Category II

Water Quality

MAJOR INFLUENCES ON STREAM AND RIVER QUALITY ~
- *Runoff and point-source discharges from agricultural and urban areas*
- *Persistent contaminants associated with past human activities: mining, industry, urban development and agriculture*
- *Impoundments and diversions of water*

MAJOR INFLUENCES ON GROUND WATER QUALITY ~
- *Use of pesticides, nutrients and VOCs in urban and agricultural areas*
- *Physical properties of soils and aquifers, and chemical properties of contaminants*
- *Naturally occurring radon and arsenic*

2004 USGS Circular #1227

Water Quality

The quality of our water resources is integrally linked to the long-term availability of water that is clean and safe for drinking and recreation, and also suitable for industry, irrigation and habitat for fish and wildlife. The quality of the River is dependent on the landscapes draining the watersheds and streams that join to form it, including all direct and indirect discharges to water bodies.

When Henry Hudson discovered the Delaware River system in 1609, water quality was presumably pristine. However, by the early 18th century water pollution was a recognized problem, especially the contamination of springs, wells and streams that served as local sources of drinking water. The first pollution survey, conducted in 1799, noted a variety of sources in the Philadelphia harbor area, including ships, wharves, polluted wetlands, and various urban activities. Tanneries and slaughterhouses were already recognized sources of water quality problems.

Providing Clean Water

Making the connection between polluted water and disease, such as typhoid, provided the impetus for constructing public supply pipelines, for segregating human waste from water supply, and subsequently for filtering source water. Concern for water-borne diseases led Benjamin Franklin to leave money to Philadelphia specifically for developing a municipal water system, which the City did, drawing first water from the Schuylkill (1801) and then the Delaware River (1850). Typhoid outbreaks in the 1860s prompted debates and discussion that eventually resulted in the construction of the world's largest sand filtration plants in 1899. By 1915 most cities in the basin had a safe water supply, drawing from either new wells or filtered surface water.

Intense development and use of the River system, waves of population, industrial expansion, and even the increased use enabled by the provision of pubic water supply all contributed to further pollution and degradation of water quality. While water-related diseases had been controlled, other problems were surfacing. By the early 20th century the Delaware was experiencing the collapse of major fisheries, including the historic shad fishery, partly as a result of pollution and low oxygen in the River.

Surveys in 1929 and 1937 indicated that the entire estuary from Trenton to Wilmington was "substantially" polluted with a zone of "gross" pollution in the Philadelphia-Camden area. While pollution was an evident problem, serious efforts to control it at the source did not occur until 1936 with the creation of the Interstate Commission on the Delaware River (INCODEL). This advisory commission was formed to augment and coordinate state efforts and its highest priority was the cleanup of stream pollution.

Pollution Control

Until INCODEL, wastewater added to the Delaware system was discharged

1799
1st government pollution survey notes contamination entering the river from ships and sewers.

1832
Cholera caused by contaminated drinking water kills over 100 people in Philadelphia.

1936
90% of all gas sold in the USA contains tetraethyl lead.

1950
The urban reach of the Delaware River is noted as one of the most polluted stretches of river in the world with essentially zero oxygen during summer.

1967
DRBC adopts a waste load allocation program with the states and starts pollution abatement programs.

1970
1st US Earth Day celebrated; US EPA established; NEPA adopted.

1971
US EPA gives notice of proposed phase-out of leaded gasoline.

without treatment, with the exception of Trenton and a one small plant in Philadelphia which had primary treatment. Through INCODEL, a basin-wide program was implemented and the first set of interstate water quality standards adopted in the 1939–1945 period. War-time action slowed the implementation of the new water quality program and added to the pollution problems in the estuary as industrial and port-related activity increased. However, as a result of the INCODEL program, new sewage treatment plants were built throughout the basin in the post-war period. By the end of the 1950s, 75% of the basin communities, including the major cities responsible for 60% of the sewage discharges, had adequate sewage treatment.

During this time problems from coal mining and processing were also tackled. Desilting basins were constructed and 30–40 tons of coal silt were dredged from the Schuylkill under one of the first non-agricultural nonpoint pollution control programs in the nation. As a result of these efforts, water quality improved even in the most grossly polluted portion of the estuary. Dissolved oxygen levels rose; the river was no longer anoxic.

Comprehensive management

Remnants of hurricanes Connie and Diane caused major flooding in 1955 and indirectly instigated a new generation of management as the Army Corps of Engineers initiated its first comprehensive river basin planning effort. One product was a pioneering study of water pollution control and the development of one of the first water quality models for an estuary. Another result was the establishment of the Delaware River Basin Commission (DRBC) in 1961. Expanding on the advisory powers of INCODEL, DRBC was created by concurrent federal and state legislation and is accorded broad responsibility. This responsibility includes regulatory authority in all facets of water resource management, including water supply and water quality.

In 1967 DRBC adopted higher water quality standards for dissolved oxygen, and new bacteria standards for recreational use. To meet the criteria, some 90 municipal and industrial dischargers were given waste load allocations in 1968 as part of a prescient administrative program that served as a prototype nationally for complex water pollution control problems. In 1972, the Federal Water Pollution Control Act amendments required discharge permits, provided construction funds, added enforcement, and other incentives to ensure implementation of water pollution control efforts. This generation of efforts, which ended in 1987, resulted in the construction of many municipal and wastewater treatment facilities, decreased discharges of oxygen-demanding waste, and long-lasting improvements in dissolved oxygen levels that have benefited fish populations, especially the American shad.

In 1992 DRBC adopted an anti-degradation program designed to protect the high water quality of the portions of the River that had been designated as part of the national Wild and Scenic River system. The Special Protection Water (SPW) program, initially applied to 121 miles between Hancock NY and the Delaware Water Gap, was expanded in 2008 to include the Lower Delaware Scenic and Recreational River. The protection of existing water quality is now the policy for all 197 miles of the non-tidal Delaware River.

Emerging issues

Technological advances in computers, telemetry, satellite imagery, and detection have enabled impressive strides in instantaneous monitoring, source tracking, water quality modeling, and pollutant detection. Our understanding of the functional pathways of contaminants and the potential harm to individuals and populations is vastly expanded, and our grasp on the full range of potential pollutants is tightening.

Some of the major water quality concerns of the past still resonate in

1972
FWPCA amendments establish construction grant program for wastewater treatment and permit process for discharges.

1980s
Basin states impose numerical P limits at WWTPs through tertiary treatment. By late 1980s, over $1.5 B spent on improving wastewater treatment along the Delaware River and tributaries between Wilmington and Trenton.

1992
DRBC adopts Special Protection Waters regulations to preserve the high water quality of the upper and middle Delaware Scenic River reaches.

1994
In accord with federal mandate, industry ends manufacture of phosphate laundry detergent.

1994
US blood lead levels (a proxy for lead in the environment) declined by 78 percent from 1978 to 1991.

the early 21st century. Public health is still a focus. The concentration of toxic substances, notably mercury and PCBs, in some species of fish is responsible for consumption advisories in all of the basin states. Water borne diseases are far less a threat than they once were, but the viruses too small to be captured by typical treatment processes remain a potential peril.

Dissolved oxygen (DO) remains a parameter of concern. In 1973 US EPA suggested that fishable water quality standards were unattainable in portions of the Delaware, but assessments since have shown that improvements in dissolved oxygen concentrations are possible, and actual. Rebounding fish populations are further proof. The most recent monitoring in the estuary region, however, indicates that progress may be slowly eroding and new initiatives may be necessary to maintain and improve DO levels.

Several toxic substances, such as metals and PCBs, are being addressed through discharge requirements, state and federal site remediation programs, TMDLs and pollution minimization plans. The elimination of phosphorus from detergents contributed to improvements in DO, but nutrient reduction criteria—and strategies to address them—remain elusive as we continue to grapple with contributions from point and nonpoint sources, and the spectre of increasing wet-weather loadings and temperatures under changing climatic conditions.

New substances are emerging as compounds of concern, including pharmaceuticals and constituents in personal care products and manufacturing processes. Improvements in our ability to measure smaller and smaller amounts of compounds in water samples has enhanced water quality assessments and research on public and ecological health effects. In addition to neurological impairment and cancer, our concerns extend to the potential for multi-generational and reproductive effects of new compounds on humans and wildlife.


R. LIMBECK, DRBC

Stream monitoring for macroinvertebrates.

Reporting

Water quality indicators included in this report are:

- Nutrients : Nitrogen & Phosphorus
- Dissolved oxygen
- Water clarity
- Metals: Copper
- Toxic compounds: Pesticides and PCBs
- Trends in tributary water quality
- Support of designated uses
- Fish consumption advisories

A feature on contaminants of emerging concern closes this section.

1995
Most of the 99 major dischargers to the Delaware are in compliance with DRBC water quality standards.

1996
DRBC adopts regulations governing the discharge of toxic pollutants from wastewater treatment plants to the tidal Delaware River. Numerous toxic substances, some carcinogenic, are covered under the new rules.

2003
On behalf of NJ, PA, and DE, and based on work conducted by DRBC, USEPA establishes total maximum daily loads (TMDLs or "pollution budgets") for the tidal Delaware River to address the presence of PCBs.

2006
Water quality in the Delaware River continues to improve; mean annual oxygen level at Philadelphia measures 6 mg/l, up from 2 mg/l in 1967.

2008
Lower Delaware from Water Gap to Trenton included in Special Protection Waters Program.

Indicator • Nutrients

Indicator Description

Nutrients, such as Total Nitrogen (TN) and Total Phosphorus (TP) are critical to the growth of aquatic life. An overabundance of nutrients can lead to excessive plant and algal growth, causing major impairments to ecological health and specific water quality problems such as low Dissolved Oxygen (DO). Whether or not a water body exhibits the negative effects of high nutrient levels can be controlled by many other factors: water clarity; temperature; the availability of trace nutrients like silica; and the species of organisms living in the water body. Because of this, water quality criteria for nutrients can be very different from stream to stream. The states and DRBC are currently working to determine what concentrations of TN and TP will protect the aquatic resources in the Delaware River Basin, and the appropriate water quality criteria to protect these resources.

Desired Condition

Although specific criteria have not been set, nutrients are managed to support aquatic life and DO criteria (BP Goal 1.2, CCMP Action W12).

Status

Fair: Concentrations are high compared to other estuaries, but do not seem to be causing harmful effects, such as eutrophication.

Levels of TN in the Delaware River and estuary tend to be roughly 10 to 20 times higher than levels of TP. Concentrations of TN and TP are lowest in the headwaters of the Delaware River and increase downstream. Nutrient concentrations peak near the midpoint of the estuary and then decrease again toward the mouth of the Bay (Fig. 2.1). Since the current concentrations of nutrients have not resulted in the typical symptoms of excessive nutrients, it is difficult to determine whether the current concentrations are at a level that warrants regulatory control. However, measurements of low DO concentrations raise concerns about nutrients or other pollutants in those areas (See the discussion of DO on the next page.)

Trends

Data from a station in the Delaware River near the Philadelphia Airport show a very large decrease in phosphorus was achieved by 1985; a similar, but much smaller decrease in nitrogen was achieved by 1990 (Fig. 2.2). Although nutrient levels are still very high today compared to other estuaries, the concentrations are stable and there do not appear to be obvious problems.

Actions and Needs

- States and DRBC should continue efforts to define the relationships between nutrients, water clarity, algal growth, DO, and ecological health and determine nutrient levels that will protect water resources and prevent the harmful effects on aquatic communities.

Fig. 2.3 Nutrient Monitoring Sites

Fig. 2.1 Nutrient Concentrations by River Mile

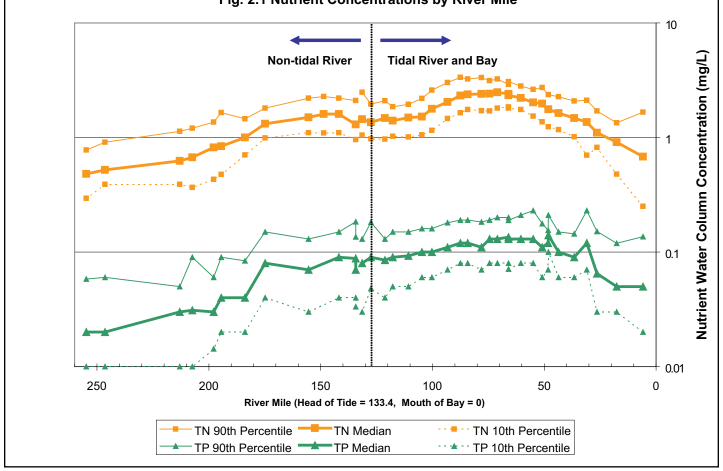
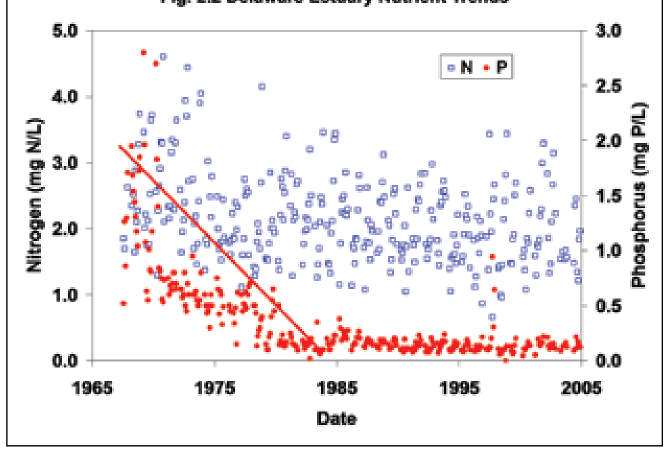


Fig. 2.2 Delaware Estuary Nutrient Trends



Indicator • Dissolved Oxygen

Indicator Description

Dissolved oxygen (DO) in surface water is one of the most basic and important measures of the health of a waterbody, affecting a wide array of aquatic plants and animals. Low DO has both chronic (long term) and acute (immediate) impacts, ranging from shifts in biological communities to fish kills and disruption of fish migration. Oxygen enters water at the water surface and through photosynthesis of aquatic plants and algae. Plants and animals also respire, utilizing some of this oxygen. DO can become too low to support healthy aquatic communities when concentrations of oxygen-demanding pollutants are too high and/or when high concentrations of nutrients like nitrogen and phosphorus cause excessive plant growth. When the excess plants die and decompose, they use DO in the water.

Desired Condition

Dissolved oxygen levels should meet standards supportive of aquatic life (BP Goal 1.3, CCMP Action W12). State criteria apply to watershed tributaries, and range from 4.0 to 7.0 mg/L. DRBC criteria apply to shared waters of the river and estuary and vary by Water Quality Zone, from 3.5 to 6.0 mg/L.

Status

Good: DRBC and state DO standards are generally being met; upper basin DO is better than lower basin.

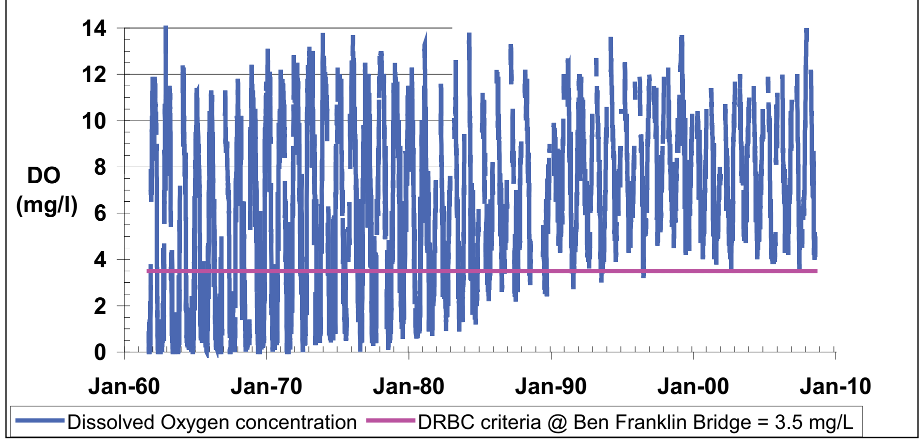
Minimum DO criteria are routinely being met in the tributaries and most of the mainstem River (Fig. 2.6). Five year medians at selected stations along the river remain above their respective state standard, although within the last five years some stations in the Lower and Bay regions have shown a decrease in DO concentrations according to an analysis by Delaware's Water Resources Agency (see Table 2.2 for *Trends in Tributary Water Quality*).

Currently, DO concentrations in the non-tidal river and in the upper portion of the estuary routinely meet DRBC's minimum criteria. However, in the lower estuary near Reedy Island where the DO standard is more stringent, DO criteria violations are a common summertime occurrence and Delaware has listed this segment of the River for TMDL development by 2019. Although the cause for these violations is not clear at this time, DRBC and other agencies are working to better understand all the factors, including nutrient loadings, which may be contributing to the DO criteria violations.

Trends

With the water quality improvements to waste treatment in the mid-1980s, the Delaware River and tributaries have been able to maintain DO concentrations that support aquatic life and meet state and DRBC criteria. Figure 2.4 illustrates the increase in dissolved oxygen concentration at the Ben Franklin Bridge since the 1960s. The noticeable change during the 1980s were the direct result of discharge regulations and waste treatment enhancements. Before this time much of the tidal river below Trenton frequently violated minimum DO criteria. Figure 2.5 shows the number of days criteria has been violated at stations with continuous gages since 1970. Improvements in DO concentrations in the mainstem river have supported the return of shad and other important fisheries to the basin. As previously noted, the number of criteria violation days has recently increased at the Reedy Island Station, requiring vigilance and research to determine the cause.

Fig. 2.4 Dissolved Oxygen
Delaware River at Ben Franklin Bridge, Philadelphia
USGS 01467200



Actions and Needs

- Because DO tends to be higher in the daytime (when aquatic plants are photosynthesizing) and lower at night, its important to measure DO around the clock with continuous monitoring stations, to be sure that DO levels are not unhealthy.

- Without continuous monitoring on the tributaries, data reflect intermittent sampling, and only median values can be compared to the criterion, which is usually a minimum value to protect aquatic resources.

SOURCE: US DEPARTMENT OF AGRICULTURE

Dissolved oxygen, our most fundamental indicator of water quality conditions, is critical for aquatic life.

Fig. 2.5 Comparison of DO Violation Days from 1970 through 2007 at 5 Delaware River Continuous Monitoring Sites

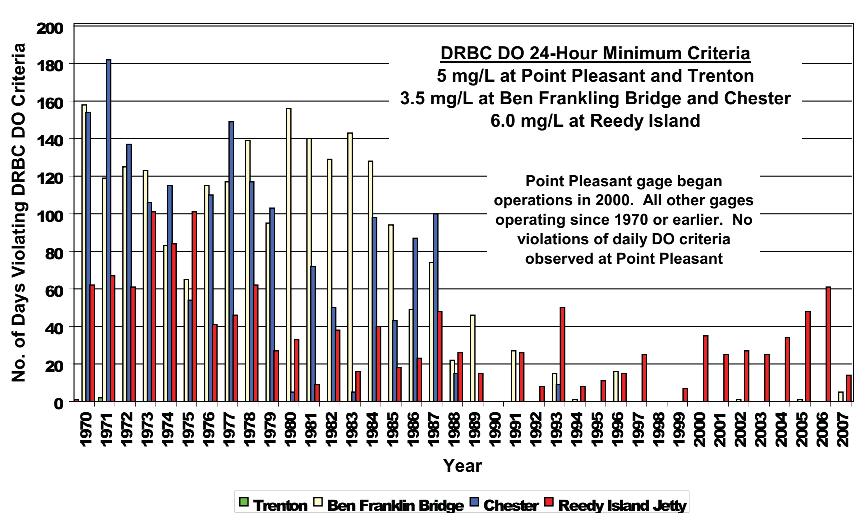
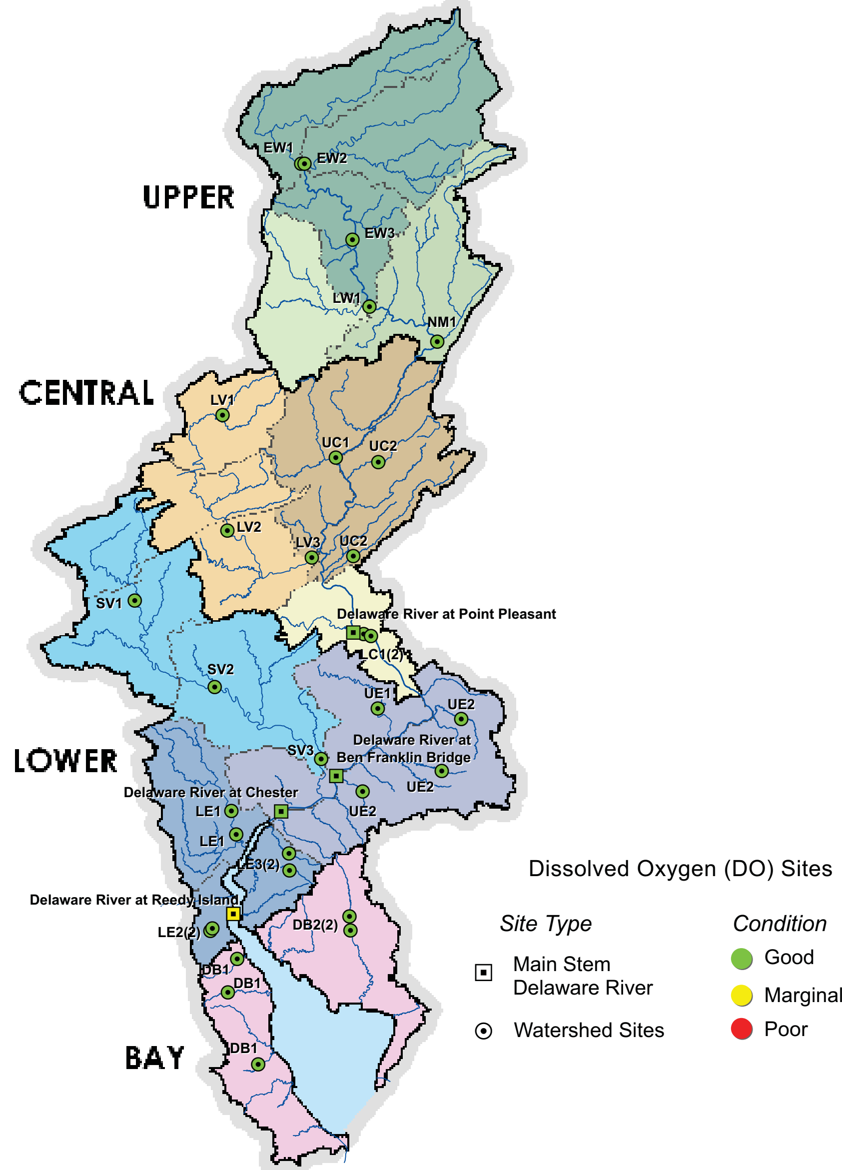


Fig. 2.6 DO Condition at Selected Sites



Indicator • Water Clarity

Water Clarity

- Total Suspended Solid (TSS)
- Turbidity
- Chlorophyll-a

Indicator Description

Total Suspended Solids (TSS), turbidity, and chlorophyll-a are three distinct but related indicators that all pertain to the amount of particulates suspended in the water that influence water clarity. TSS is a measure of the total amount of particulate solids per unit volume of water. These solids include living, non-living, organic, and inorganic particles. Turbidity is an optical property of water where particles and colloidal matter from living and non-living sources cause light to scatter, rather than pass through the water column. Excessive turbidity can impair bottom plants by filtering out sunlight needed for photosynthesis. Finally, chlorophyll-a is a photosynthetic pigment found in plants such as phytoplankton. When measured in surface water, chlorophyll a provides an indication of how much phytoplankton is in the water.

Suspended particulates are important for river and estuarine ecology because they provide sediments to help tidal marshes keep pace with sea level rise, and some suspended particles such as phytoplankton are important foods for animals such as mussels and oysters. In disturbed systems, however, suspended solids and phytoplankton often become overly concentrated and out of balance with natural processes. Therefore, these three measurements provide some indication of both the ecological status and overall health of the river system, especially as it relates to eutrophication (over fertilization).

Most estuaries have an area of elevated turbidity and solids, known as an estuary turbidity maximum (ETM). The ETM is a natural consequence of the chemical and hydraulic

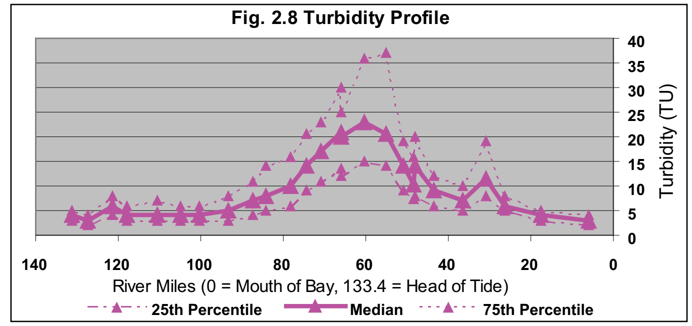


Fig. 2.8 Turbidity Profile

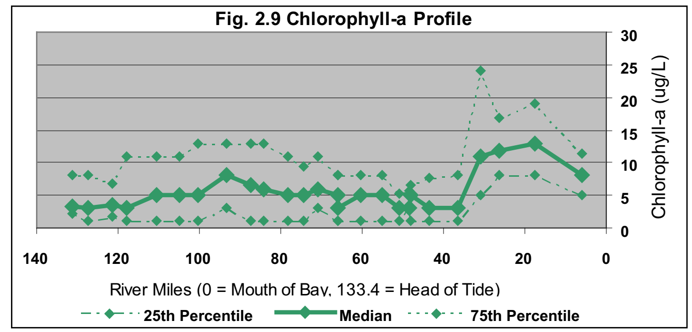


Fig. 2.9 Chlorophyll-a Profile

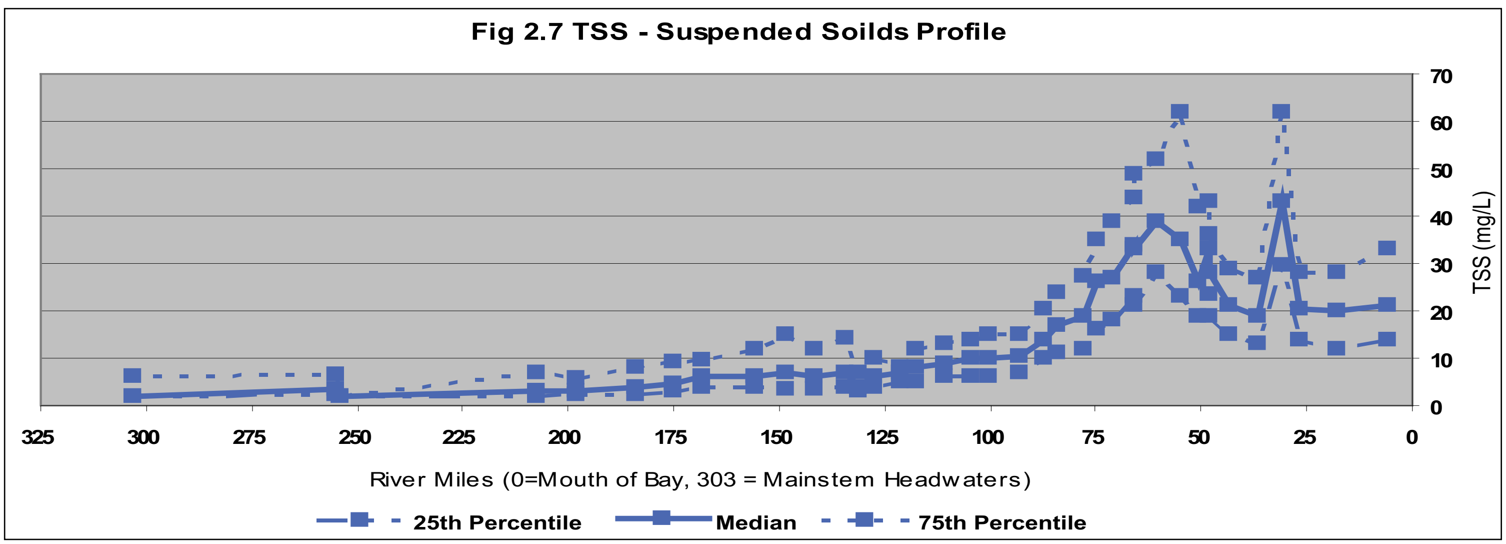


Fig 2.7 TSS - Suspended Soilds Profile

mixing of fresh and salt water. The Delaware ETM is centered near river mile 60 in the estuary, but its location can change depending on tides and fresh water flows from upstream.

Desired condition

Protection of aquatic life (BP Goals 1.2, 1.3, and 1.4; CCMP Action W12).

Since clarity is affected by a number of chemical and physical conditions, setting criteria is difficult. Both too little and too great a concentration of suspended solids are problematic for aquatic systems, and the range is also dependent on the physical and chemical attributes of each system. Delaware, New York and Pennsylvania do not have water quality standards for TSS in streams; New Jersey has set a maximum TSS level of 40 mg/l for warm water streams and 20 mg/l for cold water streams. The DRBC has adopted a TSS maximum of 150 mg/l for the tidal Delaware River. Negative effects from suspended solids and nutrients usually result in impacts to dissolved oxygen.

Status

Good: Naturally turbid estuary; non-tidal river is generally clear except after storm events.

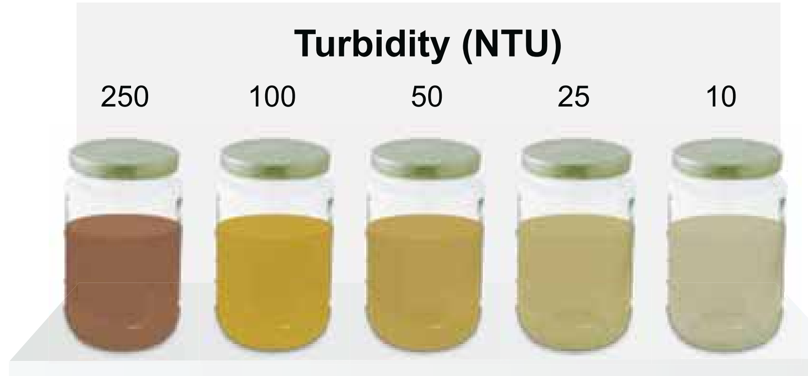
In the Delaware River system, TSS values range from 1 or 2 mg/L to more than 60 mg/L (Fig. 2.7). Turbidity is typically between 1 and 40 turbidity units, well below the maximum 150 unit criteria (Fig. 2.8). Chlorophyll-a concentrations usually range from below detectable levels to 30 ug/L (Fig. 2.9). In some estuaries, efforts to control eutrophication include surface water standards for chlorophyll-a, as a measure of the effectiveness of efforts to control excess nutrients. Currently, DRBC does not have criteria for either TSS or chlorophyll-a in surface water, but could consider developing criteria as part of a broader nutrient strategy.

Trends

Because TSS, turbidity, and chlorophyll-a concentrations change with location, tidal and freshwater flows, temperature and season, identifying specific trends in concentrations is very difficult. Overall, these indicators appear to be stable throughout the period from 1990 through 2005.

Actions and Needs

- The regional science and management community will need to continue efforts to define relationships among nutrient concentrations and forms, water clarity, and phytoplankton.
- A better understanding is needed regarding the importance of sediment supply for habitats such as tidal marshes and how this can be assured through regional sediment budget management.
- Ongoing efforts to both understand and monitor suspended solids will help identify the most appropriate measures for ensuring good water quality in the Delaware River and estuary.



BASED ON: HTTP://WWW.WATER.NCSU.EDU/WATERSHEDS/INFO/TURBID.HTML

Turbidity, the amount of suspended material in water, is measured in nephelometric turbidity units (NTUs).

Indicator • Copper

Indicator Description

Copper is a naturally occurring trace element found in surface waters and essential to virtually all plants and animals. However, even at low concentrations dissolved copper can be toxic to aquatic life. Sources of dissolved copper contributing to concentrations in water and sediment include metal finishing, leather processing, fungicides and pesticides.

Desired Condition

Concentrations in water and sediment that do not pose a threat to aquatic life (BP Goal 1.3; CCMP Actions T1-T5).

Status

Fair: Dissolved copper concentrations are below or near water quality criteria.

Figure 2.10 shows concentrations of copper at sites in the tidal Delaware River (Fig. 2.11). Assessment in estuarine areas transitioning from fresh to marine waters is complicated by the impact of ions on the toxicity of copper to aquatic life. DRBC has aquatic life objectives for dissolved copper similar to the following EPA criteria:

Fresh water, chronic: 9 ug/L,
Fresh water, acute: 13 ug/L
Marine waters, chronic: 3.1 ug/L
Marine waters, acute: 4.8 ug/L

However, DRBC's fresh water criteria are based on water hardness in the Delaware River.

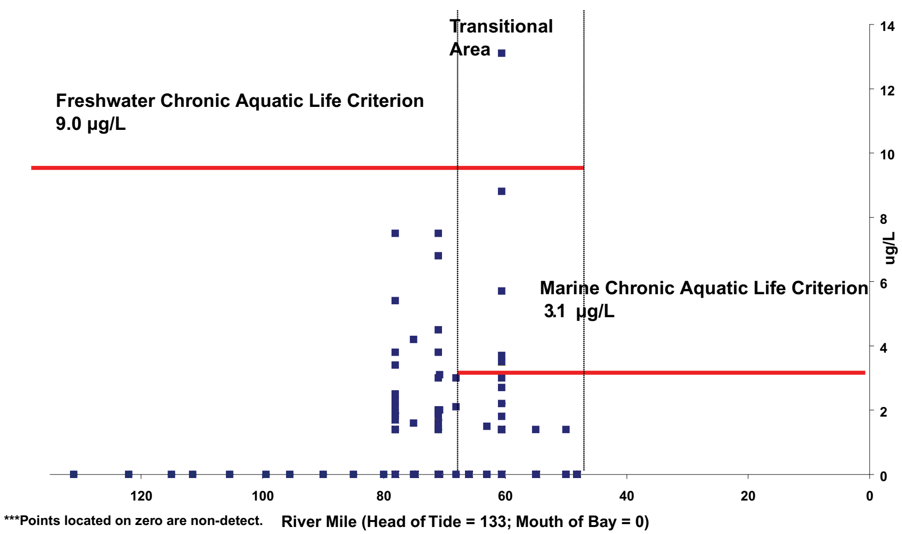
Trends

Dissolved copper concentrations have remained steady.

Actions and Needs

- Increased monitoring of copper and other metals is necessary for improved assessment capability, especially river miles 48 to 68.
- Coordination of monitoring among agencies should assure the use of state of the art methods and procedures as well as harmonization of assessment methodologies.
- The Biotic Ligand Model (BLM), developed to improve the predictions of metal bioavailability and toxicity, is currently recommended for use in fresh water. Its usefulness for monitoring and assessment in the basin, including estuarine and marine waters, is being investigated.

Fig 2.10 Dissolved Copper 2004 to 2006



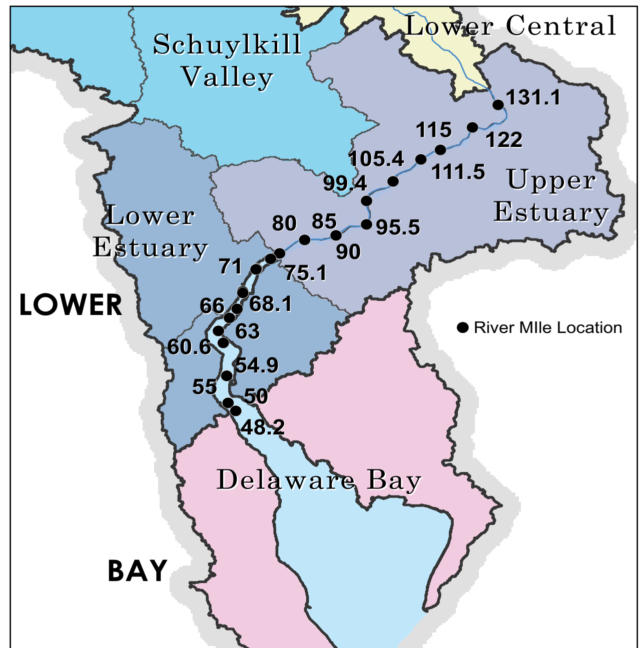


Fig. 2.11 Copper Monitoring Sites

Indicator • Fish Consumption Advisories

Indicator Description

Fish consumption advisories are issued by each state to inform the public when locally-caught fish are not safe to be eaten due to known levels of contamination. The advisories recommend either limiting or avoiding consumption of certain fish from specific water bodies. The two most common pollutants to cause advisories in the Delaware River Basin are mercury and polychlorinated bipheynls (PCBs), which both bioaccumulate in the aquatic ecosystem. Eating fish that contain these harmful substances is the principal way to be exposed to these chemicals. Therefore, fish consumption advisories are an important tool to help protect public health and to identify areas where further management of pollution may be needed.

Desired Condition

Finfish and shellfish that are safe to eat; a systematic and coordinated approach to assessing and communicating the results of fish and shellfish contaminant data. (BP Objective 4.1.D; CCMP Action T6).

Status

Poor: There are fish consumption advisories for waterbodies in all four Basin states and on the main stem of the Delaware River (Fig. 2.12).

The amount of contaminants fish accumulate depends on the species, size, age, sex, and feeding area of the fish. Generally, older and larger individual fish have accumulated the most contaminants, although in some cases contaminants are shed each time the fish spawn. Since fish accumulate many contaminants in their fatty tissues, certain species with higher oil content can pose more risk than others when both inhabit polluted areas.

The American eel and carp caught throughout the main stem of the Delaware should not be eaten at all and no fish should be consumed from upper Zone 5. Contaminants found in Delaware River basin fish tissue causing consumption advisories include: PCBs, Mercury, Dioxin, Chlorinated Pesticides, Dioxin/Furans, Dieldrin, DDT, Chlordane, and Toxaphene.

It is important to use caution when comparing fish advisories across state lines or in shared waters. Fish consumption advisories are based on risk assessments, and each state may use different methods to evaluate the risk of eating contaminated fish. Therefore, the number of meals recommended for each type of fish may vary even for the same levels of contamination. Inconsistencies also exist in the way the basin states list their advisories to the public.

For more information about fish consumption advisories, including specific locations, meal limits and individual fish species, search for "fish consumption" at these web sites:

- www.depweb.state.pa.us/watersupply
- www.state.nj.us/dep/dsr/njmainfish.htm
- www.fw.delaware.gov/Fisheries
- www.dec.ny.gov

Actions and Needs

- Provision of clear and consistent information to the public based on more uniform assessment methods.

The term *Bioaccumulation* refers to the uptake and retention of a chemical by an organism from all surrounding media (e.g., water, food, sediment).

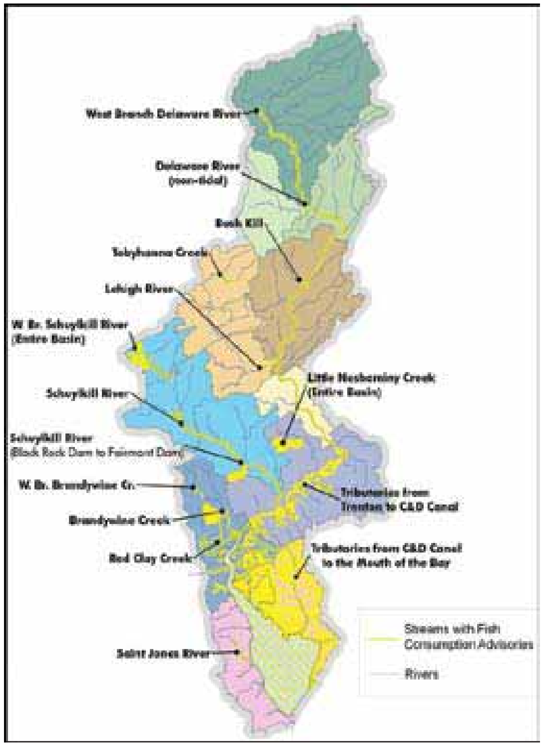


Figure 2.12. The map shows waterways where advisories are currently in place. Recommendations may range from one 8 oz. meal per week of one type of fish to no consumption of any fish.

Indicator • Pesticides

Indicator description

Atrazine and metolachlor are among the pesticides most frequently detected in ground water and surface water by the USGS's NAWQA Program and the USEPA's National Survey of Pesticides in Drinking Water. Both are designed to persist in soil for several months during the growing season for continuous weed control. However, both pesticides are water soluble, allowing the toxins to mobilize and pollute streams and ground water.

Atrazine is registered with the EPA as a Restricted Use Pesticide; it is classified as toxic to aquatic life, especially aquatic plants. It is a known human carcinogen, ground water contaminant, and a suspected endocrine disruptor. Atrazine is used primarily to control weeds on agricultural fields for crops such as corn and evergreen tree farms—especially for conservation tillage or "no-till" farming—and along highways for non-selective vegetation control.

Metolachlor is of low toxicity to humans but slightly to moderately toxic to some aquatic life. It is classified as a possible human carcinogen based on studies in rats and it may also cause developmental impairment. Metolachlor is primarily used for weed control in the production of corn, soybean, and woody ornamentals. It is sometimes used in formulations with other pesticides such as atrazine, cyanazine, and fluometuron.

Desired condition

Detection in ground and surface water supplies at concentrations below limits suspected of causing heath effects on humans and wildlife (BP Goals 1.2, 1.3; CCMP Actions T1-T5).

The EPA recommended level for Atrazine is 3 µg/L (ppb) and the World Health Organization (WHO) guidance is 2 ppb. EPA does not currently have a recommended concentration for for Metolachlor, but WHO guidance is 10 ppb.

Status

Fair: Pesticides prevalent, but in low concentrations.

The percentage of sampling sites with detected concentrations of atrazine was higher than that of metolachlor for both surface and ground water, indicating that atrazine contamination is more prevalent than metolachlor (Figs 2.13, 2.14). In the basin, atrazine

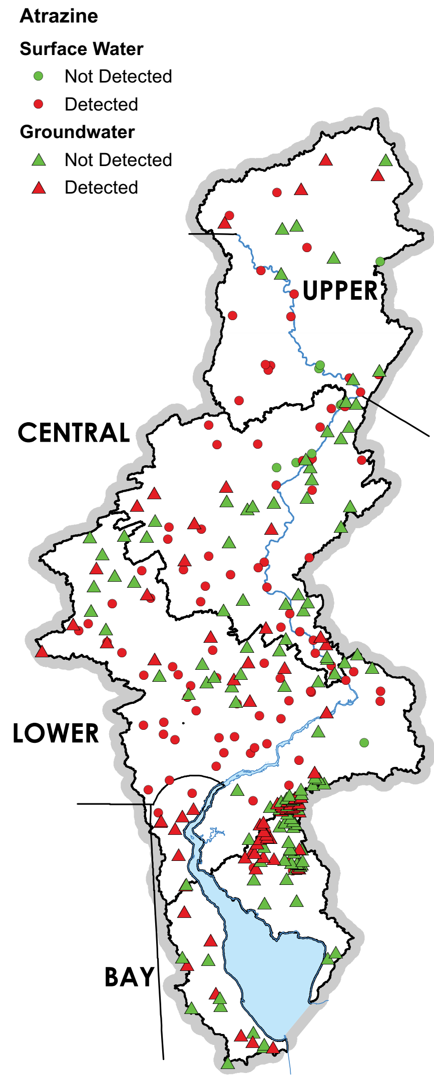


Figure 2.13. Atrazine detections in the Delaware River Basin. The USGS NAWQA studies found concentrations of Atrazine above the detection limit in 95% of Surface water stations and 40% of ground water stations.

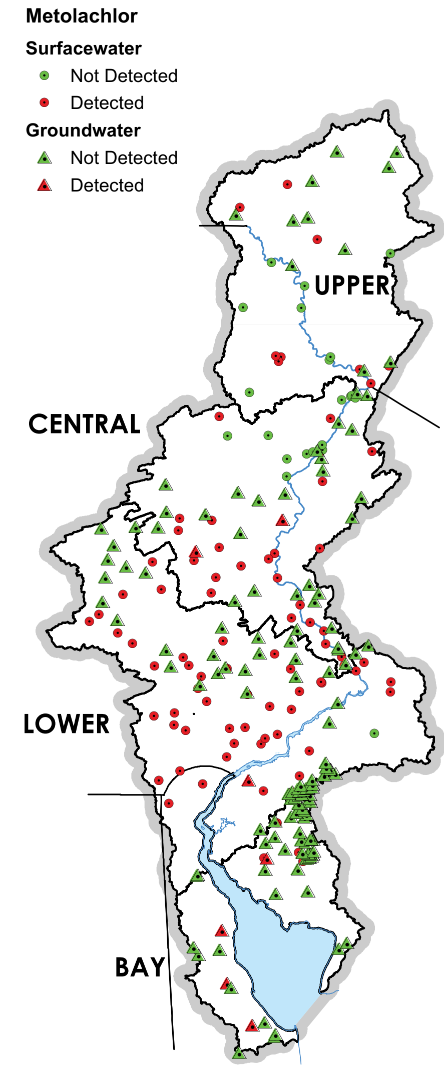


Figure 2.14. Metolachlor detections in the Delaware River Basin. The USGS NAWQA studies found concentrations of Metolachlor above the detection limit in 81% of Surface water stations and 31% of ground water stations.

was detected in 95% and Metolachlor in 81% in surface waters sampled. In ground water, atrazine was detected in 40% of samples, and metolachlor in 31% of samples.

The median concentration of atrazine at basin sampling sites was almost 0.05 ug/L for urban watersheds and 0.12 ug/L for agricultural watersheds. Surface water concentrations are highest in runoff from agricultural fields, especially following major runoff events occurring within a few weeks of application. Ground water concentrations are expected to be highest in areas with a long history of agricultural land use, especially corn crops, and where surface and ground water systems are connected sufficiently to allow infiltration.

Concentratiotns of atrazine and metolachlor generally were lowest in the northern part of the basin above the confluence with the Lehigh (Table 2.1). All median concentrations were below the drinking water standards. However, atrazine and metolachlor break down into degradation products that are detected as frequently or more frequently than parent compounds, an issue that demands further investigation about environmental and human health impacts.

Trends

It is difficult to determine trends over time in atrazine and metolachlor concentrations. The USGS National Water Quality Assessment (NAWQA) program provided a baseline assessment of these pesticides based on five years of data (1998–2001). NAWQA monitoring is continuing at selected sites as part of a specialized national program to assess pesticides, but currently there is not a program to specifically address pesticides in basin waters.

Actions and Needs

- Surface and ground water concentrations should be matched with levels of atrazine and metolachlor application; areas of concern should be identified and monitoring efforts stratified to capture conditions and trends in these areas.
- Periodic sampling is needed to determine trends in concentrations of atrazine, metolachlor, and their degradation products in ground and surface waters across the basin.
- Additional research is needed to determine the affect of these and other pesticides and their degradates on the aquatic environment, and the synergistic effects of multiple pesticides on humans and aquatic organisms.

Table 2.1 Atrazine and Metolachlor Concentrations

Subwatersheds	Median Atrazine ug/l	Median Metolachlor ug/l
Upper Region (NY and PA)		
EW1 West Branch (Cannonsville)	*0.020	*0.020
EW2 East Branch (Pepacton)	*0.002	*0.003
EW3 Mainstem (above Narrowsburg)	0.006	<0.001
LW1 Lackawaxen	0.005	0.002
NM1 Neversink-Mongaup	0.001	0.001
Central Region (PA and NJ)		
UC1 Pennsylvania tributaries	0.001	<0.001
UC2 New Jersey tributaries	0.011	0.006
LV1 Lehigh River above Lehighton	*0.004	*0.001
LV2 Lehigh River above Jim Thorpe	0.080	0.026
LV3 Lehigh River above Easton	0.233	0.054
LC1 Lower Central (above Trenton)	0.063	0.025
Lower Region (PA, NJ and DE)		
SV1 Schuylkill River above Reading	ND	ND
SV2 Schuylkill R . above Valley Forge	0.111	0.021
SV3 Schuylkill River above Phila.	0.047	0.025
UE1 Pennsylvania piedmont	0.030	0.022
UE2 New Jersey coastal plan	0.008	0.027
LE1 Christina River	0.158	0.045
LE2 C and D Canal, DE	ND	ND
LE3 Salem River, NJ	ND	ND
Bay Region (NJ and DE)		
DB1 DE Bayshore watersheds	ND	ND
DB2 NJ coastal plain	0.013	0.092
ND= no data * median based on 2 or fewer samples		

Table 2.1. Concentrations of atrazine and metolachlor generally were lowest in the northern part of the basin, above the confluence of the Lehigh River. USGS 2001.

For More Information:
Detailed information on atrazine, metolachlor and other pesticides found in water supplies can be found by reading "Pesticide compounds in streamwater in the Delaware River Basin, December 1998-August 2001" by Hickman, et al
located at: http://pubs.er.usgs.gov/usgspubs/sir/sir20045105

Indicator • Toxics

Indicator description

Polychlorinated biphenyls (PCBs) are toxic compounds shown to cause cancer in animals and serious non-cancer health effects to the immune, reproductive, nervous, and endocrine systems. Studies provide supportive evidence for potential carcinogenic and non-carcinogenic effects in humans as well. PCBs persist in the environment for long periods of time because they bond strongly to soil and sediments and bioaccumulate (See p. 37 for a definition) in fish and wildlife.

Invented in 1927, PCBs are mixtures of synthetic organic chemicals with the same basic chemical structure and similar physical properties ranging from oily liquids to waxy solids. Due to their non-flammability, chemical stability, high boiling point and electrical insulating properties, PCBs were used in hundreds of industrial and commercial applications including electrical, heat transfer, and hydraulic equipment; as plasticizers in paints, plastics and rubber products; in pigments, dyes and carbonless copy paper and many other applications. Based on the evidence that PCBs are persistent in the environment and can cause harmful health effects, the Toxic Substances Control Act (TSCA) of 1976 prohibited the manufacture, processing, and distribution of PCBs.

Desired Condition

PCB concentrations in water, sediment and fish tissue that are designed to protect human health and the environment (BP Goals 1.2, 1.3; CCMP Actions T1-T5). These include the following numeric criteria:

- drinking water: 500 ppt (EPA)
- ambient water for aquatic life protection: 14 ppt chronic (EPA)
- ambient water to protect wildlife: .074 ppt (EPA-Great Lakes Initiative)
- ambient water for human health protection: .016 ppt (DRBC-proposed)

Status

Poor: PCBs persist in the Basin's water, sediment and fish tissue.

Extensive analysis of the sources and fate of PCBs has been studied by DRBC as part of the development of the Total Maximum Daily Load (TMDL) for Zones 2-6. As illustrated in Figure 2.15, the current sources of PCBs to the tidal river are non-point sources accounting for 25% of loadings and point sources contributing 18%. The non-tidal river above Trenton, the Schuylkill River and other tributaries to the tidal river contribute about 34.5%.

Contaminated sites contributed 11% of total loading. The Delaware Toxics Reduction Program (DelTRiP) is a multi-agency effort to identify, track, prioritize, and report the status of contaminated sites that contribute or potentially contribute to toxics within the basin. The program, started in 2004 through a grant from EPA, is currently focused on PCB contamination. According to the January 2008 report, 128 sites have completed remediation for PCBs and 81 sites are in some stage of remediation including 28 of unknown status (Figure 2.16). Future DelTRiP reports will update this information with a focus on sites of unknown status.

Trends

Despite the ban on PCB manufacture in 1979, PCBs still persist in landfills, streambeds, terrestrial sediments, and some closed electrical systems. They remain a ubiquitous legacy pollutant in much of the basin, but concentrations vary greatly, and there is evidence that concentrations in fish tissue is decreasing (Figure 2.17).

The goal of the TMDL for the tidal

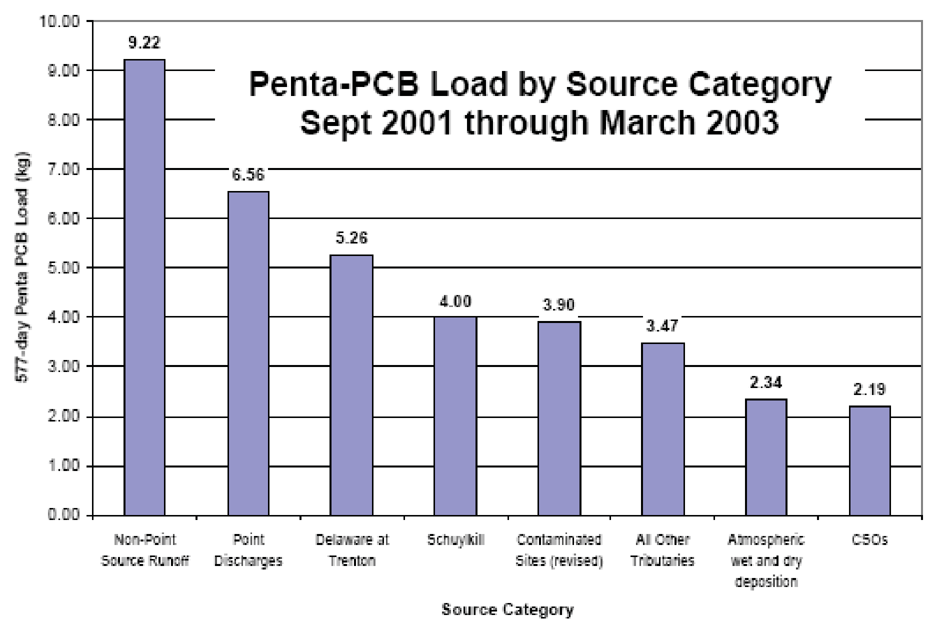
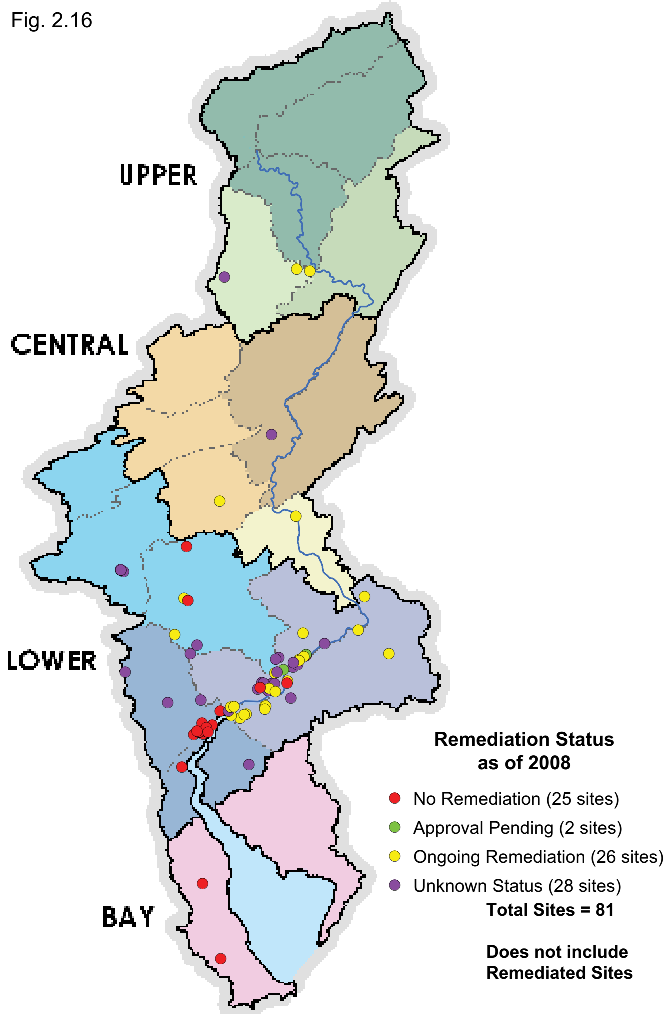


Figure 2.15. Non-point and point source sources contribute more PCBs to the tidal portion of the river more than any other. The non-tidal Delaware and the Schuylkill River also have high loadings of PCBs. Data collected September 2001–March 2003.

Fig. 2.16



SOURCE: DRBC

The Lower Schuylkill is a major contributor of PCBs in the Delaware Estuary. This photo taken in 1999 at Bartram's Gardens shows the heavy industrial area along the Schuylkill just above its confluence with the Delaware.

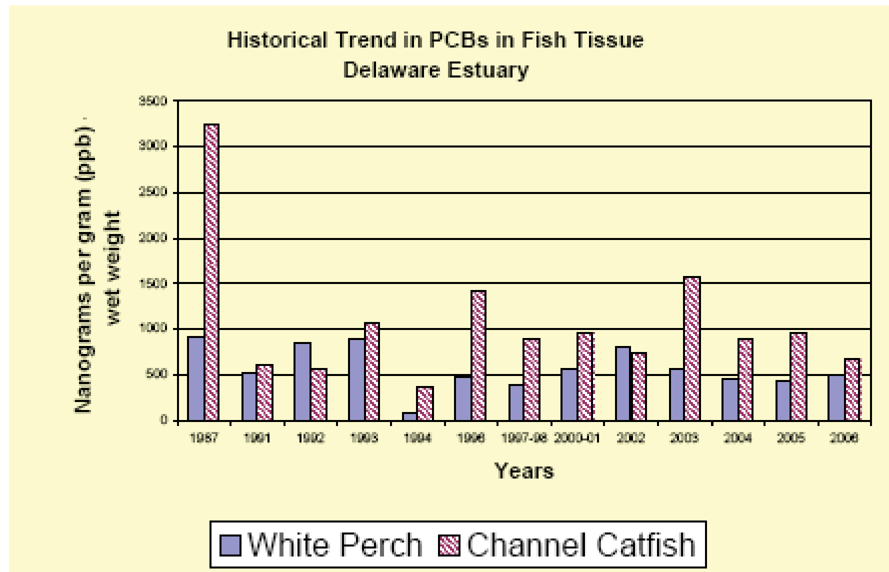


Figure 2.17. PCBs are still found in fish tissue in the Delaware Estuary but concentrations appear to be diminishing.

Delaware River is to reduce PCB loadings and eliminate consumption advisorties based on this contaminant. The first stage is a non-numeric approach, all point sources are required to conduct monitoring and 42 dischargers are required to submit a Pollution Minimization Plan (PMP). This plan identifies all known and potential sources of PCBs on their property, and outlines a procedure to find all unknown sources and implement strategies for minimizing and preventing releases from all identified sources. The permittees must also document measured progress in this effort in an annual report to DRBC.

Actions and Needs

- Continued monitoring and source identification is needed for PCBs in the Delaware River Basin.
- Removal and containment should be done as sources of PCBs are found.
- Revised water quality criterion for PCBs and regulations addressing the long-term attainment of this criterion. A second stage of the TMDL program will be implemented and completed by December 2009.

Indicator • Support of Designated Use: Tributaries

Indicator Description

This indicator reports conditions on tributaries relative to their designated uses. Each state independently identifies uses for each waterbody, for example, drinking water supply, contact recreation (swimming), and aquatic life support (fishing), and specifies scientific criteria to support that use.

Biennial assessments are mandated by the federal Clean Water Act (CWA). Waterbodies that are not attaining water quality standards are included on a "List of Water Quality Limited Waters" or "303(d) List" and reported to US EPA to satisfy section 303(d) of the CWA. States must prioritize 303(d)-listed waterbodies for TMDL analyses and identify those high priority waterbodies for which they anticipate establishing TMDLs in the subsequent two year cycle.

Desired Condition

All streams meet standards set to support their designated uses per the federal Clean Water Act (BP Goals 1.2, 1.3, 1.4; CCMP Action W12).

Status

Fair: Approximately 37% of basin stream miles do not meet required conditions. The presence of fish consumption advisories is a major factor in 303(d) listings in the basin. Not all waters of the basin have been assessed.

Trends

Figure 2.18 is a composite of data across four biennial reporting cycles (2002 through 2008). The ability to geographically report on each state analysis is dependent on the availability of geographic information suitable for mapping and on final condition assessment information. Differences in assessment and reporting methodologies among the basin states complicate attempts to assemble and compare results, as do periodic changes instituted by the states. For example, in 2006 NJ changed its reporting units from stream segments to watershed units.

Actions and Needs

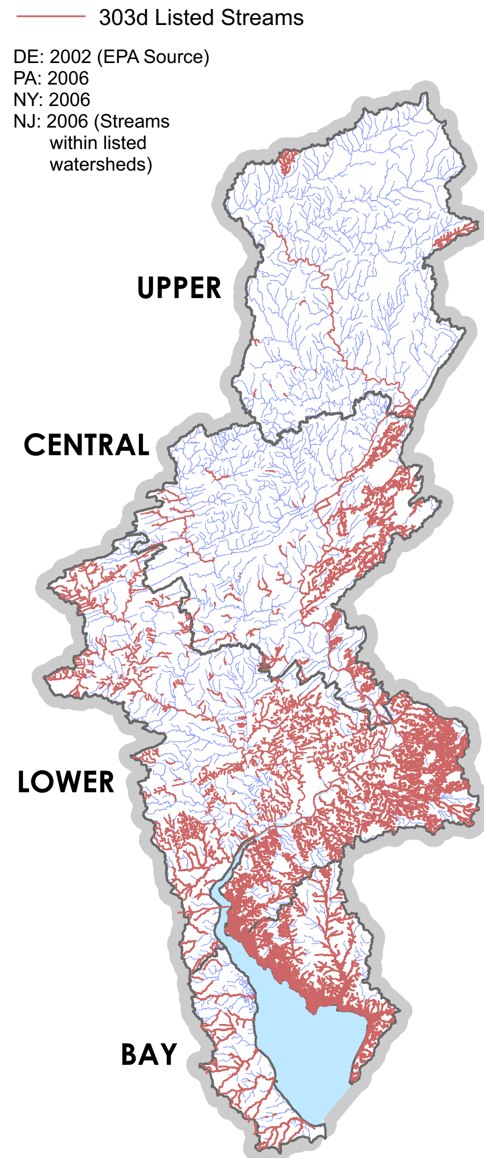
- Better cartographic representation of impaired waters information in all four states.
- Assessment information relevant to chemical, physical and biological conditions.
- Comparable reporting of summary statistics.

A TMDL (Total Maximum Daily Load) is the sum of the allowable amount of a single pollutant from all contributing point and nonpoint sources. It includes a margin of safety and seasonal variation in water quality.

Table 2.2 Unattaining 303(d) Listed Streams

State	Data Year	Total Tributary Miles	Total 303(d) Stream Miles	Stream Miles w/Consum. Advisories	% of Total	% of Total w/o Consum. Advisories
DE Total	2002	2,480	569		23%	
NJ Total	2006	6,975	5,786		83%	
NJ Consum. Advisories				3,597		31%
NY Total	2006	4,197	81		2%	
PA Total	2006	10,578	2,512		24%	
PA Consum. Advisories				658		18%
TOTAL		24,230	8,948	4,255	37%	19%

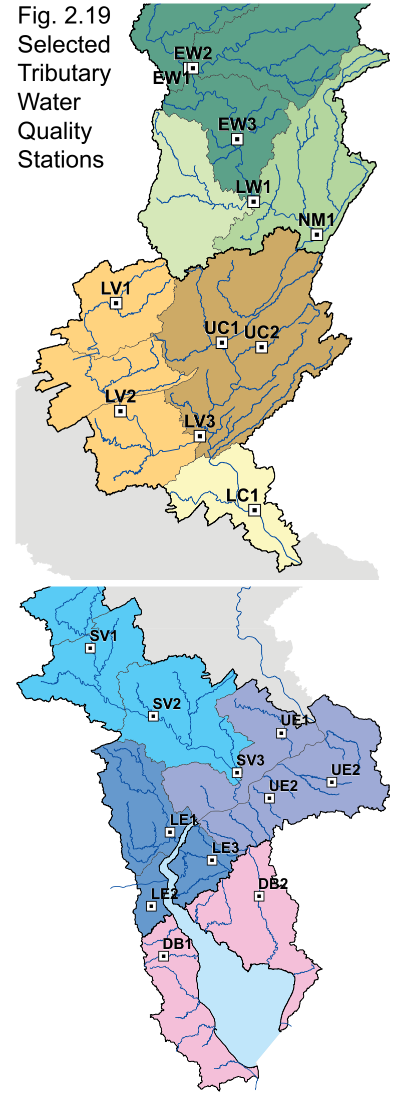
Fig. 2.18
303d Listed Streams and Watersheds



Indicator • Trends in Tributary Water Quality

Lower and Bay ◆ Upper & Central

Fig. 2.19 Selected Tributary Water Quality Stations



Indicator Description

This indicator reports trends in conditions on representative fresh-water tributaries relative to four water quality parameters that effect living resources: dissolved oxygen (DO), nitrogen (N), phosphorus (P) and total suspended solids (TSS). The assessment was developed by the Water Resources Agency at the University of Delaware with assistance from Penn State, Cornell and Rutgers and is based on water quality data from the EPA STORET, USGS NWS and state water quality information systems.

Five year median values for each parameter were compared to targets:

- DO: applicable state criteria.
- N: 1.0, 2.0, and 3.0 mg/L (DE low, moderate and high TMDL targets)
- P: 0.1 mg/L (NJ criterion)
- TSS: 40 mg/L for warm water and 20 mg/L for cold water (trout) streams (NJ criteria).

Although many years of data are available, 1990 was selected as the beginning year for trend analysis to exclude water quality improvements related to the waste water infrastructure investments of the 1980s.

Desired Condition

Improving or constant conditions in streams, where water quality meets or is better than criteria (BP Goals 1.2, 1.3, 1.4; CCMP Action W12).

Status and Trends

Upper and Central Regions: Good

DO levels are very good and show increases at 6 of 9 watershed stations. P is below 0.1mg/L and has improved or remained constant, except at the lower Lehigh station (LV3) where it is slightly elevated, but improving. Water quality in the lower Lehigh appears to be degrading since 1990 with respect to N and TSS (Table 2.3).

Lower and Bay Regions: Fair

DO, while good to fair, is decreasing at 6 of 11 stations. N, while constant, is higher than the moderate target (2.0 mg/L) at half the stations, and phosphorus is constant but above 0.1 mg/L at 8 of 11 stations. TSS is high, but improving, on the Smyrna River (LE2) (Table 2.3).

Actions and Needs

- More consistent monitoring is needed: at least one station in each region had insufficient periods of record for one or more parameters.
- Metals data were generally not sufficiently robust to assess because of changes in detection capability or incomplete records.
- This initial look should be expanded to include additional watershed stations.

Table 2.3 Trends in Water Quality of Selected Tributary Streams

Upper and Central Region Stations	DO (mg/l)	N (mg/l)	P (mg/l)	TSS (mg/l)
	SHORT	TERM	SINCE	1990
EW1 West Br. Delaware R. Hancock, NY	10.4 ●	0.4 ●	0.01 ▲	6 ●
EW2 East Br. Delaware R. Hancock, NY	9.9 ●	0.2 ●	0.01 ●	5 ●
EW3 Hancock - Narrowsburg, NY	Insufficient Data			
LW1 Lackawaxen R. at Lackawaxen, PA	12.6 ▲	0.2 ●	0.02 ▲	6 ●
NM1 Delaware River at Pt. Jervis, NY	10.7 ▲	0.2 ●	0.02 ●	5 ●
UC1 Brodhead Cr at Del. Water Gap, PA	12.0 ▲	0.5 ●	0.05 ▲	2 ●
UC2 Paulins Kill at Blairstown, NJ	10.0 ●	1.0	0.02 ●	7 ●
LV1 Lehigh River at Stoddartsville, PA	11.5 ▲	0.2 ●	0.01 ▲	4 ●
LV2 Lehigh River at Walnutport, PA	12.1 ▲	0.7 ●	0.02 ▲	8 ▼
LV3 Lehigh River at Glendon, PA	11.2 ▲	2.1 ▼	0.11 ▲	9 ▼
LC1 Wichechocke Creek at Stockton, NJ	Insufficient Data			

Lower and Bay Region Stations	DO (mg/l)	N (mg/l)	P (mg/l)	TSS
SV1 Schuylkill River at Berne, PA	10.5 ▼	1.0 ▲	0.02 ▲	6 ▼
SV2 Schuylkill River at Pottstown, PA	10.1 ●	3.0 ●	0.12 ▲	8 ●
SV3 Schuylkill R. at Philadelphia, PA	10.8 ▲	3.2 ●	0.23 ▲	2 ▲
UE1 Neshaminy Cr. at Langhorne, PA	10.7 ●	2.3 ●	0.18 ▲	6 ●
UE2 N. Br. Rancocas at Pemberton, NJ	7.1 ▼	I.D.	0.05 ●	I.D.
UE2 Cooper River at Haddonfield, NJ	7.2 ▼	1.0 ●	0.23 ●	19 ●
LE1 Brandywine R. above Wilmington, DE	9.9 ▲	2.5 ●	0.12 ●	9 ●
LE2 Smyrna River at Route 9 bridge, DE	6.1 ▼	0.6 ●	0.21 ●	86 ▲
LE3 Salem River at Woodstown, NJ	9.5 ▲	3.7	0.15 ●	17 ●
DB1 Leipsic River at Route 13, DE	7.9 ▼	0.1 ▲	0.23 ●	20 ●
DB2 Maurice River at Norma, NJ	8.2 ▼	2.0	0.01 ●	3 ●

Legend
Green numbers = Good
Blue numbers = Fair
Red numbers = Poor
▲ = Improving
● = Constant
▼ = Degrading

Indicator • Support of Designated Use: River and Bay

Indicator Description

This indicator reports whether or not the water quality of the River is supportive of its designated uses, including: drinking water, aquatic life, recreation, and consumption of fish and shellfish, although not all uses are designated for all ten water quality zones. This assessment is conducted every two years in accordance with USEPA requirements. A full explanation of the assessment can be found in the 2008 Delaware River and Bay Integrated List—Water Quality Assessment available at www.drbc.net.

Desired Condition

Water quality that meets the criteria designed to ensure support of designated water uses per the federal Clean Water Act (BP Goals 1.2, 1.3, 1.4; CCMP Action W12).

Status

Fair: Ranges from poor (fish consumption and aquatic life) to good (drinking water and recreation).

The assessment involves comparing key water quality parameters by river assessment units (water quality management Zones) with applicable water quality criteria adopted by DRBC to support the designated use(s). The non-tidal assessment units include Zones 1A, 1B, 1C, 1D, and 1E and the designated uses assessed include aquatic life, drinking water, primary recreation, and fish consumption. Zones 2, 3, 4, and 5 make up the tidal portion of the River and fish consumption, aquatic life, and recreation apply to all the tidal zones. Drinking water use is only applicable to Zones 2 and 3 of the tidal river. Delaware Bay is Zone 6 and its designated uses include aquatic life, primary recreation, fish consumption, and shellfish consumption.

The final assessments for 2008 by zone and designated use are listed in Table 2.4 and shown in Figure 2.20.

Integrated Assessment Summary

Aquatic life is supported in zones 3 and 6. In Zones 1A and 1E, pH does not meet criteria; and Zones 2 and 4 do not meet temperature criteria. Additionally, in Zone 5 approximately 17% of the samples assessed for DO did not meet the 24-hour average criteria.

Drinking water use is supported in all designated zones.

Primary contact recreation is supported in all applicable zones, except Zone 4 below RM 81.8 where there are insufficient data.

Fish consumption is not supported in any zone, based upon the assessment methodology used. This means that an advisory has been issued by a State with a recommendation to limit consumption of at least one species of fish. In most instances, the contaminants are PCBs and mercury. New York did not issue any fish advisories for the Delaware River, however fish advisories due to mercury are listed for the reservoirs feeding the Delaware River. Recently compiled toxics data from fish tissue collected in 2004 and 2005 also support fish advisories in the tidal river. PCBs remain the primary cancer risk driver, followed by dioxin and dioxin-like chemicals. Mercury levels in striped bass are moderately elevated and contribute to non-cancer health risks.

Shellfishing support varies within Zone 6 based on periodic pathogen exceedences.

Actions and Needs

- Examination of DO issues, including assessment of current monitoring and adequacy of existing criteria in the tidal river.
- Implementation of the PCB Total Maximum Daily Load (TMDL) for Zones 3, 4, 5 and 6.
- Review and assessment of the adequacy of current water quality criteria.

Table 2.4 2008 Integrated Listing Category for the Delaware River by DRBC Water Quality Management Zones

Zone	Aquatic Life	Drinking Water	Recreation	Fish Consumption	Shellfishing	Final 2008 Assessment Category	Final 2006 Assessment Category
1A	NS	S	S	NS	NA	5	5
1B	ID	S	S	NS	NA	5	5
1C	ID	S	S	NS	NA	5	5
1D	ID	S	S	NS	NA	5	5
1E	NS	S	S	NS	NA	5	5
2	NS	S	S	NS	NA	5	5
3	S	S	S	NS	NA	4A	5
4	NS	NA	ID (below RM 81.8)/S	NS	NA	5	5
5	NS	NA	S	NS	NA	4A	5
6	S	NA	S	NS	S/SS/NS/ID	4A	5

S: The assessment unit supports the designated use.
SS: The assessment unit supports the designated use, but with special conditions.
NS: The assessment does not support the designated use.
NA: DRBC WQR does not contain applicable criteria for a parameter in the AU.
ID: Insufficient or unreliable data is present.
4A: A TMDL to address a specific segment/pollutant combination has been approved or established.
5: Available data and/or information indicate that at least one designated use is not being supported or is threatened, and a TMDL is needed.

- Additional real-time monitoring is an identified need that can only enhance our ability to assess and report water quality conditions.

Fig. 2.20 Support of Designated Uses: Delaware River and Bay

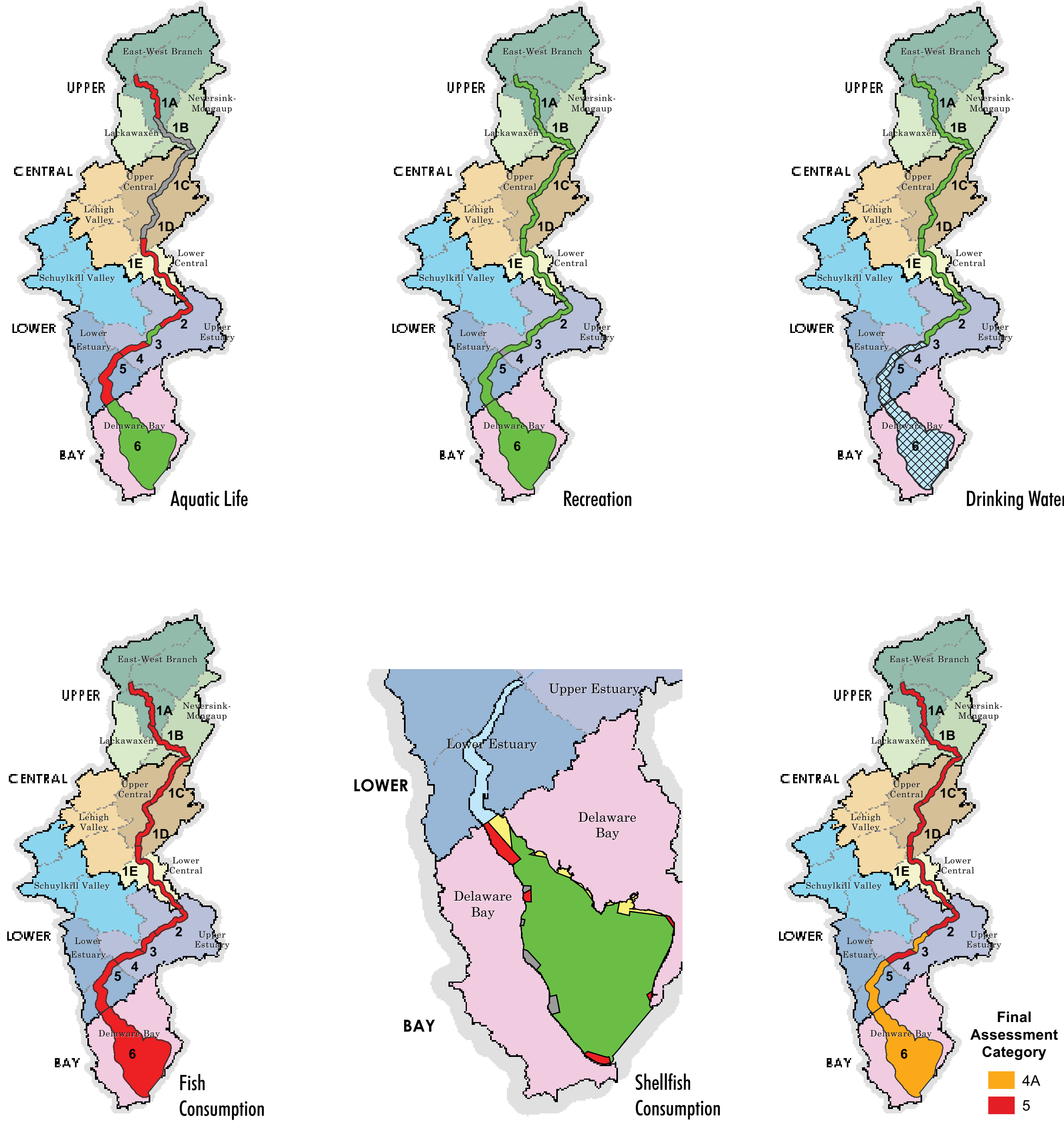
Upper Region
EW • East and West Branch watersheds
LW • Lackawaxen watershed
NM • Neversink and Mongaup watersheds

Central Region
UC • Upper Central watersheds
LV • Lehigh Valley
LC • Lower Central watersheds

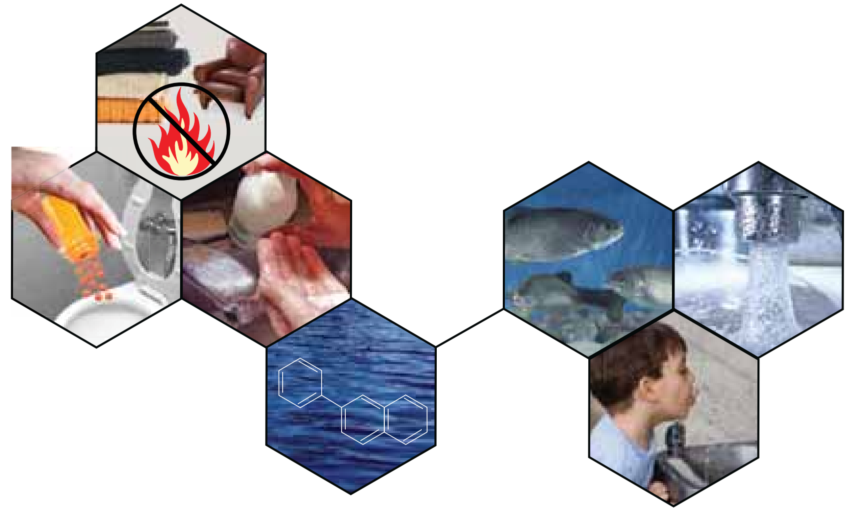
Lower Region
SV • Schuylkill Valley
UE • Upper Estuary watersheds
LE • Lower Estuary watersheds

Bay Region
DB1 –Bay watersheds in DE
DB2 – Bay watersheds in NJ

Supporting
Supporting, but with Special Conditions
Not Supporting
Insufficent Data
Not Assessed



Contaminants of Emerging Concern



Description

Contaminants of emerging concern are chemicals that are not regulated through water quality programs, but are of interest to scientists because of their persistence, bioaccumulation, and potential for toxicity to aquatic life and humans. Although their fate and transport are not fully understood, and a consensus has not yet been reached concerning their toxicity, these substances are believed to have the potential to cause adverse impacts on human health or the environment, including causing cancer and reproductive effects. Contaminants of emerging concern include pharmaceuticals, personal care products, flame retardants, insecticides, plasticizers, and resistant pathogens (bacteria and viruses).

Status

Significant work is being conducted to study emerging contaminants in the Delaware River Basin. Polybrominated diphenyl ethers (PBDE) are manufactured flame retardants used in everyday items, from computer casings to carpet pads to foam cushions in chairs and couches. In the environment PBDEs accumulate in the fatty lipid tissue of humans and animals. Figure 2.21 shows the relative concentrations among 18 tissue samples of eel from six sites in the Delaware River. Concentrations are measured in nanograms (10^{-9}, parts per trillion or ppt) of PBDE per gram of tissue.

In 2007, DRBC conducted a pilot survey in the tidal Delaware River, sampling and analyzing ambient waters for pharmaceuticals and personal care products (PPCP), perfluorinated compounds (PFC), hormones and sterols, nonyl phenols, and polybrominated diphenyl ethers (PBDE).

- Twenty-one out of 54 PPCP compounds were detected.
- Aquatic ecotoxicity data, primarily based on individual compounds and single species tests, are readily available for only 16 out of the 21 PPCP compounds which limits the assessment of risk to aquatic life.
- PFCs were measured in concentrations that exceed benchmarks for water quality.
- Nonyl phenol levels did not exceed current EPA water quality criteria.
- PBDE were measured in pg/L to ng/L concentrations with distributions similar to those observed in other North American locations.
- Natural and synthetic hormones were reported in ng/L levels. Concurrent, short-term chronic toxicity tests for survival, growth, and reproduction in the ambient water samples did not indicate toxicity for species and endpoints measured.

> **How small is…**
>
> A nanogram is
> 10^{-9} or 1/1,000,000,000
> or one trillionth of a gram
> ppt = part per trillion = ng/Liter
>
> A picogram is
> 10^{-12} or 1/1, 000,000,000,000 or
> one billionth of a gram
> ppb = parts per billion = pg/Liter

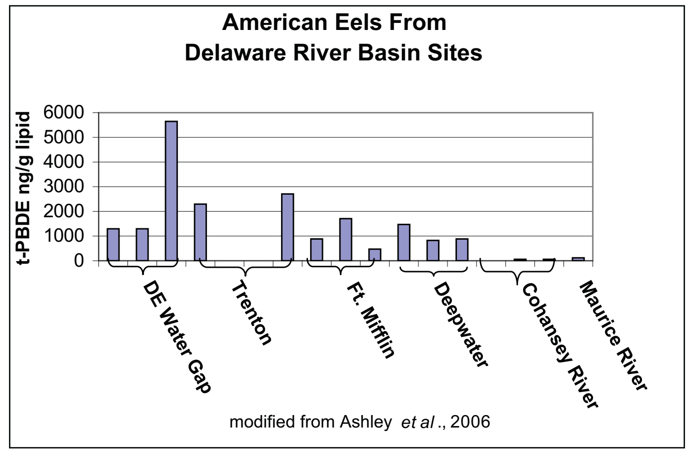


Fig. 2.21. American Eel PBDE concentration

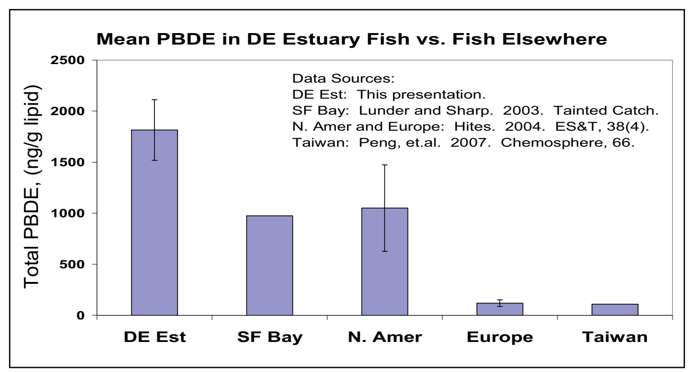


Fig. 2.22. PBDE in DE Estuary Fish

Trends

The levels of PBDEs in people's bodies are reported to be doubling every 2 to 5 years, and are 40 times higher in North America than on other continents. A comparison of PBDE concentration in fish from the Delaware Estuary and fish found in other locations is illustrated in Fig. 2.22. These data suggest that PBDE concentrations are significantly higher in fish from the Delaware than from other parts of North America, and orders of magnitude greater than those from Europe and Taiwan. The effect levels and human health implications of these compounds have yet to be established.

Actions and Needs

- Systematic monitoring is needed to understand how and where these substances are being released into the environment, what is happening to them once they enter the environment, and the risk they pose to humans and to our ecosystem.
- Assessment of ecotoxicity from emerging contaminants in the tidal Delaware River would be further informed by estrogenicity screening, biomarker measurements and population (sex ratio) surveys.

Learn more about contaminants of emerging concern at these web links.

Delaware River Basin Commission Emerging Contaminants
http://www.state.nj.us/drbc/emc.htm

United States Environmental Protection Agency (USEPA) Pharmaceuticals and Personal Care Products
http://www.epa.gov/ppcp/

United States Geological Survey (USGS) Emerging Contaminants in the Environment
http://toxics.usgs.gov/regional/emc/

Proper Disposal of Prescription Drugs Consumer Guidance (White House Office of National Drug Control Policy)
http://www.whitehousedrugpolicy.gov/drugfact/factsht/proper_disposal.html

Teleosis Institute List of National Pharmaceutical Take-Back Programs and Resources
http://www.teleosis.org/gpp-national.php

Fig. 2.23 Pharmaceuticals and Personal Care Products

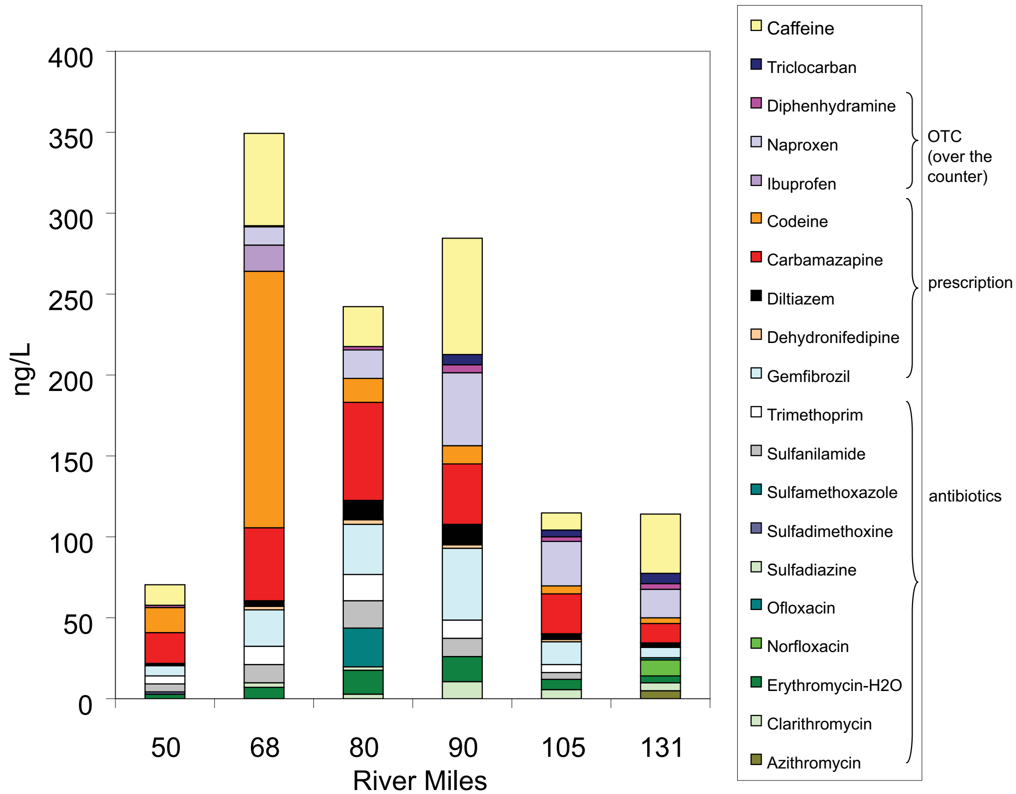


Fig. 2.24 Perflourinated Compounds (PFCs) in theTidal Delaware River 2007

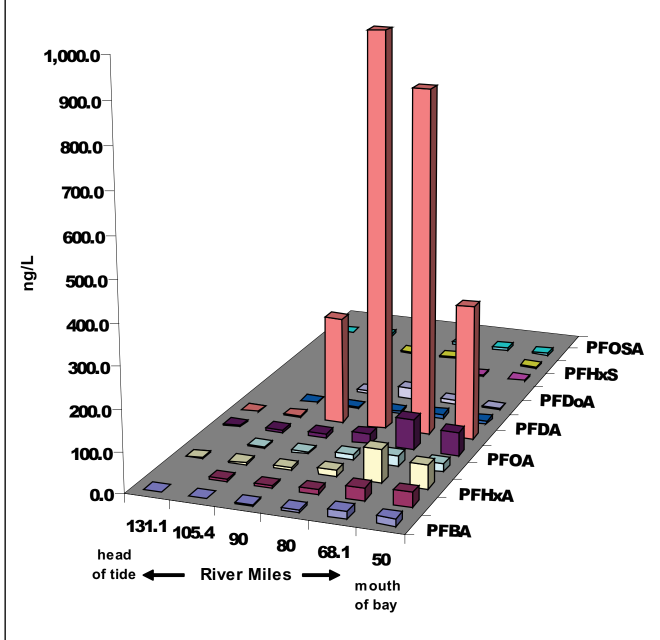


Fig. 2.24. Results of a 2007 DRBC study show concentrations in nanograpms per liter of perflourinated compounds (PFCs) by river mile.