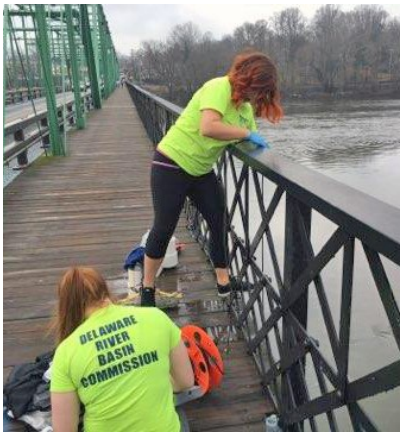
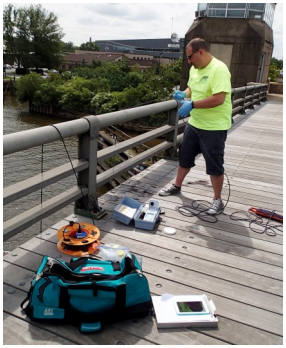
Water Quality Programs of the Delaware River Basin Commission





Delaware River Basin Commission

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Photos from top, left to right:

1. DRBC intern Vicki Trucksess (seated) and DRBC Water Resources Scientist Elaine Panuccio collect Delaware River samples at the Calhoun Street Bridge in Trenton, N.J. to be analyzed for nutrients. Photo by DRBC.
2. DRBC Geologist Bob Damiani collects a water sample from a Delaware River tidal tributary for nutrient analysis. Photo by DRBC.
3. (from left to right) DRBC Water Resource Planner Doug Rowland, DRBC intern Andrew Garcia, and DRBC Water Resources Scientist Elaine Panuccio (underwater—snorkel) perform biomonitoring on the Delaware River. Photo by DRBC.
4. DRBC Sr. Environmental Toxicologist Ron MacGillivray, Ph.D. (left), and Sr. Geologist Greg Cavallo, PG, collect a sediment sample from a tidal tributary to the Delaware River. Photo by DRBC.
5. DRBC interns Julia Ragazzo (left) and Megan Andreason (right) monitor the Delaware River from Kittatinny Visitor Center's beach near the Delaware Water Gap as part of DRBC's Scenic Rivers Monitoring Program. Photo by DRBC.
6. DRBC staff perform nutrient monitoring of the Delaware River from the Calhoun Street Bridge in Trenton, N.J. Photo by DRBC.
7. DRBC Water Resource Modeler Dr. Li Zheng (left) and Water Resource Modeling Manager Dr. Namsoo Suk collect surface water samples for nutrient analysis. Photo by DRBC.
8. DRBC Water Quality Assessment Manager John Yagecic, P.E. (front) and former intern Eric Wentz prep samples collected for radiochemistry analysis for the lab. Photo by DRBC.
9. DRBC Water Resources Scientist Elaine Panuccio holds the net used to collect macroinvertebrates (aquatic bugs) underwater during a biomonitoring sampling event on the Delaware River. Photo by DRBC.

Water Quality Programs of the Delaware River Basin Commission

Introduction

A Historical Perspective

Pollution in the Delaware River, particularly in the tidal reaches of its urban centers, began to be a recognized problem by the eighteenth century and continued to be a serious issue over the next 200 years. This was mostly due to rapid population growth and increased industrial activities, which used the river as an open sewer and dumping ground. Severe pollution was most evident by the prevalence of waterborne illnesses and in the sharp decline of migratory fish populations, such as the American shad and Atlantic sturgeon. Parts of the estuary were considered dead zones, almost or completely devoid of oxygen needed for the survival of aquatic life.

The 1937 *Philadelphia Record* editorial page cartoon depicts the time when the tidal Delaware was an open sewer, where pollution in some stretches robbed the river of all its oxygen needed to support fish and other aquatic life.

What Was Done?

In the late 1930s, these problematic conditions prompted the formation of the Interstate Commission on the Delaware River Basin, or INCODEL, by Delaware, New Jersey, New York, and Pennsylvania. Cleaning up the severe water pollution in the Delaware Estuary was at the top of this advisory commission's priorities. The first set of interstate water quality standards was adopted through INCODEL, initiating the creation of new sewage treatment plants and also the completion of dredging the Schuylkill River and Delaware Estuary of coal silt, which was one of the nation's first non-point source pollution control programs.

Building on the experiences of INCODEL, the Delaware River Basin Commission (DRBC or commission) was established in October 1961 when the Delaware River Basin Compact became law. The commission was formed well before the 1970 creation of the Environmental Protection Agency, the 1972 passage of the federal law commonly known as the Clean Water Act, and the formation of many state environmental agencies. Like INCODEL, the commission's members are the four basin states (Delaware, New Jersey, New York, and Pennsylvania), but the DRBC includes a fifth representative, the federal government.

However, DRBC is distinctly different than the advisory INCODEL, as it acts as a regional body with the force of law to manage the water resources of the Delaware River Basin without regard to political boundaries. The compact's signing marked the first time that the federal government and a group of states joined as equal partners in a river basin planning, development, and regulatory agency. The *ex officio* commission members are the basin state governors and the

commander of the North Atlantic Division of the U.S. Army Corps of Engineers, who represents the federal government and all federal agencies.

(seated left to right) Governors Robert Meyner of New Jersey, Elbert Carvel of Delaware, and David Lawrence of Pennsylvania joined President John F. Kennedy at the White House on November 2, 1961, to participate in a ceremonial signing of the Delaware River Basin Compact.

DRBC delved head-first into its water resources management role, initially focusing on cleaning up the tidal river's polluted waters. In 1967 it adopted comprehensive water quality standards, including bacterial standards for primary and secondary contact recreation (i.e., swimming and boating, respectively), and standards for dissolved oxygen. The standards were tied to an innovative waste load allocation program which factored in the waste assimilative capacity of the tidal Delaware River (the predecessor to today's "total maximum daily loads", or TMDLs).

A year later in 1968, the DRBC adopted regulations for implementing and enforcing the standards. The Clean Water Act of 1972 further assisted the implementation of water pollution control efforts in the basin by establishing technology-based and water quality-based standards and enforcement programs and creating the National Pollutant Discharge Elimination System (NPDES), which regulates point source discharges into surface waters via a permitting system. Funds for constructing municipal and wastewater treatment facilities were also provided by government partners. Later modifications to the Clean Water Act focused on the important issues of toxic pollutants and non-point source pollution.

> "Only the Delaware among the nation's river basins is moving into high gear in its program to combat water pollution."
>
> 1968—Stewart Udall, Secretary, U.S. Dept. of the Interior (1961–1969)

By the late 1980s, over one billion dollars had been spent on improving wastewater treatment facilities in the Delaware River Basin, which benefited communities along the river and strengthened fish populations. DRBC began its Delaware Estuary Toxics Management Program in 1989 to develop methods to control the discharge of toxic pollution from wastewater treatment plants into the estuary. New rules were adopted in 1996 that added many toxic substances to what was originally regulated in wastewater treatment plant discharge. DRBC's toxics criteria was most recently updated in 2010, and a revision to its water quality criteria for polychlorinated biphenyls (PCBs) was approved in December 2013.

In contrast to the conditions found in the more heavily developed estuary, monitoring demonstrated that water quality in the non-tidal Delaware was already better than standards. DRBC in 1992 launched its Special Protection Waters (SPW) program, which set regulations in place to "keep the clean water clean" in the 121-mile stretch of the Delaware River from

Hancock, N.Y. to the Delaware Water Gap. In 2008, SPW designation was expanded to include the Lower Delaware Scenic and Recreational River, making the entire 197-mile non-tidal Delaware. This is believed to be the longest stretch of river in the nation with an anti-degradation policy program in place.

> "Water quality in the non-tidal portion of the Delaware River is perhaps the purest of all the large rivers in the mid-Atlantic and northeastern United States."
>
> 2012 – National Park Service, *Delaware River Basin Wild and Scenic River Values* (Sept. 2012)

How About Now?

Today, the clean-up of the Delaware is hailed as one of the world's top water quality improvement success stories. The river now supports year-round fish populations, as well as those returning to their natal waters to spawn. Bald eagles, which depend on fish as their primary food source, reside and nest throughout the basin from the river's headwaters to the bay. Pleasure craft marinas line waterfronts once visited only by commercial vessels, and river-based recreation is one of the region's top economic sources. Officially designated water trails exist for the non-tidal Delaware and a portion of the tidal river, as well as for the Lehigh and Schuylkill rivers, the two largest tributaries to the Delaware.

These improvements, as well as other DRBC accomplishments, over the past fifty-plus years are rooted in the Delaware River Basin Compact's chief canon: that the waters and related resources of the basin are regional assets vested with local, state, and national interests that all share joint responsibility to maintain and protect. DRBC stresses the importance of partnerships as a wise leveraging of public dollars and a way to work together towards this common goal.

However, this accomplishment does not mean that the work is over. While water quality is still in need of improvement in some sections of the river, it is better than standards in other stretches and needs to be maintained at these higher levels. As new technology enhances DRBC's ability to detect, monitor, track, and model pollution in the river, the commission's policies, programs, and abatement efforts must adapt and evolve in order to continually improve the basin's water quality for future generations.

Learn more about DRBC at https://www.nj.gov/drbc/about/.
Learn more about DRB water quality at https://www.nj.gov/drbc/quality/.

The Foundations of DRBC's Water Quality Initiatives

Article 5 of the Delaware River Basin Compact defines the commission's water quality mandates, which direct the DRBC to take the lead on water quality matters pertaining to the basin by adopting regulations:

> "…to control such future pollution and abate existing pollution, and to require such treatment of sewage, industrial or other waste within a time reasonable for the

> construction of the necessary works, as may be required to protect the public health or to preserve the waters of the basin for uses in accordance with the comprehensive plan." (Compact, §5.2)

The commission's first Water Quality Regulations were adopted in March 1967 and are divided into two main sections: Article 3 - Water Quality Standards for the Delaware River Basin and Article 4 - Application of Standards. Standards were created for main stem water quality zones and also for the basin in its entirety. The regulations, which have been updated and revised periodically, are a part of the commission's Water Code and are an important mechanism by which commission members work together to manage the water resources of the basin. Three of the four basin states (not NYS) utilize these standards either directly or if they are more stringent than state standards.

The Compact also provides that no project having a substantial effect on the water resources of the basin shall be undertaken unless it shall have been first submitted to and approved by the commission (Compact, §3.8). The commission reviews projects that withdraw from or discharge to the basin's waters over certain thresholds. In accordance with Section 3.8 of the Compact, the commission is required to approve a project whenever it finds and determines that the project would not substantially impair or conflict with the comprehensive plan, i.e., not adversely impact the water resources of the basin. The commission provides by regulation for the procedure of submission, review, public input, and consideration of projects and for its determinations pursuant to Section 3.8.

Learn more about DRBC's authorities, regulations, and guidance at https://www.nj.gov/drbc/about/regulations/.

DRBC Tenets for Integrated Water Resources Management

There are several self-evident truths about integrated water management that the commission adheres to when managing the basin's water resources, including its water quality. First, water does not respect political boundaries and should be managed on a holistic, watershed basis that takes into account surface water and groundwater and also stormwater and wastewater. Second, what happens on the land affects the water and what happens upstream affects downstream users. Third, water management is collaborative; all levels of government, including federal, state, interstate, and municipal, as well as local stakeholders, must be engaged in the process. And, lastly, water management must be adaptive to changing conditions, new science and technology, and the changing of regional priorities.

The commission works with various federal, state, and local agencies, non-profit organizations, and other stakeholders. The commission oversees various advisory committees and subcommittees that bring together all of these partners to share information on a variety of issues. Several, including the Monitoring Advisory and Coordination Committee, the Toxics Advisory Committee, and the Water Quality Advisory Committee, focus specifically on addressing water quality topics. This coordination amongst its many varied stakeholders,

regardless of political boundaries or agendas, demonstrates DRBC's ability to be a forum to address issues that affect the watershed as a whole.

The DRBC framework allows its five members to come together to jointly determine what is needed to best improve and protect the basin's water resources and how to accomplish this in an integrated, non-duplicative, and adaptive manner based on sound science. The nature of DRBC's water quality management activities relies on this interstate coordination and cooperation. For instance, the agency maintains agreements with all four basin states regarding project review. Projects that lie within the basin must comply with DRBC standards as well as state standards; whichever standard is stricter applies. All docket approvals and new or amended DRBC regulations are considered by the commission after an open process that includes holding public hearings and inviting public comment. All commission regulatory decisions are made at public meetings.

DRBC's Water Quality and Monitoring Programs: You Can't Manage What You Don't Measure

The commission uses a multi-faceted strategy to water quality regulation that provides a rational approach to protecting and restoring water quality in the basin. The waters of the basin are protected for designated uses through established water quality criteria that specify what levels of individual parameters are appropriate to protect the uses for the different water quality zones of the river (see map on right). Criteria have been established to protect both human health and aquatic life. DRBC's monitoring programs provide a mechanism to evaluate how those criteria are being met, and assessment of collected data provide the link to how well the designated uses are being protected.

In addition to monitoring to ensure compliance with established water quality standards, DRBC staff scientists monitor to maintain existing water quality in Special Protection Waters, where water quality is above standards. Monitoring is also undertaken to develop total maximum daily loads (TMDLs) and assimilative capacity determinations, to establish and calibrate water quality models, and to track the salt front for reservoir operations. Additionally, monitoring helps evaluate emerging threats to the water resources of the Delaware River Basin.

Every other year DRBC compiles the Delaware River and Bay Water Quality Assessment Report for the U.S. EPA to assess the Delaware River and Bay's

support of various uses, such as aquatic life, drinking water, fish consumption, and recreation, which are protected by the DRBC's Water Quality Regulations and the federal Clean Water Act. The most recent assessment report was submitted to the U.S. EPA in 2016.

Learn more at https://www.nj.gov/drbc/programs/quality/.

Brief Summaries of DRBC Water Quality and Monitoring Programs

Special Protection Waters (SPW): Keeping the Clean Water Clean

The SPW program, initially adopted by the DRBC in 1992 and expanded in 1994 and 2008, is designed to prevent degradation in streams and rivers where existing water quality is better than the established water quality standards through stricter control of wastewater discharges and reporting requirements. Currently, the entire 197-mile non-tidal Delaware River from Hancock, N.Y. to Trenton, N.J. is considered Special Protection Waters, three-quarters of which is also included in the National Wild and Scenic Rivers System.

The shaded area in this map depicts the drainage area to SPW.

The program states that there will be no measurable change in existing water quality (EWQ) of SPW waters except towards natural conditions. This is accomplished by taking a watershed approach, looking also at the drainage area of the designated waters, and by regulating both point and non-point source discharges. It allows new or expanded pollutant loadings as long as they do not measurably change the existing water quality and considers the cumulative impacts of these loadings, rather than just looking at them individually.

SPW regulations are unique in that they require monitoring to determine if measurable change is occurring at designated interstate and boundary control points where existing water quality has been defined. This monitoring program is conducted through an informal partnership between the National Park Service (NPS) and the DRBC called the Scenic Rivers Monitoring Program. Data collected are also used in computer models developed for priority tributaries, i.e. those that have a high number of existing discharges or are expected to have new growth and associated wastewater discharge needs. The models are used to predict possible changes to water quality and to establish discharge limits to prevent a measurable change.

DRBC believes that these regulations establish an anti-degradation policy on the longest stretch of any river in the nation. Ensuring that the level of water quality in Special Protection Waters

is not degrading over time is the ultimate goal of the program: to keep water quality above existing standards, or, simply, to keep the clean water clean.

In 2016, DRBC published the *Lower Delaware Water Quality Assessment*, which compared water quality data initially collected from 2000-2004 to the assessment period of 2009-2011. The report showed that for most water quality parameters at most locations, there were no measurable changes to EWQ in this 76-mile stretch of river from Portland, Pa. to Trenton, N.J. These results demonstrate that DRBC's Special Protection Waters (SPW) program is working and plays an important role in managing water quality in the Delaware River Basin.

Also in 2016, DRBC released a technical document entitled *Existing Water Quality Atlas of the Delaware River Special Protection Waters*. This report compiles EWQ for 85 locations on the entire upper, middle, and lower Delaware River SPW. The primary use of the Atlas will be to document site-specific water quality, allowing the commission to monitor for measurable changes in the river and track SPW program effectiveness over time.

Learn more about SPW at https://www.nj.gov/drbc/programs/quality/spw.html.
Learn more about the Lower Delaware Water Quality Assessment at https://www.nj.gov/drbc/programs/quality/lower-delaware_EWQassessment2016.html.
Learn more about the SPW Water Quality Atlas at https://www.nj.gov/drbc/programs/quality/spw_ewq-atlas.html.

DRBC/NPS Scenic Rivers Monitoring Program and Lower Delaware Monitoring Program

DRBC and NPS partner in this effort to monitor and manage the water quality in the Special Protection Waters and National Wild and Scenic River segments of the Upper Delaware Scenic and Recreational River (UPDE), the Delaware Water Gap National Recreation Area (DEWA), and the Lower Delaware Scenic and Recreational River (LDEL). All of these river segments are considered to have exceptionally high scenic, recreational, ecological, and/or water supply values.

DRBC staff collect water samples from the Lower Delaware for the Scenic Rivers Monitoring Program.

NPS staff lead the monitoring programs in UPDE and DEWA, while commission staff are in charge of the LDEL program. The goals are to assess compliance with EWQ targets and to determine whether EWQ is currently being maintained in SPW. Every three-five years, throughout the 197-mile non-tidal river, close to 60 sites are sampled between May and September and analyzed for nutrients, dissolved oxygen and other conventional pollutants, solids, and bacteria. Samples are taken from the main stem river and also at tributary confluences and are analyzed by academic institutions or state laboratories.

Learn more at https://www.nj.gov/drbc/programs/quality/spw.html.

DRBC Biological Monitoring Program

DRBC staff collect a macroinvertebrate sample as part of DRBC's biomonitoring program.

DRBC's biomonitoring program began in 2001 and includes the development and implementation of methodologies for assessing ecosystem health and biological water quality criteria to support evaluation of water quality in the non-tidal Delaware River. Every two-three years, typically during August and September, commission staff collect samples at 25 riffle habitat sites from Hancock, N.Y. to just above the head of tide at Trenton, N.J. These sampling efforts include collection and identification of benthic macroinvertebrates (aquatic bugs); certain species are more sensitive to pollution and finding these are a good indicator of water quality. Benthic periphyton (alga) are also sampled and habitat characteristics are documented to provide a complete overview of the diversity and health of the aquatic life community.

The biomonitoring program also gathers information on other significant natural resources of the Delaware River Basin, such as fisheries, aquatic plants, mussels, and invasive species (both aquatic and riparian plants and animals). In addition, staff support the member states and the U.S. EPA in their regional biological monitoring surveys. Samples are analyzed by the Academy of Natural Sciences of Drexel University in Philadelphia, Pa.

Learn more at https://www.nj.gov/drbc/quality/reports/biomonitoring.html.

Special Project: Juvenile American Shad Monitoring

Volunteers sort and count the fish collected during the survey to determine the number of young-of-the-year American shad.

In addition to being active throughout the year sampling the Delaware River and analyzing data for its various water quality programs, DRBC staff periodically assist with monitoring efforts led by partner agencies or basin cooperatives. In this special project, DRBC helps basin state and federal fisheries biologists during the late summer and fall by providing manpower and expertise to count numbers of juvenile American shad in the non-tidal Delaware River. American shad, a member of the herring family, are anadromous fish, meaning they are born in fresh water, live for several years as adults in the ocean, and return to their natal waters (where they're born) to spawn (lay their eggs) in the spring. Juvenile American shad, called young-of-the-year (YOY), are those that are born in the spring and spend their first summer in the river. As the water temperatures cool, they travel south to overwinter in the warmer waters of the Delaware Estuary and Bay before heading out to the Atlantic Ocean.

To help determine how well the fishery is doing each year, YOY shad numbers are monitored in the non-tidal Delaware at various locations as they travel downriver towards the estuary. The shad are collected by seining, using a large net to catch the fish in the river. Other fish species are also caught, and the fisheries team must then sort and identify which are YOY shad so their numbers can be recorded.

Learn more at https://www.nj.gov/drbc/home/newsbytes/approved/20171025_shadYOY.html.

Special Project: Monitoring to Establish Baseline Conditions in the Upper Delaware Basin in Advance of Potential Natural Gas Development

The commissioners' decision in 2010 to place a de facto moratorium on shale gas drilling in the basin pending adoption by DRBC of new regulations specific to natural gas development allowed time for staff to conduct monitoring in order to characterize pre-gas drilling baseline conditions in the upper section of the Delaware River Basin. In this region, the Marcellus Shale underlies the commission's Special Protection Waters drainage area, where regulations require no measurable change to the existing high water quality. By establishing pre-gas drilling conditions, DRBC will be in a stronger position to minimize impacts from gas development activities should they commence and to compel remedial action if impacts to water resources do occur.

DRBC intern Carey Wu works on a HOBO® meter deployed in the Oquaga Creek in 2013.

The five main focus areas for baseline characterization included:

- Reanalysis of frozen samples for hydraulic fracturing-related parameters
- Deployment of HOBO® continuous conductivity meters
- Collection of new biological samples to fill gaps in existing monitoring efforts
- Evaluating appropriate toxicity tests
- Radiochemistry Monitoring

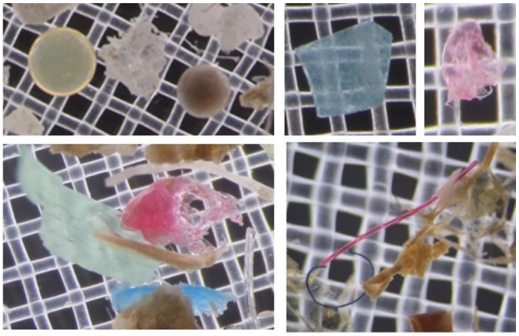
Learn more at https://www.nj.gov/drbc/programs/natural/baseline-monitoring.html.

Special Project: Lower Delaware River Mussel Study

In the summer of 2013, to help fill the gap in understanding freshwater mussel occurrence and species distribution, the DRBC and the USGS leveraged funds and in-kind contributions to conduct mussel surveys of the non-tidal lower Delaware River. The surveys began near the Portland-Columbia footbridge (river mile 208) and extended 75 miles downstream to the head of tide at Trenton, N.J. Surveys were conducted in three phases, totaling seven weeks. A final report was completed for the National Park Service in 2014.

Learn more at https://www.nj.gov/drbc/home/spotlight/approved/20131115_mussels.html.

Special Project: Microplastics Study



As seen under the microscope: microplastics collected from the Delaware Bay by University of Delaware researchers. Photo courtesy of the University of Delaware.

Plastic is perhaps the most prevalent type of debris found in our oceans, rivers, and large lakes. Plastic debris comes in all shapes and sizes, but those that are less than five millimeters in length (or about the size of a sesame seed) are called "microplastics." These tiny particles easily pass through water filtration systems and end up in receiving waters. Over time, larger plastics degrade into microplastics, but microplastics also include manufactured items such as microbeads, synthetic microfibers, and resin pellets.

Not much is known to date about microplastics and their impacts on human health and aquatic life. To date, few microplastics studies have been conducted in the Delaware River Basin. Understanding the inputs of microplastics is a vital first step towards understanding the prevalence and potential problems posed by this contaminant. In 2018, DRBC received a grant from the Delaware Watershed Conservation Fund to monitor for microplastics and model loadings of microplastics in the upper Delaware River Estuary—from Trenton, N.J. to the C&D Canal. This reach of river is largely urbanized and is likely a major contributor to microplastics found in the estuary and bay.

DRBC will collect samples from four sites in the upper Delaware River Estuary and ten tributary sites. Samples will be collected in spring and fall 2019 and will be analyzed for microplastic concentrations. Data collected during microplastic monitoring efforts will be used to model microplastic dynamics in the estuary. These models will allow us to identify high plastic-loading tributaries, which will be targeted for cleanup efforts.

This project will provide DRBC with a better understanding of the concentration and distribution of microplastics in the upper Delaware River Estuary and will lay the groundwork for future microplastics monitoring and cleanup efforts in the basin and beyond.

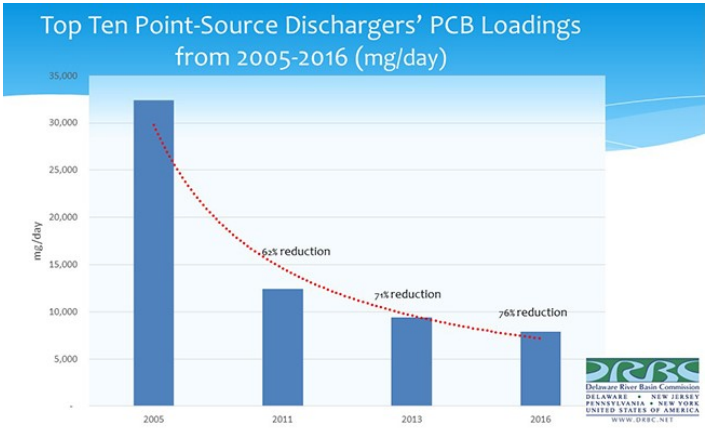
Learn more at https://www.nj.gov/drbc/quality/reports/microplastics.html.

Monitoring for PCBs & Pollutant Minimization Plans

Polychlorinated biphenyls (PCBs) are a class of carcinogenic chemicals present in the waters of the Delaware Estuary at concentrations up to 1,000 times higher than the water quality criteria. Widely used in transformers, capacitors, and other electrical equipment, the U.S. banned the manufacture of PCBs in 1976. Existing uses were permitted, however, and their chemical stability allows them to persist in the environment to this day. There are numerous sources of PCBs in the Delaware Estuary, which enter fish and other wildlife through absorption or ingestion, and accumulate in their tissues at levels many times higher than in the surrounding water and sediment and at levels unsuitable for human consumption.

Because high levels of PCBs have resulted in state-issued fish consumption advisories for certain species caught in the Delaware Estuary, these waters were and continue to be listed as impaired, requiring the establishment of a PCB total maximum daily load (TMDL). A TMDL expresses the maximum amount of a pollutant that a water body can receive and still attain water quality standards.

At the request of the three estuary states and the U.S. EPA, DRBC, working closely with its Toxics Advisory Committee and others, developed the technical basis for the Stage 1 PCB TMDLs for the Delaware Estuary (DRBC WQ Zones 2-6). The U.S. EPA established the Stage 1 PCB TMDLs for Zones 2-5 in 2003 and for Zone 6 in 2006. To support the implementation of the Stage 1 TMDLs, DRBC monitors ambient waters, sediment, and fish tissue to provide precise and defensible data on the PCB concentrations in the Delaware Estuary.



In addition to checking water, sediment, and fish for PCBs, DRBC requires Pollution Minimization Plans (PMPs) to reduce or eliminate PCBs where they are known to exist. The PMP rule, adopted by the commission in May 2005, establishes a non-numeric approach requiring the track down and reduction of point source and non-point source discharges of PCBs in the Delaware Estuary. The goal of this program is to work toward meeting water quality standards and to eliminate fish consumption advisories due to PCBs. PMPs require biennial PCB sampling and submission of an annual report summarizing PCB loading reduction efforts.

Recent reports show that the PMPs required by DRBC are working. The top ten dischargers responsible for 90% of the point-source PCB loading have reduced their contributions 76% from 2005-2016. This improvement hopefully will be reflected as reduced amounts of PCBs found in fish tissue in future years.

In December 2013, DRBC approved a revision to its human health water quality criteria for protection from carcinogenic effects of PCBs in Zones 2 - 6 of the Delaware Estuary. With DRBC's adoption of revised PCB criteria, it is anticipated that the U.S. EPA will establish new TMDLs (Stage 2 TMDLs) corresponding to the updated criteria.

Learn more about PCBs at https://www.nj.gov/drbc/quality/toxics/pcb.html.
Learn more about PMPs at https://www.nj.gov/drbc/programs/quality/pmp.html.

Assessment of Metals in Estuarine Waters

DRBC staff collect a filtered sample during a July 2012 special copper survey in the Delaware Estuary.

DRBC monitors metals, such as copper, zinc, nickel, and mercury, in ambient water, sediment, and tissues of aquatic life of the Delaware Estuary to ensure compliance with water quality criteria. Water quality assessment of metals is complicated by factors such as field sampling techniques, analytical issues with contamination, detection limits associated with routine analytical procedures, and the applicability of freshwater or marine criteria in the river's estuarine waters. DRBC works to ensure the use of the most appropriate methods and procedures for the conduct of monitoring studies in the basin.

In water quality Zone 5 of the Delaware River, which extends from the Pa.-Del. state line south to Liston Point, Del., copper concentrations continue to be near water quality criteria with several apparent exceedances of the marine criteria in the vicinity of Pea Patch Island, Del. In 2012, the DRBC performed additional data collection for copper, zinc, and nickel using enhanced analytical methods and modified collection procedures in this section of the Delaware River. The technique used is called "Cleans Hands/Dirty Hands" and results in very low contamination of the sample by other metal sources. The information collected as part of this study will provide additional data to help determine metals concentrations in ambient water and whether the commission's metal criteria are exceeded.

Learn more at https://www.nj.gov/drbc/quality/toxics/monitoring-metals.html.

Monitoring Toxicity in the Delaware Estuary

Monitoring toxicity is an essential component of programs designed to protect water quality and assess compliance with regulatory standards. Based on DRBC's water quality regulations for the estuary to protect against short-term (i.e. acute) and long-term (i.e. chronic) effects on aquatic life from toxic pollutants, no adverse effects should be observed in toxicity tests with undiluted ambient water. As part of ongoing programs to control toxic substances in the Delaware Estuary, the DRBC conducts periodic monitoring of ambient water toxicity in the estuary and has requested monitoring of acute and chronic effluent toxicity by dischargers.

Learn more: https://www.nj.gov/drbc/quality/toxics/ambient-tox.html.

Delaware Estuary Water Quality Monitoring Program

Initiated in 1967, *the Delaware Estuary Water Quality Monitoring Program is one of the longest running monitoring programs in the world.* Each year, DRBC contracts with the Delaware Dept. of Natural Resources and Environmental Control to collect surface water

samples in the Delaware Estuary, from the head of tide at Trenton, N.J. to the mouth of the Delaware Bay. Samples are collected at 22 stations to manage water quality and ensure that criteria are being met. The goals of the program are to provide accurate, precise, and defensible estimates of the surface water quality of the Delaware Estuary and to allow assessment of water quality criteria compliance. Sample analysis includes routine and bacterial parameters, nutrients, dissolved oxygen, heavy metals, chlorophyll-a, dissolved silica, and volatile organics.

Bacterial sampling results are posted on the commission's web site, and the other data are inputted into U.S. EPA's water quality database, STORET, which is available to the public.

DRBC staff developed an interactive application that allows the user to explore water quality data collected from the DRBC Delaware Estuary Boat Run Water Quality Monitoring Program from 1999-2016.

Learn more and use the data application at https://www.nj.gov/drbc/quality/datum/boat-run.html.

Contaminants of Emerging Concern

Contaminants of emerging concern (CECs) are chemicals that have entered the environment through human activities and are not routinely monitored for and are currently unregulated. They have been detected in humans or other organisms and have been found to persist in the environment. Examples include pharmaceuticals and personal care products (PPCPs), hormones, flame retardants (PBDEs), and flame repellents/non-stick surface coatings (PFASs).

DRBC's Dr. Ron MacGillivray collects surface water samples to analyze for PFCs, a contaminant of emerging concern.

Although most of these compounds have been detected in surface waters at very low concentrations, there is concern about how CECs may impact drinking water and the river's ecology. Increased interest in these substances and their toxic effects by scientists, the public, and regulators is occurring due to improved analytical methods and a growing body of information on the adverse effects of CECs.

A number of efforts have been undertaken within the Delaware River Basin to identify, understand, and prioritize CECs, including a three-year effort by DRBC to investigate the presence and concentration of PPCPs, PFASs, and PBDEs in the ambient waters of the tidal Delaware River. The commission has an ongoing monitoring program for PFAS/PFC in the main stem Delaware River, examining surface water, fish tissue, and sediment.

Learn more at https://www.nj.gov/drbc/quality/reports/cecs.html.

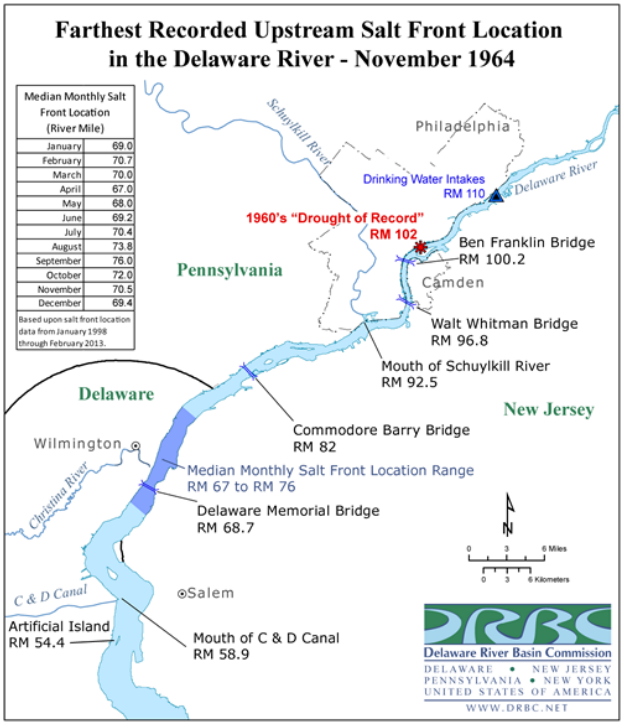
Fish Tissue Monitoring

Since 1990, DRBC has periodically sampled tissues of resident fish species in the non-tidal and tidal portions of the main stem Delaware River. In the non-tidal portion, samples of smallmouth bass and white sucker are collected at three locations: Milford, Pa. (river mile [RM] 246), Easton, Pa. (RM 183), and Lambertville, NJ (RM 149). In the tidal portion of the river, samples of channel catfish and white perch are collected at five locations: Crosswicks Creek (RM 128), Tacony-Palmyra Bridge (RM 107), Woodbury Creek (RM 91), Raccoon Creek (RM 80), and Salem River (RM 58). The samples are analyzed for PCBs, chlorinated pesticides, dioxins/furans, flame retardants, perfluorinated chemicals, mercury, and other metals. These data are used to track the progress of the PCB TMDLs that were established by the U.S. EPA in 2003 and to identify chemical compounds that may pose a risk to human health through fish consumption. These data are also forwarded to state agencies for their use in establishing fish consumption advisories for fish caught in the Delaware River.

Learn more at https://www.nj.gov/drbc/quality/datum/fish-tissue.html.

Chloride Monitoring

DRBC has adopted criteria and monitors chlorides as part of the commission's flow and drought management program, which focuses on controlling the upstream migration of salty water from the Delaware Bay during low-flow conditions. As salt-laced water moves upriver, it can increase treatment costs for public water suppliers and corrosion control costs for surface water users, particularly industry. Salinity levels also affect aquatic living resources.



The seven-day average location of the salt front, the 250 mg/L chloride concentration based on drinking water quality standards originally established by the U.S. Public Health Service, is routinely tracked as it fluctuates along the tidal Delaware River in response to changing flows, which either dilute or concentrate chlorides in the river.

Learn more at https://www.nj.gov/drbc/quality/conventional/chlorides-monitoring.html.

DRBC Modeling Efforts

DRBC develops and applies various models for basin waters. Examples of models created and utilized by DRBC staff include the following:

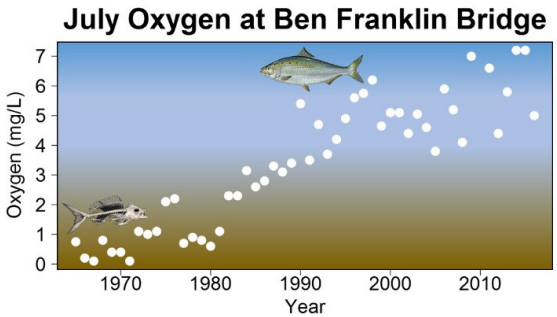
- A real-time flow and transport model, which is run nightly and tracks the movement of water in the tidal Delaware River. If a spill occurs, the most recent model run can be used along with a water quality model to predict where the pollutant will go and what the concentrations will be. This is especially important to protect drinking water intakes in the tidal Delaware River;
- Models to determine mixing zones for total dissolved solids, toxic pollutants, and heat dissipation areas for regulated discharges;
- Assimilative capacity determinations for a water quality parameter of concern;
- TMDL development to support basin states and the U.S. EPA; and
- No Measurable Change evaluations for dischargers in Special Protection Waters.

Learn more at https://www.nj.gov/drbc/quality/reports/models.html.

Dissolved Oxygen and Nutrient Levels in the Delaware Estuary

Most forms of aquatic life need dissolved oxygen (DO) to respire or "breathe," and it is important to maintain adequate levels for both migrating and native fish species, juveniles and adults. Oxygen enters water both by direct absorption from the atmosphere and as a by-product of photosynthesis by algae and aquatic plants.

Warmer water generally contains less oxygen than colder water, so the amount of DO naturally varies seasonally and daily as water and air temperatures change. Salinity also affects DO; saltier water carries less oxygen than fresh water. Other things that can decrease the amount of dissolved oxygen in water include wastewater discharges, decaying leaves and algae, some chemical compounds, and nutrients.



This graphic depicts how dissolved oxygen levels in the Delaware River at the Ben Franklin Bridge have improved dramatically since the late 1960s.

Although the worst of the dissolved oxygen problems have been addressed by the commission over the past 50 years, DO conditions in the Delaware Estuary remain a concern even today. Automatic monitors track dissolved oxygen levels at four locations, and although current conditions typically meet the criteria, mid-summer DO is, at times, only 50% or less of full saturation levels in the areas near the Ben Franklin Bridge.

The commission is examining whether current criteria for dissolved oxygen may need

revision to be better protective of fish reproduction. And, looking ahead, temperature and salinity in the tidal river may increase due to sea level rise and global climate change. This could potentially lower the river's oxygen carrying capacity, therefore making other water quality improvements necessary just to maintain the current, yet still highly changeable, levels of dissolved oxygen in the estuary.

DRBC interns Andrew Garcia and Megan Andreason collect water samples, which will be analyzed for nutrients.

Additionally, DRBC and its partners in state and federal agencies, the regulated community, and the environmental community are studying the connections between dissolved oxygen and nutrient levels in the estuary. Nutrients, such as nitrogen and phosphorus, are natural, essential components of aquatic ecosystems, assimilated by living things to promote growth.

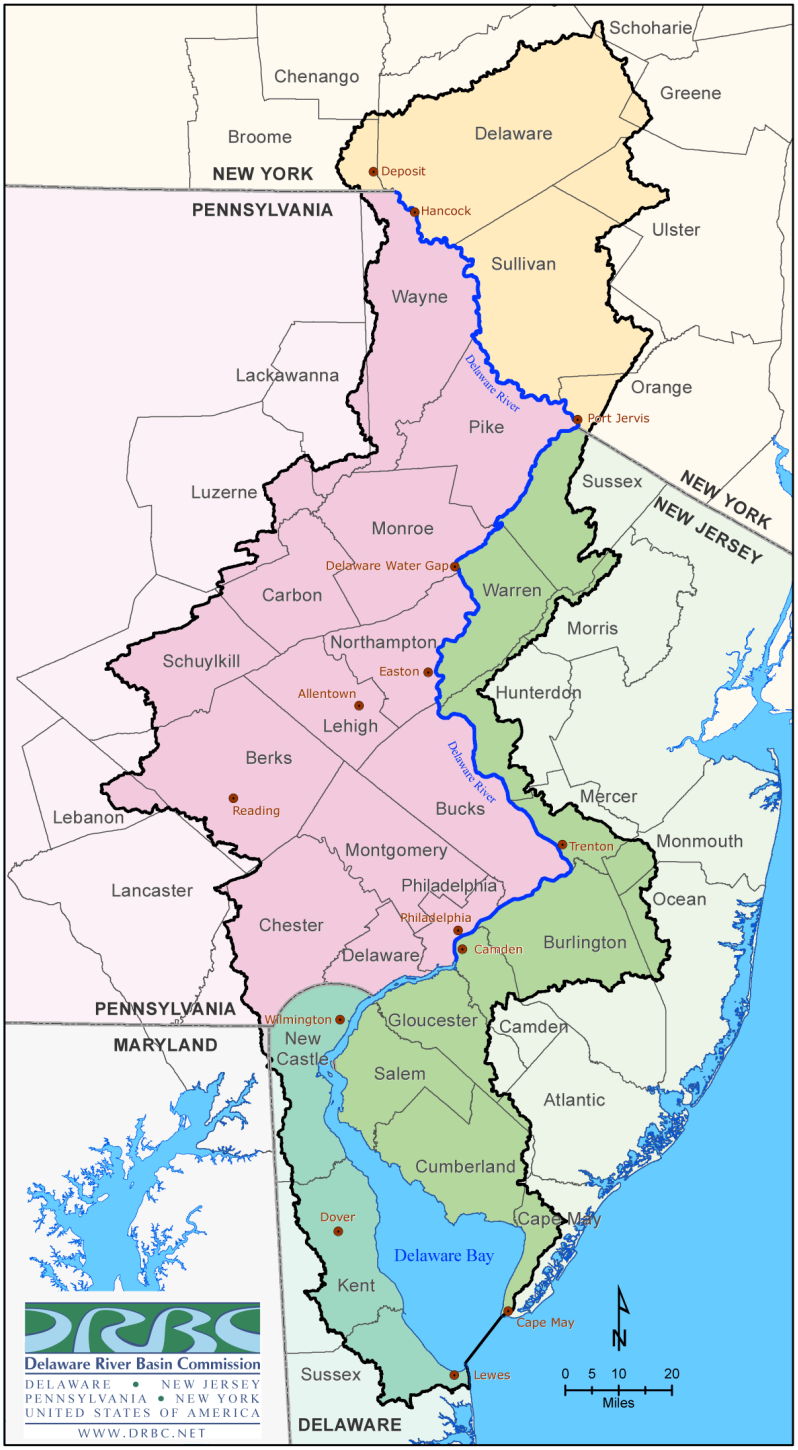
While nutrients are good at certain levels, high levels can overstimulate the production of plants and algae, which utilize dissolved oxygen as they decompose, therefore reducing oxygen levels in the water. This leads to poor conditions in streams and reduced water quality. According to the U.S. EPA, "high levels of nitrogen and phosphorus in our lakes, rivers, streams, and drinking water sources cause the degradation of these water bodies and harm fish, wildlife, and human health."

Nitrogen and phosphorus pollution comes from fertilizers, animal waste, septic systems, storm runoff, and sewage treatment plants. This type of pollution is reported to be a problem in more than half of the water bodies in the nation, including the Delaware Estuary which has an area of reduced dissolved oxygen in the urban river corridor. Elevated levels of nitrogen have been identified as a potential cause.

DRBC serves as the lead coordinating agency among the U.S. EPA and the basin states for evaluating nutrient conditions in the shared interstate waters of the Delaware River and the Delaware Estuary. The DRBC also is the lead agency in determining the nutrient criteria or nutrient-related criteria, if appropriate, that are needed to protect aquatic life, public and industrial water supplies, and recreational uses of these shared resources.

DRBC is currently undertaking a study to identify appropriate levels of nutrients and necessary measures to take, especially in relation to dissolved oxygen. To address both nutrients and dissolved oxygen, a process has been initiated to measure the point sources of nutrients and oxygen-depleting materials and to build a water quality model to integrate this information and forecast future scenarios for the Delaware Estuary. Although the results from such efforts are not yet available, the goal is to select an appropriate path towards improved dissolved oxygen levels in the Delaware Estuary and healthier fish populations.

Learn more about dissolved oxygen at https://www.nj.gov/drbc/quality/conventional/DO.html.
Designated Use Study: https://www.nj.gov/drbc/quality/conventional/designated-use.html.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