Downstream

by Jesse Smith

In the 1940s, the Delaware River at Philadelphia was so dirty that pilots could smell it from the air. The water was so harsh it corroded metal and discolored paint. Fish killed by pollution washed up on the Delaware's banks. The lack of oxygen in parts of the river blocked the critical migration of others.

The Delaware River was strained along much of its length by the middle of the 1900s. States fought over its water in times of drought, and they struggled to contain its water in times of flood. Salt water from the tidal Delaware Bay threatened to infiltrate drinking water supplies. Exploding populations also contributed to the mess, with sewage output growing faster than sewage treatment. During World War II, shipyards, oil refineries, and manufacturers that supported the United States' military efforts further burdened the river.

By the mid-1900s the problems of the Delaware were too big for any one state to handle alone. So in 1961, the four states through which the river flows—New York, New Jersey, Pennsylvania, and Delaware—entered into a partnership with the federal government to oversee the water resources of the Delaware River basin. Named the Delaware River Basin Commission, the partnership established pollution standards. It established water quality monitoring procedures. It promoted the creation of small watershed alliances across the basin to stimulate community involvement in environmental concerns. And water quality across the basin improved. Today, the Delaware River Basin Commission continues to manage those resources, which stretch across 13,000 square miles and serve more than 13 million people.

This history is part of *Downstream*, a new temporary exhibition at the Science History Institute in Philadelphia. The exhibition explores more than 200 years of scientific analysis and political interventions into the waters that surround the organization's home. Drawing on the Institute's deep collection of scientific instruments, books, and ephemera—as well as loans from partner organizations—*Downstream* invites visitors to explore the changing relationship between knowledge and action behind efforts to keep water clean from the late 1700s through the present. The exhibition also represents the Institute's ongoing efforts to use the public history of science to educate, entertain, and engage as broad an audience as possible.

Exhibiting Water

Downstream is organized according to five historical episodes. The first begins in the late 1700s in the Institute's Old City Philadelphia neighborhood. The city was a wet and stinky mess at the time. Pits used as household toilets overflowed into basements and backyards. Businesses making candles, soap, and leather dumped foul waste into small streams that flowed toward the Delaware River. The city's bustling port reeked of rotting garbage at low tide. Stagnant water fouled the city's famous public squares. Horses, cows, dogs, and pigs filled the streets, making the messes that live animals do. Dead animals were often left to rot.

All this activity dirtied the natural springs and public wells that supplied water to residents and businesses of the growing city. And when yellow fever killed thousands in 1793, many blamed miasmas, or "bad airs" that emerged from rotting and decaying organic matter. Philadelphia identified the Schuylkill River, three miles to the west, as a safe and clean replacement for the foul water people pulled from polluted streams and wells around their homes and businesses. Though it was just three miles from the heart of Philadelphia, the Schuylkill was then surrounded by fields and forests, with few homes and little industry on its banks. In 1801, steam engines began pumping clean Schuylkill water east to the residents and businesses of Philadelphia.

The purity of the Schuylkill was short-lived. Across the 1800s, upstream manufacturers were putting more waste into the river. And the growing city was sending greater amounts of often deadly sewage into the Schuylkill. Between 1860 and 1890, waterborne typhoid fever killed 16,000 residents, or anywhere from three to 12 percent of the city's population in a given year. It made many more seriously ill. The bacteria that causes typhoid travels in sewage, and it sickens and kills when people consume food or water that's been touched by infected sewage.

Downstream

But by the end of the century, the city (and much of the world) was armed with a better understanding of disease. The germ theory of disease gradually eclipsed earlier miasmatic ideas. Specific germs, and not broader environments, were the new enemy in the fight to keep people safe. Armed with this knowledge, Philadelphia adopted slow sand filtration to physically treat its water supply in the early 1900s; in 1914, it adopted chlorination and the chemical treatment of water. These interventions eliminated nearly all water-borne illness and disease in the city.

This story is told in *Downstream* with evocative objects from the Institute's collections, including a brass microscope, a copy of George Chandler Whipple's 1914 text *The Microscopy of Drinking Water*, and images from the 1915 book *Water Purification Plants and their Operation*. In addition, the Philadelphia Water Department loaned the Institute a sample of a wooden pipe from the 1800s. Part of an early underground infrastructure of water delivery, such technologies were also physically tapped to fight deadly fires in Philadelphia.

Around the same time that the city of Philadelphia was cleaning its water supply, the commonwealth of

Pennsylvania was identifying water pollution as a statewide problem. One hundred miles upstream of Philadelphia, a booming mine industry poured coal dust and acidic byproducts into the river's headwaters. Sewage from growing towns and cities along the river flowed into the Schuylkill. Downstream, slaughterhouses and factories used the river as a cheap and easy way to dispose of their waste.

Pollution from mines, factories, humans, and animals disrupted natural river processes, killed plants and animals, and posed threats to human health. Across Pennsylvania, similar patterns of urbanization, industrialization, deforestation, and mining damaged the state's rivers and streams. Scientists increasingly recognized that pollution in one place threatened the health and safety of another.

This is the second episode of *Downstream*. In this section of the exhibition, Institute objects including thermometers and pH meters ground stories of scientists, doctors, and engineers working in new fields such as bacteriology, public health, and sanitary engineering in the early 1900s to learn more about water and the broader environment. They knew that sewage carried harmful organisms. But bustling factories and mines also added new toxic chemicals to water. Water researchers in Pennsylvania and other states found inorganic heavy metals such as lead and arsenic, as well as organic hazards such as phenol chemicals, in water. Oil from wells in western Pennsylvania leaked into streams. And mine acid runoff corroded metal and degraded concrete.

Downstream shares several critical interventions from this period. In 1905, the American Public Health Association and the American Water Works Association published *Standard Methods for the Examination of Water and Sewage*—a set of comprehensive and standardized water analysis techniques that are still updated today. And in Pennsylvania, with one water user unable to control what another did at a distance, the state took administrative and legislative action. In 1905, Pennsylvania became one of the nation's first states to pass a water protection law. The Purity of Waters Act gave the state's Commissioner of Health the power to regulate sewage. The Act, however, was limited to sewage pollution and didn't address the waste generated by the economically valuable coal industry. It took several more decades of pollution, science, and advocacy for Pennsylvania to address the problem of coal mine pollution. In the exhibition, a watercolor painting of a coal dredge (loaned to the Institute by Philadelphia's Independence Seaport Museum) depicts the massive cleanup of the Schuylkill

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River between 1945 and 1955, which removed between 30 and 40 tons of coal waste from the river.

The exhibition then moves to the historical moment described above, when the water quality (and water quantity) challenges facing the Delaware River basin could not be solved by any single state alone. As the U.S. Senate wrote in 1961 of the proposed Delaware River Basin Commission, “there is one river, one basin, all water resources are functionally interrelated, and each use is dependent upon the other. Therefore, one comprehensive plan and one coordinating and integrating agency is essential for efficient development and operation.” [1] This third episode of *Downstream* reveals the exhibition to proceed not only through time, but across increasing scales of action as well. As our knowledge of water (and of the environment more broadly) increased in this period, the scope of water oversight increased as well.

That knowledge included better understanding of the decreasing quality of water across the basin. Instruments in this section of the exhibition include a Jackson candle, nephelometer adapter for a pH meter, and a Secchi disk—all used to quantify the turbidity (or cloudiness) of water; a photoelectric colorimeter that could screen water for chlorine, fluoride, cyanide, iron, molybdenum, and zinc; and a portable oxygen analyzer that could determine the quantity of dissolved oxygen in a sample. It also includes a 1964, 16-foot-tall model of the Delaware River basin, donated to the Institute by the Delaware River Basin Commission. The Institute believes this model was used in the 1960s to identify the Commissions’ activities to a broad public.

Just as the Commission was seeing improvements to water quality in the basin, a national environmental

movement was emerging. Boosted by popular works and images such as Rachel Carson’s *Silent Spring* and images of Ohio’s Cuyahoga River on fire, public support for greater interventions into environmental challenges increased. Behind this movement was an increasingly sophisticated understanding of the environment. Methods for analyzing chemicals changed dramatically in the mid-1900s. These new techniques revealed many kinds of chemical pollution in waterways, including dangerous chemicals that could not be seen or smelled. Electronic instruments such as spectrophotometers and mass spectrometers measure physical characteristics of a sample to identify its composition. By combining new analytical instruments with older separation techniques such as chromatography, chemists could more rapidly and precisely determine the types and concentrations of chemicals in a complicated sample. An ion chromatograph on display, for example, could monitor drinking water for contaminants such as cyanide and arsenic. It could also detect charged molecules characteristic of fertilizer runoff or untreated sewage, such as nitrates and phosphates.

Intense public concern about pollution drove the federal government to act in the 1970s. President Richard Nixon created the Environmental Protection Agency in 1970. In 1972, the Clean Water Act set a sweeping national goal that all surface waters in the U.S. be “fishable and swimmable” by 1983. Every major discharger of wastewater had to obtain a permit from the EPA and reduce the contamination in their discharge. The Act also created the largest federal public works program in U.S. history. Cities and towns constructed sewage treatment plants using federal subsidies that covered up to 75% of the construction costs. And in

Downstream

1974, the Safe Drinking Water Act directed the EPA to set health-based standards for contaminant levels in public water supplies. Local water utilities had to monitor for specific contaminants using EPA-approved technology.

Visitors to this fourth section of *Downstream* also learn how, in 1976, a citizen lawsuit forced the EPA to finally set allowable levels for 126 different chemicals being discharged into waterways by permit holders. Companies and water utilities would have to routinely measure many water samples to show they complied with EPA standards. The EPA also specified an analytical method, combined gas chromatography-mass spectrometry (GC-MS), and a recently developed instrument, the Finnegan Model 1015, that should be used to demonstrate that discharged water met EPA standards.

The exhibition concludes by examining the emerging concern of microplastics in water. Scientists aren't exactly sure what dangers microplastics pose to human, animal, and environmental health. But concern over microplastic beads in products such as toothpastes and face scrubs led the U.S. to ban microplastics from cosmetics in 2015. And scientists continue to use techniques such as Fourier transform infrared spectroscopy to study the types, amounts, and possible threats of microplastics that are increasingly found in waters around the world. This is work happening across all the scales of action explored in *Downstream*. The city of Philadelphia, the commonwealth of Pennsylvania, the Delaware River Basin Commission, and multiple federal agencies are all studying microplastics in water.

This is not a sweeping indictment of plastics. As the exhibition explains, In 2019, the World Health Organization cautioned that efforts to reduce plastics should not ignore the benefits of some plastics for health and safety. The WHO cited plastic packaging that extends the shelf life of food; of plastic medical equipment such as single-use gloves, syringes, and IV tubes; and of critical health devices made of plastic like

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heart valves and prosthetics. The WHO also warned that concern over microplastics should not draw attention from the ongoing fight to provide clean water around the world. Today, drinking water contaminated with human and animal waste continues to sicken two billion annually. And it kills more than one million people every year.

Doing the Public History of Science

The development of *Downstream* included some longstanding challenges in the interpretation of the history of science for public audiences. Scientific instruments like an ion chromatograph, for example, can be unfamiliar and inscrutable for non-practitioners. The exhibition team also must consider how much is necessary for visitors to engage with the relationships between science and society more broadly. In *Downstream*, this was achieved through "How Did We Know?" exhibition content that introduces visitors to an analytical technique or knowledge practice; "How Does It Work?" content that explains that technique or practice; and "What Did We Do?" stories that reveal how knowledge informed political and social decisions about water.

At the same time, *Downstream* presented the Institute with novel opportunities for the public history of science. As an exhibition based in both the history of science and environmental history, the curatorial team was able to ground the stories of water analysis and protection in both time and place. Text and visual assets—including maps, posters, fine art, illustrations,

advertisements, and films from the 1950s and '60s—tell stories of the water around the Science History Institute and encourage visitors to think about the changing relationships between knowledge, action, and the specificity of place. Timelines in each of the exhibition's historical episodes, however, offer glimpses of contemporaneous efforts to know and protect water beyond the Delaware River basin. These include, for example, the first use of chlorination to chemically treat water in the United States in Jersey City, New Jersey, in 1908; the Massachusetts State Board of Health's discovery of the link between sewage and typhoid fever outbreaks; and the establishment of national water pollution laws in France, Japan, and India, among other countries.

Over the next year, the exhibition (which runs through January 2023) will be supplemented with digital lesson plans, supported by the Society for Analytical Chemists of Pittsburgh & Spectroscopy Society of Pittsburgh, and a digital exhibition, supported by Villanova University's Lepage Center for History in the Public Interest and Drexel University's Lenfest Center for Cultural Partnerships [2]. And the Institute's museum will continue to interpret the public history of science through upcoming exhibitions on the histories of synthetic colors and food science. 🍷

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<https://www.sciencehistory.org/downstream>