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Rising Waters, Rising Threat

How Climate Change Endangers America's Neglected Wastewater Infrastructure

By Ben Bovarnick, Shiva Polefka, and Arpita Bhattacharyya October 2014

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Introduction and summary

The second anniversary of Superstorm Sandy recalls the tragic loss of 117 lives across eight states, evoking images of flooded streets, power outages, and stranded communities.[1] The storm also caused significant damage away from news cameras—underground and offshore—to wastewater infrastructure. Sandy's powerful rainfall and record-setting storm surge[2] overwhelmed wastewater systems throughout coastal New York and New Jersey, resulting in the overflow of almost 11 billion gallons of raw sewage into the stricken region's streets, rivers, and coastal waters. This was enough untreated effluent to fill the Empire State Building 14 times.[3]

Unfortunately, wastewater overflow is not unique to superstorms or to the East Coast. As climate change strains aging sewer systems around the country through increasingly severe weather and sea-level rise, the resilience of wastewater infrastructure is becoming a critical public and environmental health issue for communities and municipal and state governments.

The United States has an expansive but aging wastewater system that was built to meet the needs of a much smaller population. The United States had 14,780 wastewater treatment facilities and 19,739 wastewater pipe systems as of 2008.[4] The American Society of Civil Engineers, or ASCE, found that many of the nation's pipes were installed shortly after World War II and are reaching the end of their originally intended lifetimes;[5] some sewers are more than 100 years old.[6] Aging wastewater infrastructure has immediate, dangerous consequences. The ASCE estimates that aging pipes and inadequate capacity lead to the discharge of 900 billion gallons of untreated sewage and wastewater into U.S. waterways each year, enough to cover New York City under a layer 127 feet deep.[7] According to a *New York Times* report, municipal sewer systems are the nation's biggest violators of the U.S. Clean Water Act, and more than one-third of them have violated pollution laws at least once since 2006.[8]

This worn-out, faulty infrastructure requires new investments in order to protect public health and the environment. As climate change poses increasingly severe and costly hazards to these systems, states and municipalities should ensure that any investment in new sewer infrastructure incorporates climate risk. Federal, state, and local governments can achieve this through several innovative strategies.

This report recommends taking the following steps to keep American waters clean and protect public health from disruptions and overflows in wastewater treatment systems:

- Integrate climate risk into all new wastewater infrastructure
- Finance resilience improvements through state infrastructure banks
- Prioritize resilience in state revolving-fund investments, accounting for regional differences in climate change vulnerability
- Invest in green infrastructure and the protection and restoration of wetlands and coastal ecosystems to protect and supplement wastewater treatment systems

Modern wastewater infrastructure is a vital part of everyone's daily lives, protecting Americans from waterborne diseases and preserving the nation's waterways as ecological, recreational, and commercial assets. But Americans' preference to keep their minds out of the gutters, sewer mains, and treatment plants that comprise this system makes it easy for political leaders to neglect this infrastructure—at least until catastrophes such as Superstorm Sandy necessitate unpleasant spills and costly cleanups. As climate change exacerbates the most extreme weather and speeds sea-level rise, deficiencies in wastewater infrastructure will get harder to ignore—and increasingly costly to clean up after failures. To protect public health, the environment, and the economic gains provided by good water quality, local, state, and federal officials must act quickly to repair and upgrade the nation's rapidly aging wastewater infrastructure. This action must accommodate both contemporary and future levels of service demand and withstand the worsening effects of climate change.

Sanitary sewer overflow, or SSO: An SSO is an unintentional discharge of wastewater or sewage from sanitary sewer systems due to overloaded pipes, blockages, pump or power failures, broken lines, or other defects. SSOs can spill into public waterways and back up into buildings or neighborhoods, posing threats to property and public health.[9]

Combined sewer overflow, or CSO: A CSO is an infrequent, intentional discharge of wastewater from a combined sewer system, which usually collects rainwater, sewage, and industrial wastewater into a single pipe for treatment. These systems are typically designed with an overflow that can intentionally discharge the combined effluent into nearby bodies of water in the event of heavy rain or snowmelt that exceeds the system's maximum volume.[10] The majority of combined sewer systems in the United States are in the Great Lakes region and the Northeast.[11]

U.S. wastewater systems are threatened by climate change

Global warming is exacerbating the hazards that threaten the nation's aging municipal wastewater systems, including sea-level rise, coastal storms, droughts, and heavy rainfall events, often called downpours. This portends an increase in the already destructive amount of sewage that overflows into lakes, rivers, and oceans.

First, coastal flooding is expected to increase due to an accelerating rise in sea level. In the past 100 years, the United States has experienced measurable sea-level rise due to global warming: Tide gauges and geological evidence along the eastern seaboard show that seas are around 1 foot higher than they were 100 years ago.[12] However, the rate of sea-level change is far from steady. According to an analysis by the National Oceanic and Atmospheric Administration, or NOAA, for the National Climate Assessment, or NCA, the rate of sea-level rise nearly doubled between 1900 and the 1990s.[13] Furthermore, because of expected ocean warming and melting ice sheets in Greenland and Antarctica, the NCA predicts with "high confidence"—a greater than 90 percent chance of occurrence—that the global mean sea level will rise about 3.9 feet by 2100. In the case of maximum ice and glacier melt, it could rise as high as 6.6 feet.[14] Put in more tangible terms, scientists now predict that sea-level rise will make Sandy-scale flooding a "20-year-event"—one that has a 5 percent chance of happening in any given year—by 2100.[15]

The hazards of higher sea levels affect wastewater systems in several specific ways. First, sea-level rise increases the risk of flooding for many wastewater facilities in the United States. As baseline sea levels rise, they reduce the level of intensity necessary for storm surges to destroy coastal infrastructure. In the San Francisco Bay Area, there are 22 wastewater treatment plants on the shoreline that are vulnerable to a 55-inch rise in sea level.[16] Climate Central estimates that as many as 3,070 wastewater treatment facilities in the coastal Northeast[17] and Florida will be vulnerable to coastal flooding by the end of the century in the NCA's worst-case scenario for ice-cap melting.[18] As mentioned, many of these plants already lack the capacity to handle current storms, meaning that sewage spills will likely become an even more frequent occurrence.[19]

Rising sea levels also harm wastewater systems underground by raising coastal groundwater levels and increasing the infiltration of seawater. These impacts can reduce the overall capacity of wastewater systems, resulting in more frequent sewage overflows. They can also introduce seawater into treatment systems, impairing facilities' mechanical and biological integrity, increasing maintenance costs, and reducing system effectiveness.[20]

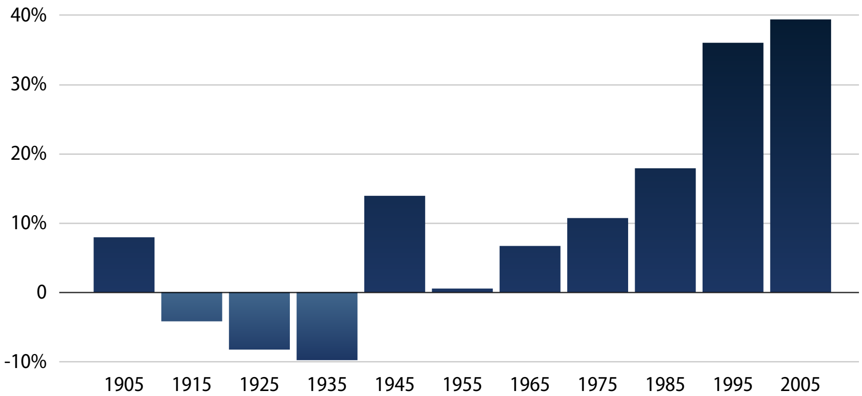
Second, climate change is projected to increase the strength of coastal storms,[21] and such events can cause physical damage to wastewater treatment facilities across wide regions.[22] According to a U.S. Environmental Protection Agency, or EPA, report, Hurricane Katrina affected 208 wastewater treatment facilities in 2005, including 117 in Mississippi, 78 in Louisiana, and 13 in Alabama, forcing many to close in the aftermath of the storm.[23] Nearly two weeks after the hurricane, only 40 percent of the affected wastewater facilities were able to operate normally.[24] According to NOAA, there is inadequate evidence to suggest that global warming causes an increase in the frequency of tropical storms such as hurricanes.[25] However, scientific evidence does show a link between warming and hurricane intensity.[26] In fact, NOAA projects average Atlantic hurricane intensity will increase 2 percent to 11 percent and rainfall will increase about 20 percent by 2100—both of which magnify hurricanes' destructive power.[27] Therefore, the effects of recent severe hurricanes such as Sandy, Irene, and Katrina provide valuable insights into the risks from future extreme weather events.

Inland wastewater facilities are also at risk from global warming. Increasing frequency of heavy rainfall, induced by climate change,[28] has the potential to overwhelm wastewater systems, resulting in unintentional SSOs and more frequent CSOs. In March 2010, an extreme rain event in New England brought 12 inches of rain over the course of three days, flooding the Pawtuxet, Blackstone, and numerous other rivers.[29] While such a storm cannot be directly linked to climate change, the Northeast is projected to experience an 8 percent increase in extreme precipitation events by 2050 and a 13 percent increase by 2100.[30] In Warwick, Rhode Island, the extraordinary intensity of the March 2010 storm overloaded the town's wastewater treatment plant past the point of failure, which caused raw sewage to mix with the rainwater and exposed hundreds of homes in Warwick, Cranston, and Johnston, Rhode Island, to nearly 1 foot of the foul effluent.[31] Similarly, 2014 storms in Minnesota,[32] Michigan,[33] and Maryland[34] overwhelmed local wastewater systems, causing sewage spills into waterways and homes. This threat appears likely to worsen and to affect more Americans nationwide as climate change increases the frequency of these heavy rainfall events.[35]

FIGURE 1

The frequency of extreme precipitation events in the United States is increasing

Decadal frequency of heavy downpours compared to the 1901–1960 baseline average



Note: Heavy downpours are defined as two-day precipitation totals that were historically exceeded only once every five years. Data come from long-term observations from 930 weather stations nationwide, excluding Alaska and Hawaii.

Source: Katharine Hayhoe and others, "Heavy Downpours Increasing." In U.S. Global Change Research Program, "National Climate Assessment" (2014), available at http://nca2014.globalchange.gov/report/our-changing-climate/heavy-downpours-increasing; Kenneth E. Kunkel and others, "Monitoring and Understanding Trends in Extreme Storms: State of Knowledge," *Bulletin of the American Meteorological Society* 94 (2013): 499–514.

Drought can also disrupt wastewater treatment through water shortages.[36] Climate change is projected to exacerbate drought conditions in the Western United States and therefore to increase the strain on wastewater systems.[37] During a 2012 drought in Texas, the Trinity River Authority issued a press release explaining to residents that lower water levels would cause the normal flow of sewage through the system—which is propelled by gravity—to slow down. Ultimately, this slowdown caused solids to accumulate at pipe joints and increased the frequency of blockages.[38] To make matters worse, the water that did flow into the treatment plant had higher levels of ammonia and total suspended solids, which led to increased levels of contaminants in the water pumped out of the plant into the receiving waterway.[39] As droughts continue throughout much of the West, many wastewater systems could be increasingly subject to incidents similar to these.[40]

The costs of inaction

Although investments in wastewater resilience can be expensive, they are worth the cost. Before Superstorm Sandy, New York City completed $9.3 billion of upgrades to the resilience of its wastewater infrastructure and treatment facilities from 1997 to 2002.[41] While the storm produced massive damage to the region, the New York City Department of Environmental Protection reported that the total cost to its wastewater infrastructure was only $95 million, or 10 percent of the original investment in resilience improvements.[42] While substantial, this is a fraction of the damage incurred by nearby facilities elsewhere in New York state and New Jersey. The nearby Nassau County Bay Park Wastewater Treatment Plant alone required $810 million in recovery funds from the Federal Emergency Management Agency, or FEMA—the largest single federal award for an infrastructure project related to the storm—after the storm surge caused 2.3 billion gallons of sewage to overflow into the surrounding neighborhood and the Hudson River, disrupting normal operations for 44 days.[43] Meanwhile, New York City was able to restore all its wastewater treatment operations after five days—with the exception of treatment facilities in the Rockaways, which were restored after two weeks.[44]

Similar to the investments New York City undertook, a 2008 state assessment estimated that New Jersey would need to spend $11 billion to improve its wastewater treatment infrastructure from 2008 to 2028.[45] Just four years later, Superstorm Sandy wrought an estimated $3.01 billion in wastewater costs, damaging unprepared wastewater facilities and sewer systems around the state.[46] Combined with the $1.06 billion in damage to New York state wastewater treatment facilities and infrastructure, Superstorm Sandy inflicted more than $4 billion in damage to unprotected wastewater treatment operations across the two states.[47] The EPA distributed $600 million to New York and New Jersey for recovery costs, allocated through congressionally appropriated disaster relief.[48] However, this still left a shortfall that both states have been forced to fill. New Jersey announced in August that 235 projects would receive $1.3 billion in low- and no-cost loans to repair damage to wastewater infrastructure.[49]

These considerable expenditures underestimate the entirety of costs associated with wastewater infrastructure damage from Superstorm Sandy, as they do not include damage to ecosystems, waterways, beaches, and neighborhoods contaminated by sewage and wastewater spills.[50] Because they are broadly dispersed, the impacts of wastewater pollution from SSOs and CSOs on the American economy are difficult to fully quantify, but evidence suggests they are substantial. Approximately 722 municipalities comprised of more than 40 million people—ranging from small towns to large cities such as Philadelphia and New York—have combined sewer systems that dump sewage into their watersheds during major storms.[51]

First, the rivers, lakes, and seashores that receive wastewater runoff also happen to be top American vacation destinations.[52] As a result, sewage-fouled waterways and beach closures following major storms result in substantial economic losses for recreation- and tourism-based businesses that depend on healthy coasts. Studies in Southern California[53] and Michigan[54] both found that the daily economic cost of closing just one beach due to pollution was about $37,000. In 2012, there were 5,634 days of beach closures and beach advisories nationwide due to storm-water runoff; in 2011, which was a significantly wetter year, there were 10,780 days of closures and advisories.[55] Although a national average economic cost per day of beach closures is not available, these findings suggest that the impact of inadequate wastewater management to coastal businesses and communities is considerable.

Second, sewage spills also carry significant health costs, exposing people to pathogens and toxins.[56] Another Southern California study found that the fecal contamination of ocean waters in Los Angeles and Orange counties alone causes as many as 1,479,200 gastrointestinal illnesses every year, with a public health cost of between $21 million and $51 million.[57] The EPA estimated in 2011 that 3.5 million people around the nation contract illnesses each year after contact with raw sewage from SSOs.[58]

Public health risks

The damaging impacts of climate change—including sea-level rise, extreme weather, increased rainfall, and drought—on wastewater treatment systems are not only matters of inconvenience or expensive repair, but they also present a major public health risk. When excessive rainfall and flooding overwhelm sewer systems, it can force untreated sewage and wastewater to flow out of sanitary sewer systems into local communities, damaging property and threatening public health by leaking into basements and contaminating groundwater.[59] When the public is exposed to contaminants in untreated wastewater—such as viruses, bacteria, worms, and toxic chemicals—individuals can be subject to respiratory, skin, and intestinal infections; illnesses such as the stomach flu; and more serious diseases such as cholera and dysentery. Contaminated water supplies also put local food supplies at risk.[60]

The restoration of many wastewater treatment facilities damaged by Hurricane Katrina was delayed beyond two weeks, increasing the potential for a public health crisis. The large amount of time required to restore regular wastewater treatment combined with the extreme damage caused by the storm surge led to waterways and floodwaters contaminated with untreated sewage and wastewater.[61] Floodwater testing conducted by the EPA and the Louisiana Department of Environmental Quality after Katrina found that E. coli levels were 10 times higher than the EPA's recommended levels for contact.[62] Similarly, wastewater facilities damaged by coastal flooding from Superstorm Sandy resulted in more than 10 billion gallons of sewage spilled into waterways and neighborhoods.[63]

Public health risks depend on the type of wastewater system in place. In cities that utilize combined sewer systems, large precipitation events increase the chances for sewage exposure. EPA regulations for combined sewer systems allow up to four CSO events per year, in which untreated wastewater is directly discharged into local waterways.[64] An EPA study of combined sewer systems found that climate change could lead to a 12 percent to 50 percent increase in storm events that lead to CSOs, in excess of the currently allowance of four events.[65] The EPA monitors combined sewer systems for compliance with the Clean Water Act and the National Pollutant Discharge Elimination System and issues fines for noncompliance or excessive overflow events.

Unlike the semi-intentional overflows of combined sewer systems, SSOs spill into basements and city streets, in addition to local waterways, often causing severe damage to property. In a 2004 report to Congress, the EPA estimated there are up to 75,000 SSOs every year.[66] As climate change increases the likelihood of extreme precipitation events,[67] SSOs may also become increasingly common as wastewater systems struggle to cope with severe rainfall and are strained by continually aging pipes.

Recommendations: Opportunities for strategic wastewater investment

Around the country, homeowners, businesses, and tourists visiting America's beaches and waterways rely on an aging, inadequate wastewater infrastructure that is increasingly vulnerable to the destructive impacts of global warming. Failure to make investments in the capacity and resilience of these systems—and to account for evolving climate change risks in infrastructure planning—will only exacerbate the already severe environmental and public health impacts of untreated sewage discharge and lead to untenable system failures and unaffordable repair costs. Although the cost of new investment will be substantial in the short term, efficient and demonstrably affordable strategies exist to increase resilience and avert greater costs over the long term. Therefore, it is imperative that municipal and state governments initiate the planning needed to ensure the long-term adequacy and resiliency of their wastewater infrastructure—and that the federal government continue to expand its support for these efforts so that needed system upgrades can be swiftly implemented.

The Center for American Progress recommends taking the following steps to keep America's waters clean and protect public health from disruptions and overflows in wastewater treatment systems:

- Integrate climate risk into all new wastewater infrastructure
- Finance resilience improvements through state infrastructure banks
- Prioritize resilience in state revolving-fund investments, accounting for regional differences in climate change vulnerability
- Invest in green infrastructure and the protection and restoration of wetlands and coastal ecosystems to protect and supplement wastewater treatment systems

Integrate climate risk into all new wastewater infrastructure

City planners should consider elevating, relocating, and building any new wastewater treatment plants further from flood- or storm-surge-prone waters and ensure that existing systems have adequate capacity to accommodate large influxes of storm water. Some cities and states are already beginning to take action to incorporate projections of more frequent and extreme weather into wastewater infrastructure design and construction. For example, in building the new Deer Island Sewage Treatment Plant outside of Boston, the Massachusetts Water Resources Authority, or MWRA, raised the plant 1.9 feet above the ground to fully protect it from a 100-year flood. The plant also has an onsite power plant to ensure access to an uninterrupted power supply.[68] MWRA planners increased the diameter of the main tunnel into the plant to maintain the hydraulic capacity needed during increased precipitation and storm surges.[69] Similar long-term planning and considerations should be taken into account whenever new plants are upgraded or built. States and municipalities should seek federal assistance to properly site new wastewater facilities. NOAA already helps localities avoid siting new facilities in flood zones by sharing climate data and sea-level-rise projections.[70] State and local governments should use this information to develop adequate green infrastructure and man-made protections to withstand flooding in areas where plants cannot be moved.

Finance resilience improvements through state infrastructure banks

Because wastewater treatment facilities rely on electric pumping stations to move wastewater through pipes and treatment systems, power outages and operational failures by backup generators can shut down pumps and force plants to spill untreated sewage directly into waterways. During Superstorm Sandy, a 12-foot storm surge flooded New Jersey's Passaic Valley Sewerage Commission, crippling its pumping stations and electrical infrastructure and spilling 3.9 billion gallons of untreated and partially treated sewage. The resulting power outage and damage to electrical components shut down the plant's pumps and forced 840 million gallons of untreated sewage directly into Newark Bay.[71] The plant is undergoing $290 million in repairs and resilience upgrades to again reach capacity.[72] Coordinated investments in onsite power generation and energy resilience can reduce the chances that flooding and extreme weather threaten such infrastructure operation.

In response to the significant costs of Superstorm Sandy, New Jersey is currently in the process of developing the New Jersey Energy Resilience Bank, or ERB, to strengthen its energy infrastructure and deploy distributed energy resources that can maintain power for vital infrastructure in the wake of extreme weather.[73] Initial funding for the bank will come from a $200 million Community Development Block Grant-Disaster Recovery, or CDBG-DR, award allocated as part of the Superstorm Sandy recovery appropriations, and the state has indicated that the ERB will prioritize financing for wastewater treatment plants. New Jersey should commit to maintaining ERB financing beyond the point at which the initial CDBG-DR grant is disbursed in order to expand resilience efforts beyond infrastructure directly affected by Superstorm Sandy.[74]

Similarly, New York state plans to establish a $900 million fund to protect wastewater treatment plants affected by Superstorm Sandy in 100-year and 500-year flood zones that will be managed by a state infrastructure bank.[75] The New York Infrastructure Bank will allow the state to centralize infrastructure investment and ensure that resources are used efficiently.[76] The bank will be funded through federal recovery funds, state revenue, and public and private investors, with funding totaling approximately $2 billion.[77] In both New York and New Jersey, federal disaster assistance was available to launch these infrastructure banks. While states that have not required similar disaster recovery assistance will not have access to such funds, they can benefit by planning for investment outside of an emergency situation. They can also explore plans for a rational combination of public and private spending.

Prioritize resilience in the Clean Water State Revolving Fund

Following Superstorm Sandy, the Disaster Relief Appropriations Act set aside $500 million in EPA funding to support wastewater system improvements through the Clean Water State Revolving Fund, or CWSRF. Since its creation in 1987, the CWSRF has provided more than $5 billion annually to all 50 states and Puerto Rico for water-quality and wastewater treatment projects. This is a total of more than $100 billion in mobilized capital, supporting more than 33,320 low-interest loans for local wastewater infrastructure investment.[78] Congress and President Barack Obama should preserve and support this vital, highly successful program. In order to ensure these resources are used efficiently, the EPA should work with states to incentivize resilience efforts in CWSRF projects and to prioritize improvements in wastewater systems that are most vulnerable to the impacts of a changing climate, including sea-level rise, drought, and extreme rainfall events.[79]

Invest in wetlands, coastal ecosystems, and green infrastructure

To address the sometimes prohibitively high costs of upgrading wastewater treatment infrastructure, some cities have begun to deploy innovative new approaches designed around nature's unmatched ability to absorb and recycle pollutants. These methods meet infrastructure needs effectively and provide remarkable cost savings compared with traditional artificial solutions.

In 2011, Philadelphia began a 25-year, $2.4 billion "Green City, Clean Waters" plan that incorporates the natural capabilities of soils, aquifers, and wetlands to capture and filter urban runoff to achieve cost-effective solutions.[80] Consulting firm CDM Smith—which the city hired to help address its inadequate combined sewer system and comply with federal water-quality laws—found that the traditional approach of installing multiple, massive wastewater detention tunnels beneath the city would cost $8 billion to $10 billion, significantly more than the city could afford.[81] Through collaboration with the consulting firm and the EPA, Philadelphia is working to green one-third of its impervious surfaces—the concrete, steel, and asphalt that shunt storm water directly into the sewer system—by transforming them into porous, vegetated landscapes such as gardens and parks, which absorb, filter, and hold storm water in place.[82] In addition, the city is investing in the restoration of wetland and waterway ecosystems to enhance the natural filtration of pollutants associated with wastewater discharge. By investing in pollution capture both before and after storm water passes through the city's combined sewer system, this green-infrastructure-based plan is expected to eliminate pollution equivalent to the artificial capture of 85 percent of the city's wastewater output.[83]

This approach to storm-water management also benefits citizens in ways beyond pollution control. It creates accessible local jobs, improves and expands access to parks, increases property values for homes near parks and public gardens, and reduces heat-related fatalities thanks to new shade trees planted throughout the city.[84] These external benefits further enhance the cost effectiveness of the Green Cities, Clean Waters program.

Just as Philadelphia has set itself up as a national leader in the use of green infrastructure for wastewater management, other municipalities nationwide are also beginning to incorporate this approach to control water pollution and enhance infrastructure resilience to hazards such as coastal flooding, realizing significant cost savings over the construction of conventional artificial infrastructure. A recent study on flood-control options to help the San Francisco Bay address sea-level rise found that Bay Area cities could protect their coastal assets—including wastewater treatment facilities—by constructing shorter, broader earthen levees fronted by restored saltwater marshes. This project could achieve the same flood protection and wave reduction delivered by much taller and more-capital-intensive traditional levees.[85] These shorter, wetland-fringed levees would lower the cost of the needed flood protection from more than $12 million per mile for a traditional levee system to less than $7 million per mile,[86] representing "total savings [that] could eventually exceed more than a billion dollars" over the San Francisco Bay's 275 miles of vulnerable coastline, according to the *San Jose Mercury News*.[87]

The EPA is responsible for the enforcement of the nation's water-quality-control laws and ensuring that pollution-control systems are adequate. An EPA study that evaluated 12 nationwide examples found that, in 11 cases, green infrastructure systems provided desired water-pollution control equivalent to that of traditional systems but at a cheaper cost, while offering additional auxiliary benefits similar to those enjoyed by Philadelphia.[88]

An April CAP analysis on the economic value of coastal ecosystem restoration underscores the potential of nature-based approaches to enhance wastewater management systems. In three case studies of projects funded by the American Recovery and Reinvestment Act of 2009, each taxpayer dollar invested yielded an average of $15 in benefits to the U.S. economy in the form of pollution control, carbon capture and storage, resilience, wildlife habitat, and other services.[89]

Conclusion

The New York Times reported in 2009 that New York City's combined sewer system was designed to accommodate rainfall from a five-year storm—precipitation so heavy that it is only expected to occur twice per decade. At intensities beyond that, the sewers would begin to back up and discharge untreated sewage into public waterways; planners had anticipated that the rarity of these occurrences would mitigate their adverse effects. Yet New York City experienced three separate storms in 2007 strong enough to qualify as 25-year storms—downpours "so strong they would be expected only four times each century," based on historic rainfall records.[90] As James Roberts—then the deputy commissioner of the New York City Department of Environmental Protection—succinctly described, "When you get five inches of rain in 30 minutes, it's like Thanksgiving Day traffic on a two-lane bridge in the sewer pipes."[91]

Infrastructure is at its best when it goes unnoticed[92] and its users can go about their business without impediment. This is especially true when it comes to management of wastewater. Unfortunately, the consequences of human-caused global warming are already causing Thanksgiving traffic jams in wastewater systems with alarming frequency, resulting in illnesses and beach closures that are much more problematic than holiday traffic. Lawmakers and municipal planners must initiate and accelerate efforts to upgrade the nation's rapidly aging wastewater infrastructure, both to address maintenance backlogs and to prepare for the new realities of climate change, including droughts, extreme weather, and sea-level rise. If they do not, decades of progress on public health, environmental protection, and economic development spurred by cleaner waterways is liable to be washed away.

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