanna River	Abandoned Mine Drainage	Flow Alterations
		Abandoned Mine Drainage	pH
		Abandoned Mine Drainage	Metals
		Abandoned Mine Drainage	Siltation
		Hydromodification	Flow Alterations
		Hydromodifcation	Other Habitat Alterations
		Urban Runoff/Storm Sewers	Siltation
		Channelization	Other Habitat Alterations

Subbasin/ State (ID)	**Watershed Name**	**Source of Impairment**	**Cause of Impairment**
		Land Development Upstream Impoundment Source Unknown	Water/Flow Variability Cause Unknown Cause Unknown
PA(4G)	Bowman Creek	No Listings	
PA(4F)	Tunkhannock Creek	No Listings	
PA(4G)	Mehoopany Creek	No Listings	
PA(4F)	Meshoppen Creek	No Listings	
PA(4D)	Wyalusing Creek	No Listings	
PA(4D)	Wysox Creek	No Listings	
PA(4C)	Towanda Creek	Abandoned Mine Drainage Abandoned Mine Drainage	Metals pH
PA(4C)	Sugar Creek	No Listings	
Upper Susquehanna			
PA(4E)	Susquehanna River	No Listings	
PA(4B)	Cayuta Creek	No Listings	
NY	Susquehanna River	Atmospheric Deposition	Mercury
NY	Cayuta Creek	No Listings	
NY	Wappasening Creek	No Listings	
PA(4B)	Wappasening Creek	Animal Feeding Agriculture	Nutrients
NY	Catatonk Creek	No Listings	
NY	Owego Creek	No Listings	
NY	Apalachin Creek	No Listings	
PA(4B)	Apalachin Creek	No Listings	
NY	Nanticoke Creek	No Listings	
NY	Choconut Creek	No Listings	
PA(4E)	Choconut Creek	No Listings	
NY	Chenango River	Atmospheric Deposition	Mercury
NY	Otselic River	No Listings	
NY	Tioughnioga River	No Listings	
NY	Snake Creek	No Listings	
PA(4E)	Snake Creek	No Listings	
PA(4E)	Starucca Creek	No Listings	
NY	Unadilla River	Atmospheric Deposition	Mercury
NY	Ouleout Creek	No Listings	
NY	Otego Creek	No Listings	
NY	Shenevus Creek	No Listings	
NY	Cherry Valley Creek	No Listings	
NY	Oaks Creek	No Listings	
NY	Salt Lick Creek	No Listings	
Chemung			
PA	Chemung River	No Listings	
NY	Chemung River	No Listings	
NY	Seeley Creek	No Listings	
PA(4B)	Seeley Creek	No Listings	
NY	Cohocton River	No Listings	
NY	Canisteo River	No Listings	
NY	Tioga River	No Listings	
PA(4A)	Tioga River	Road Runoff Small Residential Runoff Atmospheric Deposition Upstream Impoundment Abandoned Mine Drainage Abandoned Mine Drainage	Siltation Siltation pH Siltation pH Metals
NY	Cowanesque River	No Listings	
PA(4A)	Cowanesque River	Agriculture Agriculture Municipal Point Source	Nutrients Siltation Nutrients

Subbasin/ State (ID)	Watershed Name	Source of Impairment	Cause of Impairment
		Upstream Impoundment Industrial Point Source Industrial Point Source Removal of Vegetation	Organic Enrichment/Low DO Thermal Modifications Cause Unknown Siltation

Lower Susquehanna: Major and Minor Contributing Tributary 303(d) listings within each major watershed
5 other Subbasins: Major Contributing Tributary 303(d) listings within each major watershed.

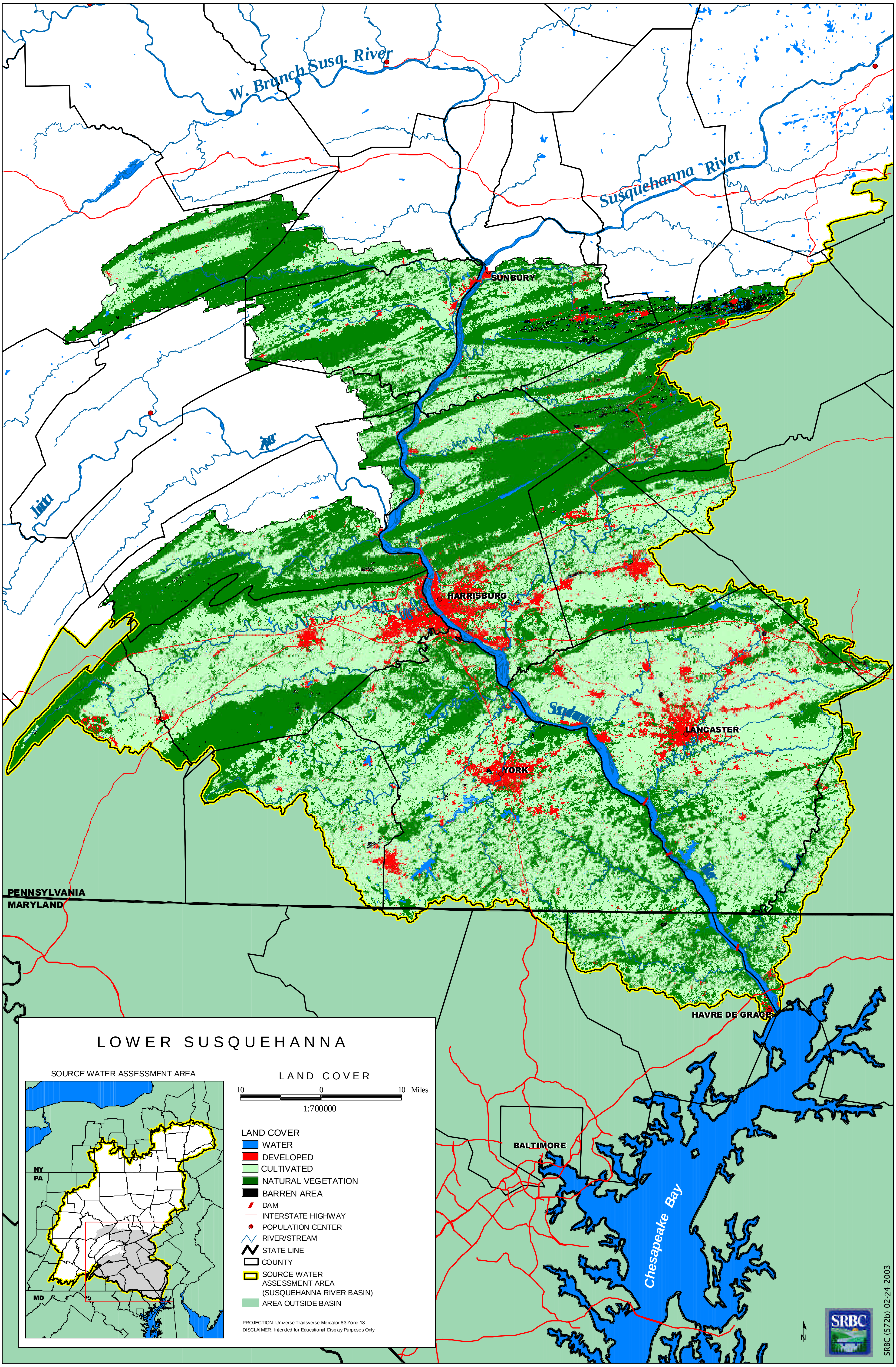
Appendix 3. Pa TMDL List

County Name	TMDL Name	Cause	Pollutant(s)	Other Counties
Lancaster	Conowingo Creek	NPS (ag runoff)	Phosphorus, sediments	
	Muddy Run Watershed	NPS (ag runoff)	Phosphorus, sediments	
	Pequea Creek	NPS (ag runoff)	Phosphorus, sediments	
	Chickies Creek Watershed	NPS (ag runoff)	Nitrogen, Phosphorus, sediments	
	Donegal Creek Watershed	NPS (ag runoff)	Phosphorus, sediments	
	Conewago Creek Watershed	Primarily agriculture	N, P, Sediments	Lebanon, Dauphin
Dauphin	Conewago Creek Watershed	Primarily agriculture	N, P, Sediments	Lebanon, Lancaster
	Bear Creek	AMD	AL, FE, MN, pH	
Lebanon	Conewago Creek Watershed	Primarily agriculture	Nitrogen, Phosphorus, sediments	Lancaster, Dauphin
Cumberland	Conodoguinet Creek Watershed	Point and NPS (runoff)	Phosphorus, sediments	Franklin
Lebanon	Quittapahilla Creek Watershed	NPS (ag runoff)	Phosphorus, sediments	
	Deep Run Watershed	NPS (ag runoff)	Phosphorus, sediments	
	Earlakill Run Watershed	NPS (ag runoff)	Phosphorus, sediments	
Franklin	Conodoguinet Creek Watershed	Point and NPS (runoff)	Phosphorus, sediments	Cumberland
Schuylkill	Hans Yost Creek	AMD	AL, FE, MN, pH	
Northumberland	Shamokin Creek Watershed	AMD	AL, FE, MN, pH	Columbia, Montour
Montour	Shamokin Creek Watershed	AMD	AL, FE, MN, pH	Columbia, Northumberland
Columbia	Shamokin Creek Watershed	AMD	AL, FE, MN, pH	Montour, Northumberland
Huntingdon	Shoup Run Watershed	AMD	AL, FE, MN, pH	
Blair	Kittaning Run Watershed	AMD	AL, FE, MN	Cambria
Cambria	Kittaning Run Watershed	AMD	AL, FE, MN	Blair
Clinton	Tangascootack Watershed	AMD	AL, FE, MN, pH	
	Two Mile Run	AMD	AL, FE, MN, pH	
	Drury Run Watershed	AMD	AL, FE, MN, pH	
Bradford	Stephen Foster Lake	Overland Runoff	Phosphorus, TSS	
Potter	North fork Cowanesque River Watershed	NPS (ag runoff)	Phosphorus, sediments	Tioga
Clearfield	Little Muddy Run, and East Branch	AMD	AL, FE, MN, pH	Blair
Cambria	Little Muddy Run, and East Branch	AMD	AL, FE, MN, pH	Clearfield
Jefferson	Whites Run Watershed	AMD	AL, FE, MN, pH	

Appendix 4. Large Format Map Attachments

Map 1. Susquehanna River Basin Land Cover

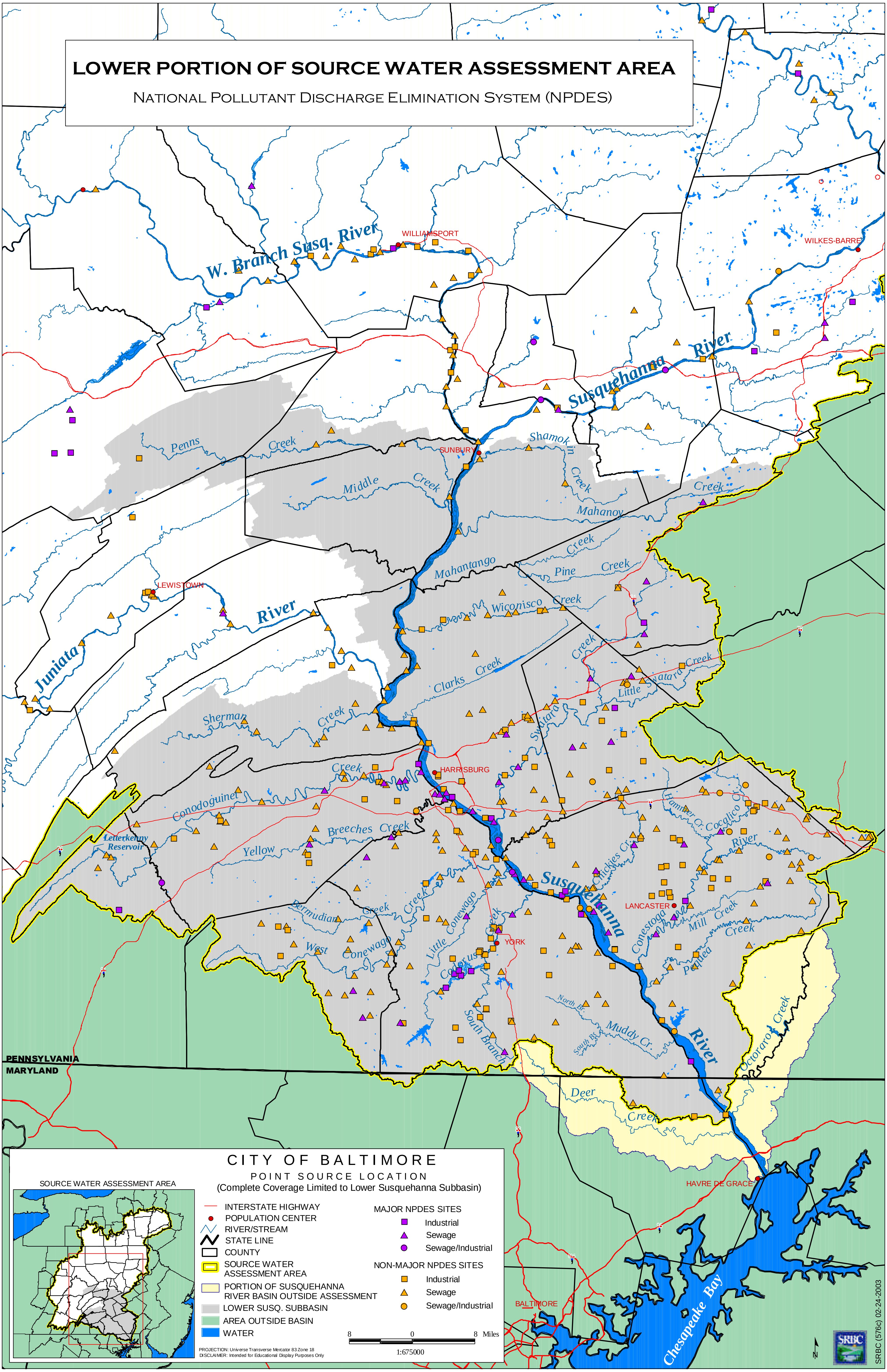
Map 2. NPDES Discharge Sites for the Lower Susquehanna. Subbasin



LOWER SUSQUEHANNA

LOWER PORTION OF SOURCE WATER ASSESSMENT AREA

NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES)



CITY OF BALTIMORE

POINT SOURCE LOCATION

(Complete Coverage Limited to Lower Susquehanna Subbasin)

- INTERSTATE HIGHWAY
- ● POPULATION CENTER
- RIVER/STREAM
- STATE LINE
- ☐ COUNTY
- ☐ SOURCE WATER ASSESSMENT AREA
- ☐ PORTION OF SUSQUEHANNA RIVER BASIN OUTSIDE ASSESSMENT
- ▨ LOWER SUSQ. SUBBASIN
- 🟩 AREA OUTSIDE BASIN
- 🟦 WATER

MAJOR NPDES SITES
- ■ Industrial
- ▲ Sewage
- ● Sewage/Industrial

NON-MAJOR NPDES SITES
- ■ Industrial
- ▲ Sewage
- ● Sewage/Industrial

PROJECTION: Universe Transverse Mercator 83 Zone 18
DISCLAIMER: Intended for Educational Display Purposes Only

SRBC (576c) 02-24-2003