

Water Quality: A Half Century of Progress

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EPA Alumni Association

March 25, 2016

The EPA Alumni Association (EPAAAA) has developed this and six other web-based subject matter essays in support of its Half Century of Progress project. An integrated summary based on these materials is contained in [Protecting the Environment: A Half Century of Progress](#), which is available on the Association website. The Association has developed these materials to inform high school and college students and other members of the public about the major environmental problems and issues encountered in the United States in the latter half of the 20th century, as well as the actions taken and progress made in mitigating these problems.

A number of retired EPA program managers and subject matter experts worked together to produce each of the essays. This document was reviewed by the EPAAA Board of Directors and members of the association. We welcome comments on this document, which you may email to [the EPA Alumni Association](#).

Water Quality

Water is essential for people and other living creatures. We use water to quench our thirst, to cook our food, brush our teeth, shower and to flush our wastes away through sewer systems. We enjoy splashing in it during a day at the beach, wading in it during a fishing trip or paddling across it in the kayak. Water irrigates the food we eat and supports industry. It is critical to the survival of fish, wildlife, waterfowl, shellfish, and aquatic insects. The water we use today is the same water that was here in pre-Columbian times, that Lewis and Clark paddled in 1805, that supported the Industrial Revolution, and that we will need to support us through this millennium and beyond.

And yet, in the 1950s and 60s, America's rivers, lakes, estuaries, and wetlands were seriously polluted. In 1965 President Johnson declared the Potomac River at Washington, DC, to be a "national disgrace." The Georgetown Gap in the city's sewer system discharged 15 million gallons of raw sewage into the river every day.



Georgetown Gap Sewage Outfall: Photo: EPA Documerica

The Potomac was not the only severely degraded waterbody. An August 1, 1969 article in *Time Magazine* read: "Some River! Chocolate brown, oily, bubbling with subsurface gases, it oozes rather than flows. Anyone who falls in the Cuyahoga does not drown, Cleveland's citizens joke grimly, he decays." In the late 1960s, the Cuyahoga River at Cleveland occasionally caught on fire. In the early 1970s Lake Erie was declared "dead," due to massive algal blooms and oxygen-starved waters.



Cuyahoga River Fire. Photo: James Thompson, Cleveland Press Collection, Cleveland State U.

Early federal laws provided only limited authority and funds to deal with the serious insults to the nation's waters. The 1948 Federal Water Pollution Control Act emphasized that water pollution control was primarily the responsibility of the states. Interstate agreements were encouraged but not required. The federal role emphasized research and support for state programs. The law declared pollution of interstate waters to be a public nuisance subject to abatement through

a federal enforcement action, but only when the pollution endangered the health or welfare of people in a state other than where the pollution occurred. Also the state where the pollution originated had to agree to control the pollution. Not surprisingly, few cases moved forward.

By the 1960s several states had integrated their water programs in a single department combining health, natural resources, and environmental functions. Additional states had initiated permit programs that placed pollution control requirements on industrial and municipal wastewater discharges. These programs were inconsistent across state lines. For example, two identical facilities on opposite sides of a river that happened to be in different states could have very different water pollution control requirements, or perhaps none at all. This patchwork of state requirements with a very limited federal role led some industries to locate facilities in states with weaker environmental requirements that could be met at lower cost.

The Clean Water Act

Effective control of water quality degradation was brought about by the implementation of the Federal Water Pollution Control Act of 1972, otherwise known as the Clean Water Act (CWA). It was among several key pieces of legislation enacted soon after the Environmental Protection Agency (EPA) was created. The Act established a national water quality framework that was to be implemented by EPA in partnership with the states. It also established a number of fundamental precepts that continue to guide water quality programs: 1) to restore and maintain the chemical, physical, and biological integrity of the nation's waters; 2) to make unlawful the discharge of any pollutant from a point source (a point source is typically a pipe or other conveyance discharging pollutant(s)); and 3) to recognize, preserve, and protect the primary responsibilities of the states to prevent, reduce and eliminate pollution and to provide financial assistance to states and municipalities. The Clean Water Act built on earlier federal water quality legislation and has itself been amended several times since 1972.

The water quality framework includes: the states monitoring their waters and establishing Water Quality Standards (WQS) for all waterbodies (e.g. streams, rivers, lakes, estuaries); the requirement for all point sources to apply basic level of treatment to their discharges, based on an evaluation of available technology; waters are assessed and, if they do not meet standards (are "impaired"), a total maximum daily load (TMDL) or loading budget is required. TMDLs identify needed point source and non-point source reductions of pollutants causing the impairments. TMDLs specify additional controls for point sources, which are incorporated into permits, and non-point source controls. When reductions specified by a TMDL are achieved, the impaired water body will meet Standards. This framework for protecting and restoring waters is described more fully below and depicted in the Appendix.

Water Quality Standards (WQS) The 1972 Act required states to establish standards for all intrastate waters and brought the existing interstate standards into the CWA framework. For the first time, all US waters were covered by requirements for water quality.

A WQS includes the identification of a designated use, for example, drinking water supply, bathing beach, fish habitat, etc. and numerical and narrative criteria to support that use (criteria are typically scientifically derived numerical values developed to protect a use, e.g. the level of dissolved oxygen necessary to support a healthy trout fishery; limits on pathogens at bathing beaches; specific chemical parameters, etc.). Early standards focused on basic protection of drinking water supplies and fisheries with criteria for dissolved oxygen, temperature and acidity. Amendments to the Clean Water Act adopted in 1987 required criteria for toxic pollutants. EPA is now working toward ecoregion-based biological criteria and criteria for nutrients. The current techniques for development and adoption of criteria are significantly more complex than earlier versions due to the availability toxicity data, the advancements in risk assessment methods, better methods to identify pollutants at extremely low levels, and availability of additional monitoring data.

Point Sources The Clean Water Act in 1972, for the first time, established federal jurisdiction over discharges from point sources into of the nation's waters which were prohibited unless authorized by a permit. The Act created a new EPA permit program, the National Pollutant Discharge Elimination System (NPDES) to implement and enforce the point source requirements. The CWA also authorized states, territories and tribes to assume responsibility for the NPDES program if they agreed to meet EPA program regulations. Today, most states implement the permit program subject to EPA oversight.

The permit program was implemented in two phases.

The First Phase: The first round of pollution reductions implemented through permits is based on technology. The concept behind technology-based controls is that facilities within a category of dischargers, for example paper mills, should provide treatment that represents the best available treatment determined to be affordable. The requirement applies to all facilities within that category nationwide. A mill in Pennsylvania has the same treatment technology requirement as a similar mill in Alabama or California.

Technology-based requirements for industry are established through EPA-developed Effluent Guideline Limitations. Effluent Guidelines are industry-specific regulations published by EPA based on comprehensive analysis of engineering and economic data for a particular industrial category. EPA has published 57 Guidelines that have resulted in the removal of 702 billion pounds of pollutants from our nation's waters.¹ The program

¹Various pollutants of different toxicities are "normalized" to be equivalent to the toxicity of a pound of copper in developing this value.

has changed the face of water pollution control for US industry and has materially improved our water environment.

The technology-based requirement for municipal wastewater treatment plants is called secondary treatment. Secondary treatment removes 85% of the organic waste and suspended solids from domestic sewage. By contrast, primary treatment removes approximately 30% of those pollutants. In 1972, 142 million Americans were served by sewer systems and the wastewater of 62 million (44% received treatment less than secondary. By 2008, 226 million Americans were served by sewers with the wastewater of 222 million (98% receiving treatment at a secondary level or greater. Essentially every city across the nation was a partner, along with the states and EPA, in planning, designing, and building the infrastructure needed to support these improvements in treatment.

The Second Phase: The second phase of the permitting process is to determine whether the technology-based limit will be adequate, taking into account all other sources of pollution entering a water body, to meet Water Quality Standards. If not, limits are developed for pollutants based on the needs of that water body. The calculation of these water quality based limits use available ambient water quality data, water quality models and discharger effluent data. Typically, water quality limits are set for oxygen demanding materials, suspended solids, pathogens, ammonia, metals, and nutrients.

As municipal sewer systems were built and expanded during the late nineteenth and the first half of the twentieth century, it was commonplace for industries to discharge untreated wastewater into the sewer system. These discharges often interfered with the treatment process, contaminated the biosolids (the byproduct of the treatment process making it unsuitable for reuse as a fertilizer product; or passed through the treatment plant and contaminated the waters receiving the treated sewage. Amendments to the CWA adopted in 1977 required large municipalities and those with significant industrial users to establish an Industrial Pretreatment Program. Today over 1,500 cities are implementing a pretreatment program and work with local industry to remove tons of hazardous materials at the source before they enter municipal sewer systems.

Currently, approximately 6,700 major point source NPDES are permits in place (a major point source is a facility with flow greater than one million gallons per day) and another 109,000 municipal and industrial point sources are covered by either individual or general permits. General permits can be issued to a class of similar dischargers. In some cases the permitted source need only notify EPA or the state permitting agency that it is aware of and will comply with the terms of the general permit. Recent additions to the permit program include: discharges from vessels in US waters to control the introduction of invasive species which cause billions of dollars of damage annually

(199,000 vessels permitted, and the application of pesticides in waters now covering more than 360,000 applicators.

Implementation and enforcement of the NPDES permit program, and the continuous actions by the many thousands of dischargers to meet their pollution control requirements, are the backbone of CWA water quality protections.

Monitoring, Assessment, and Listing The CWA requires states to monitor and assess their waters regularly and to identify or list waters that are not meeting WQS. For each of these waterbodies a total maximum daily load (TMDL, or a loading budget by pollutant, must be developed. The TMDL assigns allowable loads, and therefore needed reductions, to point sources and non-point sources to achieve the WQS.

During the early years of CWA implementation, the states focused on issuing permits and obtaining compliance with effluent guidelines and secondary treatment – the technology-based requirements. They developed very few TMDLs. Several lawsuits were brought by clean water advocacy groups to compel the development of TMDLs during the mid-1990s. To resolve these suits and avoid additional ones, the Agency placed emphasis on TMDL development. Over 67,000 TMDLs have been completed representing a significant step forward in the clean water program. These plans describe pollution reductions necessary to restore water quality, and have highlighted the need for more effective control of non-point sources.

Non-Point Sources Pollution from runoff that is not discharged by a pipe or ditch or other “discrete conveyance” is called “non-point” source pollution. The primary cause of waters failing to meet standards for nutrients, sediments, and pathogens is pollution from non-point sources. Clean Water Act permitting requirements do not apply to these sources but the Act recognizes non-point pollution as a component of the water quality challenge. Where a TMDL must be developed it is required to identify reductions (load allocations) for non-point sources. The 1987 CWA Amendments authorized a grant program which has transferred nearly \$4 billion to states and tribes to support their efforts to reduce non-point source pollution. The US Department of Agriculture provides technical assistance and money to farmers for control of polluted runoff. The Clean Water Act does not authorize EPA to compel entities which discharge non-point source pollution to abate their pollution.

Wet Weather Challenges Traditional wastewater point sources were the focus of water quality programs through the mid-1980’s. As progress was made with both municipal and industrial sources, attention turned to the pollutant loadings from wet weather sources, including combined sewer overflows (CSOs and municipal separate storm sewer system discharges.

The sewer systems in more than 770 US cities include combined sewers. Combined sewers are designed to collect both wastewater and stormwater and transport that flow

to treatment plants. When the plant capacity is exceeded, the additional flow of untreated sewage and stormwater is discharged. A typical combined sewer system will discharge untreated sewage to local waterways every time there is measurable rainfall, which can be 70 to 80 times per year with total overflows up to a billion gallons or more.

In 1994, EPA issued the CSO Policy which called for the control of CSOs through a phased approach, ultimately leading to the requirement that WQS be met even during wet weather. The control of CSOs has required major capital construction programs in many communities. Two early adopters of CSO control programs were the Metropolitan Water Reclamation District of Greater Chicago and the Milwaukee Metropolitan Sewer District, both of which used systems of large (20 to 30 foot diameter tunnels to collect and store excess flows that is then pumped back through the treatment plant once the rain induced flow subsides. The results have been dramatic. In Milwaukee, overflows into the river system leading to lakefront beaches averaged 8.5 billion gallons per year (gpy) in the two years before the system came on-line compared with 1.1 billion gpy over the last ten years. Many cities including Washington DC, St. Louis, Philadelphia, and Cleveland are in various stages of implementing their CSO control programs.

The 1987 CWA Amendments clarified that stormwater which is collected by drains and pipes in a separate storm sewer system must be managed under the clean water permit program. Large municipal systems (population >100,000 and selected industrial sources were required to be permitted in the mid-1990s, and permits for smaller systems were required by 2003. Most stormwater permits are based on systems of best management practices that are reviewed and improved with each five-year permit. Recent advancements focus on retaining stormwater on-site, and filtering it through wetlands and other vegetation before discharge to streams or using vegetation to encourage the water to be absorbed into the ground or evaporated. This suite of techniques is often called green infrastructure. These approaches hold great promise for controlling storm water more economically and are being incorporated into many local programs. Currently, approximately 7,000 municipal, 90,000 industrial and 121,000 construction stormwater permits are in place, providing a management framework for reducing pollutants from stormwater before they enter local waterways.

Financial Assistance Prior to the 1972 CWA, federal grants were available for up to 55% of the costs of construction of municipal wastewater treatment plants. By 1971, the annual funding level for these grants had reached \$1 billion. The CWA included significant new funding through the Construction Grants Program. Up to 75% of the costs of a project were eligible for grants and \$18 billion was made available for a three-year period. Over the 19 years of the Program, (1972 – 1990 federal grants of \$53 billion funded over \$80 billion in municipal treatment works.

In 1987, Congress replaced the Construction Grants program with a State Revolving Loan Fund (SRF) Program. In this program, EPA grants to the states, along with a

20% state match, created a loan fund in each State to provide loans to municipalities for wastewater infrastructure at below-market interest rates. A total of \$36.2 billion in EPA capitalization grants to the state SRFs, together with the state match and leveraged funds, has resulted in more than \$100 billion in funded projects through 2014.

The CWA municipal construction assistance programs have been a resounding success. Construction Grants, SRF loans and individually earmarked grant projects have funded, with the highest levels of financial and management integrity, approximately \$190 billion in municipal wastewater infrastructure in thousands of communities across the nation, accelerating the pace of clean water protection. This assistance supported wet-weather control projects in Chicago and Milwaukee and the nutrient treatment projects around the Great Lakes which led, by the 1990s, to the restoration of Lake Erie to be a world class walleye fishery. In Washington, DC, daily sewage overflows have been eliminated and the largest advanced wastewater treatment facility in the world has been constructed, removing nitrogen and phosphorus to the limit of technology, and restoring the Potomac River, which now hosts national bass tournaments. These and many other significant and visible improvements around the country have resulted from Clean Water Act financial assistance programs.

Wetlands For much of US history, wetlands - swamps, fens, bogs, potholes, marshes and seasonally saturated or flooded areas - were considered worthless at best and disease-ridden nuisances at worst. They were drained or filled for agricultural production and for development. Indeed, farmers were encouraged by federal subsidies to convert wetlands to crop production. By the 1950s, half the nation's historic wetlands had been destroyed leaving several large states, including California, with less than 10% of their original wetlands. With that destruction came a realization that wetlands were valuable habitat for fish, as well as ducks and other migratory waterfowl. In addition, wetlands reduce the more severe effects of flooding and storm surges, and provide other valuable services to society and nature. As scientists and naturalists began to document these benefits, federal policy began to shift.

The 1972 Clean Water Act provided that "dredged or fill material" should be regulated somewhat differently than other pollutants. The Army Corps of Engineers was directed to issue or deny permits for placement of dredged or fill material into "waters of the United States," under "guidelines" issued by EPA. EPA can "veto" any permits inconsistent with those guidelines. While states could "assume" this program, only two have done so, but many others play key roles by regulating dredged or fill material under programs recognized by general permits issued by the Corps. Discharges from normal, ongoing agricultural activities were exempted.

EPA guidelines called for denial of permits if individually or cumulatively they would cause unacceptable degradation of waters of the United States. Additionally, permits

should not be issued if there is a practicable alternative that does not adversely affect waters. Permit holders must minimize impacts of their projects on aquatic resources. Restoration or creation of wetlands or other waters is typically required to offset any losses that can't be avoided. Controversy developed as the CWA was implemented, and extended the Corps' traditional role of regulating structures and discharges that could pose hazards to navigation. In response, Congress considered legislation to restrict the waters to which the Clean Water Act program would apply. However, rather than restricting the geographic scope of the Clean Water Act, Congress provided, in 1977, for States to "assume" the section 404 program and authorized general permits for multiple discharges for similar kinds of activities.

Agricultural Policy Change & National Wetlands Policy Forum In 1985 agricultural policy vis-à-vis wetlands also shifted to recognize the value of these special areas. "Swampbuster" provisions provided that farmers and ranchers would be ineligible for farm program benefits if they converted undisturbed wetlands to agricultural use. In 1988, a non-partisan, diverse group of leaders from agriculture, state and local government, environmental groups and other was convened by the Conservation Foundation at EPA's behest. This National Wetlands Policy Forum issued a Report which called for a variety of program and policy actions by federal, state and private interests to achieve "no net loss of wetlands" in the short term and a long term goal to increase the quality and quantity of the Nation's wetlands resource base.

Many of the Forum recommendations were implemented. The US Department of Agriculture implemented several programs to restore tens of thousands of acres of previously converted wetlands. A significant decline in the rate of wetlands loss followed. From an annual net rate of loss of nearly 300,000 acres/year in the 1970s and 1980s, the loss rate fell to less than 60,000 acres/year in the 1980s and 1990s. The nation realized a net increase of wetlands in the period 1998-2004.

States and Tribes The CWA established a partnership between EPA and the states in the implementation of key programs. The states have the lead in: establishing Water Quality Standards; monitoring and assessing waters; developing TMDLs; implementing non-point source programs; and managing the construction grant and SRF programs. In addition, 46 states have been authorized to implement the NPDES permit program and two states issue dredged or fill material permits in place of the Corps. The state partnership role is supported through annual program grants that in 2014 totaled \$230 million.

The 1987 CWA Amendments provided that tribes could be treated in the same manner as states for most CWA programs. Recognized tribes receive annual program grants and, to date, EPA has approved WQS submitted by 40 tribal governments.

Other Programs This paper has focused on the core water quality programs and their accomplishments. In addition, a number of other programs have made significant contributions to protecting public health and the environment in supporting the mission of restoring and maintaining the nations waters. These include:

- *Geographic Programs:* Water is a uniquely local resource. Geographic programs focused on a particular water resource that is valued by the public have successfully focused resources, tools, and public attention. Some of these geographic focus areas/programs include: Chesapeake Bay Program, Great Lakes Program, National Estuary Program (includes 28 estuaries nationally), Gulf of Mexico Program, Charles River, and the Everglades.
- *Fish Advisories:* Through the 1980s, advice provided to consumers regarding contaminants in fish was largely based on the sensitivity of outdated analytical methods. Beginning in the early 1990s work by EPA, in consultation with the states, has resulted in protocols for sampling and testing fish tissues and for assessing and managing risk that are in use today by the states. Health advisories provide information to recreational anglers, subsistence fishers, and Native Americans regarding what fish to eat, in what amount and frequency and how to prepare caught fish for the table. These groups are better informed and protected today as a result.
- *Ocean Dumping and Vessel Discharges:* Radioactive wastes, solid waste, and biosolids (sewage sludge) were all transported from the US and dumped in ocean waters until those practices were outlawed over time. When discharged in marine waters, dredged material, from deepening ports and marinas, is subject to permits issued by the Corps of Engineers in conformance with EPA Guidelines at sites designated by EPA to minimize adverse effects on marine ecosystems. EPA and the Corps are encouraging the beneficial reuse of dredged material, including in habitat restoration. Discharges from vessel operations and other discharges to ocean waters are also subject to special requirements.
- *On-site Systems:* More than 20% of US housing stock is served by on-site wastewater (septic tank) systems. These backyard systems have often received little thought or attention. The EPA On-site Systems Program has worked with the states, academia, and industry representatives to improve the technical design, maintenance, and management of existing and new on-site systems. A series of design manuals and management handbooks and an ongoing collaborative that includes 18 partner organizations have increased the overall level of available quality information and continuing professional focus on this issue, that is critical to the protection of local groundwater and surface water.
- *Beach Program:* A family day at the beach on a day following a rain event used to pose unrecognized public health risks. The Beach Program has

successfully brought together the states, local beach resource managers, and EPA to better assess the risk of contaminated stormwater or wastewater overflows and the exposure of the beach going public. Better sampling, analytical methods, and communication tools now allow beach managers to make better and more timely decisions on whether to open or close their beaches and to better inform the public about beaches with a history of overflow related contamination.

- **WaterSense:** A 2014 General Accountability Office report surveying state water managers found 40 states anticipate non-drought related water shortages over the next 10 years. The WaterSense Program gives consumers reliable information regarding products, practices, and fixtures that save water without sacrificing performance. Since it launched in 2006, the WaterSense Program has saved 757 billion gallons of water and has saved consumers \$14.2 billion in water and energy costs. In addition, the program has eliminated 37 million metric tons of greenhouse gas emissions from the treatment, pumping, and heating of water which was conserved.

Future Challenges

In the four decades since the passage of the CWA there has been remarkable progress in restoring and protecting our nation's waters. As the US population grew by 116 million (57%), every American city expanded and upgraded its wastewater infrastructure and industry made significant investment in improving its water quality and water quantity footprint. The burning rivers, odor and floatable nuisance issues, daily sewage overflows, and large-scale fish kills are, for the most part, in the past. However, lingering challenges from the past along with a number of emerging issues threaten our water environment today.

Climate The first reaction of many is that climate change is an air / atmospheric issue. It is true that many of the controls will focus on power generation, fuel choices and carbon dioxide management. As our climate continues to change, however, many of the significant impacts will be on water resources. Extended drought will have ecological effects on aquatic communities. More severe rainfall and flooding will have scouring effects on streams, accelerate sediment and nutrient wash off into local waters and exceed the design capacity of combined sewer and storm sewer control systems. Rising sea levels will change the salinity along our coastlines and affect biological communities as well as threaten wastewater infrastructure in many coastal communities. Ocean warming and acidification will degrade coral reefs, and affect fisheries and recreational resources. As greenhouse gas control strategies are implemented, a comprehensive strategy to address water sector mitigation and adaptation will be critical for years to come.

Scope of Clean Water Act Protections While several efforts in Congress to curb wetlands protection were unsuccessful in the 1990s, significant uncertainty has been introduced into the CWA regulatory protections for some wetlands, small streams, and isolated ponds as a result of Supreme Court decisions. In 2001, the Supreme Court held that use of wetlands by migratory birds was not, by itself, a sufficient basis to establish that wetlands were subject to Clean Water Act protections. In 2006, a Michigan developer appealed his conviction for filling wetlands on a property he wished to develop on the grounds that they were not subject to regulation under the CWA - because they were separated from traditionally navigable waters by a man-made berm. Notwithstanding unified state and Executive Branch arguments against further restricting the geographic scope of the Act, a majority of the Supreme Court agreed with the developer. The Court disagreed, however, on what would be a sufficient “nexus” to navigable waters for a permit to be required. A 2015 regulation issued by EPA and the Corps to clarify this issue has been challenged by several states and private interests.

Wetlands The most recent National Wetlands Inventory indicates that losses have again outpaced gains, though by a very small margin. Uncertainty over the geographic scope of the Clean Water Act is one factor. Additionally, incentives for farmers to restore and protect wetlands provided by the Farm Bill are no longer as strong as they once were.

Nutrients Excess nutrients, principally phosphorus and nitrogen, in lakes, estuaries, and rivers “fertilize” algae in the water and cause it to become cloudy. Reduced light penetration from this cloudiness shades out plants living on the bottom of lakes and estuaries. Loss of these plants reduces nursery and shelter areas for fish and shellfish. Some algae, referred to as red tides or brown tides, are toxic to fish and cause breathing difficulties for some people. In addition, when algae die off, their decomposition uses up oxygen in the water – resulting in hypoxia, or “dead zones,” and fish kills. The drinking water intake for the City of Toledo was closed for several days in 2014 due to a massive algal bloom in the Lake Erie’s West Basin.

These effects have been a worsening problem over the last decade with no remedy in sight. A TMDL was completed for the Chesapeake Bay in 2010 that calls for a 25% reduction in nitrogen and a 24% reduction in phosphorus across the watershed. This is a monumental undertaking to restore the nation’s most productive estuary that will take a focused effort by all sectors for decades to come. More than one-third of the Nation’s 102 estuaries are identified as eutrophic (a condition of high nutrient concentration that often causes large swings in dissolved oxygen concentration and algal population). The anoxic (dead) zone in the Gulf of Mexico was recently measured at 7,900 square miles, the size of the States of Connecticut and Delaware combined, and has been on an increasing trend line. These impairments are adversely impacting aquatic communities, recreational opportunities and property values.

Over 12 million tons of nitrogen and 4 million tons of phosphorus fertilizers are used in the US each year. In addition, the animal agriculture industry produces 1 billion tons of manure annually, much of which is applied to crops as organic fertilizer. Air emissions from fossil fuel combustion cause a fall-out of nitrogen to waterbodies and watersheds. This atmospheric deposition is estimated to account for 21% of the nitrogen load to the Chesapeake Bay. The diversity and scale of these sources is daunting. A high percentage of the nutrient pollution loads in most watersheds is from non-point sources over which little authority exists. New science, tools, and approaches are needed.

Energy Development The public interest in the US becoming more independent of foreign sources of energy and scarce metals, along with the economic benefits of domestic production, will continue to encourage the expansion of the mining and oil and gas sectors. Many of the Effluent Guidelines that address these sectors are dated and do not address current extraction techniques or technologies. Examples include the use of mountaintop removal in coal mining and hydraulic fracturing in natural gas extraction. Both of these practices produce large volumes of wastewater high in total dissolved solids, are often in remote locations, and have been documented to have adverse effects on aquatic communities. The pressure to pursue these resources will continue. Better management approaches and technologies are needed.

Emerging Contaminants The focus of CWA programs in the 1970s through the 1990s was organic wastes, along with a suite of toxic compounds. These challenges continue. However, the current and future lists of pollutants of concern will also include pharmaceuticals and personal care products along with the range of nano-materials being introduced into society, our waste streams and our waters. Improved analytical methods, risk assessment techniques, and management approaches are needed to protect ecological systems as well as sources of drinking water.

Infrastructure Remarkable progress in the planning, design, and construction of municipal wastewater infrastructure has occurred over the last 40 years. This infrastructure inventory, largely owned and maintained by local governments, is valued in the trillions of dollars. As that infrastructure ages, its upkeep and replacement is straining local budgets. The 2008 Clean Watersheds Needs Survey documented \$298 billion in capital needs, while a 2013 American Society of Civil Engineers report graded the condition of the Nation's wastewater infrastructure a "D."

New tools, including total asset management models, allow utilities to better inventory their current networks of pipes, pumps, and plant assets and to schedule critical maintenance and replacement investments. The use of these tools often results in utilities realizing the need for increased funding. Those needs compete on a daily basis with other public safety, education, and transportation demands on local budgets. A strategy on how the local, state, and federal sectors will work to maintain and improve

as necessary the service provided by municipal wastewater infrastructure is critical to water quality protection and sustaining healthy local economies.

Economic Tools The endpoint of many of the nation's environmental laws is human health protection. The analytical decision making tools and models used in health protection decision making are generally well established.

The CWA also focuses on the chemical, physical, and biological integrity of the nation's waters. As the focus on the regulatory decision process has increased, the inability to quantitatively assess the environmental benefit and economic value of our lakes, streams and wetlands is a problem. Currently, tools or techniques needed to estimate the value, in economic terms, of a healthy fish population or the opportunity to canoe on a lake not suffering an algal bloom are lacking. The economic analysis tools available to quantify the benefits of water quality are wholly inadequate and must be updated. This shortcoming has been a millstone attached to water quality decision making.

Conclusion

On November 2, 1971, Senator Edmund Muskie urged his colleagues to adopt the Clean Water Act with these stirring words:

This country once was famous for its rivers. In songs and poems and stories, Americans gloried in the now quiet, now roaring reaches of the river waters. A vigorous people, following their rivers to the oceans and beyond, built along the riverbanks a strong and productive economy.

But today, the rivers of this country serve as little more than sewers to the seas. Wastes from cities and towns, from farms and forests, from mining and manufacturing, foul the streams, poison the estuaries, threaten the life of the ocean depths. The danger to health, the environmental damage, the economic loss can be anywhere".

Much has been accomplished in the restoration and protection of the nation's waters since then. As population grows, the economy evolves, infrastructure ages, and climate changes, new challenges are testing EPA and its state and tribal partners in implementing the Clean Water Act. The resolve and commitment to restore and maintain the chemical, physical, and biological integrity of the Nation's waters must be maintained as we face these challenges with creativity and innovation.

The urgency of protecting America's water resources continues.

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Appendix: The Water Quality Framework

