NYC Environmental Protection

Innovative & Integrated Stormwater Management

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Angela Licata
Deputy Commissioner of Sustainability
NYC Department of Environmental Protection

Dear Friends of the Environment,

Protecting the waterways, environment and public health of New York City are central to the Department of Environmental Protection's mission. Today, water quality in New York Harbor is better than it has been in over 100 years. Crucial to bringing the Harbor to its current state has been nearly $10 billion in projects DEP has completed or begun since 2002. These projects include combined sewer overflow abatement, marshland restoration, nutrient removal from wastewater and hundreds of other projects.

To provide further water quality improvements, DEP is implementing an ambitious green infrastructure and stormwater management program that diverts stormwater from combined sanitary sewers and wastewater treatment plants, and reduces pollution and litter via passive and natural methods. DEP's $1.5 billion Green Infrastructure Program, the largest and most ambitious green infrastructure plan in the country, has been delivering water quality, environmental and community co-benefits since 2011. To further improve water quality in New York City and to meet the City's regulatory requirements, DEP is working with the City's regulated agencies to develop a similarly ambitious stormwater management program in the municipal separate storm sewer system (MS4) area of the City.

To develop and create the most effective stormwater management program possible, DEP looked to its peers in other municipalities to understand which methods have been successful in implementing stormwater management programs and meeting regulatory requirements. This report provides DEP with baseline knowledge to make informed and effective decisions for our community as we continue to develop and implement our stormwater management program. Of particular importance, this report identifies multi-purpose non-structural stormwater co-management efficiencies and solutions, such as encouraging green infrastructure in private development, and structural efficiencies such as creating retention facilities in parks as temporary stormwater storage areas.

DEP hopes that other service providers and municipalities find this report as helpful as DEP does, and use it to cost-effectively improve the quality of their surrounding waterbodies and deliver co-benefits to their communities. This report would not be possible without the generous time that our peers at utilities and municipalities across the country and abroad committed to developing the following case studies. The Water Research Foundation provided critical support in distributing this report.

Sincerely,

Angela Licata
Deputy Commissioner of Sustainability
NYC Department of Environmental Protection

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1 Introduction

1. Introduction

The New York City Department of Environmental Protection (DEP) owns and operates one of the largest wastewater and stormwater collection systems in the world including a combined sewer system, which conveys stormwater and wastewater within the same pipe, and a separate sewer system, which conveys stormwater in one pipe and sanitary sewage in another pipe. Both systems contribute to the water quality of the waterbodies surrounding New York City and must comply with federal and state water quality standards.

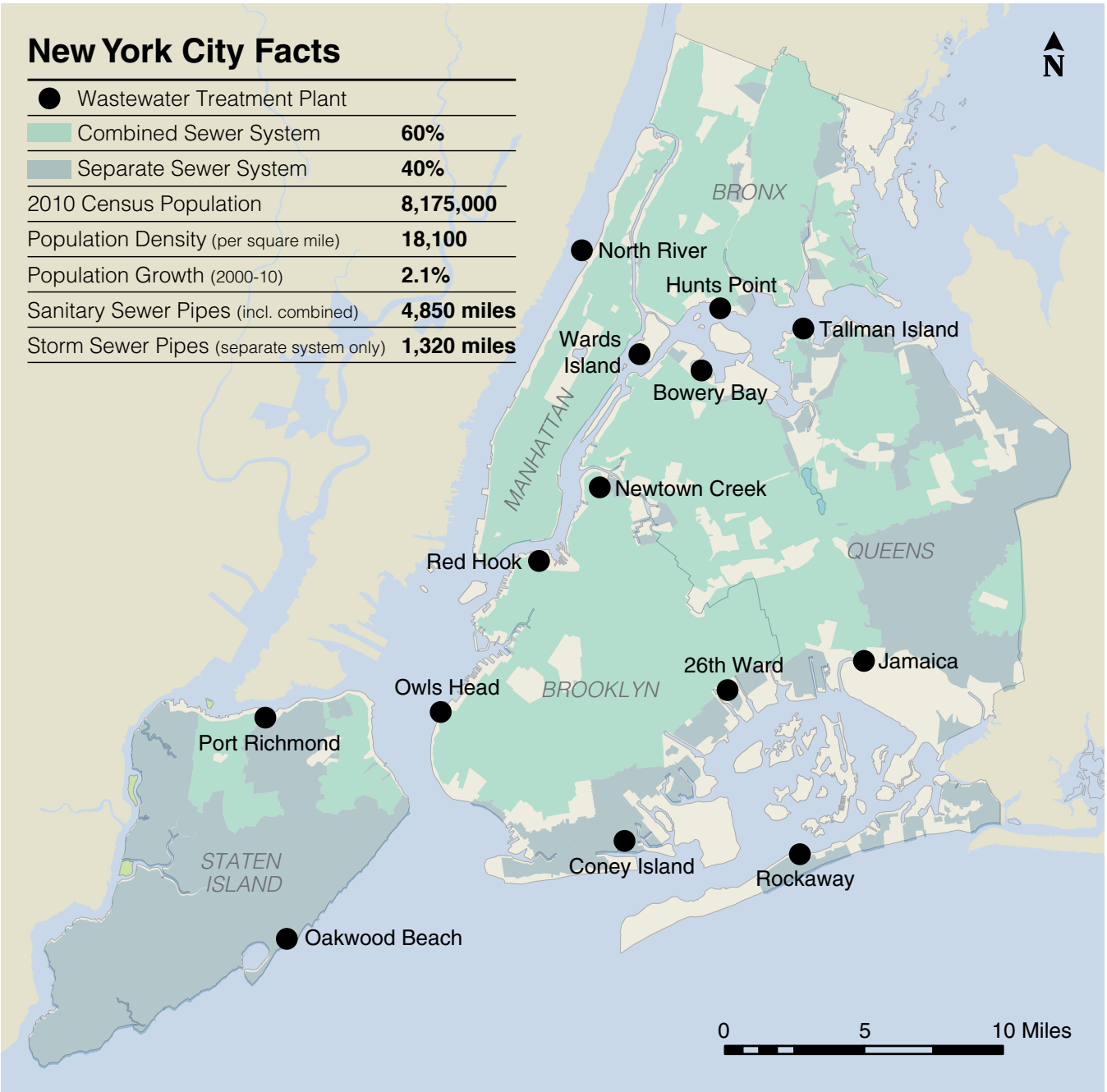
The combined sewer system is currently under a Consent Order for Combined Sewer Overflows (CSO) issued by the New York State Department of Environmental Conservation (DEC). DEC issued a State Pollutant Discharge Elimination System (SPDES) Municipal Separate Stormwater Sewer System (MS4) Permit in August 2015, which regulates water quality impacts from the separate stormwater sewer system. DEP reviewed their overall stormwater program to identify the many successful initiatives already in place and identify gaps that must be filled to meet new permit requirements. Many of the initiatives in the CSO Consent Order are also required under the SPDES MS4 Permit, allowing for a more unified approach throughout the sewer system. The City also has the opportunity to integrate solutions in a cost-effective manner to comply with both sets of regulations.

The research and information gathered for this report provides a wealth of knowledge about national and international stormwater programs that enhance our understanding of innovative and integrated stormwater solutions. The knowledge will be used to refine and enhance DEP's approach for a city-wide stormwater program. Through the generosity of the public water sector, over 34 communities contributed and provided lessons learned, challenges, and experiences with NPDES MS4 compliance, Consent Decree compliance, flood reduction programs, and other integrated stormwater management initiatives. Insights from this report will inform the future development of DEP's programs and initiatives as we strive to proactively manage stormwater and wastewater in a more holistic manner.

Downtown Manhattan
New York City, NY

New York City Wastewater and Sewer Infrastructure

The City owns and operates 14 wastewater treatment plants and 96 pumping stations that convey stormwater and wastewater. The immense system protects the environment and the health of more than eight million New Yorkers, and DEP is committed to ensuring its continued performance and reliability. In addition to the combined sewer system and the separate wastewater collection system, DEP owns and operates stormwater infrastructure that discharges directly into the local waterways. The separate stormwater system brings unique features and challenges to meeting water quality standards for the waterbodies surrounding New York City. DEP is currently developing the City's first Stormwater Management Plan and associated programs in response to the SPDES MS4 Permit using information and lessons learned from communities that have a long history of complying with similar requirements.

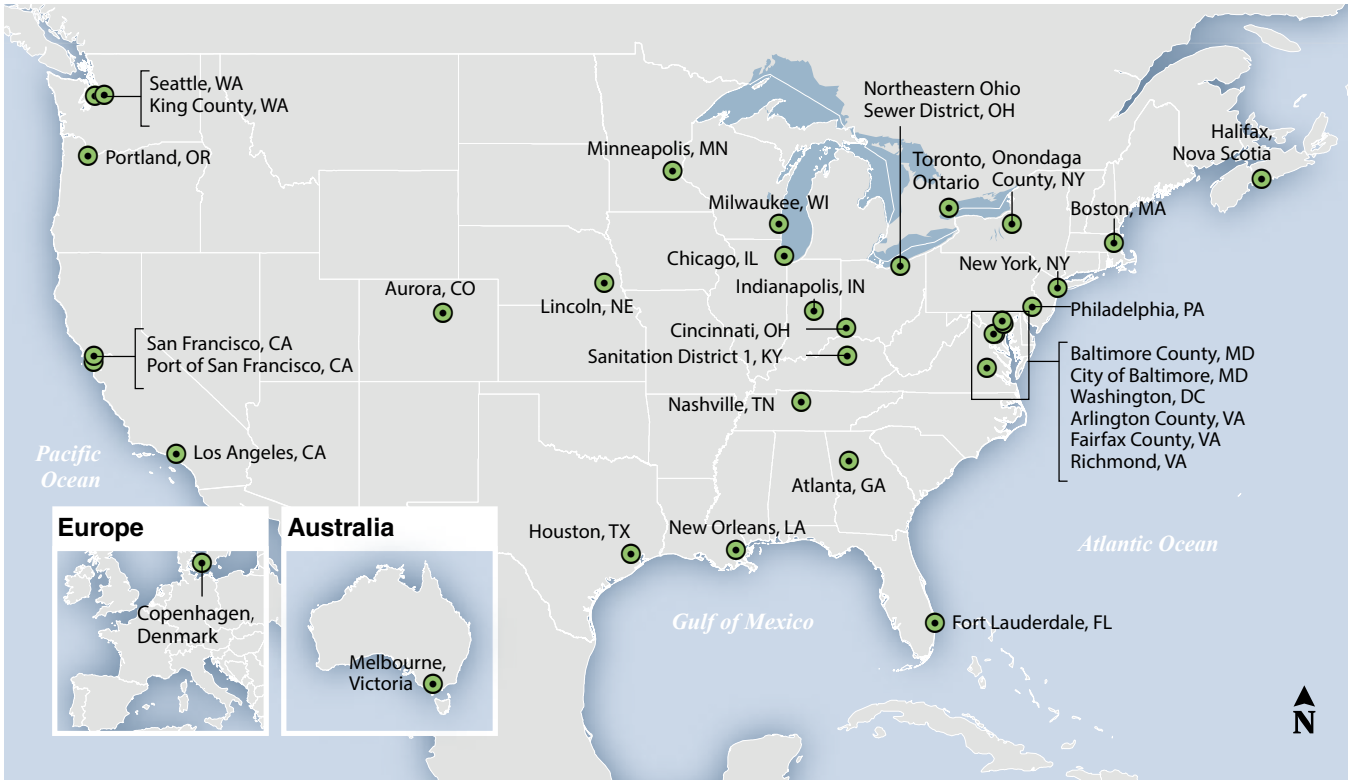


Moving Stormwater Forward

Thirty four communities across the U.S. and abroad contributed to this tremendous effort, sharing the vital data and important discussions that comprise this Innovative and Integrated Stormwater Management Report. These communities were screened from a larger sampling based on factors such as customers served, population density, projected growth, organizational structure, funding sources, impairments, regulatory requirements, infrastructure composition and diversity, and drainage patterns, among other factors. The screening resulted in a series of interviews and discussions wtih communities most similar to New York City as well as those with innovative programs that could potentially be implemented within New York City.

The discussions covered existing initiatives, programs, regulations, and future plans with senior level staff about the multiple components that go into an integrated stormwater program. The data collected was analyzed and formatted into this report to facilitate quick access to stormwater program decision making and implementation. The 34 communities that participated in the study were:

North America | Participating Communities



Arlington County, VA
City of Atlanta, GA
City of Aurora, CO
Baltimore County, MD
City of Baltimore, MD
City of Boston, MA
City of Chicago, IL
City of Cincinnati, OH
Fairfax County, VA
City of Fort Lauderdale, FL
City of Houston, TX
City of Indianapolis, IN
King County, WA
City of Lincoln, NE
City of Los Angeles, CA
City of Milwaukee, WI
City of Minneapolis, MN
City of Nashville, TN
City of New Orleans, LA
City of New York, NY
Northeastern Ohio Sewer District, OH
Onondaga County, NY
City of Philadelphia, PA
City of Portland, OR
City of Richmond, VA
City of San Francisco, CA
Port of San Francisco, CA
Sanitation District 1, KY
City of Seattle, WA
City of Washington, DC
Copenhagen, Denmark
Halifax, Nova Scotia
Melbourne, Victoria
Toronto, Ontario

The following regional agencies were also a part of the survey:

Chicago Metropolitan Water Reclamation District
Cincinnati Metropolitan Sewer District
New Orleans Water and Sewerage Board

The Innovative & Integrated Stormwater Management Report

The report topics encompass the United States Environmental Protection Agency (USEPA) recommended NPDES MS4 requirements, commonly called the six minimum control measures, and additional requirements commonly found within NPDES MS4 Permits. Additional topics that are critical to stormwater program success or those that can result in progressive and innovative water quality solutions are also covered in the report.

Each chapter covers a stormwater program topic and includes: an introduction to the program, the role stormwater has in the program, an introduction to the applicable United States federal regulations, and common high-interest factors that influence decision making critical to program development and implementation. Summaries of only the factors common to each program are presented in the report body under benchmarked data. Detailed results can be found in separate documents and databases available publically by the separate municipalities. Programs that are implemented across the overall jurisdiction of the associated respondent community are refered to as community-wide. As part of each chapter, case studies are presented for a sampling of the communities with progressive programs in the topic area.

2 Innovative Stormwater Planning, Policy, and Regulations

2.1 Innovative Stormwater Planning
2.2 Green Infrastructure Programs
2.3 Riparian Buffers
2.4 Floodplains
2.5 303(d) Lists and Total Maximum Daily Loads
2.6 Stormwater Role in Source Water Protection
2.7 Climate Change and Stormwater Resiliency

2.1 Innovative Stormwater Planning

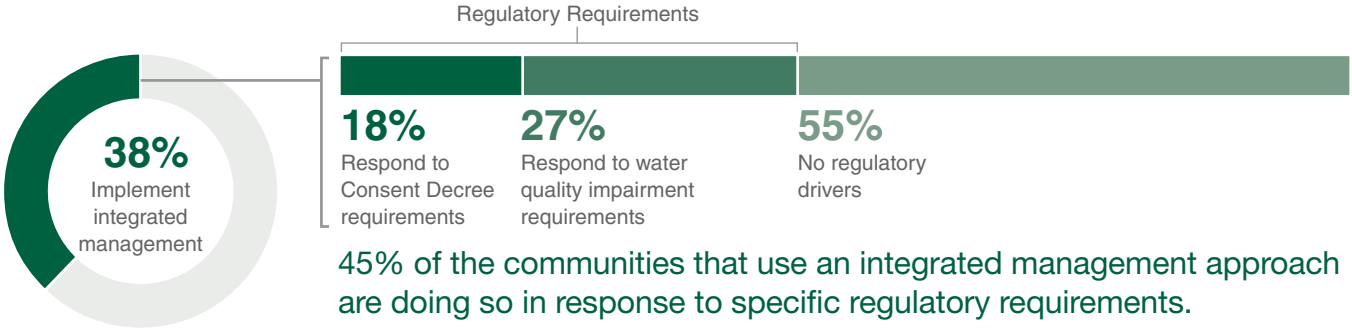
Water infrastructure includes three different systems: drinking water, wastewater, and stormwater. The challenges associated with water infrastructure are escalating for some communities because of population growth, climate change, regulatory drivers, and citizen desires. Historically, communities have managed each of the water infrastructure systems separately, but integrated water management has become a new area of focus to more effectively meet these challenges.

The key result of an integrated management approach is an increase in efficiencies from managing stormwater, wastewater, and drinking water programs hollistically. An integrated management approach helps communities meet obligations while optimizing investments. The result is that communities gain flexibility and efficiency for meeting water quality standards while addressing broader community goals. Some of the approaches perform cost-benefit analyses of different solutions. The end result of an innovative approach assessment is a solution with the most positive cost-benefit.

38% of respondent communities use an integrated management approach. Of these, all recognize increased efficiency and co-benefits.

Integrated Stormwater Management Drivers

Integrated management is voluntary. However, communities that are responding to a Consent Decree or Total Maximum Daily Load (TMDL) water quality impairment may use integrated management to more effectively comply with regulations and optimize synergies. The community regulatory drivers influence the type and level of detail of the integrated approach.



45% of the communities that use an integrated management approach are doing so in response to specific regulatory requirements.

The three water infrastructure systems: drinking water, stormwater, and wastewater.

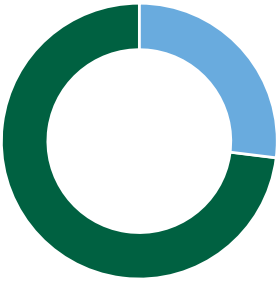
Integrated Stormwater Management Approach

Each community determines if an integrated management approach is appropriate for local conditions, including watershed impairments and potential solutions (wastewater versus stormwater, green versus gray, conveyance versus attenuation, and source control versus end of pipe treatment).

An integrated management approach can follow a structured and documented method, such as the methods published by the EPA, or may follow less structured methods as long as the effort considers multiple infrastructure systems. The effort is considered "integrated" as long as two or more infrastructure systems (stormwater, wastewater, or drinking water) and possible solutions are assessed together. A standard approach to stormwater management typically evaluates only stormwater infrastructure.

For communities within the United States, the EPA offers guidance that some communities use to set up their program. The EPA has published policy documents that outline the approach and features of an integrated plan. A community that follows the EPA Guidelines not only gains the benefits of the integrated plan, but also can use the plan to more effectively comply with regulations.

85% of communities utilizing an integrated management approach have developed community-specific approaches to integrated management and planning.



73%
Follows community-specific integrated management and planning approach

27%
Follows EPA guideline approach

Infrastructure Managed

Most integrated management approaches assess stormwater and wastewater. Drinking water can also be incorporated. 22% of respondent integrated management communities, all outside the United States, manage all three types of infrastructure with an integrated approach.

56% of integrated management communities manage stormwater and wastewater together.

56%
Include stormwater and wastewater

22%
Include stormwater and drinking water

22%
Include stormwater, wastewater, and drinking water

Regulations

Regulations typically require separate permits for stormwater, wastewater, and drinking water. The regulations do not include specific requirements for innovative approaches that combine management of the three water infrastructures. However, EPA policy statements include an innovative approach called integrated planning. The integrated planning approach is voluntary. The integrated planning approach does not change regulatory standards or delay necessary improvements.

CASE STUDY

Seattle, Washington

In an effort to protect the City of Seattle's (Seattle) waterways and provide the most cost-effective solutions, Seattle is taking an innovative approach to improving water quality. Seattle has proposed implementing stormwater projects to be completed by 2025 that will provide more effective water quality benefits than CSO Long Term Control Program (LTCP) projects and will treat larger volumes of water. By doing this, Seattle hopes to defer LTCP projects past 2025 to focus resources on stormwater projects that will improve water quality in the receiving waterbodies. The integrated plan examines consent decree requirements, waterbody impairments, and wet weather flow volumes.

Seattle's integrated plan compared the projected pollutant load reductions for the candidate stormwater projects with the projected pollutant load reductions for the candidate LTCP projects. For all representative constituents of concern, except ammonia-N, the highest-ranked candidate projects were stormwater projects. The analyses of these projects showed that a greater pollutant load reduction was expected because the candidate stormwater projects treat larger volumes than the candidate LTCP projects. In the process of developing the integrated plan, Seattle also completed pollutant load modeling and exposure assessments. The modeling and assessments indicated that multiple combinations of the stormwater projects provide significantly greater water quality benefits than the combined six LTCP reduction projects. Seattle also used these analyses to gain approval from the EPA and Washington State DOE to focus resources on the candidate stormwater projects and defer LTCP projects until after 2025.

Seattle submitted the integrated plan to the EPA and the Washington State Department of Ecology in May 2015 and the plan was accepted. The City of Seattle is currently implementing the integrated plan and the proposed projects.

Ballard Roadside green infrastructure

CASE STUDY

Richmond, Virginia

In an effort to have "Cleaner Water Faster", the City of Richmond (Richmond) is taking a comprehensive approach to improving water quality. Richmond is pursuing a watershed-based integrated permit that will be supported by an integrated water resources management plan. The integrated permit consolidates all of the previously independent wastewater and stormwater permits into a single permit with the goal of water quality standard compliance. By doing this, Richmond hopes to unify the management of drinking water, wastewater, and stormwater systems and achieve greater efficiency.

The integrated water resources management plan goes beyond the basic permit requirements and lays out a blueprint for achieving water quality standards. Intended to reflect broader community goals and visions, the plan is being developed through intensive involvement from both the community and technical stakeholders. This process has allowed Richmond to define the overall goal of the plan as the ability to "manage, preserve, protect, and restore watersheds in Richmond to fully support designated uses of all waters". The plan includes a characterization of City watersheds and identifies possible strategies to achieve goals.

The integrated plan supports the permit by providing data and information on how to implement projects to achieve permit requirements. The plan also includes more wide-ranging goals for the City that are derived with community input. This process has required considerable support and buy-in from the EPA, Virginia Department of Environmental Quality (DEQ), and community stakeholders. Richmond started the integrated planning process in 2014 and expects to have a final permit issued by June 2018.

Richmond's efforts followed the EPA's Guidelines (*Integrated Municipal Stormwater and Wastewater Planning Approach Framework,* June 5, 2012). It should be noted that the integrated approach does not remove obligations to comply with the Clean Water Act, nor does it lower regulatory or permitting standards. This is a voluntary process through which Richmond hopes to gain flexibility and efficiency in meeting water quality standards while addressing greater community concerns and goals.

The Integrated Virginia Pollutant Discharge Elimination System (VPDES) Permit is a regulatory vehicle that sets specific water quality standards. The permit will combine the regulatory requirements of the wastewater treatment plant, combined sewer system, and stormwater system. By doing this, Richmond hopes to unify management of the systems and achieve greater efficiency.

Richmond is working closely with the DEQ in developing the draft VPDES permit. By assisting in permit development, Richmond hopes to not only have a permit that adheres to regulatory requirements but also one that complements community goals.

RVA H2O
EVERY DROP COUNTS

2.2 Green Infrastructure Programs

Green infrastructure reduces and treats stormwater at its source while delivering environmental, social, and economic benefits. Green infrastructure designs typically include peak control, volume control, and water quality treatment. As a result, watershed-wide green infrastructure programs are effective at addressing sources of impairments, thereby protecting and restoring the water quality of receiving waterbodies.

Prior to the NPDES MS4 Stormwater requirements, communities focused most of their stormwater-related efforts on gray infrastructure impreovement projects that reduced flood damage. The design of gray infrastructure is based on controlling peak discharge and, in most cases, does not focus on other stormwater impacts such as runoff volume and water quality. Many communities began to refine their stormwater management program after the NPDES MS4 stormwater requirements were promulgated to consider runoff volume and water quality, not just peak discharge.

For some time, many communities' programs only tested green infrastructure as pilot applications. The green infrastructure was installed, monitored, and refined to ensure the features were successful in the urban environment. Some community programs are now installing green infrastructure in wider applications so that cumulative watershed benefits are provided. The wider applications are defined as comprehensive programs because they include large-scale implementation of multiple green infrastructure practices that collectively manage a large watershed.

97% of respondents are implementing some green infrastructure. 47% have comprehensive green infrastructure programs.

47%
Comprehensive green infrastructure program

50%
Pilot green infrastructure program or implemented as needed

3%
Only gray infrastructure program

Green infrastructure includes features such as rain gardens, bioswales, green roofs, green streets and alleys, and rainwater harvesting. Each community's motivation to expand its green infrastructure program is influenced by drivers such as regulations, climate conditions, and community interest of natural systems in the urban setting.

Each community's ability to advance a green infrastructure program is influenced by challenges such as land use density, available budget, and public support. The community must find the appropriate balance between the drivers and challenges to advance its green infrastructure program.

Bioswale in Milwaukee, WI

Drivers

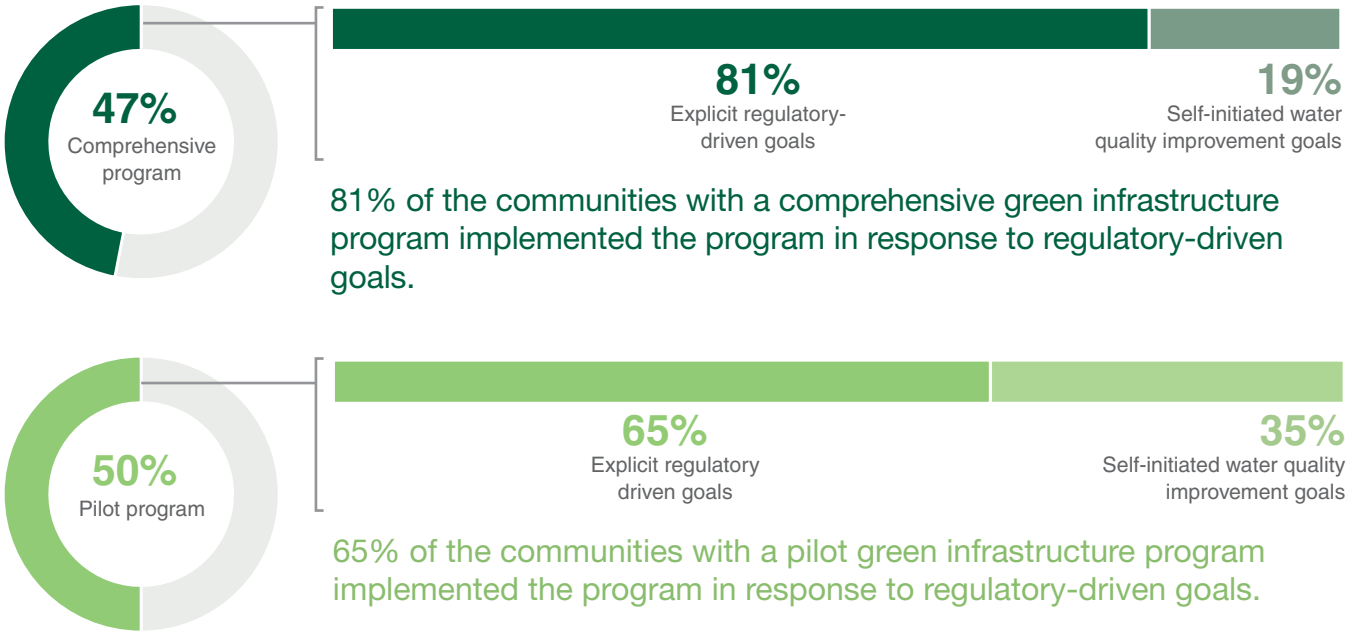
Communities that are implementing comprehensive green infrastructure programs are responding to either specific regulatory drivers or self-initiated water quality improvement goals.

Specific Regulatory Drivers

Regulatory drivers may include a Consent Decree with goals such as reducing infiltration/inflow to the combined or separate sewer system by better controlling stormwater. The reduced infiltration/inflow results in reduced sewer overflows. Another regulatory driver may include a TMDL associated with stormwater pollution.

Self-Initiated Water Quality Improvement Goals

Communities typically implement self-initiated water quality improvement goals because the water bodies are a visible community asset. Citizens see and recognize the value of the protection and/or restoration of the water bodies. An example of a self-initiated water quality improvement goal may be the reduction of trash/floatables to waterbodies visible on a public shoreline.



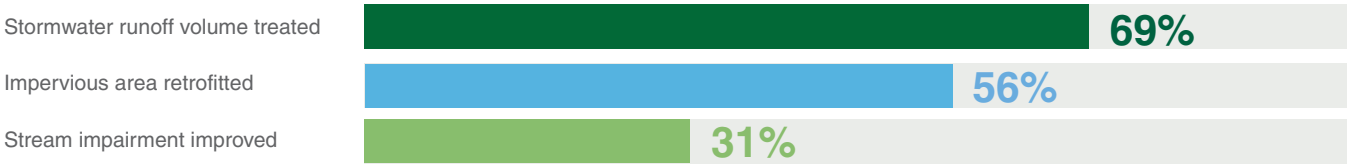
Dean Street right-of-way rain garden, New York City, NY

Success Measurement

Regulatory-driven programs use metrics that are quantified. Communities measure the success of their comprehensive green infrastructure program based on progress toward meeting their community goals. The goals may be directly dependent on quantifiable actions such as number of impervious acres managed or treated, number of projects, and volume of stormwater runoff managed or treated. Conversely, the goals may be less quantifiable such as a general improvement trend shown by stream monitoring.

100% of the communities with comprehensive green infrastructure programs quantify their success.

Success Measure Distribution



Financial Resources

A community's annual green infrastructure budget relative to the total projected green-infrastructure need is an indication of the community's commitment to meet watershed improvement goals.

80% of the comprehensive programs have reliable funding to ensure a continuous and steady implementation.

80%
Have reliable funding

20%
Funding varies year-to-year

Baltic Street right-of-way rain garden, New York City, NY

The Patrick Henry Drive median green street, Arlington, VA

Regulations

40 CFR Part 122 – EPA Administered Permit Programs: National Pollutant Discharge Elimination System describes the six minimum control measures that small MS4s must implement. Community-wide green infrastructure programs are not required explicitly as one of the six minimum control measures and are only subsets of two of the minimum control measures; post-construction stormwater management, and pollution prevention/good housekeeping for municipal operations.

CASE STUDY

Portland, Oregon

The City of Portland Bureau of Environmental Services (BES) uses green infrastructure to reduce stormwater runoff and improve water quality and habitat, while also providing services and benefits related to community livability, health, and energy. The goal is also motivated by a CSO Administrative Order and NPDES MS4 Permit. Portland has implemented a Green Street Policy to encourage the implementation of green infrastructure, such as green streets in the public right-of-way. BES requires stormwater management and green infrastructure on private property and in the right-of-way through development code which prioritizes the use of green infrastructure where feasible.

BES performed monitoring to identify the multiple benefits of green infrastructure by measuring health, energy and carbon sequestration, and community livability. Additionally, they considered environmental equity, which is the measurement used to calculate the community benefit when best management practices (BMPs) are located in underserved neighborhoods. Green infrastructure practices examined by BES include eco-roofs, green streets, trees, invasive species removal and native revegetation, culvert removal with stream restoration, land purchase, and plantings in natural areas. Portland has installed 2096 public green facilities to date; this does not include private facilities required by the SWMM.

Maintenance of Portland's green infrastructure is critical to its success and its ability to provide multiple community benefits. Common maintenance, which typically include sediment removal, structural repairs, protection from beavers, and vegetation management, is driven by inspection and condition assessment of individual assets. Additionally, performance of stormwater facilities on private property is ensured by BES' maintenance inspection program. Additionally, Portland has many financial incentives to encourage the implementation of green infrastructure. BES has a Community Stewardship Grant Program which promotes citizen involvement in watershed stewardship by providing up to $10,000 per project to citizens and organizations. Portland also offers the Clean River Rewards Program, which promotes private green infrastructure stormwater management through utility discount.

Green street on 12th Avenue in Portland, OR

Green street on Burnside Street in Portland, OR

CASE STUDY

New York, New York

New York City DEP has used the area-wide approach to implement a green infrastructure program in CSO priority watersheds to meet Consent Decree milestones. DEP has been identifying Priority CSO Tributary Areas (Priority Areas) based on annual CSO volume, frequency of CSO events, and outfalls that may be affected by Waterbody/Watershed Facility Plans (WWFPs) or other future system improvements. DEP also notes outfalls in close proximity to existing and future public access locations.

The identification of Priority Areas enables DEP to focus resources on specific outfall tributary areas, analyze all potential opportunities, select potential, preliminary, and final sites for green infrastructure implementation, and saturate these areas with green infrastructure. DEP continues to review and expand the number of Priority Areas.

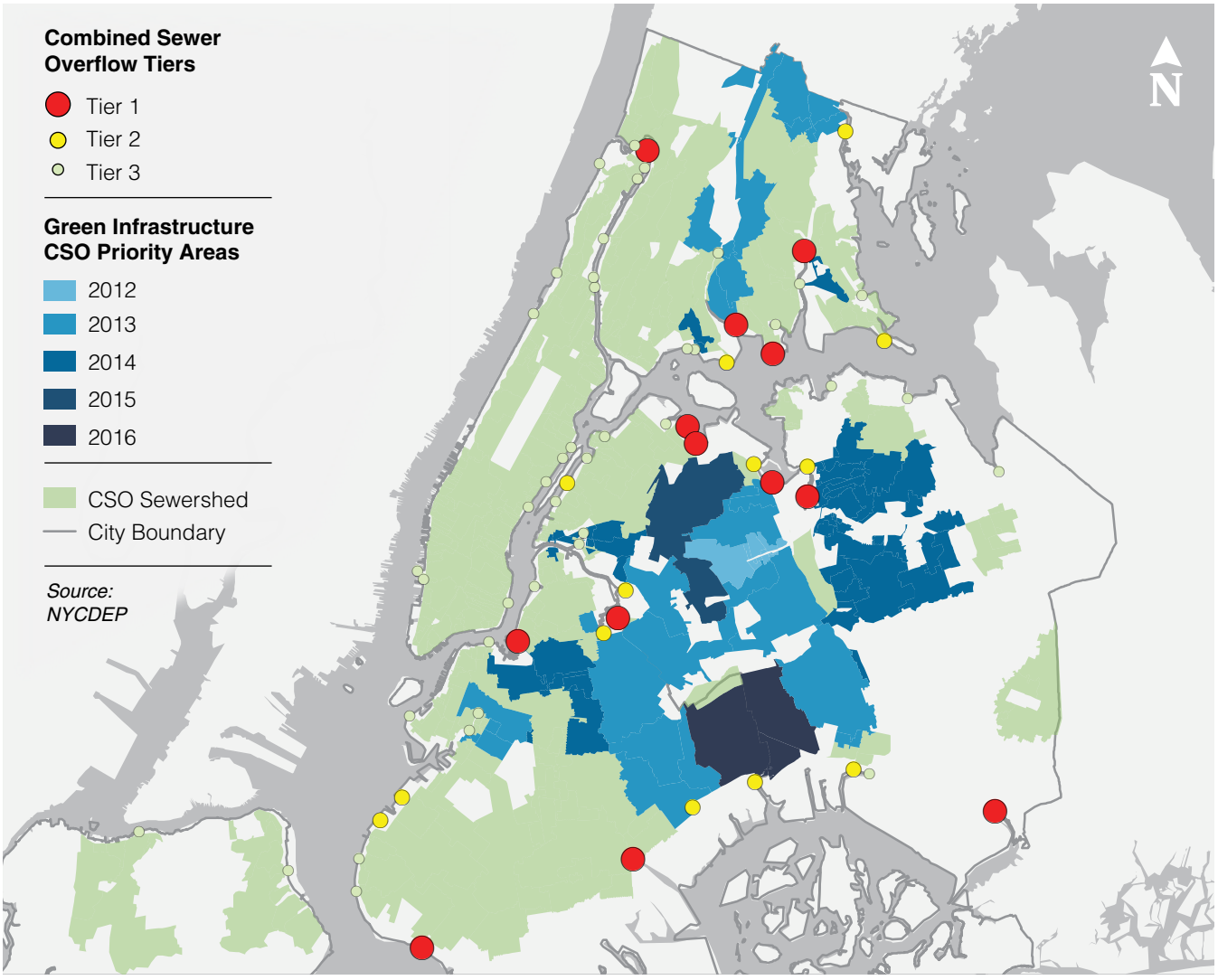
DEP's standardized green infrastructure designs and procedures enable efficiencies in design and construction and systematic implementation. This approach also provides an opportunity to measure and evaluate the CSO benefits of area-wide green infrastructure implementation at the outfall level.

Right-of-way rain garden in New York City, NY

DEP utilizes the area-wide strategy for all public property retrofits. DEP has developed standard siting and design processes for right-of-way green infrastructure implementation and works directly with its partner agencies on retrofit projects at public schools, public housing, parkland, and other City-owned property within the Priority Areas. DEP coordinates with partner agencies on a regular basis to review designs for new projects and gather current capital plan information to identify opportunities to integrate green infrastructure into planned public projects.

The area-wide strategy and associated standardized procedures have enabled DEP to apply green infrastructure at its current scale. However, there are several challenges that DEP faces during green infrastructure implementation. Some of these challenges include existing urban street conditions, geologic and soil conditions (such as high bedrock or clay soils), high groundwater tables, and utility conflicts. In some cases there is no alternative but to reject sites due to infeasibility. However, DEP and partner agencies have made progress developing solutions to some of these obstacles.

CSO Tiers and Green Infrastructure Priority Areas



Note: These CSO outfalls are classified by tiers depending on the volume of annual discharge: Tier 1 outfalls discharge over 500 million gallons per year (mgy) and comprise roughly 50% of all CSO volumes, Tier 2 outfalls discharge between 250 to 500 mgy and make up an additional 20% of CSO volume, and Tier 3 outfalls discharge between 50.7 to 250 mgy and make up an additional 10% of CSO volume.

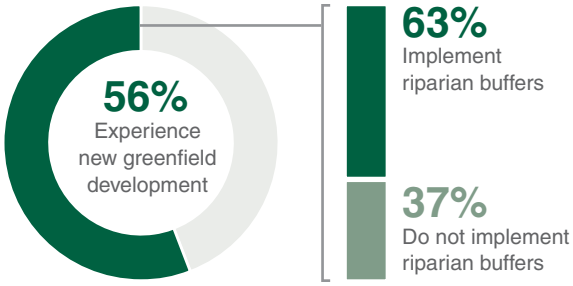
2.3 Riparian Buffers

Waterbodies are comprised of both the actual body of water, such as a stream, river, or lake, and the adjacent riparian buffer or shoreline. The riparian buffer is the area next to the channel that is periodically inundated during storm events. The combined system (waterbody and riparian buffer) conveys storm and groundwater, stores floodwater, and supports aquatic and other life. Protection of the riparian buffer allows the waterbody to fulfill all of its natural functions.

Preserving the natural buffer system of the contributing streams is one of the most effective methods to treat stormwater and thereby protect water quality of a waterbody. Benefits of the riparian buffer include protecting water quality by filtering pollutants, providing storage for floodwaters, allowing channels and shorelines to meander naturally, providing suitable habitats for wildlife, providing shade to reduce water temperatures, and providing soil stability through root mass.

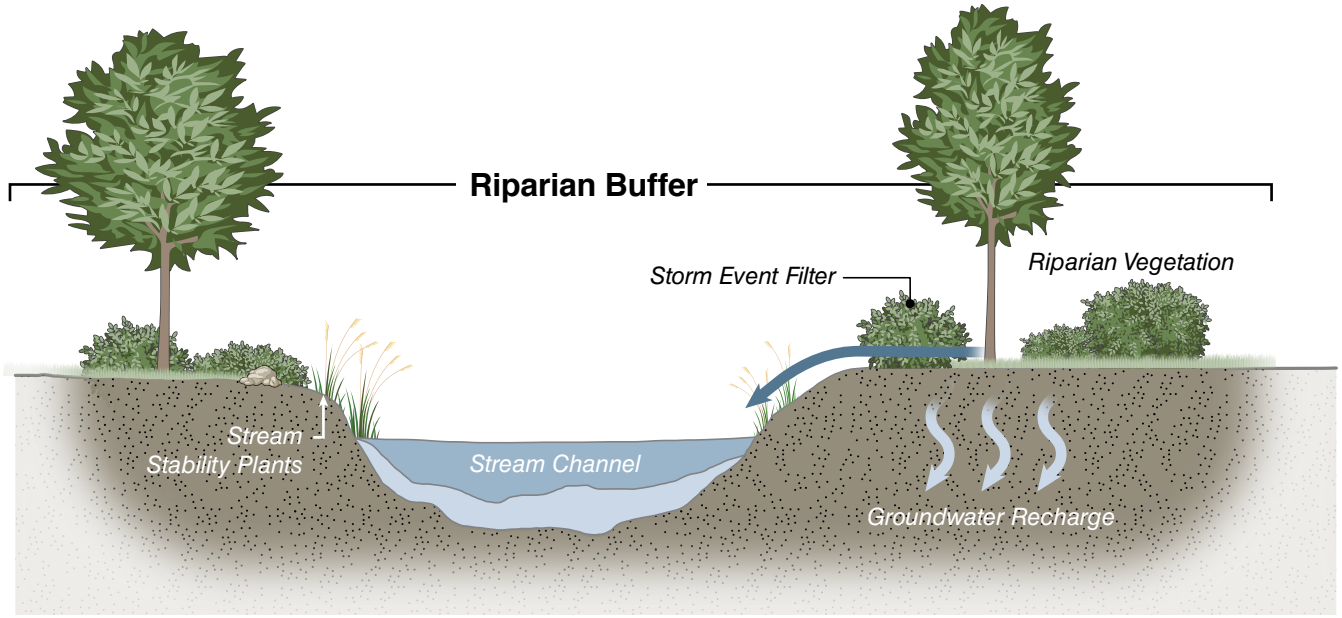
Preserving the natural buffer system when land is being developed is significantly more cost effective and facilitates community acceptance versus restoration of riparian buffers in an existing development.

56% of respondent communities are experiencing significant new development in greenfield areas, and 63% of these implement riparian buffer requirements.



Riparian Buffer Preservation Standards

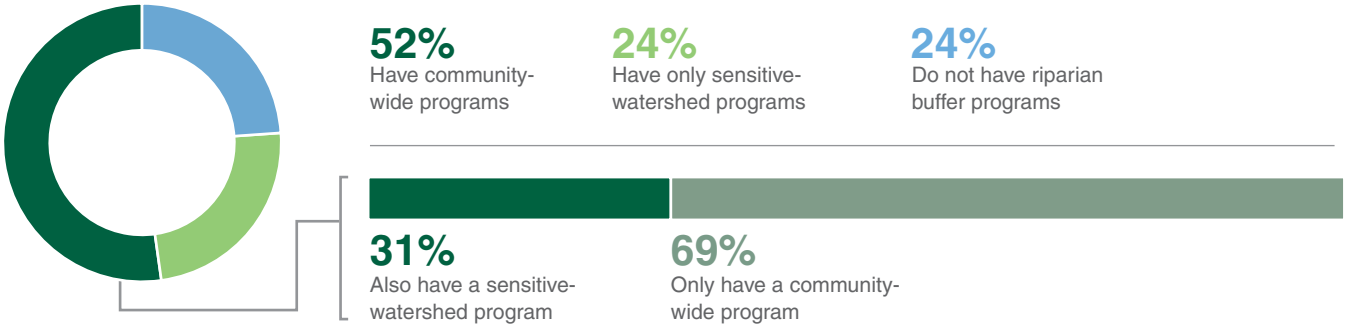
The decision to implement an effective riparian buffer control program must balance the level of protection with compliance cost. A key factor that influences the balance of the level of protection and compliance cost is the determination of which stream systems are required to have riparian buffers.



Watershed Requirements

Some of the benchmarked communities require riparian buffers in watersheds with sensitive receiving waters. In these sensitive watersheds, riparian buffer regulations are more protective as compared to the community-wide buffer regulations.

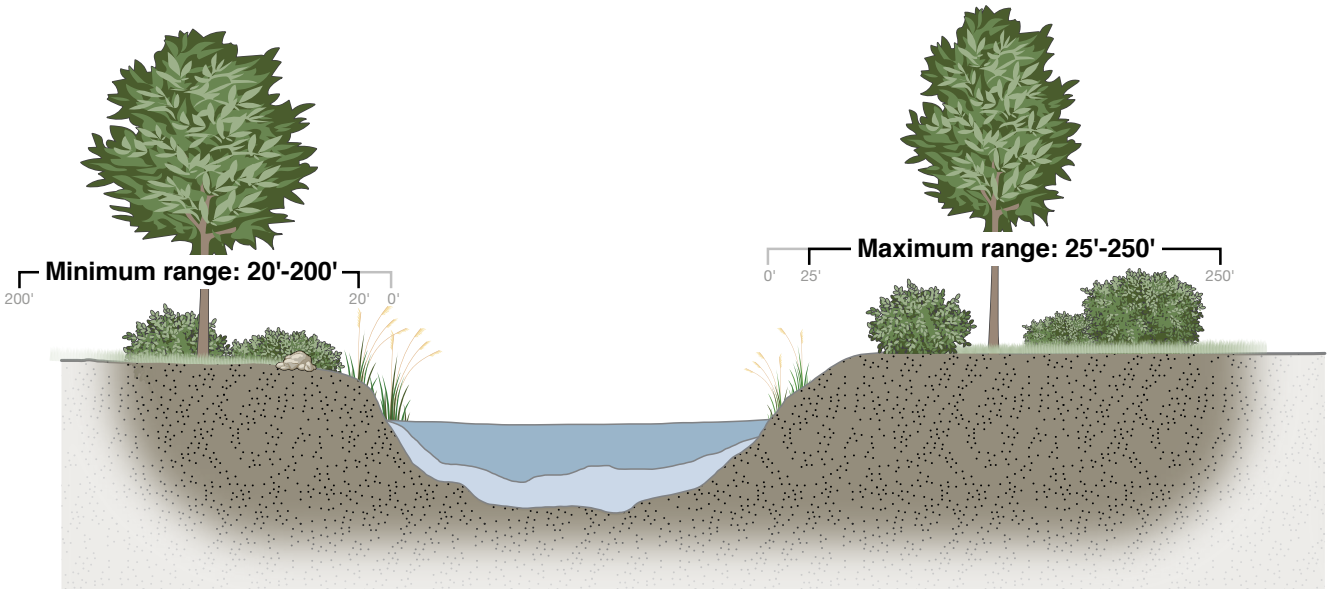
76% of the total respondent communities have a community-wide and/or a sensitive-watershed riparian buffer program.



Aerial view of a riparian buffer on a stream.

Buffer Width Ranges

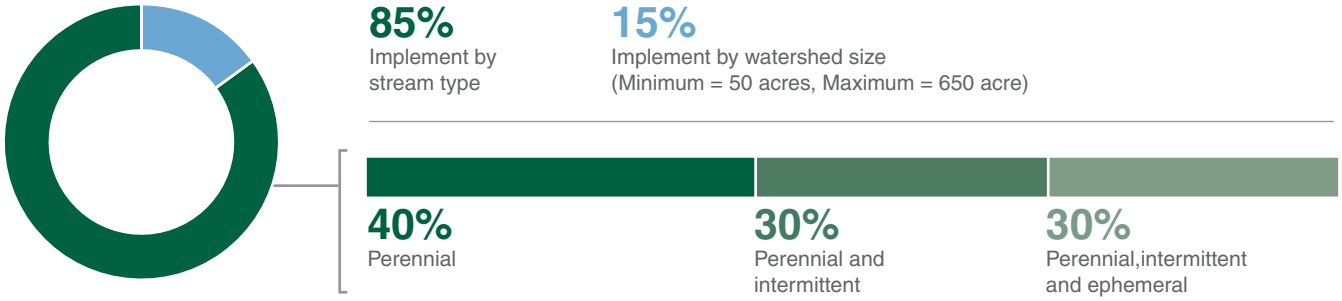
Selecting a buffer width that is effective in providing the appropriate benefits while balancing the potential impacts on the developable land and community is a key decision. The minimum and maximum buffer widths are distributed as follows:



Stream Buffer Requirement

The benchmarked communities that implement riparian buffer programs do so based on either watershed size or stream category (perennial, intermittent, ephemeral). Implementation methods based on watershed size are the most efficient and straight forward for both plan reviewers and applicants. Stream category methods consider those site specific conditions, but require additional effort to implement. Definitions of stream categories are typically based on an approved Army Corps or state regulatory agency methods.

85% of respondent communities implement riparian buffer programs based on stream types. 40% of respondent communities that implement based on stream types only include perennial streams.



Perennial Stream

Perennial streams maintain flow throughout the year.

Intermittent Stream

An intermittent stream becomes seasonally dry when the groundwater table drops below the elevation of the stream-bed during dry periods.

Ephemeral Stream

An ephemeral stream only flows in direct response to pre-cipitation.

Regulations

There are no federal regulations requiring riparian buffers. Instead the regulations require state and local agencies to assess pollutant sources and methods to protect from pollutant sources, which in turn can result in the development of local riparian buffer regulations.


Great Falls National Park

CASE STUDY

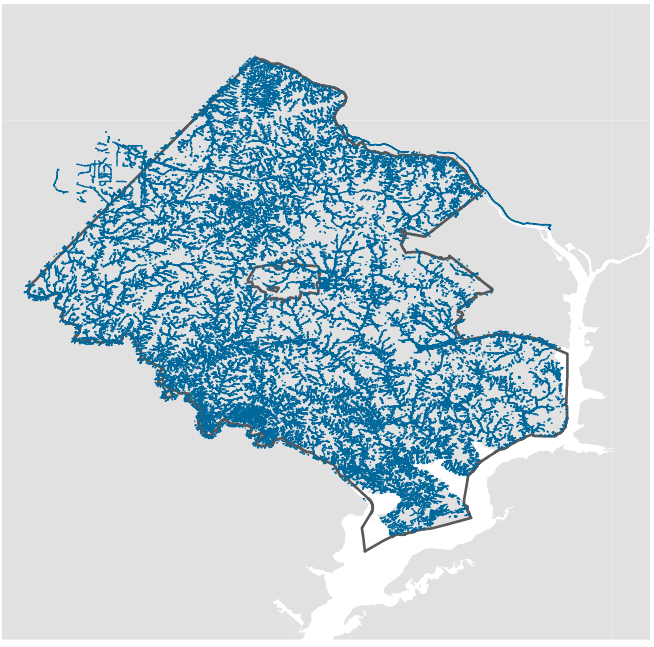
Fairfax County, Virginia

Fairfax County implemented a local Chesapeake Bay Preservation Ordinance in 2002 with the intent of protecting existing high-quality state waters, restoring other state waters to a condition or quality that permits all public uses, safeguarding clean waters from pollution, preventing any increase in pollution, reducing existing pollution, and conserving water resources for public health, safety, and welfare.

Fairfax County's Chesapeake Bay Preservation Ordinance aims to achieve these goals through many programs, one of which requires 100-foot wide riparian stream buffers as resource protection areas. The local ordinance goes further to protect water quality by expanding the standard definition of resource protection areas to include all perennial streams. Lakes and ponds that form the source of a perennial stream, or through which a perennial stream flows, are considered to be a part of the perennial stream.

The 100-foot buffer on perennial waterbodies protects existing vegetation, but does not mandate restoration of those areas where the existing condition is not vegetated or forested. Pollution prevention is achieved through the filtering and interception functions of the intact riparian buffer. Fairfax County completed a project to define and map all perennial streams to aid in plan review and enforcement.

Big Rocky Run is a perennial stream in Fairfax County, VA



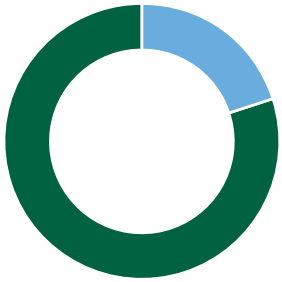
Map of perennial streams in Fairfax County, VA

2.4 Floodplains

A floodplain is an area of land adjacent to a stream or river that extends from the channel to the base of the valley. The area experiences inundation during large storm events. Proper floodplain management reduces the potential for loss of life and flood damages and promotes the natural and beneficial use of the floodplain.

A regulatory floodplain is an area that is subject to floodplain regulations. The Federal Emergency Management Agency (FEMA) is responsible for oversight of local communities' floodplain management programs and defining baseline floodplain regulations. In addition, communities that comply with baseline FEMA floodplain management standards are eligible for the National Flood Insurance Program (NFIP) and receive FEMA disaster assistance funds and flood insurance subsidies. The key measure for community participation in the NFIP is that the community must adopt and enforce floodplain regulations and policies that are at least as protective as FEMA baseline standards. The community may elect to implement floodplain regulations and policies that are more protective than FEMA minimum standards. This conservative approach contributes to further reducing the potential for loss of life and flood damage and increases the natural and beneficial functions of the floodplains.

80% implement floodplain regulations that are more protective than FEMA baseline standards.



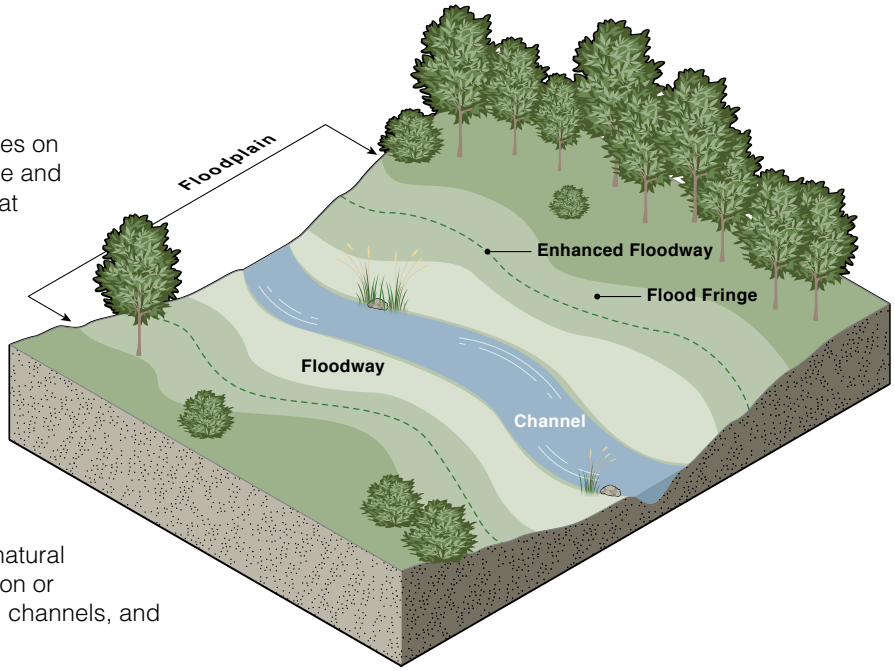
80%
Implement More Protective Floodplain Requirements

20%
Implement FEMA Baseline Requirements

Floodplain Schematic

Traditional floodplain management focuses on the prevention and reduction of loss of life and flood damage. Examples of measures that support the traditional focus are channel improvements, floodplain regulations, flood warning, and retrofitting/ removing buildings from the floodplain.

In recent years, floodplain management goals have changed and now include the preservation and restoration of the natural and beneficial functions of the floodplains. Examples of measures that support the natural and beneficial functions include restoration or preservation of wetlands, buffers, natural channels, and streams.



Floodplain Management Standards

FEMA baseline standards include the following requirements:

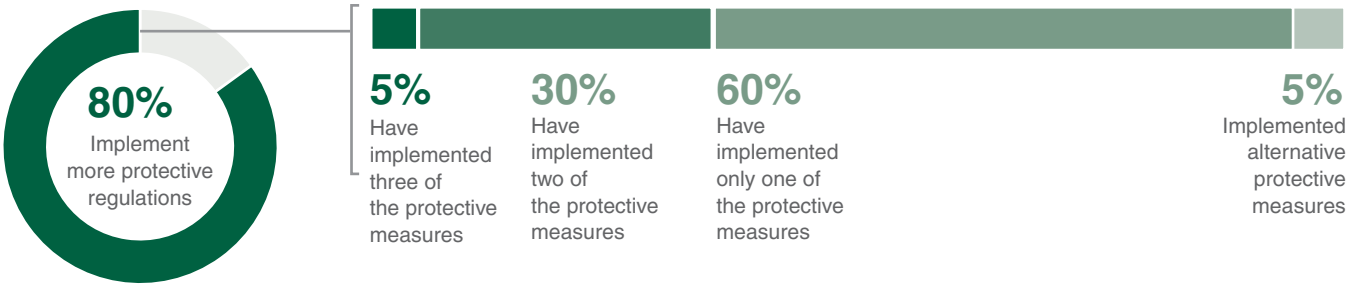
- Heated living space for buildings must be elevated one foot above the 100-year floodplain elevation.
- Discharges used to define floodplain limits are based on existing land use conditions in order to set flood insurance rates.
- The floodplain is divided into a floodway and flood fringe. The floodway is the area of the floodplain with higher flood depths and flow velocity. The flood fringe conveys and stores flow with lower velocity and depths.

Factors that influence a community's desire to implement a more protective floodplain management program include the history of floods, damage, and loss of life. In addition, exposure to potential future flood damage also influences a community's desire for a more protective floodplain management program. The future flood damage potential is influenced by the potential for land use change, development pattern and pace, and number of buildings in or near the floodplain.

Floodplain Protective Measures

Of the communities exceeding FEMA baseline standards, the floodplain protective measures differ. Flood mitigation options include regulations to limit development in floodplain areas and using projected future land use models. They also may be comprised of infrastructure projects, such as removing existing buildings from flood hazard zones and improving stormwater drainage system capacity. They can also include natural systems protection, such as preservation of floodplains as open space and protect and restore natural flood mitigation features. These measures are described in further detail below.

60% of respondent communties implement only one of the floodplain protective measures, while 30% implement two of the floodplain protective measures and 5% implement three of the floodplain protective measures.



Storage Preservation

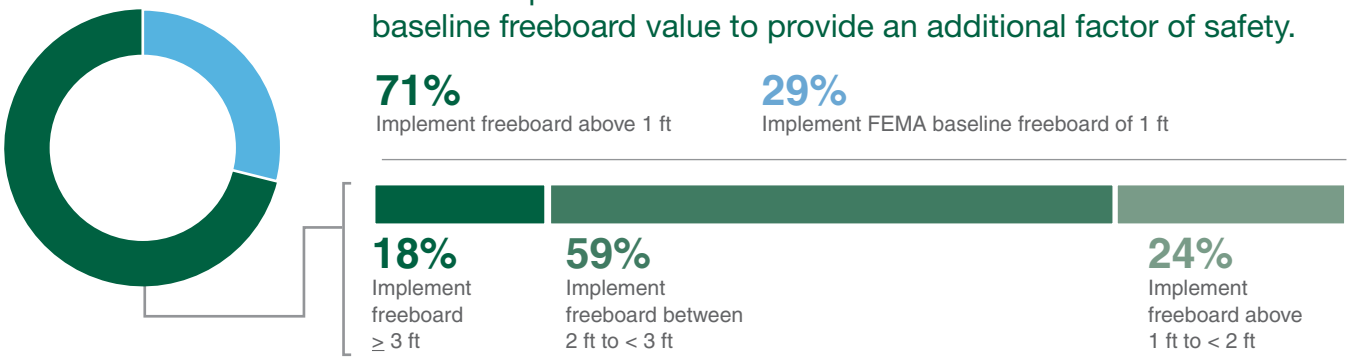
Floodplain storage provides natural peak flow attenuation to reduce impacts and protect downstream systems. Preservation of floodplain storage also ensures the natural peak flow attenuation is maintained and ensures the natural and beneficial uses of the floodplains are maintained.

50% of respondent communities elect to be more protective by preserving floodplain storage.

At a park in Chicago, IL, stormwater floods the green space.

Additional Freeboard

FEMA requires that all heated living space is elevated one foot above the 100-year flood elevation. The one foot freeboard provides a factor of safety.

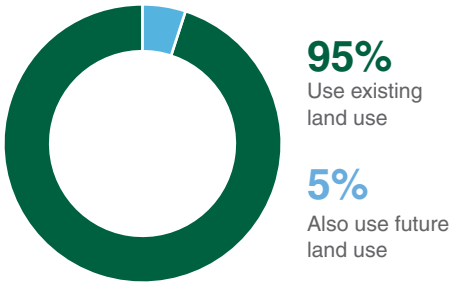


Houses meeting freeboard requirements in coastal areas by raising living spaces to the required height above the 100-year flood elevation.

Land Use Basis for Modeling and Map Development

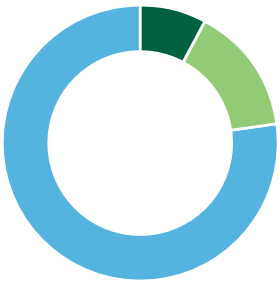
Flood insurance rates and claims must be based on existing flood damage, therefore FEMA flood studies are based on existing land use hydrology. Future land use hydrology modeling and studies provide the tool to manage the watershed so that areas that could become floodplains are regulated.

95% of respondent communities elect to use only existing land use flows for floodplain regulation.



Floodway Width

The permitting process for development is relatively straightforward in the flood fringe. However, flow depths and velocities are greater in the floodway, so the permitting process for development is more deliberate. A wider floodway reduces the area within the floodplain available for development, provides more protection, and promotes the natural and beneficial uses of the floodplain.

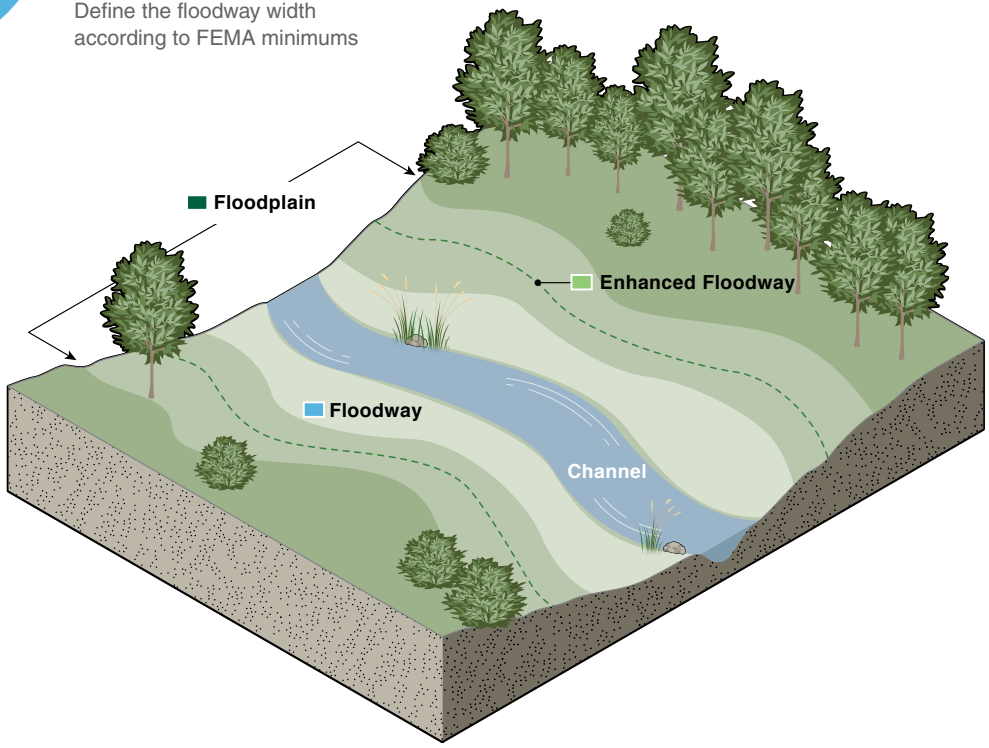


8%
Define the floodway as the floodplain

15%
Define an enhanced floodway width

77%
Define the floodway width according to FEMA minimums

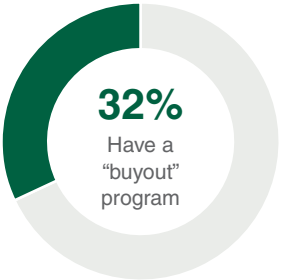
23% of respondent communities are more protective by implementing wider floodways.



Retrofit Floodplain Measures

FEMA and state agencies provide grants to purchase, retrofit, and remove buildings from the floodplain and thereby reduce flood damage potential, known as "buyout" programs. In addition, the removal of buildings supports the goal of restoring the floodplain's natural and beneficial uses.

32% of respondent communities implement a program to retrofit or remove buildings from the floodpain.



Regulations

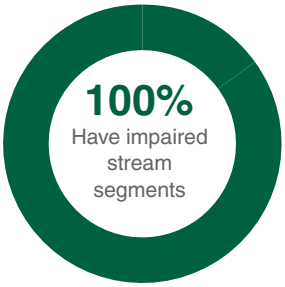
Minimum requirements for participation in the NFIP are set forth in Title 44, Part 59. 60, 65, and 70 of the Federal Regulations: National Flood Insurance Program.

2.5 303(d) Lists and Total Maximum Daily Loads

Pollutants or conditions that exceed set thresholds are considered water quality impairments or stressors. Per section 303(d) of the Clean Water Act, states are required to submit lists of waterbodies that do not meet their designated uses and water quality standards. Some waterbodies are required to have numeric limits for contribution to a waterbody, known as Total Maximum Daily Loads (TMDLs). Communities target removal or mitigation of these stressors to meet Total Maximum Daily Uses and meet designated uses.

Each community's 303(d) listing and subsequent TMDL are dependent on a federal and state process. The conditions that regulatory agencies consider during the development of the 303(d) list and subsequent TMDL include: designated uses, chemical and biological monitoring data, habitat, and benthic macro-invertebrate community.

100% of respondent communities within the United States have some stream segments that are impaired and do not meet their designated uses.



Per section 303(d) of the Clean Water Act, states are required to submit lists of waterbodies that do not meet their designated uses and water quality standards. For example, the regulatory agency may determine that a waterbody's "designated use" is for protection and propagation of fish, shellfish, and wildlife. If the waterbody shows signs of elevated pollutant/stressors, degraded habitat, or other factors that indicate that "protection and propagation of fish, shellfish, and wildlife" is not suitable, then the state adds the waterbody to the 303(d) list. The pollutant or condition that resulted in non-compliance with the designated use is also documented.

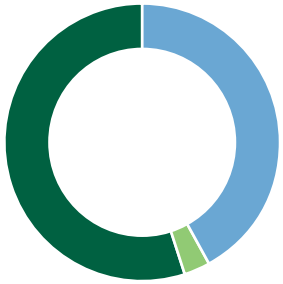
A TMDL is a method to address the impairment by implementing a pollution budget. A TMDL for a particular pollutant in a particular watershed/waterbody is the calculated maximum amount of that pollutant that the watershed/waterbody can contain and meet the applicable water quality standard. An allocation of the necessary reductions of the pollutant sources is included in the TMDL. TMDLs include management plans that aim to reduce the pollutant sources to the allocated levels. The TMDL approach to water quality improvement includes an "adaptive management" element where the participating communities assess the pollution reduction strategies at set schedule milestones and adjust the strategy to ensure that the TMDL goals are met. The ultimate goal of the TMDL process is to attain or maintain water quality standards and comply with the designated use.

Algae often forms when there is a surplus of nutrients from stormwater runoff entering a waterbody.

Local Watershed Management Plans

Typically, a community provides input on source reduction strategies for the TMDL during management plan development. In addition, some communities provide input on the monitoring program and watershed management plan implementation. In most cases, the 303(d) listing and TMDL process are driven by the regulatory agencies. For a typical TMDL process, the community only has significant influence during the management plan development phase when each pollutant source is assessed and methods to reduce the pollutant source to appropriate levels are determined. However, a community may elect to steer the 303(d) listing and TMDL process more proactively by developing a local watershed management plan.

59% of respondent communities are required to meet numeric requirements for waterbody impairments, while 3% of the communities implement programs on a voluntary basis.



59%
Have active TMDLs

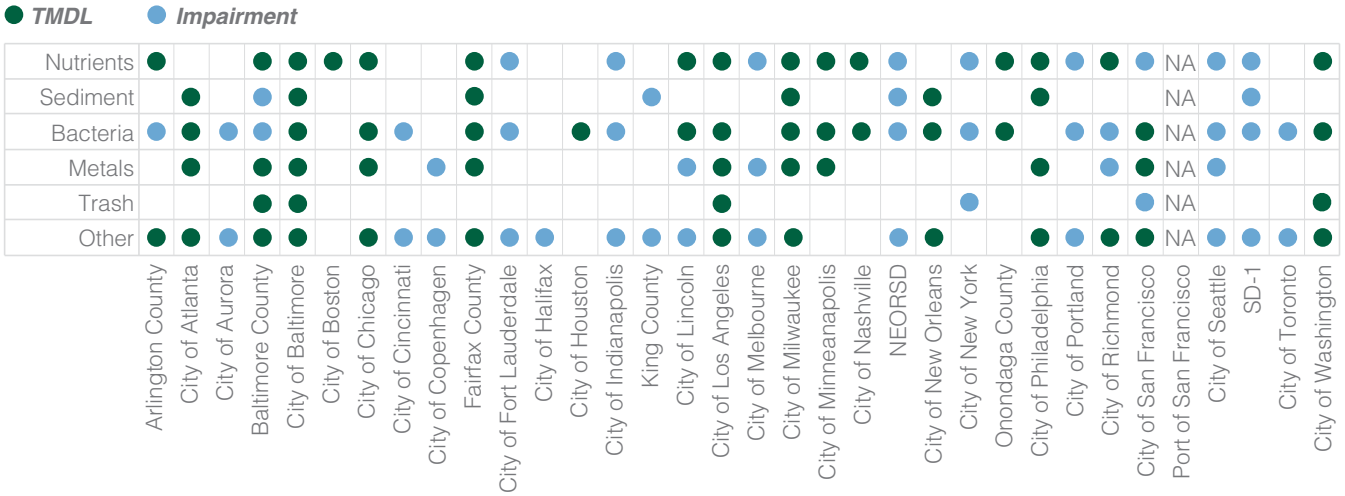
3%
Have waterbodies on the 303d List and implement voluntary watershed management plans

42%
Do not implement a watershed management plan

Pollutants

Each watershed 303(d) listing and subsequent TMDL is based on watershed specific stressors and pollutants. Identifying the stressors and pollutants helps communities understand the watershed, and develop an effective management plan.

The impairments are based on local and watershed specific conditions.



Trash commonly finds its way into waterbodies via stormwater runoff and the stormwater system.

Monitoring Program

As part of the TMDL process, communities can develop their own monitoring programs to complement the regulatory agencies' monitoring programs. More robust monitoring approaches can help the communities better refine their "adaptive management" approach. Also, the robust local monitoring plan can complement the regulatory agency data and result in a more effective community approach to address watershed impairments and regulatory compliance.

73% of respondent communities implement local monitoring to better measure the watershed management plan effectiveness.

Water quality sampling in a stream

Sampling collection using a extended bucket to prevent contamination.

Regulations

The 40 CFR Part 130.7 – Total Maximum Daily Loads (TMDL), along with individual water quality-based effluent limitations, describes the TMDL process.

CASE STUDY

Nashville, Tennessee

The Metropolitan Government of Nashville and Davidson County (Nashville) has the goal of removing all streams from the 303(d) list by 2050. The plan to accomplish this includes increasing green infrastructure, developing a robust urban forestry program, and increasing preserved open spaces. Nashville has also implemented a proactive program of monitoring local streams on the 303(d) list to better assess the health of its streams.

Nashville's Stormwater Management Plan outlines a wide range of water quality protection activities that serve to protect water quality and meet TMDL requirements. These activities – which involve various Metro Departments - include robust public education (internal and external stakeholders), illicit discharge and spill investigations, regulatory oversight of development and redevelopment sites which includes erosion prevention and sediment control measures as well as post-construction stormwater controls for both stormwater quality and quantity, and certain industrial site inspections. Nashville has also promoted stream bank protection projects and implemented no-disturb riparian buffer requirements on local streams in an effort to protect areas proximate to streams.

Nashville routinely coordinates with the Tennessee Department of Environmental Conservation on the 303(d) list with additional local data supporting possible "delisting". To date, approximately, 45 miles of Nashville streams have been removed from the 303(d) list. An additional 37 miles of Nashville streams have been removed from a single impairment category - however the streams may remain on the list for other impairments. Based on ongoing data assessments as well as ongoing and proposed water quality improvement projects, Nashville anticipates a significant de-listing request submittal in 2018.The increased amount of sampling has also demonstrated that ongoing sanitary sewer rehabilitation projects and increased infrastructure maintenance work has improved ambient water quality.

Indian Creek in Nashville, TN

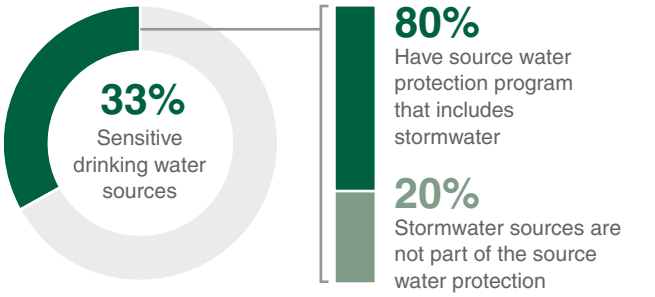
2.6 Source Water Protection

Source water refers to water from streams, rivers, lakes, or underground aquifers that is treated and subsequently used as drinking water. Source water protection includes all programs that aim to ensure source waters are not contaminated prior to treatment.

Source water that is not protected and/or becomes contaminated can significantly increase the cost of drinking water treatment, and, in some cases, result in significant challenges for the drinking water treatment plant to comply with Safe Drinking Water Act standards. For drinking water sources derived from surface water, stormwater pollution is a major factor in source water quality. Protection of the source water quality is directly dependent on protecting the stormwater runoff quality from the contributing watershed. Runoff from an undeveloped or pristine watershed is excellent source water. Conversely, runoff from an intensely-developed watershed is typically not an ideal source water.

Balancing drinking water treatment cost, source water protection cost and watershed development pressures are a challenge that many communities must address. Preserving the entire contributing watershed in an undeveloped state may be ideal, but in most cases is not feasible. Some development may be allowed, as long as a level is not exceeded where treatment of the source water becomes cost prohibitive. A community can implement development requirements for BMPs, riparian buffers, and imperviousness limits to mitigate the impact of new development on source waters and possibly enable a higher threshold of allowable development.

80% of respondent communities with sensitive drinking water reservoirs that can be impacted by stormwater pollution are protected through land use controls, riparian buffers, and BMPs.

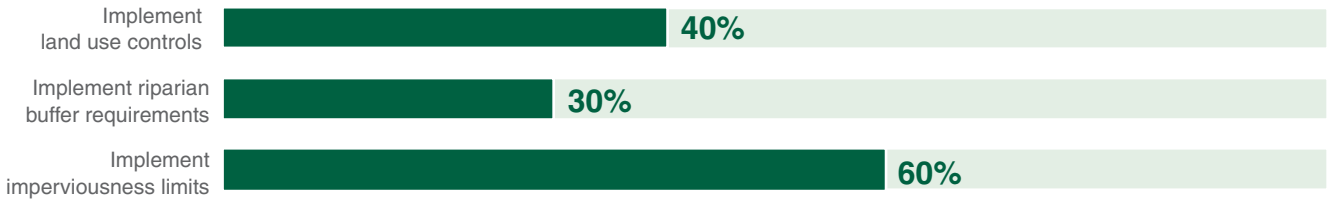


Croton Falls Reservoir is upstate of New York City, NY and is a part of the City's drinking water system.

Stormwater Pollution Source Water Protection

Each community's watershed protection program is developed to address the specific conditions of the community. For surface waters, factors considered include existing development in the source watershed, development pace, density, and size of watershed versus reservoir size.

Communities protect source water from stormwater pollution through a combination of land use controls, imperviousness limits, and riparian buffer preservation.



Land use controls

56% of the benchmarked communities limit the type of development in the source watershed in addition to imperviousness limits. Land uses that may be precluded include heavy commercial, heavy industrial, or others that have a high potential for spills or polluted stormwater runoffs.

Imperviousness limits

34% of the benchmarked communities set maximum thresholds of imperviousness in the contributing watershed. In some cases, the regulations are set up so that if the imperviousness threshold is exceeded, stormwater features such as BMPs are required to control and treat the runoff.

Riparian buffer requirements

Preserving a natural buffer system for the contributing streams is one of the most effective methods to protect a watershed's water quality. Stormwater runoff is filtered by natural buffers prior to entering the stream system and continues to be filtered as the runoff travels along the riparian corridor. 56% of the communities implement riparian buffers for all large stream segments. Other communities implement riparian buffer requirements for all stream segments in the contributing watershed.

Chapter 2.3 Riparian Buffers further examines the regulatory protections implemented by communities.

Drinking water reservoir surrounded by natural area.

Regulations

The Clean Water Act NPDES permit program focuses on discharges of pollutants, and thus does not directly impose source watershed protection requirements. CWA § 301(a); 33 U.S.C. § 1311(a). Rather, the NPDES regulations - 40 CFR Part 122 – EPA Administered Permit Programs: National Pollutant Discharge Eliminated System – impose requirements that regulated entities control discharges. In particular, consistent with the Clean Water Act, the regulations relating to MS4s focus on requirements to reduce pollutants in those discharges to the maximum extent practicable. CWA § 402(p)(3)(B)(iii); 33 U.S.C. § 1342(p)(3)(B)(iii); 40 C.F.R. § 122.34(a). Thus, federal regulations require state and local agencies to assess pollutant sources and methods to protect from pollutant sources. Those assessments can result in state and local agencies developing specific local source watershed protection regulations.

CASE STUDY

New York, New York

New York City's Department of Environmental Protection (DEP) is responsible for supplying clean drinking water to more than 8 million City residents and 1 million upstate customers, meeting present water demands, and maintaining the water supply system to meet future water demands. This is achieved through careful and coordinated management of the City's three surface water supply systems: the Catskill, Delaware, and Croton systems, shown on Figure 1.

Currently the Catskill and Delaware water supply systems operate under a Filtration Avoidance Determination (FAD). New York City is one of five major cities in the United States that has a FAD. The FAD program is independent of other stormwater regulatory programs such as SPDES MS4 requirements. As required by its FAD, DEP has a Long-Term Watershed Protection Program (Program) for the Catskill/Delaware water supply system. The purpose of the Program is to protect and improve existing water quality in the Catskill/Delaware water supply system by engaging in or funding various activities that serve protective and/or remedial water quality functions in the watershed. This Program supports New York City's goal of operating the Catskill/Delaware water supply without filtration, avoiding the high cost of filtering a majority of its potable water supply. The Program includes several programs that protect stormwater throughout the Catskill/Delaware watershed.

The Program includes many components such as the Stormwater Retrofit Program, watershed rules and regulations, the Future Stormwater Controls Program, the Nonpoint Source Pollution Strategy for East of Hudson Catskill/Delaware Basins, and the Kensico Water Quality Control Program and Related Programs.

The Stormwater Retrofit Program implements stormwater best management practices (BMPs) at existing sites throughout the West-of-Hudson watershed, thereby reducing the loading of suspended solids, pathogens, excessive nutrients, and other pollutants into water courses and the reservoir systems through stormwater runoff. As part of this program, the City also funds stormwater assessments and planning efforts that yield specific proposed stormwater retrofit projects and management practices in the context of an overall plan.

The watershed rules and regulations for the Protection from Contamination, Degradation and Pollution of the New York City Water Supply and Its Sources, 10 NYCRR Part 128; 15 Rules of the City of New York Chapter 18, gives DEP regulatory authority over certain activities that, if improperly carried out, could threaten to add nutrients, pathogens, and other contaminants into the water supply. The Watershed Rules and Regulations are directed primarily toward controlling sewage collection and treatment, stormwater discharges, and impervious surfaces. In general, they require that persons proposing to engage in a regulated activity in the watershed meet stringent standards set out in the regulations and, in many cases, obtain prior DEP review and approval of the activity.

For more information about DEP's FAD Stormwater Programs, go to DEP's 2016 Long-Term Watershed Protection Plan at: **http://www.nyc.gov/html/dep/pdf/reports/2016_long-term_watershed_protection_program_plan.pdf**

The Future Stormwater Controls Program funds the incremental costs of stormwater measures for new development and redevelopment required solely by the NYC Watershed Rules Regulations above the state and federal requirements.

The Nonpoint Source Pollution Strategy for East-of-Hudson Catskill/Delaware Basins based upon watershed surveys, water quality monitoring, and the Croton Watershed Strategy, is designed to reduce known non-point sources of pollution and identify and eliminate other sources of non-point pollution. This effort includes the funding and construction of BMPs. In addition, DEP has an East-of-Hudson Septic Repair Program for the West Branch, Boyd Corners, Cross River and Croton Falls basins. This program helps protect these unfiltered supplies from contamination by human pathogens resulting from failing septic systems.

The Kensico Water Quality Control Program and Related Programs protect and improve water quality in the Kensico Reservoir. This reservoir serves as the final impoundment for more than a billion gallons of potable water that enters from the Catskill/Delaware watersheds each day. Maintaining high quality water in Kensico Reservoir is one of the highest priorities for DEP. Major ongoing elements of the Kensico Water Quality Control Program include active stormwater and waterfowl management programs, a septic repair program, periodic maintenance dredging at intake channels, and maintenance of stormwater retrofits, turbidity curtains, and hazardous spill containment facilities.

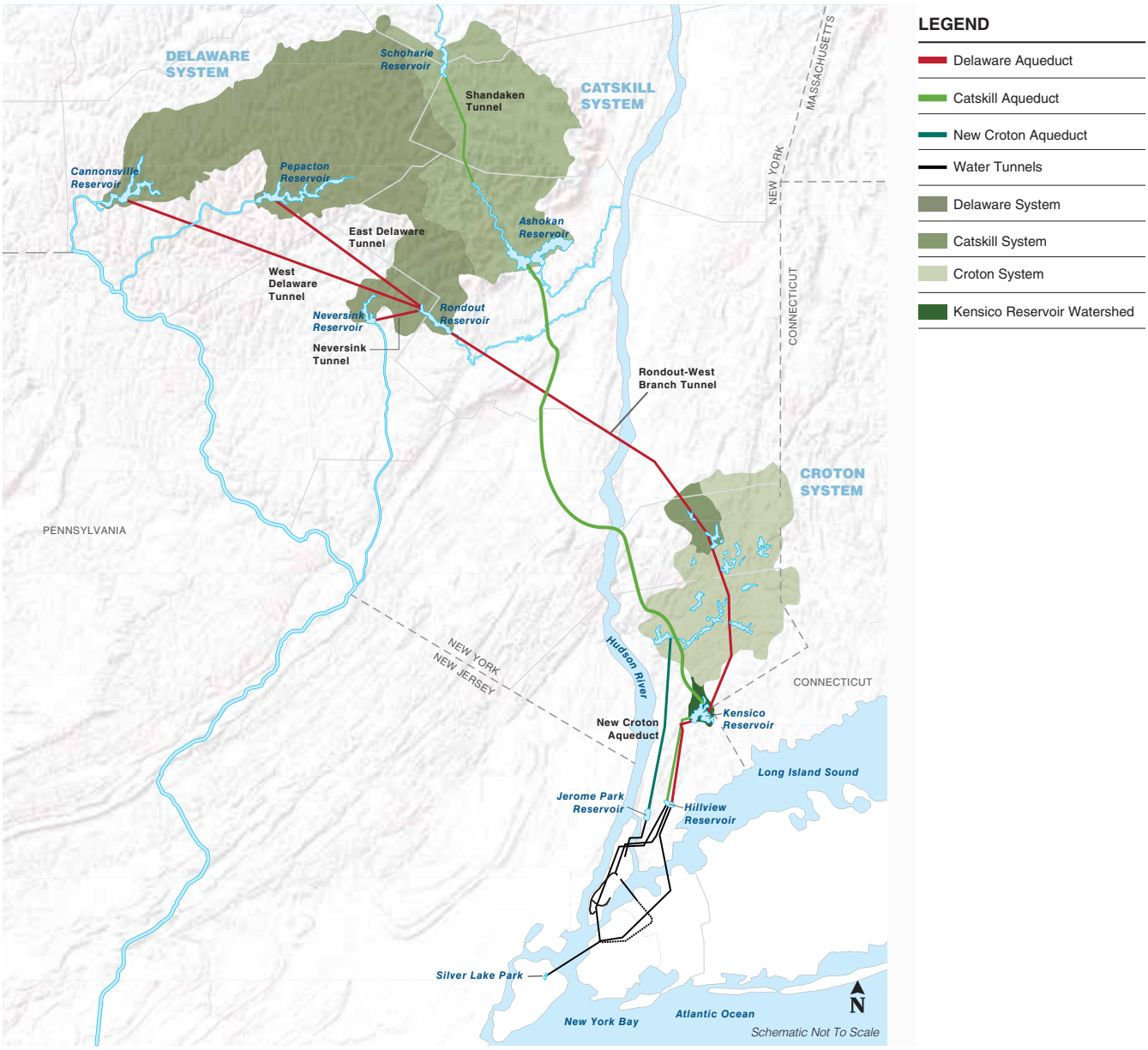


Figure 1: New York City's Water Supply System

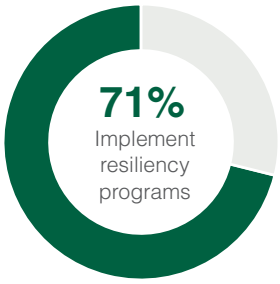
2.7 Climate Change and Resiliency

The average temperature on Earth has risen over the past century and is projected to continue to rise, changing our climate. The glaciers and ice caps are also melting, and sea levels are rising. Climate change includes changes in weather patterns, average weather conditions, and time variation of weather.

Climate change includes increases in total rainfall depth, intensity, and frequency. These changes have contributed to more frequent storm events with greater flood damage, and additional and longer droughts. As a result, communities are more exposed to dangerous flooding conditions, have more potential for human life loss, and have increased annual flood damage costs.

Each community's exposure to climate change impact varies, and different infrastructure elements are impacted to different degrees. The implementation of climate change and resiliency programs are based on a community's perceived exposure to potential damages associated with climate change. In addition, political environment can also influence a community's approach to climate change resiliency.

71% of respondent communities with infrastructure that is sensitive to climate change are implementing programs that mitigate some of the potential impacts.



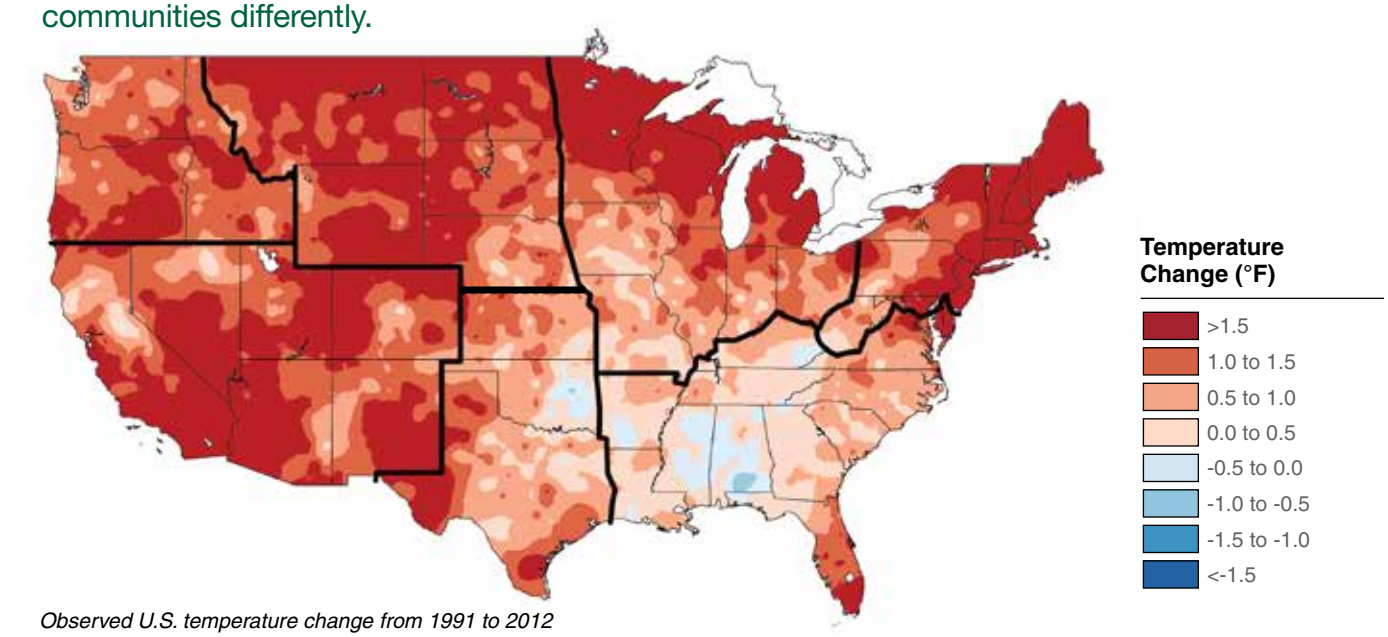
Evidence of drought in California

Climate Change Resiliency Drivers

Each community has a different driver or set of drivers that motivates the climate change initiative. For some communities, sea level rise may be the primary driver. For others, more intense rainfall and frequent flood damage may be a greater concern. Alternatively, communities with limited drinking water sources may be focused on climate change impacts on the drinking source water.

Temperature

The rising average temperature on Earth impacts climate and weather in all communities differently.

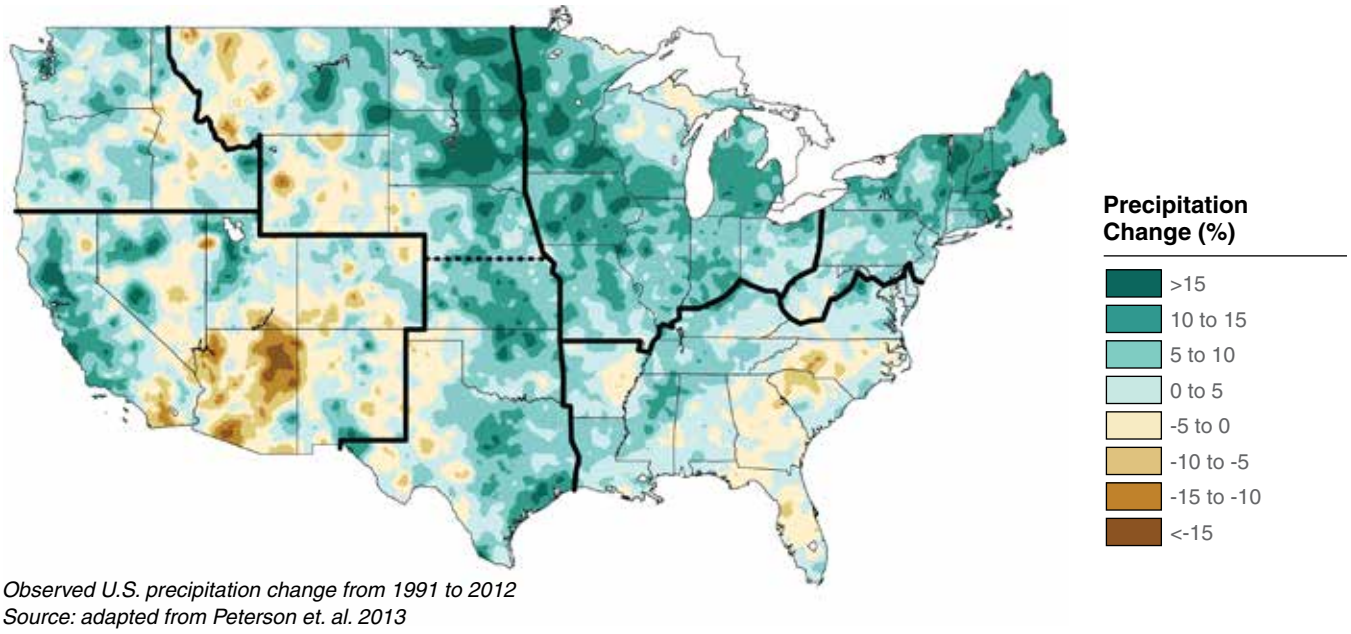


Observed U.S. temperature change from 1991 to 2012
Source: NOAA NCDC / CISCS-NC

Drought

As the climate changes, the annual precipitation in local areas is also changing. An increase in rainfall leads to flooding and a decrease in rainfall leads to drought. Drought can have a profound impact on a community, especially in the form of water supply loss. Water supply loss can occur in the form of lack of snow, and therefore snowmelt to fill reservoirs, or the lack of rain to fill surface water reservoirs.

13% of respondent communities are taking action to prevent drought.

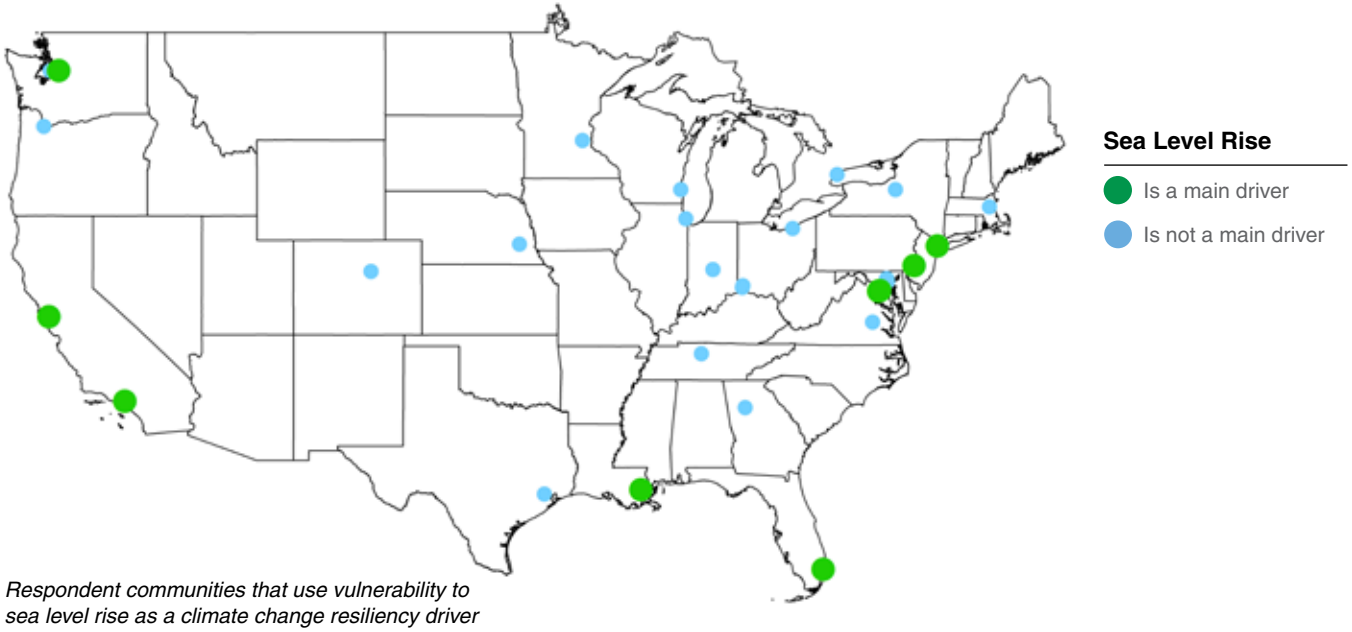


Observed U.S. precipitation change from 1991 to 2012
Source: adapted from Peterson et. al. 2013

Sea Level Rise

As glaciers and ice caps melt with increasing temperatures, the ocean water volume increases and results in rising sea levels. Sea level rise impacts are first observed in coastal communities at elevations at or below sea level. Many coastal communities have critical infrastructure at or below sea level that is vulnerable to flooding damages as sea levels rise and flood surrounding areas. Additionally, storm surge during weather events increases in height and therefore increases risk as ocean volumes increase and tide levels rise.

Coastal communities are responding to sea level rise.

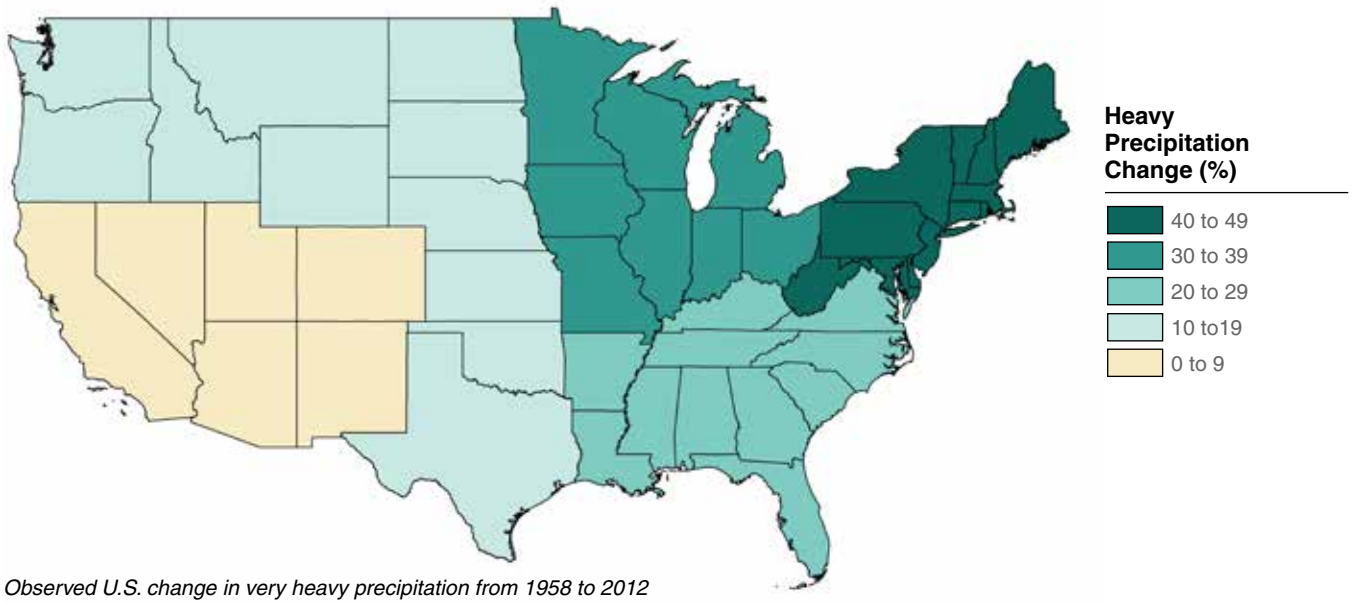


Respondent communities that use vulnerability to sea level rise as a climate change resiliency driver

Heavy Precipitation Events

Climate changes and weather patterns may cause an increase in intense rainfall events that can result in flooding and increase urban flood damange.

42% of respondent communities are facing an increase in intense rainfall events.



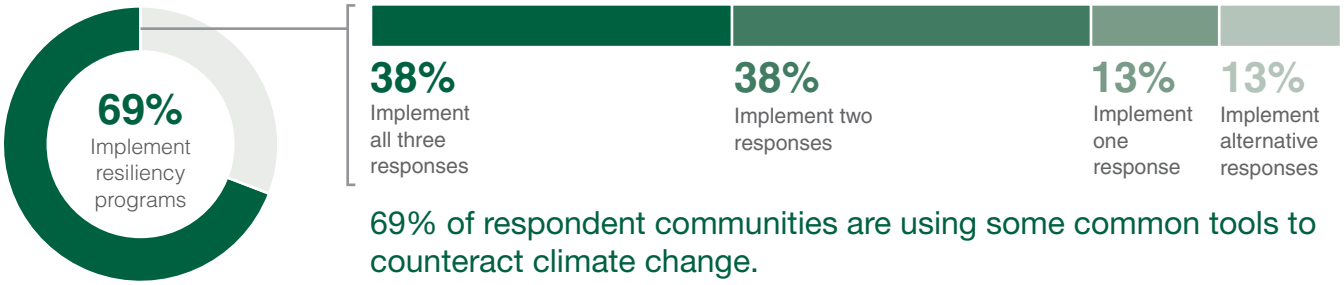
Observed U.S. change in very heavy precipitation from 1958 to 2012
Source: updated from Karl et al. 2009

Climate Change Responses

Communities' responses to climate change vary. The responses include:

- Revised stormwater design standards to account for greater rainfall depths, higher rainfall intensities, and more frequent flood events.
- Refined coastal design standards using higher sea level assumptions for infrastructure design.
- Increased investment in retrofitting or removing buildings and infrastructure that may be exposed to sea level rise and/or more severe flood events.
- Heightened focus on retrofitting critical infrastructure such as wastewater treatment plants, mass transit systems, hospitals, drinking water and sewer treatment and distribution systems, emergency evacuation transportation corridors, etc.
- Enhanced future planning methods such as scenario planning to explore infrastructure planning options that mitigate future impacts of climate change and provide a factor of safety.

The responses can be grouped into three programmatic approaches: design standard revisions, scenario planning, and vulnerability/risk assessments.

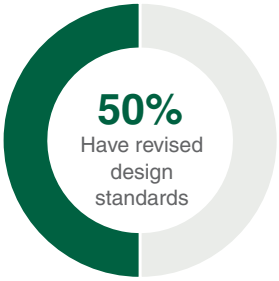


69% of respondent communities are using some common tools to counteract climate change.

Design Standard Revisions

Communities that have advanced climate change and resiliency efforts may revise design standards. Design standards may be revised differently for combined sewer and separate sewer areas. The most common parameters that have been changed are rainfall depth, rainfall intensity, and sea level rise.

50% of respondent communities have refined design standards to account for climate change when performing facility planning and design.



Street lamps inundated during flood; some communities choose to raise electrical infrastructure to mitigate impact during flooding events

Scenario Planning

Communities that conduct climate change scenario planning do so by estimating potential impacts of different climate change predictions through an iterative process of modeling or computing results. The resulting possible climate change scenarios and corresponding impacts to a community's infrastructure are analyzed to help inform the community's decision to more effectively respond to climate change.

75% of respondent communities use scenario planning to plan for climate change impacts and adjust the infrastructure management approach.

Damage from Hurricane Sandy in Far Rockaway, NY

Flooding from Hurricane Sandy in Brooklyn, NY

Vulnerability / Risk Assessment

Climate change may impact each community differently. Some communities may have critical infrastructure, such as drinking water and wastewater treatment plants, that are more exposed to the potential impacts of climate change. Other communities' exposure may be greater for the transportation system. Communities that have advanced climate change and resiliency efforts may perform a vulnerability assessment. The effort includes an assessment of each critical infrastructure component with regards to exposure and potential damage associated with the exposure.

75% of respondent communties have completed or are performing vulnerability or risk assessments to quantify potential climate change impacts on critical infrastructure.

56%
Completed assessment

19%
Assessment is in progress

25%
Have not yet assessed critical infrastructure

Regulations

Specific federal regulations have not been promulgated to require communities to respond to climate change and increase resiliency.

CASE STUDY

Copenhagen, Denmark

The City of Copenhagen revised its approach to citywide stormwater management due to an increased amount of intense rainfall events and dry spells interspersed with heavy thunderstorms that leave the City inundated. As a result, Copenhagen is currently planning for increasing precipitation, (a 30% increase in the extrapolation of recent events) and rising sea and groundwater levels.

Increased stormwater volume is the immediate threat to Copenhagen's main infrastructure, but the long-term concern is storm surge. Copenhagen is planning to implement innovative green-gray solutions that integrate the system more cost-effectively rather than investing more in traditional sewer system improvements. Copenhagen developed a Climate Adaptation Plan in response to the evaluated risk of damage caused by torrential rain over the next 100 years. The total risk was calculated to be about $2.2 billion (USD). Copenhagen adopted a cloudburst management strategy that included socio-economic studies and technical studies of programs and projects to manage stormwater. The strategy includes calculations of the systems required to handle large amounts of water, as well as a cost-benefit analysis and a new service level definition for surface runoff management.

Copenhagen has a variety of solutions to manage the threats from climate change, including:

- surface solutions to transport water on the street level to receiving water bodies
- underground tunnels to transport surplus of runoff that exceed street level capacity
- retention facilities upstream in the system to prevent overflow of the system downstream

The surface solutions come in the form of:

- high intensity rainfall boulevards to transport runoff
- retention boulevards to transport runoff and delay water flowing downstream
- retention facilities in parks as temporary storage of runoff

Copenhagen developed catchment plans of planned infrastructure investments to manage stormwater in each water catchment. All catchment plans are subject to comprehensive evaluation by the City government and the public. The implementation of projects within the catchment plans are prioritized based on hydraulic measures and potential urban space improvement. A business case was developed, based on evaluation of the total economic consequences, to move implementation forward quickly. A variety of challenges have been encountered in the implementation process of mixed-use infrastructure in response to climate change. These challenges include legal authority, pollutant load concerns, and coordination.

Potential site of stormwater boulevard in Copenhagen, Denmark

CASE STUDY

New York, New York

New York City faces multiple climate change threats including large storm surges, heavy rains, high winds, heat waves, droughts, rising sea levels, higher average temperatures, and increased annual precipitation. The City of New York set out to build a more resilient city by addressing climate change with the development of the *Greener, Greater New York Plan* in 2007.

In 2008, the City convened a panel of leading climate and social scientists charged with developing local climate projections. In 2009, the New York City Panel on Climate Change (NPCC) issued a report, Climate Risk Information 2009. The report projects that by mid-century, New York City could experience sea levels (under a "middle range" scenario) that are up to a foot higher, causing flooding from what is today a 100-yr storm to occur 2-3 times as often. It also projected that by the 2050s NYC is likely to experience more frequent heavy downpours and many more days at or above 90 degrees Fahrenheit. The work of the Climate Change Adaptation Task Force and City agencies demonstrates the power of informative analyses to drive thoughtful planning and decision making.

In response to the devastating impacts of Hurricane Sandy in 2012, the City further increased its resiliency planning efforts and released A *Stronger, More Resilient New York* plan in June 2013. This comprehensive plan contains actionable recommendations both for rebuilding the communities impacted by Sandy and increasing the resilience of infrastructures and buildings citywide. *A Stronger, More Resilient New York* plan is a nearly $20 billion plan towards which the City committed to contributing $1 billion in new funding.

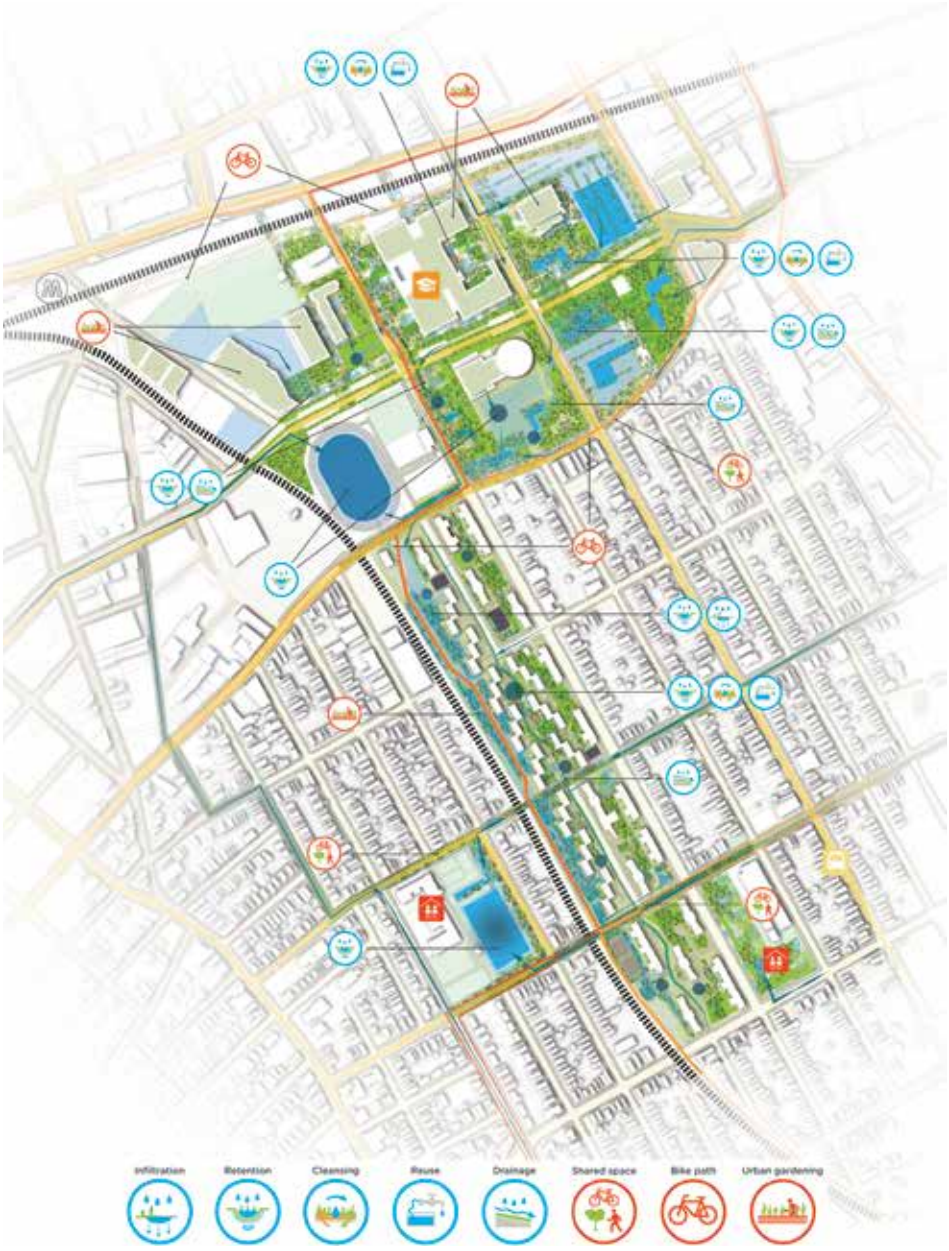
Flooding in Southeast Queens, NY

A Stronger, More Resilient New York plan includes 15 initiatives to increase resiliency in response to climate change. The main stormwater initiatives include reducing combined sewer overflows with green infrastructure and high-level storm sewers citywide, continuing to implement and accelerate investments in Bluebelts across the city, building out stormwater sewers in areas of Queens with limited drainage systems, and periodically reviewing rainfall trends and implications for stormwater infrastructure.

Recent storms, including heavy rain events and coastal flooding, demonstrate that New York City's water and wastewater system have risks from extreme weather that must be addressed through implementation of further climate adaptation interventions. Heavy rainfall events ("cloudbursts") can inundate urban areas and potentially cause severe damage. DEP, in cooperation with the City of Copenhagen, has started to develop innovative solutions to heavy rainfall and associated physical and societal impacts by conducting the Cloudburst Resiliency Planning Study, focusing on a pilot area in Southeast Queens. Through inland flood risk analysis and enhancing stormwater management through storage and surface flow conveyance, DEP is seeking to address intense rainfall through integration of gray and green strategies in coordination with ongoing urban infrastructure planning.

The Cloudburst Resiliency Planning Study first examined the underlying conditions of the area – identifying where flooding occurs, available greenspace that can be utilized, and what other challenges and opportunities for co-benefits exist within the community. Once defining characteristics were identified, a master plan was developed highlighting areas for potential intervention and opportunities to incorporate green infrastructure to safely slow and convey floodwaters to retention areas. Furthermore, the plan looks to align green infrastructure to improve connectivity within the community, creating green corridors between parks and other social hotspots. Pilot projects that were identified through this process are meant to act as a buffer for storms that are not captured by sewers due to the size of the storm or the lack of infrastructure, alleviating chronic flooding in upstream areas where sewer pipes may not extend until downstream portions are completed.

The first pilot project, at New York City Housing Authority's South Jamaica Houses, will be designed to manage runoff from large rain events, capturing floodwater in a large rain retention area. It will direct runoff from adjacent buildings, and in the future it may also direct runoff from adjacent properties. Whereas traditional green infrastructure manages the first inch of runoff, DEP will likely seek to manage 2 inches or more by activating an underutilized greenspace located in the housing complex. On dry days, this space will provide a more functional space that can be actively used by the community for activities such as gardening, whereas during heavy rain events it can safely flood, mitigating negative impacts on the community. The conceptual plan also identifies several adjacent properties that may present future opportunities to direct the flow of floodwater, as well as creating connections within and between the community through shared spaces and bike paths.



A conceptual master plan for managing large rain events in Southeast Queens.

3 Public Involvement and Education Programs

3.1 Public Education and Outreach

3.2 Public Involvement and Participation

3.1 Public Education and Outreach

A public education program includes the distribution of educational materials to the community and other outreach activities such as television or radio advertisements. The common message conveyed is that stormwater pollution impacts waterbodies and that the public can take steps to reduce those impacts.

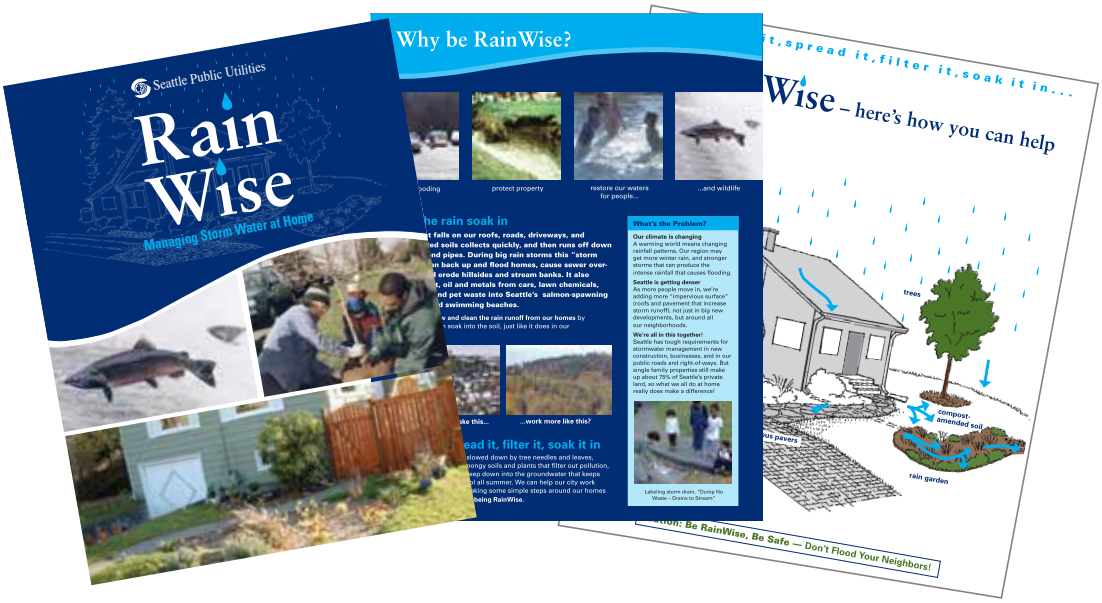
Visible parts of the stormwater system, such as lakes and streams, provide excellent and tangible community benefits, including recreation, wildlife habitat, and scenery. Most of the public recognizes that discarding trash, used oil, and fertilizers in a lake or stream adds to the pollution of the waterbody. However, the majority of people do not understand how the underground stormwater infrastructure system, such as pipes and catch basins, connects to these waterbodies.

This lack of understanding reduces the awareness that any pollutants, trash, used oil, and fertilizer they release can end up in catch basins, and then be conveyed to streams and lakes via the underground system.

Public education and increased awareness/understanding of the stormwater drainage system can be one of the most cost-effective methods to reduce stormwater pollution from entering our waterbodies.

100% of respondent communities have customized their public education program to address local conditions such as pollutants, receiving waters, and audience.

Public education approaches that are successful in some communities may not be successful in others because of the differences in audiences, water quality focus, watersheds, and pollutants. Therefore, communities take a tailored approach to developing their public education program to ensure local effectiveness.



Stormwater management public education materials

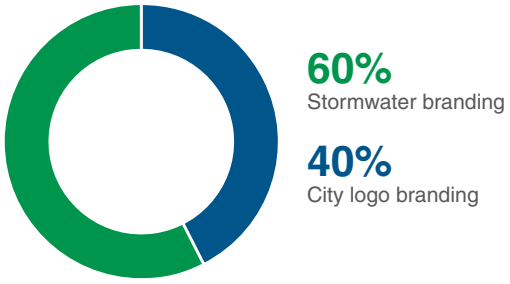
Public Education Program Implementation

When developing a public education program, the specific conditions of the community that must be considered in include demographics, types of pollutants, and sensitive waters. The program also refines and builds tools to respond to the specific needs of the community. Successful public education is commonly achieved through branding, partnership with adjacent communities, and social media campaigns.

Branding

Many communities develop a graphic image or slogan that is displayed during all public education or advertisement efforts. This branding typically reinforces the stormwater message that the entire system is connected and the pollutants that enter the stormwater system (including the underground system) ultimately are discharged to streams and lakes. Some communities do not include a stormwater message and use the standard City logo.

60% of respondent communities implement branding with a stormwater message.



Trash removing water wheel in the Baltimore Harbor

Regional branding for the stormwater program in area around Houston, Texas

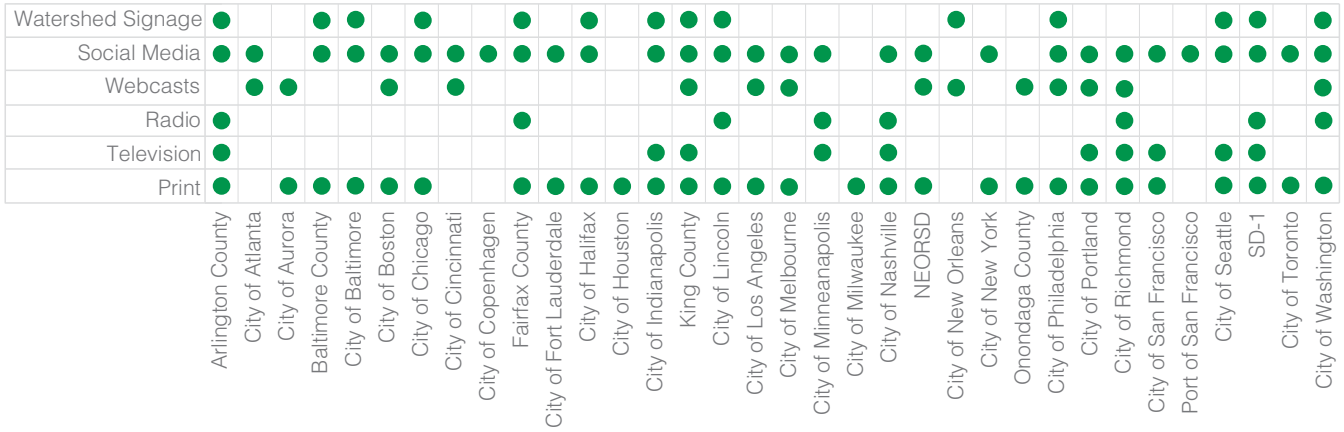
Regional Consortiums

Water quality, streams, and watersheds, do not stop at jurisdictional boundaries and, in many cases, cover multiple adjacent communities. Effective public education may span multiple communities to best work towards water quality goals. For this reason, some adjacent communities have pooled their funds to perform some or all of the public education activities.

58% of respondent communities participate in regional consortiums to coordinate regional public education.

Media

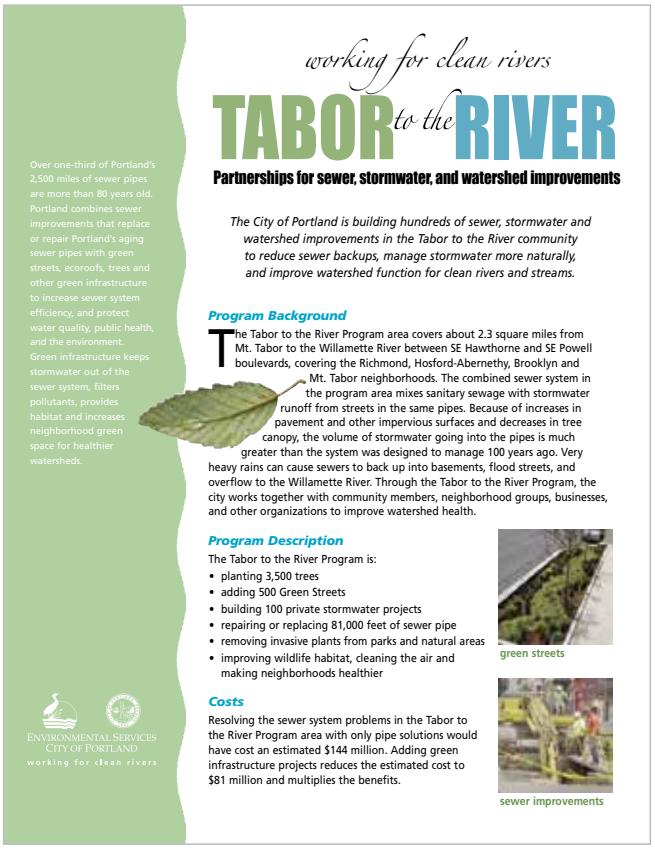
Many communities use a number of media sources to ensure that the messaging is effectively delivered and heard. Different media sources are available to each community. Media sources can include utility bill inserts, radio, television, newspaper advertisements, door hangers, and catch basin stenciling.



Watershed Signage

Roadway signs that communicate to readers that they are entering a watershed boundary effectively illustrate how the entire area is connected to the waterbody, and that all actions taken within the area can impact the waterbody.

Watershed signage to mark the entrance at a watershed boundary


working for clean rivers

TABOR to the RIVER

Partnerships for sewer, stormwater, and watershed improvements

Over one-third of Portland's 2,500 miles of sewer pipes are more than 80 years old. Portland combines sewer improvements that replace or repair Portland's aging sewer pipes with green streets, ecoroofs, trees and other green infrastructure to increase sewer system efficiency, and protect water quality, public health, and the environment. Green infrastructure keeps stormwater out of the sewer system, filters pollutants, provides habitat and increases neighborhood green space for healthier watersheds.

The City of Portland is building hundreds of sewer, stormwater and watershed improvements in the Tabor to the River community to reduce sewer backups, manage stormwater more naturally, and improve watershed function for clean rivers and streams.

Program Background

The Tabor to the River Program area covers about 2.3 square miles from Mt. Tabor to the Willamette River between SE Hawthorne and SE Powell boulevards, covering the Richmond, Hosford-Abernethy, Brooklyn and Mt. Tabor neighborhoods. The combined sewer system in the program area mixes sanitary sewage with stormwater runoff from streets in the same pipes. Because of increases in pavement and other impervious surfaces and decreases in tree canopy, the volume of stormwater going into the pipes is much greater than the system was designed to manage 100 years ago. Very heavy rains can cause sewers to back up into basements, flood streets, and overflow to the Willamette River. Through the Tabor to the River Program, the city works together with community members, neighborhood groups, businesses, and other organizations to improve watershed health.

Program Description

The Tabor to the River Program is:

- planting 3,500 trees
- adding 500 Green Streets
- building 100 private stormwater projects
- repairing or replacing 81,000 feet of sewer pipe
- removing invasive plants from parks and natural areas
- improving wildlife habitat, cleaning the air and making neighborhoods healthier

green streets

Costs

Resolving the sewer system problems in the Tabor to the River Program area with only pipe solutions would have cost an estimated $144 million. Adding green infrastructure projects reduces the estimated cost to $81 million and multiplies the benefits.

sewer improvements

Environmental Services
City of Portland
working for clean rivers

Watershed-focused public education material

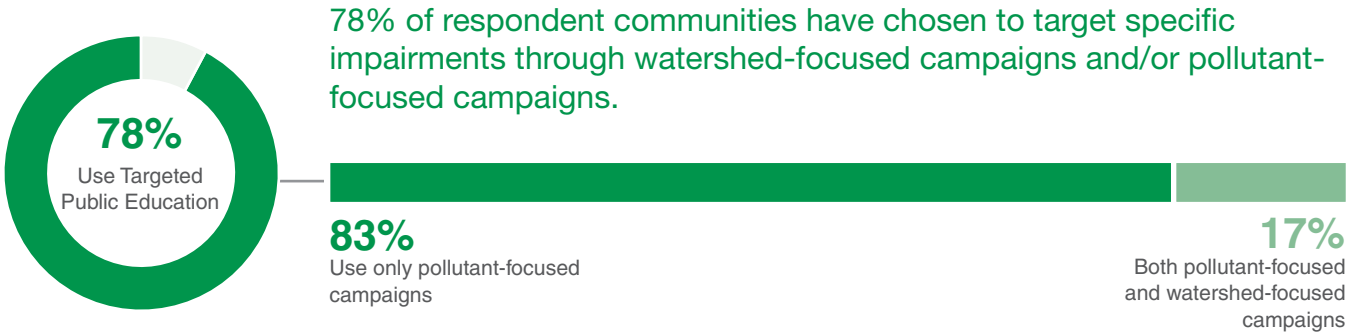
Targeted Public Education

Watershed-Focused Campaigns

Communities with sensitive watersheds, such as those used for drinking water supply, may elect to present watershed specific messages. 17% of respondent communities use watershed-focused campaigns to provide targeted public education within sensitive watersheds.

Pollutant-Focused Campaigns

Communities that are addressing 303(d) listed impairments or TMDL restrictions may focus public education campaigns on activities that are related to their pollutants of concern. For example, a community with a floatable/trash TMDL may develop and implement a public education campaign focused entirely on the reduction of floatable/trash loads.



Pollutant-focused public education material

Regulations

40 CFR Part 122 – EPA Administered Permit Programs: National Pollutant Discharge Elimination System describes the six minimum control measures that small MS4s must implement and are commonly found within medium and large NPDES MS4 permits including public education. Public education regulations require permittees to promote, publicize, inform, and report on stormwater management programs.

CASE STUDY

Los Angeles, California

The City of Los Angeles has a robust approach to include public education and involvement in the planning and implementation of its stormwater program. Citizens participate with committees, provide feedback to maximize support, and act as advocates for stormwater investments around the City.

Los Angeles recently passed Proposition O, an ordinance that provides funding for water quality improvements including TMDL compliance ($500 million). Each individual project funded under Proposition O requires a separate approval process by the Administrative Oversight Advisory Committee and the Citizens Oversight Advisory Committee.

The goal of the Integrated Resources Plan (IRP) is to implement the correct infrastructure in the correct locations at the correct time. In order to achieve this goal, the Department of Public Works, Department of Water and Power, and many other Los Angeles offices worked with hundreds of stakeholders over seven years to plan facilities and programs that match the interests of stakeholders and the City government. The public outreach process is planned to continue throughout the implementation phase as necessary. In the immediate future, as part of the IRP, Los Angeles is developing a public outreach program to explore the feasibility of implementing groundwater replenishment with advanced treated recycled water.

Albion Riverside Park community meeting

CASE STUDY

New York, New York

DEP launched "Wait…" in May 2016, a water quality improvement pilot program that encourages voluntary reduction of discretionary water uses in residential buildings during combined sewer overflow (CSO) events. The goals of the pilot program are to increase capacity in the City's combined sewer system during large storm events, reduce the concentration of wastewater in CSOs, and broadly engage and educate the New York City community.

DEP is the first water utility in the United States to pilot this type of behavior modification program that consists of technical, creative, and outreach components. DEP utilizes real-time rainfall data, collected at the wastewater treatment plant that serves the pilot area. This data is remotely transmitted to an in-house data collection and alerting system that electronically monitors when CSO thresholds are triggered. DEP's alerting system links to an external mass text messaging service that sends an automated text alert to participants when a CSO event begins, reminding the public to wait before engaging in water-intensive activities in their homes, such as dish washing, laundry, showering and toilet flushing. When the CSO event ends, a second automated text alert is sent to all participants, thanking them for waiting.

DEP collaborated with a sustainability communications firm to formulate a messaging campaign and outreach materials. The pilot program's theme, "Heroes Wait," provides participants with positive feedback, while the messaging campaign educates participants on their connection to water quality in New York City. DEP also initiated a wide-ranging outreach program and used several tactics to engage the community and encourage participation, including street canvassing, mailings, social media posts, partner organization email blasts, and community presentations.

The primary metric for determining if pilot participants voluntarily waited is a percent decrease in consumption – compared to baseline consumption – during a CSO event. DEP's comprehensive metering system enables staff to analyze daily water consumption readings at the building level for both the baseline and CSO event analyses. DEP began monitoring participants' consumption in June 2016 for a six-month period and results indicate that water consumption among the 379 participants decreased approximately 5% from baseline conditions. DEP is initiating a second phase to further develop and expand the program and to engage a larger portion of the New York City community. This second phase will enable DEP to test new outreach and enrollment strategies, and implement technical back-end and data collection upgrades.

3.2 Public Involvement and Participation

Public education helps citizens increase their understanding of the stormwater system. Public involvement goes one step beyond public education and provides the community with an opportunity to help develop and implement its stormwater management plan. The key benefit of public involvement is that the citizens take ownership of the stormwater management plan which can result in a higher level of success.

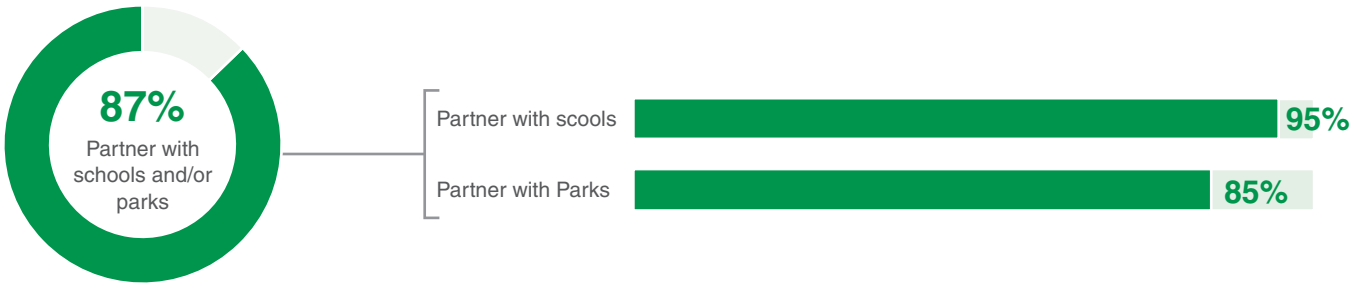
Each community's public involvement program includes citizens and stakeholders in the development, implementation, and review of the community's stormwater management program. The program also develops tools to respond to the specific needs of the community. Public involvement also includes the actual implementation of some of the stormwater management plan initiatives, including catch basin stenciling and stream clean-ups.

100% of respondent communities have tailored their public involvement program to consider their specific stakeholders, public interest, and possible partnerships.

Public Partnerships with Schools and Parks

While changing behavior of adults may be difficult, changing behavior of children may be more straightforward. In turn, children may transfer their knowledge of the importance of eliminating stormwater pollution to older generations. Information on the importance of stormwater pollution prevention can be shared with children through school and park partnerships. The outreach can include classroom presentations or outdoor learning centers where students participate in activities that reduce stormwater pollution. An example of an outdoor classroom is installing and maintaining a best management practice (BMP) on school grounds. Students learn about stormwater pollution prevention by planting, observing, and maintaining the BMP throughout the feature's lifespan.

87% of respondent communities partner with schools and/or partner with parks to provide opportunities for involvement through outdoor classrooms and learning centers.



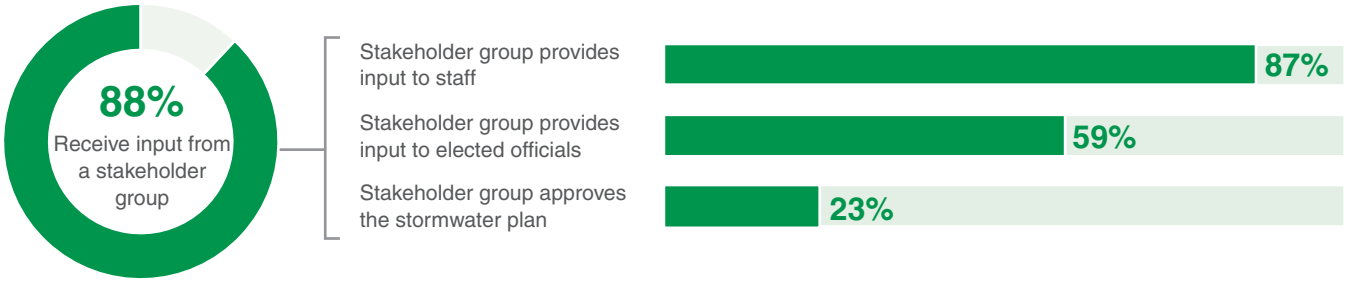
Appointed Stakeholder Group Role

Most communities engage an appointed stakeholder group to ensure that the public has an opportunity to provide input. Based on management and elected official desires, the stakeholder group can take on different roles. The stakeholder group can serve as an advisory group and:

1. Provide feedback to the stormwater staff,
2. Provide feedback to the elected officials, and
3. Act as an approving authority for any major initiatives.

Generally, the municipal authority will make decisions, but inform the public of decisions, or allow tfor public review and comment prior to decision milestones. In other cases, the public has the ability to steer the stormwater management development and implementation process. The advantage of providing the public with the additional responsibility is that the citizens may take more ownership of the stormwater plan implementation. However, additional citizen coordination can be challenging. Therefore, balancing the level of public involvement is an important decision for the community.

88% of respondent communities receive input from a stakeholder group. 87% of respondent communities that receive stakeholder input, provide feedback to stormwater staff.



Public Participation Opportunities

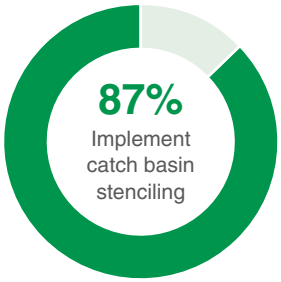
Some communities have chosen to provide volunteer opportunities to encourage citizens to take ownership of some of the stormwater management elements. Some communities also use programs such as Rain Barrel Giveaway Programs to encourage the public to capture and reuse stormwater on their private property.

Rain barrel givaway event in Hunts Point, New York

Catch Basin Marking

Volunteers ensure a positive result by labeling catch basins so that other citizens become aware that the structures discharge to waterbodies. In addition, the volunteers gain more of a connection to the importance of reducing and eliminating stormwater pollution. The volunteers take ownership of the success of the stormwater program and become strong advocates for many years to come. Catch basin art programs and competitions are another form of marking that involves the community and provides opportunity for ownership of the stormwater program.

87% of respondent communities implement a catch basin marking program.



Similar Catch Basin Medallions are used in Lincoln, NE

Catch Basin Casting in Boston, MA

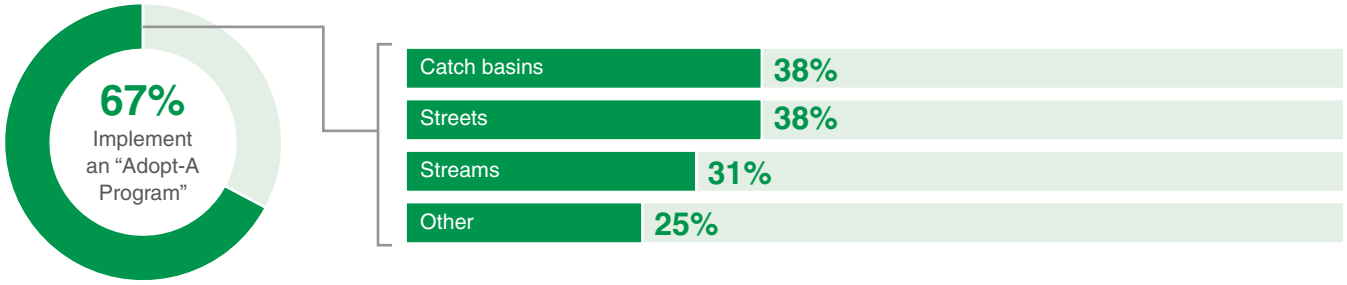
Storm drain art near the James River in Richmond, VA

Child participating in storm drain marking in Peaselburg, KY

"Adopt-A" Programs

"Adopt-A" programs allow for public citizens and stakeholders to assume some responsibility for the operation and maintenance of a piece of infrastructure. For example, common efforts completed as part of an Adopt-A-Stream program are trash collection and occasional beautification. Signage is also often used to identify when a piece of infrastructure has been adopted and advertise the efforts of stakeholders. Communities choose what types of infrastructure are available for adoption such as streams, streets, and catch basins. These programs serve two key purposes: the first is for volunteers to clean the surrounding area or infrastructure asset. The second key purpose is to increase a volunteer's awareness of the stormwater systems, and methods by which pollutant sources are reduced and/or eliminated.

67% of respondent communities involve the public by providing volunteer opportunities to maintain infrastructure elements. Many communities offer more than one infrastructure option for adoption.

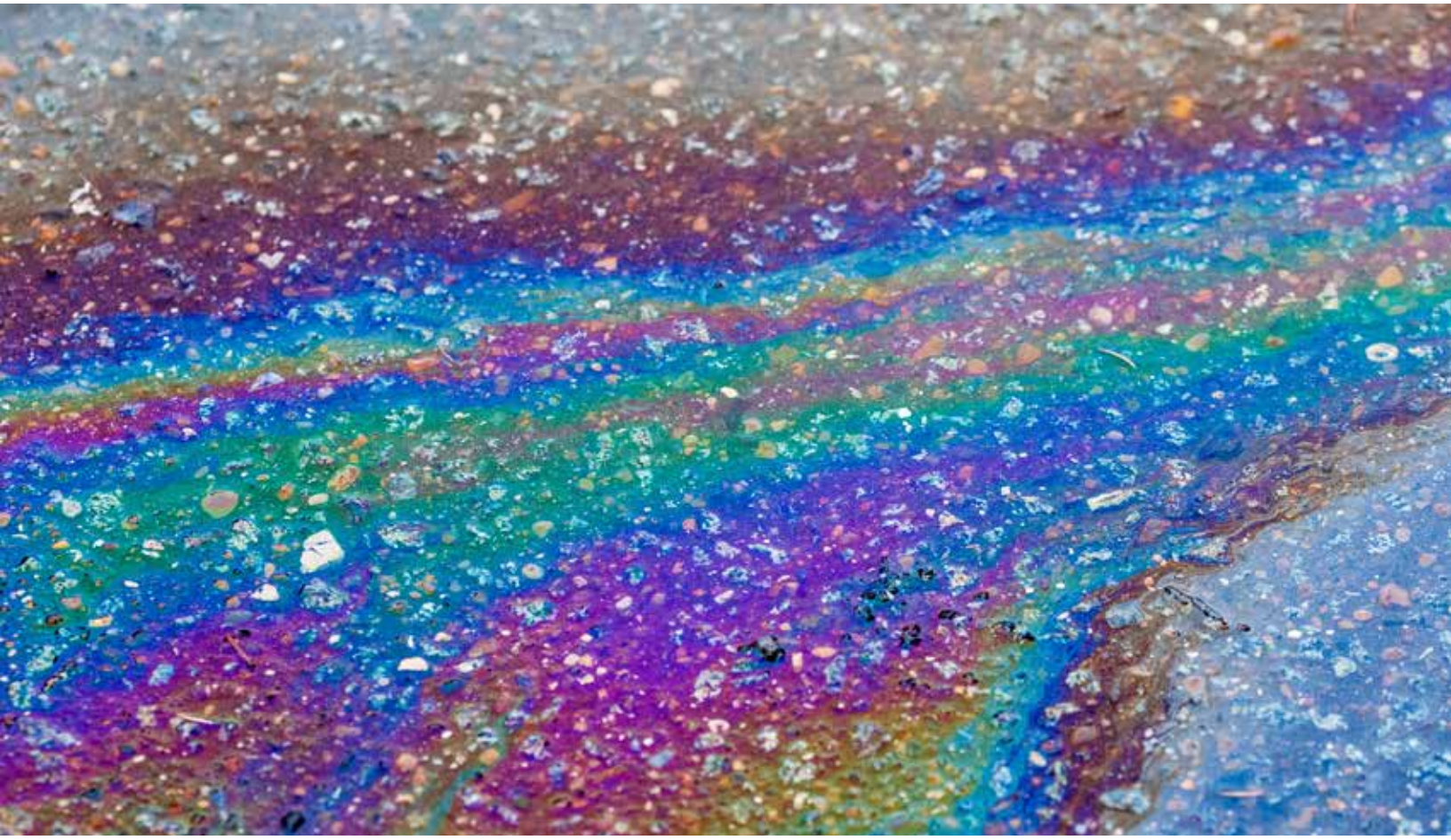


Shoreline clean-up at the Mississippi River in Minneapolis, MN

Adopt-a-Bluebelt in Staten Island, NY

Regulations

40 CFR Part 122 – EPA Administered Permit Programs: National Pollutant Discharge Elimination System describes the six minimum control measures that small MS4s must implement and are commonly found in medium and large NPDES MS4 permits, including public involvement.



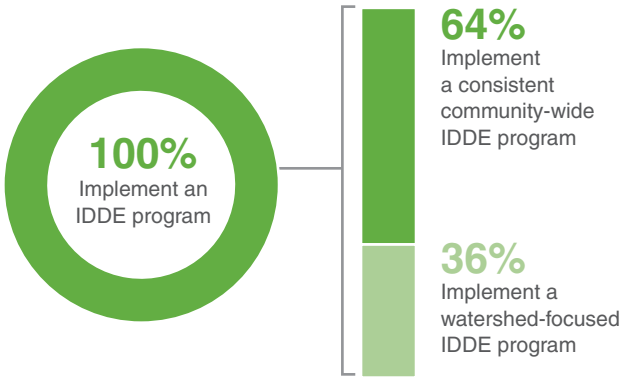
4 4.0 Illicit Discharge Detection and Elimination Programs

4.0 Illicit Discharge Detection and Elimination Programs

An illicit discharge is flow into a storm drainage system that is not allowed by permit or ordinance. Illicit discharges often include wastes and wastewater that enter the storm drainage system through pipes, spills, cracked sanitary sewer systems, and dumping of waste. Because of their high volumes and concentrations, pollutants released through illicit discharges can cause significant negative water quality impacts.

Typically, illicit discharges include high volumes and concentrations of a variety of pollutants, such as bacteria, petroleum products, heavy metals, solvents, and toxics. NPDES MS4 permits include the illicit discharge detection and elimination (IDDE) minimum measure a plan must use to detect and eliminate illicit discharges. Type, density, and other features of illicit discharges are community-specific and are dependent on age and condition of the drainage and sewer system, land use, and soils. Communities with watershed-specific regulatory requirements that are due to illicit discharge may consider a more-focused IDDE program in those watersheds.

100% of respondent communities implement an IDDE program, 64% of which are a consistent community-wide program and 36% implement a watershed-focused program.



Illicit substances such as oil and trash entering a storm drain.

Standard IDDE Program

IDDE programs include many standard activities to ensure consistent improvement of water quality in regards to removing illicit discharges. All of the programs include spill response and public education elements.

Enhanced and Focused IDDE Program

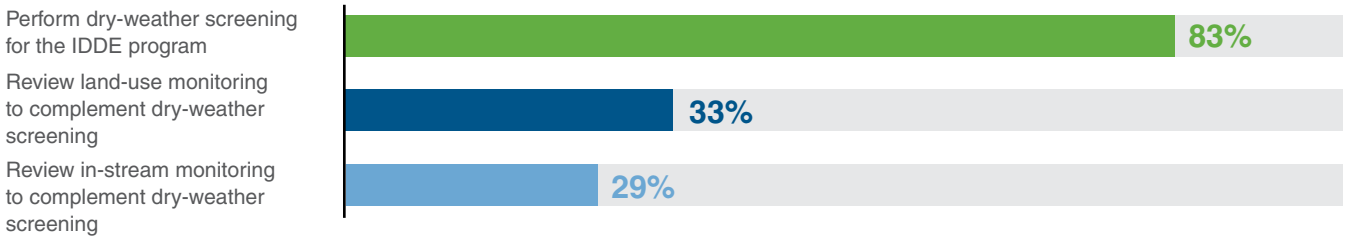
There are many different approaches to identify illicit discharges, including dry weather stream and outfall assessments; in-stream or wet weather monitoring for high pollutant concentrations; storm drainage system inspections; citizen complaint or service request assessments; fish kill assessments; facility inspections; and infrared aerial photographs.

Locating the source and elimination of illicit discharges can be challenging. Source location methods can include visual inspections of the contributing drainage system, dye and smoke testing, facility or utility plan reviews, facility inspections, and pipe video inspections.

Screening for Illicit Discharges

Dry-weather screening is the most common method to identify illicit discharges. Some communities complement dry-weather screening by reviewing other monitoring data such as in-stream monitoring and land use monitoring for high concentrations of pollutants associated with illicit discharges.

83% of respondent communities perform dry-weather screening to detect and identify illicit discharges.



Dry-Weather Flow Screening

Dry-weather flow screening is one of the primary efforts of an illicit discharge detection program. The frequency of dry-weather flow screening is adjusted by each community relative to the potential for illicit discharges and associated impacts. Communities enhance their screening efforts by performing more frequent or focused screening in priority areas which have high potential for illicit discharges or those with sensitive waters.

In-Stream and Land-Use Based Detection

In-stream and land-use based detection programs can flag high pollutant loads, which in the receiving streams may be due to illicit discharges. The community may implement programs that allow staff to perform field assessments when the in-stream or land-use based monitoring program indicates pollutant thresholds are exceeded.

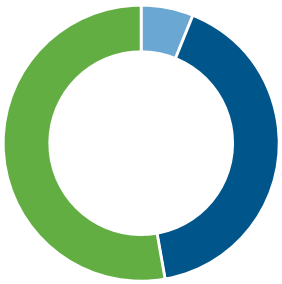
Stormwater outfall with dry weather discharge actively flowing in Aurora, CO

In-stream monitoring

Dry-Weather Flow Screening Frequency

Frequency of screening is key. Screening performed by volunteers can reduce the required investment. Additional dry-weather screening information and parameters are discussed in Chapter 10: Stormwater Monitoring and Assessment Programs.

Frequency of dry-weather screening is community specific. 53% of respondent communities inspect outfalls on a permit term basis.



53%
Screen outfalls on a permit term basis (5 Years)

41%
Screen outfalls on an annual or more frequent basis

6%
Screen outfalls less frequently than 5 years

"Adaptive Management" using Screening Results

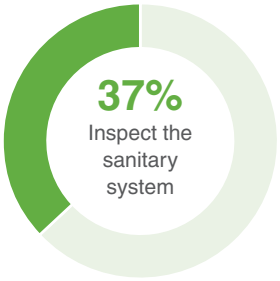
Some communities have elected to or are required to track and assess illicit discharge data. This data can be used to focus the illicit discharge detection and elimination program to areas with high potential for discharge, and to help increase the program effectiveness.

69% of respondent communities use monitoring results to target future IDDE program efforts to increase effectiveness.

Sanitary Sewer Inspection

In addition, some communities may experience significant bacteria loads from the sanitary sewer system, and therefore, have elected or are required to assess the sanitary sewer system. When present in stormwater, wastewater is considered an illicit discharge. Wastewater can originate from cross-connections, sanitary sewer overflows, amd infiltration. In most cases, the Utility Department is responsible for operation and maintenance of the wastewater system. Inspection of the wastewater system is required by some of the NPDES MS4 permits. This effort is can be led by the stormwater organization, or through a partnership with the Utility Department.

37% of respondent communities inspect the sanitary sewer system as part of MS4 Permit requirements.



Regulations

40 CFR Part 122 – EPA Administered Permit Programs: National Pollutant Discharge Elimination System describes the six minimum control measures that small MS4s must implement, and are commonly found; within medium and large NPDES MS4 permits including illicit discharge detection and elimination.

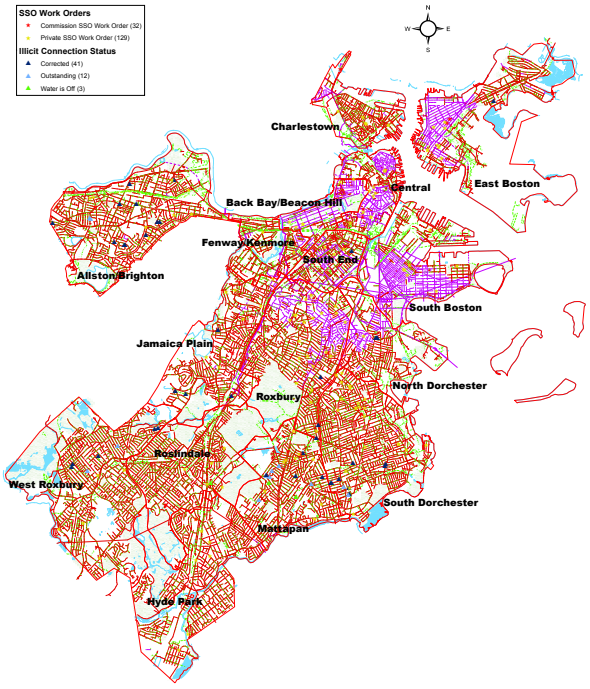
CASE STUDY

Boston, Massachusetts

Boston Water and Sewer Commission (BWSC) has a robust Illicit Discharge Detection Elimination Program to lessen the number of non-stormwater pollutants entering the separate stormwater sewer system. In general, Boston's program includes dry weather flow monitoring, investigations, and elimination of illicit discharges. As required by Boston's Consent Decree, the IDDE program is implemented systematically and on a sub-catchment priority basis.

BWSC's primary means for performing IDDE investigations include dry weather manhole inspections, dye testing of buildings' sewer laterals, video inspections of pipes, and occasionally sandbagging of manholes to detect any sources of pollution. Numerous other methods of source tracking and identification have also been tested by BWSC, including using dogs to scent evidence of sewage in drain manholes. Illicit discharge investigations are typically performed by consultants to BWSC or in-house staff. Elimination of illicit connections in the right-of-way are corrected and funded by BWSC, but those on private property are the responsibility of the property owner and are privately funded. To incentivize leaking sewer lateral elimination, BWSC offers financial assistance to property owners in the form of reimbursements through the Sewer Lateral Assistance Program. Under the program, owners of verified leaking sewer laterals may receive up to $4,000 in reimbursements for lining or relaying the lateral through a licensed bonded contractor. Prior to reimbursement, dye tests are used to confirm that the lateral no longer leaks into the storm drain system.

In 2015, the Commission initiated an Urban Runoff Water Quality Project. The project includes water quality sampling from manholes, outfalls, and gutters. Samples are being analyzed for bacterial indicators, human DNA markers, pharmaceuticals and personal care products, nutrients and other commonly sampled stormwater parameters. The main purposes of the project are to explore the use and effectiveness of alternative parameters and methods for determining whether bacteria or ammonia in storm drains or outfalls are from non-human sources, and to aid the Commission in determining where and to what extent non-human sources of bacteria and phosphorus may be contributing to contamination in the storm drain system. Findings from the project will aid the Commission in prioritizing where future illicit discharge investigations should be directed.



Verified illicit discharges and sewer system overflows during July 2016 - December 2016

5 Construction and Post-Construction Stormwater Management Programs

5.1 Erosion and Sediment Control

5.2 Post-Construction Stormwater Management Programs

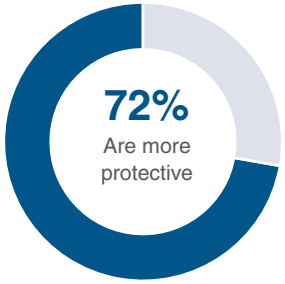
5.1 Erosion and Sediment Control

Construction activities disturb the vegetation and natural soils of a site, resulting in increased erosion potential. In addition to potentially carrying pollutants, the increased sediment volumes from denuded sites can impact receiving waters by covering the waterbody substrate and obstructing habitat. Erosion and sediment controls minimize erosion and keep eroded soil on a construction site, so that it does not wash off and pollute the receiving waterbody.

An effective erosion and sediment control program balances the level of protection with compliance cost. Level of protection is influenced by community-specific conditions such as land development pace/patterns, soils, hydrologic conditions, slopes, and watershed sensitivity. Compliance cost is influenced by project size, plan review effort, implementation/construction requirements, and inspection/monitoring. Communities select the threshold value based on local sensitivities, including soil erodibility, development trends, land use, re-grading patterns, and receiving water sensitivity.

A comprehensive erosion and sediment control program, which includes ordinances, design standards, inspections, and enforcement is key to limiting the impacts of soil erosion from construction sites. Effective programs require appropriately designed, installed, and maintained erosion and sediment control features. The inspection and enforcement program must be robust so that contractors are held accountable for failed erosion and sediment control practices.

72% of respondent communities provide a higher level of protection than federal thresholds by regulating sites that disturb less than one acre.



Erosion and sediment control measures in place during construction of a BMP in the Staten Island Bluebelt, NY

Erosion and Sediment Control Requirements

Protection Threshold Breakdown

Disturbed area thresholds may differ based on land use and to meet sensitive watershed requirements. The breakdown includes the most stringent disturbed area thresholds for each respondent community.

73% of respondent communities have a threshold lower than a quarter of an acre, or 10,890 square feet, in response to local sensitivities.

73% Have a threshold of < 10,890 sf

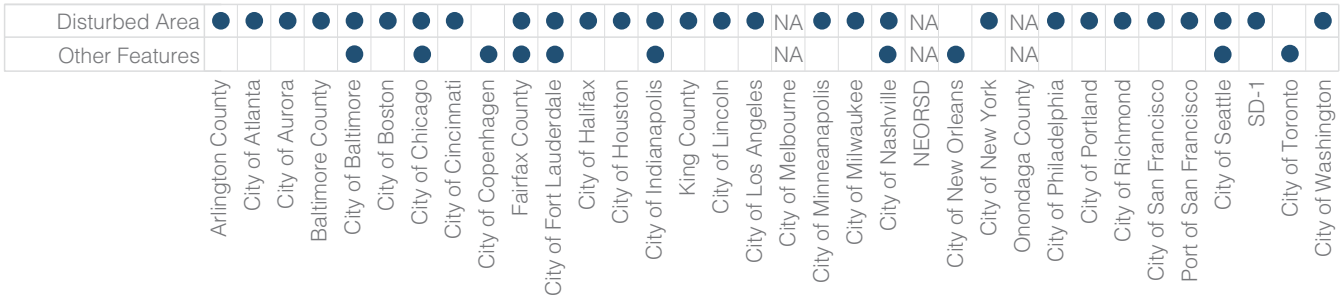
0% Have a threshold of 10,890 sf to < 21,780 sf

0% Have a threshold of 21,780 sf ≤ 1 acres

27% Have a threshold of ≥ 1 acre

Additional Screening of Project Features

In addition to community-specific disturbed area thresholds, other project features are used to identify the required erosion and sediment control measures. These features include total site area, increased impervious area, and drainage pattern changes. These additional project feature screenings ensure the appropriate factors are considered to control erosion and sediment.



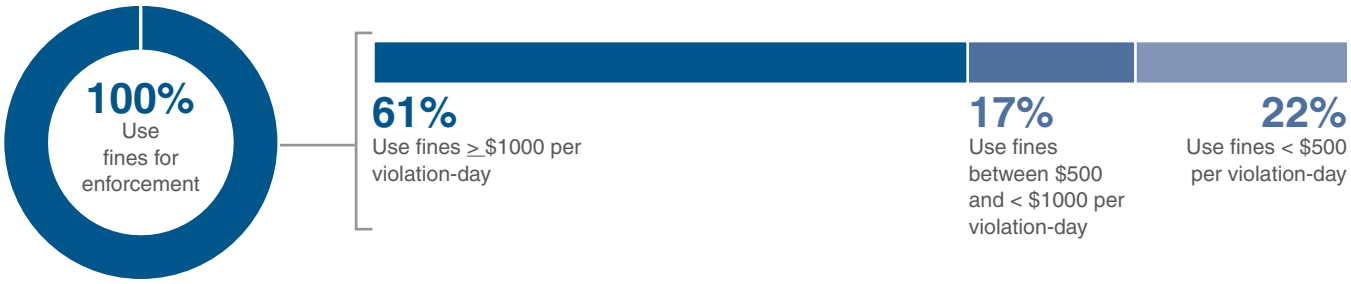
Sediment control around a storm drain

Construction runoff with sediment entering a storm drain in Arlington, VA is a hazard to the receiving streams amd waterbodies.

Fines

Selecting the appropriate deterrent for violations is critical. If the fine is below the cost of compliance, the developer may chose to ignore the regulations. Conversely, fines should not be so high as to become a burden and negatively impact development. When setting the appropriate fine amount, communities typically consider environmental impacts and associated remediation costs.

17% of respondent communities encourage compliance by implementing fines from $500 to < $1,000 per violation-day, and 61% encourage compliance by implementing maximum fines over $1,000 per violation-day.



Erosion and Sediment Control Enhancements

Enhanced erosion and sediment control may be required based on watershed-specific requirements and/or receiving stream assessments.

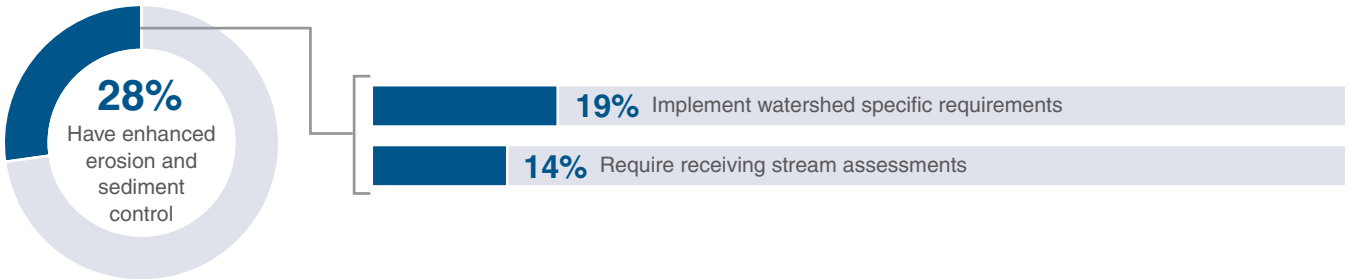
Watershed-Specific Requirement

Communities with sensitive receiving waters, such as water supply watersheds, streams that serve as habitat for threatened or endangered species, or streams on the 303d list due to impairments associated with sediment, are likely to implement more protective erosion and sediment control regulations. The more protective regulations may include different design standards and details, or lower thresholds for permit compliance.

Receiving-Stream Assessment

Streams receiving runoff have varying sensitivity. Site-specific assessments help tailor the erosion and sediment control program to address the specific needs of the waterbody.

28% of respondent communities have enhanced erosion and sediment control requirements to protect sensitive watersheds.



Regulations

40 CFR Part 122 – EPA Administered Permit Programs: National Pollutant Discharge Elimination System which describes the six minimum control measures that small MS4s must implement and are commonly found in medium to large NPDES MS4 permits, including erosion and sediment control.

CASE STUDY

Toronto, Ontario

The City of Toronto and the Toronto and Region Conservation Authority (TRCA) have a unique partnership in promoting pollution control and water quality improvements, including the erosion and sediment control program. The City of Toronto, as the municipal authority, regulates construction erosion and sediment control through the Wet-Weather Flow Management Guidelines (WWFM). The guidelines require that all development sites, regardless of size, implement temporary erosion and sediment control.

All erosion and sediment control best management practices are to be designed, constructed, and maintained in development sites in accordance with guidelines published by an area-wide organization of conservation authorities, referred to as the Greater Golden Horseshoe Area Conservation Authorities (GGHA CAs). The WWFM guidelines also require an erosion and sediment control permit to be obtained prior to any land disturbing activities on sites larger than 0.5 hectares (about 1.24 acres).

The guideline provided by the GGHA CAs provides a consolidated statement of requirements and expectations for erosion and sediment controls implemented in the Greater Golden Horseshoe Area. Additionally, the guideline explains the role of the conservation authorities and the relationships they have with their municipal counterparts.

The Conservation Authorities Act gives oversight jurisdiction to the Conservation Authority staff to be involved with the technical review of erosion and sediment controls related to the regulations. TRCA, along with many conservation authorities and their respective municipalities, have entered into a memorandum of understanding with the City of Toronto. This memorandum allows TRCA staff to review and comment on all site and subdivision plans and agreements related to stormwater management under the City of Toronto's Erosion and Sediment Control Permit.

TRCA requires an additional permit be issued by the GGHA CAs when proposed work impacts existing channels, wetlands, or regulated areas. In terms of existing channels, a potential impact can be defined as any work that straightens, changes, diverts, or interferes in any way with the existing channel of a river, creek, stream or watercourse.

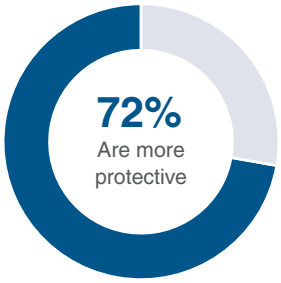
Toronto and Region Conservation *for* The Living City®

5.2 Post-Construction Stormwater Management

The amount of runoff that is generated from a site is dependent on the land use and amount of imperviousness. High imperviousness results in greater runoff volumes. Similarly, pollutant quantities in the runoff are also elevated for sites with greater imperviousness. As a result, stormwater runoff from developed land can be a significant non-point pollutant source for receiving waterbodies. Both structural and non-structural Best Management Practices (BMPs) can be implemented to control and treat the runoff at the origin site in order to protect and prevent degradation of receiving waters. A post-construction stormwater ordinance requires developers to mitigate the stormwater impacts of their projects.

An effective post-construction stormwater ordinance balances the level of protection with compliance cost. The level of protection is influenced by community-specific conditions such as receiving water sensitivity, type of pollutants, development pace/patterns, soils, and precipitation patterns. Level of protection can be increased by lowering the threshold at which site plans must consider development impacts, requiring treatment of more of the annual runoff, or installing features that treat numerous pollutants. Compliance cost is influenced by project size, plan review effort, implementation/construction requirements, and inspection/monitoring. Compliance costs can be reduced through incentives or relaxed design standards for re-development projects. In addition, compliance costs can be reduced by the implementation of off-site mitigation or fee-in-lieu-of programs.

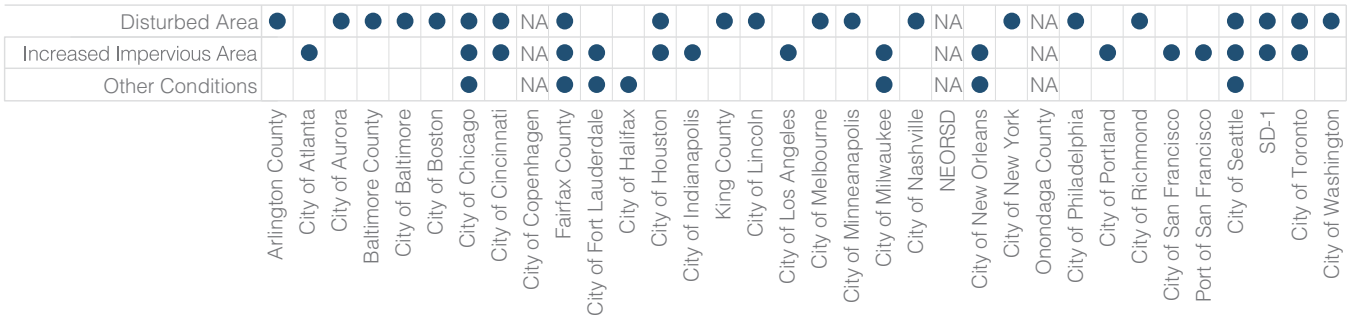
72% of the communities are more protective than typical state thresholds by regulating sites that are less than one acre of disturbed area or 10,000 square feet of impervious area.



North and South Conduit BMP, New York, New York

Post-Construction Stormwater Management Requirements

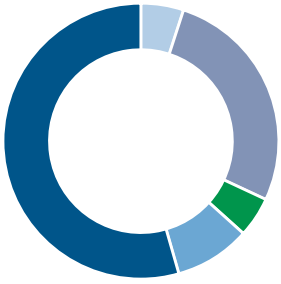
Most of the communities use disturbed area thresholds and impervious area thresholds to implement post-construction stormwater management requirements. In addition to disturbed area and impervious area, other conditions are used to determine post-construction stormwater management measures. These conditions ensure sites that impact the storm drainage system are required to manage stormwater on-site after construction.



Disturbed Area

A relatively small disturbance area threshold, such as 5,000 square feet, requires post-construction adherence for a significant number of projects, and therefore, increases the compliance and enforcement effort. A relatively large disturbance threshold, such as one acre, requires only large projects to comply. Communities select the appropriate threshold value based on a number of factors, including soil erodibility, development trends, land use, re-grading patterns, and receiving water sensitivity. Disturbed area thresholds may differ based on land use and to meet sensitive watershed requirements. The breakdown includes the most stringent disturbed area thresholds for each respondent community.

55% of respondent communities have a threshold lower than a quarter of an acre.



55%
Have a threshold < 10,890 sf

9%
Have a threshold from 10,890 sf to < 21,780 sf

5%
Have a threshold from 21,780 sf < 1 acre

27%
Have a threshold of 1 acre

5%
Have a threshold ≥ 1 acre

Impervious Area

Similar to disturbed area, communities select impervious area compliance thresholds by balancing the need for environmental protection with the desired compliance and enforcement effort. Impervious area thresholds may differ based on land use and to meet sensitive watershed requirements. The breakdown includes the most stringent disturbed area thresholds for each respondent community.

53% of respondent communities have a threshold lower than 2,500 square feet.

53%
Have a threshold < 2,500 sf

13%
Have a threshold from 2,500 sf to < 5,000 sf

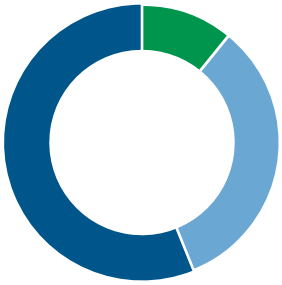
20%
Have a threshold from 5,000 sf to < 10,000 sf

13%
Have a threshold ≥ 10,000 sf

Design Goals

The EPA recommends that the BMPs selected for implementation minimize water quality impacts and attempt to maintain pre-development runoff conditions. Additionally, the selected BMPs must be appropriate for the local community and account for local conditions, development patterns, and receiving water conditions.

44% of respondent communities have a single design goal of either retention requirements or pollutant removal requirements. 56% combine these design goals to result in cumulative protection of water quality.



56%
Require both pollutant removal and retention

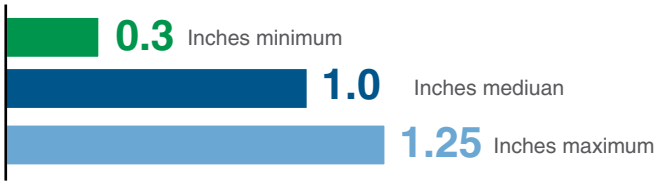
33%
Have only a retention requirement

11%
Have only a pollutant removal requirement

Retention Design Goals

Retention promotes infiltration, reduces the amount of runoff that enters the storm drainage system, and matches pre-development runoff volumes to encourage low impact and/or green infrastructure.

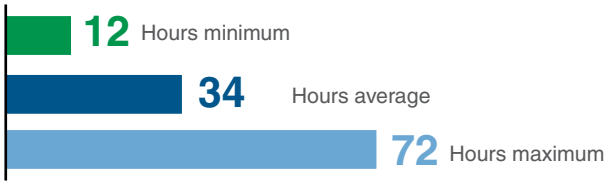
The median design depth for retention is 1.0 inch.



Detention Time Design Goals

Detention time is the length of time that runoff volume is held to slow release rates of runoff volume and promote pollutant settling.

The average design detention time is 34 hours.



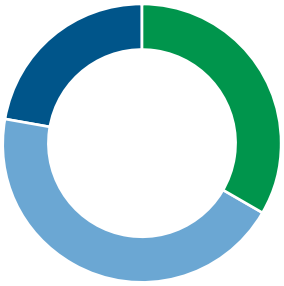
Post-construction bioretention implemented on private property in the Northeast Ohio Regional Sewer District, OH

Pollutant Removal Requirements

Post-construction BMPs are typically designed to meet goals associated with pollutant removal in addition to retention volume and detention times. Two pollutants are typically assessed: total suspended solids (sediment) and total phosphorus or total nitrogen (nutrients). Design goals are set relative to pre-development conditions or post-development conditions. For pre-development conditions, the baseline is set based on existing land use or existing pollutant load rates.

Communities that implement BMPs based on pre-development conditions require the pollutant removal to be reduced by an additional 10 to 0 percent and nutrient removal to be reduced by an additional 5 to 0 percent of the existing pollutant loads. Communities that implement BMPs measured relative to post-development conditions require sediment conditions to be an overall reduction between 70 and 90 percent of the post-development load rate and nutrient conditions to be an overall reduction between 50 and 60 percent of the post-development load rate.

Of the respondent communities that require pollutant removal, 23% implement requirements focused on the removal of nutrients and sediment.



23%
Require Both Nutrient and Sediment Removal

44%
Require only Nutrient Removal

33%
Require only Sediment Removal

Stiling basin used in the Staten Island Bluebelt, NY to reduce sediment.

Oil-water separator to be installed as part of a manhole within a stormwater management system.

Enhanced Post-Construction Stormwater Management Requirements

Each watershed and receiving water may be impacted by different pollutants, so communities may tailor post-construction stormwater ordinances to focus on watershed-specific pollutants of concern.

43% of respondent communities have enhanced post-construction stormwater management requirements to protect sensitive watersheds.

43%
Watershed based requirements

57%
Community-wide requirements

Re-Development Requirements

In many urban communities, re-development of land with existing buildings or developed uses is common due to the lack of open space available for new development. Re-development can include the removal of existing structures and construction of replacement structures or can include additions to existing structures. Communities that require re-development sites to treat stormwater runoff from existing and new impervious areas at the site improve the overall watershed health. Communities that require redevelopment sites to treat only the new or additional impervious areas only prevent degredation of the overall watershed health.

53% of respondent communities require re-development sites to manage stormwater based on the total impervious area of the site.

53%
Require management of the total impervious area of the site

11%
Require management of only the new impervious area of the site

37%
Require management of an other amount of the impervious area of the site

Re-Development Design Goals

A community may elect to encourage re-development by offering post-construction stormwater ordinance flexibility. The flexibility can include exemptions for existing imperviousness, design goals, and fee-in-lieu. Additional details of programs that provide post-construction ordinance flexibility such as fee-in-lieu are documented in Chapter 11.0 Funding Sources and Financial Incentive Programs.

69% of respondent communities require re-development sites to meet the same design goals as new development.

69%
Require to meet all design goals

31%
Flexible requirements to meet design goals

Bioretention in a parking lot of an industrial site in San Francisco, CA

Rain Garden at the Academy of Sciences in Golden Gate Park in San Francisco, CA

Post-Construction Stormwater Management Implementation

Publicly-funded projects such as roadways, fire stations, and parks may create new imperviousness. Some communities elect to require publicly-funded projects and associated new imperviousness to comply with the post-construction ordinance.

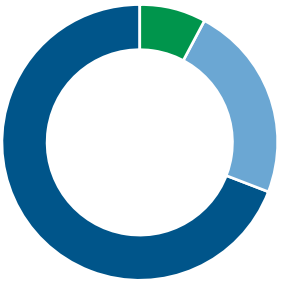
76% of respondent communities require municipal facilities to comply with post-construction ordinance elements.

Inspections

Inspection can be the responsibility of the community staff or the property owner. If the community elects to delegate the inspection responsibility to the property owner, a requirement may include that the inspection be performed by an individual that maintains a certification such as a professional engineering license.

Communities determine the inspection frequency of the post-construction sites and BMPs to ensure compliance. The inspection frequency may be based on their property owner's compliance history and the sensitivity of the watersheds. Some NPDES MS4 permits dictate the inspection frequency.

69% of respondent communities perform regular inspection on post-construction stormwater measures with municipal staff. The average inspection frequency is two and a half years.

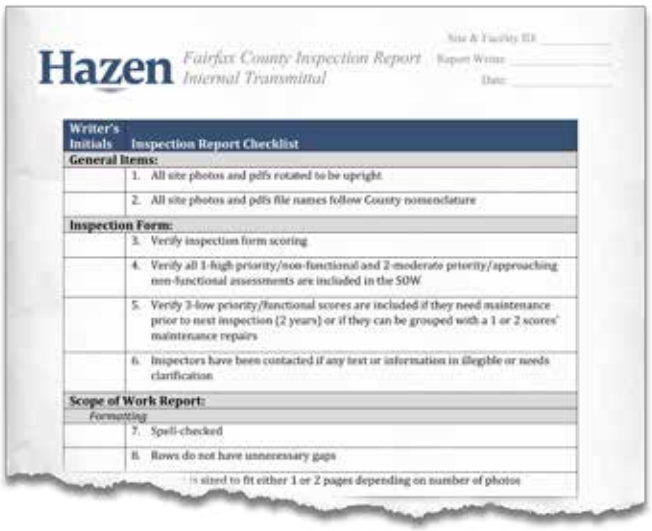


69%
Perform inspections with municipal staff

23%
Require property owners or a professional engineer to perform inspections and provide results

8%
Do not require inspections

BMP inspection in Fairfax County, VA



Hazen *Fairfax County Inspection Report Internal Transmittal*

Writer's Initials	Inspection Report Checklist
General Items:	
	1. All site photos and pdfs rotated to be upright
	2. All site photos and pdfs file names follow County nomenclature
Inspection Form:	
	3. Verify inspection form scoring
	4. Verify all 1-high priority/non-functional and 2-moderate priority/approaching non-functional assessments are included in the SOW
	5. Verify 3-low priority/functional scores are included if they need maintenance prior to next inspection (2 years) or if they can be grouped with a 1 or 2 scores' maintenance repairs
	6. Inspectors have been contacted if any text or information in illegible or needs clarification
Scope of Work Report:	
Formatting	
	7. Spell-checked
	8. Rows do not have unnecessary gaps
	is sized to fit either 1 or 2 pages depending on number of photos

BMP inspection checklist for Fairfax County, VA

Regulations

The regulation that requires post-construction stormwater treatment is 40 CFR Part 122 – EPA Administered Permit Programs: National Pollutant Discharge Eliminated System which describes the six minimum control measures that small MS4s municipalities must implement and are commonly found in medium to large NPDES MS4 permits. Post-construction stormwater treatment is one of the six minimum measures.

CASE STUDY

New York, New York

The New York City SPDES MS4 Permit requires the City to perform a study to recommend an appropriate reduction in the soil disturbance thresholds for triggering the applicability of construction and post-construction stormwater management requirements.

The study consisted of three main tasks. The first task was a literature survey to develop an inventory of construction and post-construction stormwater regulatory requirements in other major urban cities. This data collection included land disturbance thresholds for new development and redevelopment, stormwater treatment/retention/detention criteria, green infrastructure or stormwater best management practices (BMP) approaches, allowable structural controls, performance criteria, and banking and credit systems, as applicable. The data inventory also included the number of staff performing reviews and inspections, their workload in terms of the number of reviews and inspections performed per year, and the fees charged to developers for stormwater management applications, reviews, and/or inspections.

The second task consisted of an assessment of the potential benefits, costs, and constraints (including technical and administrative considerations) associated with different lot size soil disturbance thresholds for construction and post-construction requirements. Fifteen years of NYC Department of Buildings development and redevelopment data (2000-2014) and available Department of City Planning Primary Land Use Tax Lot Output (PLUTO) land use data were used to identify lot size thresholds potentially applicable to NYC-specific conditions. The lot sizes assessed ranged between 5,000 square feet and one acre. Lot information and statistical analyses were performed on different hydrology and hydraulics parameters such as impervious cover, soil type, and infiltration rates. The analysis also included the number and total area of public and private properties for each lot size, type of development/zoning/land use, and total and percent constructed impervious surface areas and remaining pervious surface areas.

The final task consisted of cost-benefit and water quality analyses for the different construction and post-construction stormwater management requirements and selected disturbance thresholds. Conceptual designs of stormwater control measures were developed and life cycle costs were evaluated for both the developer/owner (including design, construction, and O&M costs, loss of property revenues, and permitting/inspections over the design life) and the City (including municipal staff resources required for Stormwater Pollution Prevention Plan reviews and BMP inspections). The goal of this analysis was to identify the "knee-of-the-curve" for costs of controls and water quality improvements (pollutant load reductions for pathogens, total suspended solids, total nitrogen, and total phosphorous in relation to the lot size soil disturbance thresholds.

HIGH PRIORITY

	Soil Suitability	Space Availability
On-Site Vegetated Infiltration Rain gardens, **bioretention**	High	High
(Sub)Surface Infiltration and Green Roof **Permeable pavement,** infiltration trenches, turf fields, **green roof**	High	Low
Vegetated Detention with Treatment Vegetated open swales, constructed wetlands, **bioretention with underdrains,** ponds, sheet flow to riparian area	Low	High
Physical Treatment and Green Roof **Permeable pavement,** infiltration trenches, turf fields, **green roof**	Low	Low

LOW PRIORITY

Bold *stormwater control measure technologies indicate selected for sample site analysis*

CASE STUDY

Atlanta, Georgia

The City of Atlanta implemented its first post-construction stormwater management ordinance in 2004. The 2004 ordinance was focused on water quality and included requirements to capture the first 1.2 inches of runoff and remove 80% of total suspended solids. The detention requirement also called for new and redevelopment sites to reduce their peak outgoing flow rates by 30% relative to pre-developed flow rates, up to the 100-year storm event.

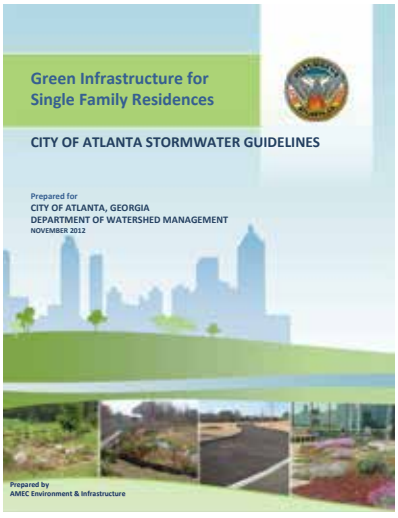
Most of the stormwater management practices implemented under this ordinance were large, dry detention ponds which eventually posed aesthetic and safety issues. In response to community concerns and other challenges, the City of Atlanta revised the post-construction stormwater management ordinance in 2013 to focus more on the management of the more polluted runoff generated from the first flush of all storms, while still aiming to provide flood protection from major storm events. The ordinance requires new retention and detention targets for the following project types: new non-residential development that involves creation of impervious cover, redevelopment that includes the creation, addition, or demolition and replacement of 500 square feet or more of impervious cover, demolition that leaves in place more than 500 square feet of impervious cover, and single family residential development for new homes and large additions over 1000 square feet of impervious surface

Water quality requirements include treating the first 1.0” of runoff with green infrastructure, and holding the first 1.0” of rainfall runoff volume on-site. Flood control requirements differ for new and re-development sites. For new development, the post-construction site is required to match the pre-development flow rate or mimic the natural conditions of the site. Redevelopment is required to detain a percent reduction based on the impervious surface that is currently present. The percent reduction is calculated using the formula:

$$\frac{\%\text{ of the site with impervious surface}}{2} = \%\text{ reduction required}$$

Flood control requirements in the 2013 ordinance apply to the 25-year, 24-hour return frequency storm event. Hydrology studies are required for all sites with stormwater management facilities, except small commercial sites that add or replace less than 5,000 square feet of impervious surface and provide the appropriate green infrastructure.

Single-family residential development is not required to comply with flood control requirements such as hydrology studies, concept plan meetings, or maintenance agreements with the City. The City of Atlanta provides a guidance document, “Green Infrastructure for Single Family Residences” to simplify the review and approval process. The document provides tear-off details and construction specifications to ease compliance and implementation.



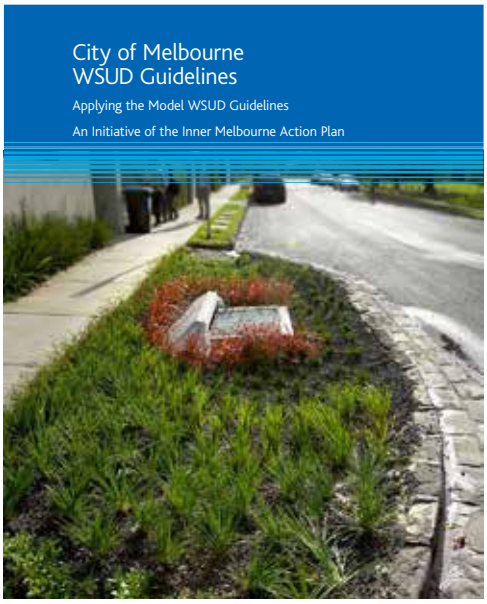
CASE STUDY

Melbourne, Victoria

The City of Melbourne's water quality is reflected in Melbourne Water's Index of River Conditions ratings for waterbodies. Three major waterways pass through the municipality and discharge to Port Phillip Bay: the Yarra River, Maribyrnong River and Moonee Ponds Creek. These waterways provide recreational, economic, tourism and aesthetic value. The water pollution issues are caused by pollution from urban stormwater runoff, urbanization of the catchment cause excessive flows after rain events and channeling of water courses.

Additionally, in recent years, Victoria has experienced a long-standing drought and a large increase in population. The combination of lower water storage and an increasing population led the City of Melbourne to explore water security and address water quality issues through a Water Sensitive Urban Design (WSUD) approach.

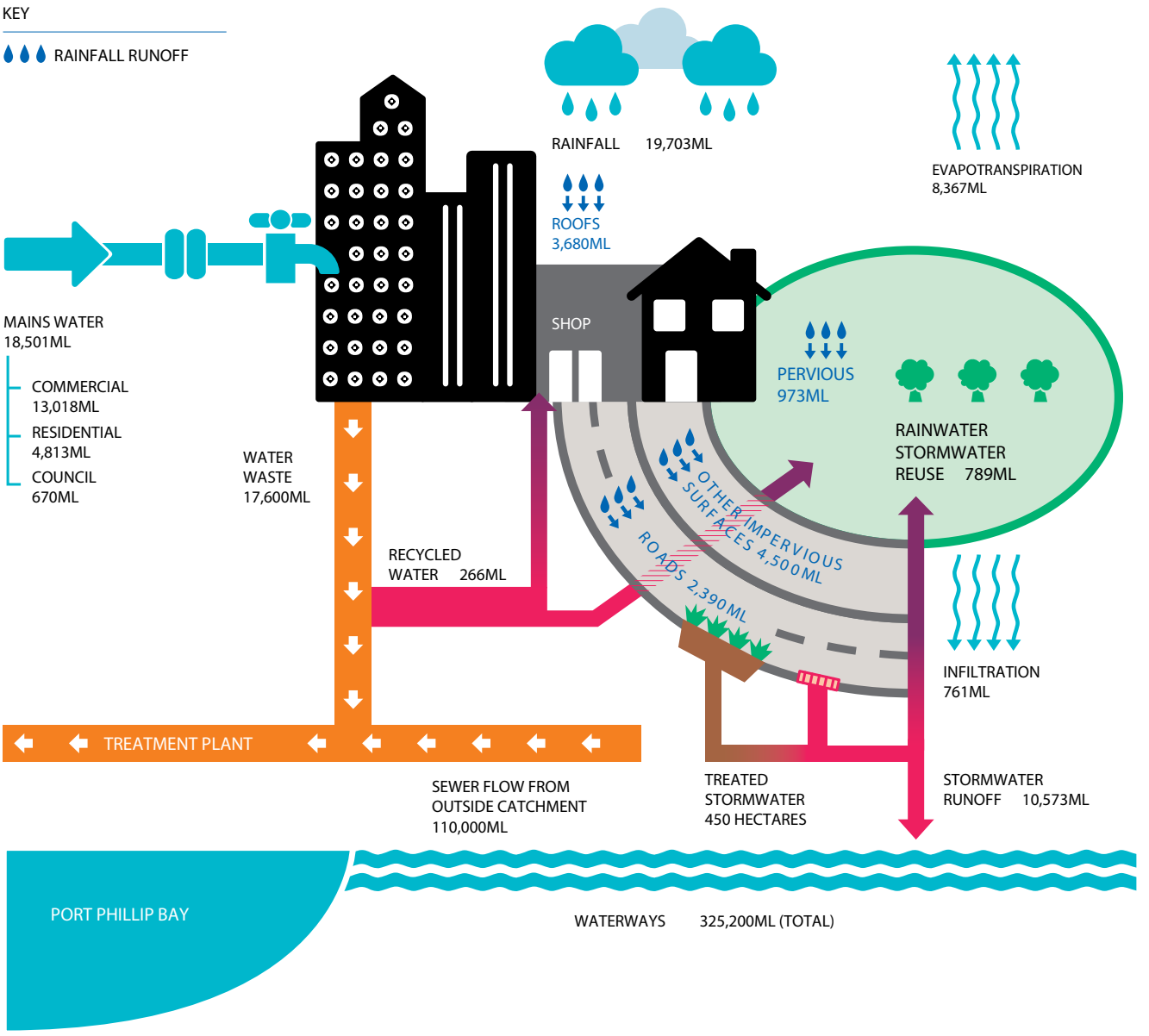
WSUD is a part of the integrated water management approach Melbourne implements, where all water streams are considered a resource. The design of WSUD aims to allow the water cycle to function naturally while remaining as part of the urban environment. WSUD seeks to achieve integrated water management by reducing potable water consumption, maximizing water reuse, reducing wastewater discharge, minimizing stormwater pollution before it is discharged to the aquatic environment, and maximizing groundwater protection. Managing flooding and sea level rise are also emerging issues as low-lying industrial land is redevelopment in high rise residential.



The process for WSUD projects includes a triple bottom line evaluation, holistically examining WSUD opportunities for environmental, economic and social impacts. Greater Melbourne has a placed a cost of nitrogen pollution which is helping to drive stormwater quality improvement. This has been back up by state and local government land planning regulation requiring developments to meet best practice stormwater management. Targeting permeability and rainwater retention on private lots will also reduce runoff and mitigate flooding.

City of Melbourne's Municipal Integrated Water Plan 2017 is the most recent in a suite of industry leading strategies and policies related to water management and liveability and include place based action to tackle the challenges of population growth and climate change. In managing WSUD intervention, Melbourne is heavily dependent on the MUSIC modelling software. As an aid to decision-making, MUSIC – Model for Urban Stormwater Improvement Conceptualisation – predicts the performance of stormwater quality management systems. It is intended to help organisations plan and design (at a conceptual level) appropriate urban stormwater management systems for their catchments.

MELBOURNE'S WATER CYCLE



6 Municipal Facilities Pollution Prevention Programs

6.0 Municipal Facilities Pollution Prevention Programs

Municipal facilities and operations include areas designated for material storage, vehicle maintenance, hazardous material transfers, snow removal and fertilizer/herbicide application, that can result in runoff with elevated pollutant concentrations and quantities if exposed to stormwater. NPDES MS4 permits require a program to prevent and reduce stormwater pollution from municipal facilities and operations.

The NPDES MS4 permits prescribe the method that the NPDES MS4 lead agency coordinates, assists, oversees, and/or enforces stormwater pollution prevention for the community's municipal facilities and operations.

Some communities have elected for the lead stormwater agency to develop and/or implement the SWPPP for each of the municipal facilities. Other communities may defer the responsibility of SWPPP development, implementation, or both to the entity with operational control of the facility.

62% of respondent communities provide overall coordination and plan production for pollution prevention by a lead agency.

57% also keep implementation of the pollution prevention plan with the same lead agency.

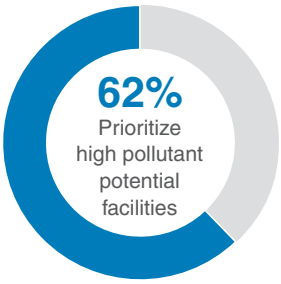
The advantage of the MS4 lead agency overseeing each municipal facility and operation SWPPP, is that the MS4 lead agency can ensure consistency between each site. In addition, the MS4 lead agency may be more aware of the technical challenges associated with stormwater pollution prevention and therefore may be able to better develop and implement more effective stormwater pollution plans.

Rikers Island salt dome in New York City

Municipal Facility Prioritization

Some communities have developed a prioritization ranking method to first address the municipal facilities/operations with the highest potential for impacting water quality.

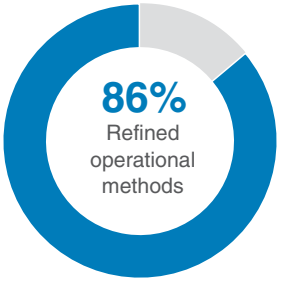
62% of the lead agencies prioritize facilities with a high potential for release of pollutants of concern so that they are addressed first.



Municipal Operation Refinements

Communities assess their municipal operations in addition to the municipal facilities. The operations that are assessed include street sweeping, trash collection, roadway maintenance, snow removal, fertilizer/herbicide applications, and deicing. For example, an operation refinement could be the replacement of conventional deicing chemicals with agents that have less impact to water quality.

86% of respondent communities have changed their operational methods to reduce stormwater pollution.



Street sweeping operation

Snowplowing operation in Onondaga County, NY

Regulations

40 CFR Part 122 – EPA Administered Permit Programs: National Pollutant Discharge Elimination System describes the six minimum control measures that small MS4 municipalities must implement and are commonly found in medium to large NPDES MS4 permits, including municipal operation pollution prevention and good housekeeping.

CASE STUDY

New York, New York

New York City's SPDES MS4 permit requires that municipal facilities located within the MS4 area be assessed for potential stormwater impacts and to implement BMPs to eliminate such potential impacts. As a part of this assessment, the permit requires New York City to consider incorporating runoff reduction techniques and green infrastructure during planned municipal upgrades, including municipal right-of-ways.

During these assessments, DEP is identifing other green infrastructure retrofit opportunities that would not be part of a regularly planned municipal upgrade project. If additional retrofit opportunities are identified, DEP is committed to further evaluating feasibility and funding the design and construction of these practices. This includes collaborative efforts among city agencies to determine which projects are best suited to evaluate and implement green infrastructure opportunities. Considerations include what projects will qualify, if any exemptions are necessary, and how feasibility is assessed consistently across multiple agencies. The criteria to determine feasibility of green infrastructure implementation may include the following:

- Preliminary assessment of physical site conditions,
- Hydrogeological analysis, and
- Environmental analysis.

Physical site conditions determine specific site constraints, such as the presence of utility lines or adjacent structures that make the location unsuitable for green infrastructure. Hydrogeological analysis determine site suitability for green infrastructure per the New York State Stormwater Management Design Manual, including elements such as soil permeability and depth to groundwater. Environmental analysis reveals if implementing green infrastructure potentially exacerbates existing environmental contamination conditions and if there are existing institutional or engineering controls. The final phase of evaluation determines if it is cost-effective to incorporate green infrastructure into the project; this last step takes into consideration overall project cost, such as design, construction, maintenance and operation.

DOT yard on St. George in New York City, NY

CASE STUDY

Fort Lauderdale, Florida

The City of Fort Lauderdale (Fort Lauderdale) is required to annually review and implement written procedures for inspection and implementation of measures to control discharges from municipal facilities that are not otherwise covered by an NPDES Stormwater permit. These facilities include operating municipal landfills, municipal waste transfer stations, municipal waste fleet maintenance facilities, and any other municipal waste treatment, waste storage, and waste disposal facilities.

Fort Lauderdale identifies necessary control measures and procedures for each facility through the use of annual site inspections. Site-specific monitoring is also performed, as needed. Fort Lauderdale also annually reviews and implements written procedures for the street sweeping program, road repair and maintenance program, equipment yards and maintenance shops and litter control programs.

In addition, Fort Lauderdale completes an annual review and implemention of written procedures for the street sweeping program for highways and streets, including right-of-ways, with curbs and gutters within the jurisdictional area and proper disposal of collected material. The procedures include the criteria for determining which roadways will be swept and the frequency of sweeping and the method for quantifying and tracking the amount of material removed by the street sweepers.

Fort Lauderdale documents the litter control program activities and identifies the equipment yards and maintenance shops that support road maintenance activities to determine the necessary control measures and procedures to be employed at each facility through annual site inspections.

Small Litter Cleaning Vehicle in Fort Lauderdale, FL

7 Industrial and Commercial Stormwater Management Programs

7.0 Industrial and Commercial Stormwater Management Programs

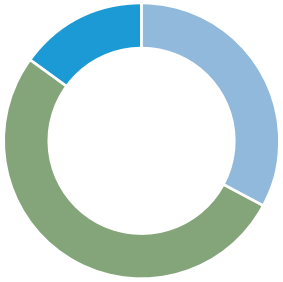
NPDES MS4 permits require communities to coordinate with some of the heavy industrial and commercial properties that discharge to the MS4 system. The industrial and commercial properties have operations such as material storage, vehicle maintenance, and hazardous material transfers that can result in runoff with elevated pollutant concentrations and quantities if exposed to stormwater.

In addition to the elevated pollutant concentrations, some of the pollution in industrial and commercial runoff can be toxic. Reduction of the potential exposure of the industrial and commercial operation or capture/treatment of the runoff are effective methods for a community to protect and/or restore the health of the receiving waterbody.

Many industries have applied for and received NPDES stormwater permit coverage either through an NPDES Individual Industrial Stormwater permit or a NPDES General Stormwater permit. The MS4 NPDES permit can request the municipality to be responsible for some or all the inspection and enforcement responsibilities of pollution prevention for privately-owned industrial facilities. Shared responsibility with the state or federal regulatory agency is also possible.

A privately-owned industrial inspection and enforcement may be more effective if performed with local municipal resources. Refinements to local ordinances may be needed. Staff resources required to perform the inspection and enforcement requires additional local investment. Some municipalities offset the inspection cost by charging a fee to each industry that is inspeted.

15% of respondent communities perform inspection and enforcement of privately-owned industries with municipal staff.

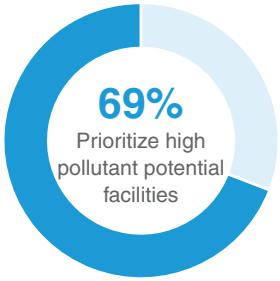


Industrial Area of Los Angeles, California

Private Industry Prioritization

Some communities have developed a prioritization ranking method to first address the commercial and industrial activities with the highest potential for impacting water quality.

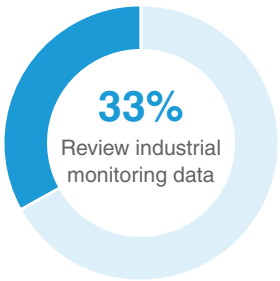
69% of the stormwater agencies prioritize potential high pollutant facilities so they are addressed first.



Private Industry Monitoring

Some communities have chosen or are required to review all of the industrial facility monitoring data to ensure that the data is being properly collected. The monitoring data compilation ensures the data is combined with the overall municipal monitoring program. The monitoring data compilation can also inform effectiveness assessment of the industrial and commercial program.

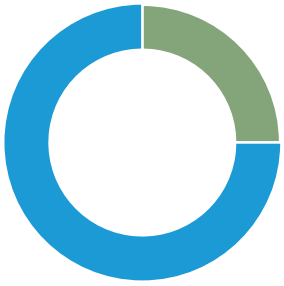
33% of respondent communities complement city-wide monitoring with industrial facility monitoring to track potential high pollutant sources.



Additional Industries

Each community's industrial and commercial coordination program typically includes the industries that have been required to maintain an industrial NPDES permit based on the Standard Industrial Classification codes listed in the Federal Register. Some communities are required or have elected to expand the list of industries that are monitored because those additional industries have been shown to be a significant pollutant source or have the potential to generate a pollutant of concern. Industries such as automotive centers, gas stations, or restaurants are three examples of industries that have been added.

75% of respondent communities expand their industrial and commercial stormwater management program to include non-traditional industries, such as automotive centers, gas stations, and restaurants.



Regulations

40 CFR Part 122 – EPA Administered Permit Programs: National Pollutant Discharge Elimination System describes the six minimum control measures that small MS4s municipalities must implement and are commonly found in medium to large NPDES MS4 permits including the coordination of industrial stormwater permitting. The Industrial Stormwater permit coordination with the municipal system permittee is not a specific requirement of the six minimum control measures.

CASE STUDY

Boston, Massachusetts

Boston Water and Sewer Commission (BWSC) is required by a Consent Decree to identify and inspect hazardous waste treatment, storage, disposal, and recovery facilities. The list includes facilities that are subject to Emergency Planning and Community Right-to-Know Act (EPCRA) Title III, Section 313; facilities that hold, or are required to hold NPDES stormwater permits; and other industrial or commercial dischargers BWSC determines are contributing a substantial pollutant loading.The requirement is that 90% of the industrial facilities are inspected every two years.

BWSC started the program by developing a database of all the industrial sites that should be included by purchasing a database that listed all industries in Boston based on Standard Industrial Classification (SIC) code. The original database included 1760 businesses which was reduced to 279 industrial facilities based on initial screening. After the initial database was created, every site was visited within a two-year period.

The standard procedures for inspections requires that property owners be notified prior to site inspections with a Facility Inspection Notification Letter at least two weeks prior to the start of the site inspection. Inspections are paid for by an inspection fee that is charged by BWSC to the business or property owner. BWSC used consultants to do the initial set of inspections that were completed using an iPad data collection application. All current inspections are done in-house by BWSC.

Inspections include an on-site records review, a physical walkthrough of the facility, and a wrap-up meeting for final questions and to discuss preliminary findings. Sampling can also be required on an as-needed basis. All field inspectors go through a training program within the first 30 days of commencing their employment or assignment to perform inspections. Refresher courses occur for all inspector personnel on an annual basis.

If businesses are not compliant, BWSC informs the business of non-compliance and communicates what actions are needed to correct the violation. If a Notice of Violation is issued, it is done so in the form of a written violation with a deadline for correction of the violation(s). If the deadline for correction is not met, then BWSC has the authority to issues fines, from $1000 to $5000 per day, depending on the violation, and may take other steps reasonable and necessary to ensure compliance, including issuance of a cease and desist order, notification of appropriate regulators (MassDEP, EPA) and revocation of necessary permits and approvals.

MBTA garage

CASE STUDY

Indianapolis, Indiana

The City of Indianapolis (Indianapolis) and Marion County NPDES MS4 Permit requires Indianapolis to identify, monitor, and control pollutants in stormwater discharges from restaurants, municipal landfills, hazardous waste treatment, storage, disposal and recovery facilities, industrial facilities subject to Superfund Amendments and Reauthoritzation Act (SARA) Title III, industrial facilities subject to the NPDES industrial permit, and industrial facilities the City determines to contribute substantial pollution. The program is required to include identification of sources, maintenance of an inventory/database of sources, inspections of sources at least once during the five-year permit term, annual inspections of ten automobile service facilities and annual inspections of ten retail gasoline stations, and support from the State with enforcement actions.

The City's Restaurant Inspection Program includes 1,421 restaurant facilities located in the separate sewer areas of Indianapolis and Marion County MS4. The inspections assess the frequency of trash, vehicle residue, and grease with the potential to impact stormwater. The assessment focuses on the parking lot, trash dumpster, and grease dumpster of a restaurant. All restaurant facilities are inspected at least once every permit term.

The City inspected 27 automobile service facilities and 27 retail gasoline outlets in 2005, as part of the second permit term requirements, to determine if the facilities were a significant source of pollutants to the separate stormwater system. The results of the inspections did not indicate that automobile service facilities or retail gasoline outlets are significant pollutant sources. The issues found included overall cleanliness of the facilities, unlabeled storm drain inlets, and maintenance of the storm drain inlets. As a result, the City implemented a comprehensive outreach and education program regarding stormwater pollution.

The on-going effect is the annual inspection of 10 automobile service facilities and 10 retail gasoline outlets to further examine possible implications to the separate stormwater system.

Automotive shop with spills

8 Floatables and Street Litter Reduction Programs

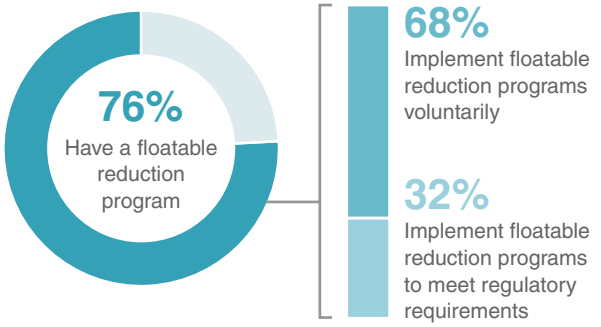
8.0 Floatables and Street Litter Reduction Programs

Refuse such as yard waste, plastic, paper, metal, glass, styrofoam containers, and plastic bags, also known generally as floatables, are abundant in urban settings. These items, if improperly discarded, often end up in local receiving waterbodies by way of stormwater flows. A floatables control program reduces trash that is washed by stormwater into the receiving waterbodies.

Not only do floatables create negative visual consequences in receiving waterbodies, but they often impact stream and shore vegetation by choking access to sunlight and water, and endanger wildlife through entanglement or ingestion. Some floatable materials are slow to decompose and may remain in the receiving waterbodies for years.

A multi-faceted floatable reduction program is typically required to reduce trash load. The multi-faceted program starts with public education and involvement efforts such as catch basin stenciling, stream clean-ups, additional trash cans, and anti-litter campaigns. The public education efforts are complemented with source reduction, structural control, and operational changes such as targeted street sweeping, plastic bag/styrofoam regulations, trash screens and/or catch basin inserts.

76% of respondent communities implement a floatable and street litter reduction program. Of these programs, 68% are voluntary and only use traditional strategies such as street sweeping and public education.



Skimmer Boat in New York City, NY

Floatables Program Drivers

Communities implement floatable programs for different reasons. Some communities implement a floatable program due entirely to citizen feedback and on a volunteer basis. Some communities implement their program pursuant to an NPDES MS4 permit requirement to reduce floatables to the "maximum extent practicable". Some communities are required to comply with specific floatable reductions in response to total maximum daily load regulatory requirements.

57% of the programs responding to regulatory requirements also have a floatables TMDL.

57%
Respond to a floatables TMDL

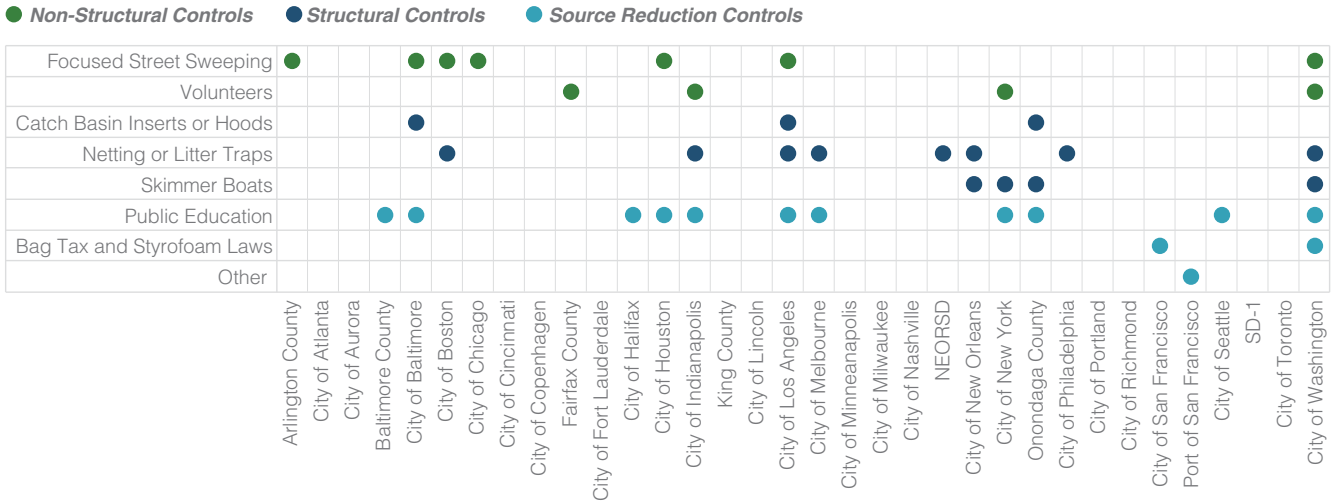
43%
Respond to other regulatroy requirements

Trash net in Jamaica Bay in New York City, NY

Floatable Reduction Strategies

Reduction strategies that are effective for one community may not be as effective for another community. Each community selects and implements options from a menu of reduction strategies that are appropriate and effective for community specific conditions.

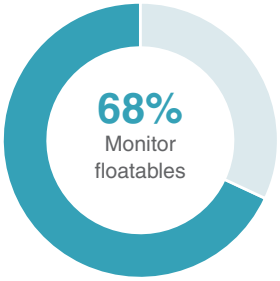
70% of respondent communities implement structural controls for floatable reduction.



Floatable Monitoring

Floatables monitoring programs may be more qualitative or quantitative. The quantitative programs may focus on determining the type of materials and relative contributions from different land uses. The monitoring program results provide data that can help each community focus and tailor its floatable reduction programs to increase the cost-effectiveness of the floatable reduction efforts.

68% of respondent communities monitor their floatables for source identification and program effectiveness.



Floatables Hotspot Identification

Identification of areas or land uses that are large floatable contributors help focus and prioritize the floatable reduction efforts.

47% of respondent communities have programs that prioritize areas of the city to focus floatable reduction efforts.

47%
Prioritize hotspot areas for floatable reduction

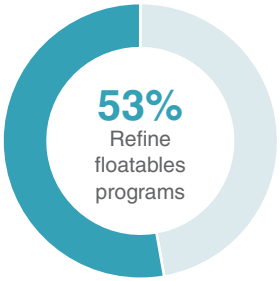
53%
Implement a consistent community-wide floatable reduction program

New Orleans French Quarter, Louisiana

Floatable Program Effectiveness Assessment

Self-assessment can help the community refine its floatable program. Metrics assessed include floatable monitoring results, floatable load assessments, and pounds removed. An adaptive or re-focused effort to achieve program goals is the result.

53% of respondent communities have performed self-assessments of the floatables reduction program to refine the program.



Regulations

40 CFR Part 122 – EPA Administered Permit Programs: National Pollutant Discharge Elimination System describes the six minimum control measures that small MS4s must implement and are commonly found in medium to large NPDES MS4 permits. Floatables control is not a specific requirement of the six minimum control measures, but benefits from some of the six minimum control activities.

CASE STUDY

New York, New York

Past studies have indicated that street litter from pedestrians is responsible for most of the floating trash and debris found in New York City's waterways. While the City has worked to reduce the prevalence of floating trash and debris using controls like street sweeping and catch basin hoods, several local waterways still remain classified as impaired by floatables. Understanding that New Yorkers can play an important role in reaching the litter standard of "none in any amount," the City is attempting to raise public awareness and change behavior.

The City has been communicating this issue to the public since the early 1990s, through the Clean Streets = Clean Beaches campaign, which aims to improve the cleanliness of local beaches and waterways by reducing litter. This campaign features beach clean-up events and posters on sanitation trucks with the goal of highlighting the connection between litter and water quality.

More recently, the City has sought to expand efforts to change the behaviors of New Yorkers. In 2015 the City launched the B.Y.O. Campaign. Shorthand for "bring your own", the B.Y.O. Campaign encourages New Yorkers to live a less disposable lifestyle by using reusable bags, mugs, and bottles. This helps reduce waste before it can become litter. B.Y.O. targets New Yorkers citywide and uses bus, subway, and digital ads to reach New Yorkers both when they are home and out-and-about. New Yorkers who take the B.Y.O. Pledge are rewarded with a reusable bag, mug, or bottle to help them fulfill their commitment.

In May 2017, the City piloted a new campaign designed to highlight the impact of litter on local waterways and wildlife. In partnership with the Wildlife Conservation Society and centered around the New York Aquarium in Coney Island, this campaign aimed to reduce littering behavior by illustrating the wildlife hurt by litter and asking New Yorkers to put their trash in the can. Paid media around the Aquarium reminded New Yorkers that their actions matter as they are outside enjoying the warmer months.

CASE STUDY

Los Angeles, California

The City of Los Angeles is required to comply with Trash TMDLs for the Los Angeles River, Ballona Creek, and Machado Lake. The requirements for these waters include a regular reduction of trash per year so that 100 percent reduction is achieved over a 10-year period. For the Ballona Creek Trash TMDL, the City successfully met the first compliance milestone established for September 2006 by achieving a 20 percent trash reduction.

Los Angeles has studied how trash is generated within the City based on the amount of trash retrieved by the crews that clean the catch basins. The study's results were based on data from 1999 to 2004 and are expressed as annual generation rates (cf/ac-yr). Data indicates that the central part of Los Angeles contributes disproportionately more trash per unit area. The central part of Los Angeles is characterized with higher population density, has more commercial and industrial areas, and has more pedestrian traffic than other areas of the City. This central part has already been targeted for priority installation of screens and inserts at catch basins to reduce trash from discharging into the Los Angeles River and Ballona Creek. Catch basins in the "medium" trash generation areas will be retrofitted with screen covers on the openings during the next few years.

Los Angeles developed a compliance strategy for the trash TMDL utilizing a two-pronged approach to protect the beneficial uses of the City's receiving waterbodies:

1. Implementation of institutional type controls (i.e., public education, street sweeping, enforcement, etc.)
2. Installation of structural trash control devices (i.e., catch basin inserts, catch basin opening screen covers, netting systems, hydrodynamic devices, etc.)

Over 7,400 catch basins have been retrofitted with catch basins inserts (August 2007 count) and over 14,300 catch basins have been retrofitted with screen covers (October 2007 count).

Los Angeles has also implemented programs to recycle plastic bags and polystyrene containers. Los Angeles is also working to reduce the use of styrofoam and other non-degradable products to support compliance with trash TMDLs.

Flow-activated catch basin cover in Los Angeles, CA

CASE STUDY

Baltimore County and City, Maryland

In January 2015, the EPA approved the trash TMDL for Baltimore Harbor. Baltimore County's and the City of Baltimore's NPDES permits require a floatable reduction effort including an inventory of existing trash reduction programs, implementation of a trash reduction education program, annual program effectiveness assessment, and implementation of programs required by the Harbor trash TMDL within one year.

In 2010, the Waterfront Partnership of Baltimore unveiled a Healthy Harbor Initiative (HHI) with a goal of making the harbor swimmable and fishable by 2020. The HHI led a group including Baltimore City, Baltimore County, and Blue Water Baltimore to develop the Healthy Harbor Plan. The HHI also convenes a Trash Work Group to address harbor and neighborhood trash problems and clean-up efforts. The Healthy Harbor Plan includes a number of strategies for reducing polluted stormwater that are similar to MS4 requirements.

Baltimore County developed a Trash TMDL Implementation Plan to outline how the County plans to meet the Trash TMDL requirements. The TMDL Implementation Plan was completed in January 2016, with the goal of meeting the reduction requirements by 2036. To target areas of high trash accumulation, an upland trash assessment monitoring plan was developed.

The Trash Reduction implementation plan is a two phase plan. The first phase of the plan is to focus on education and outreach, and incentives/enforcement actions. An evaluation of Phase I success will be performed after ten years. At this time, the County will determine if the contingent Phase II is necessary or if the reductions can be reached with Phase I actions. Phase II is the implementation of trash trapping devices.

In 2015, the City of Baltimore installed approximately 760 storm drain inlet screens and inserts to trap trash for storm events of smaller than one-inch rain. Additional neighborhoods will be added to the inlet screen/insert program based on the results of the 2015 effort. Additionally, over the next four years the City plans to install several large-scale trash interceptors. In April 2014, the City launched a citywide mechanical street sweeping program, covering neighborhoods which previously had no service or scattered, inefficient service. During the initial six months, the program removed nearly 1,600 tons of trash and debris.

WATERFRONT PARTNERSHIP OF BALTIMORE, INC.

A Healthy Harbor Plan For Baltimore, MD

9 Structural Stormwater Controls

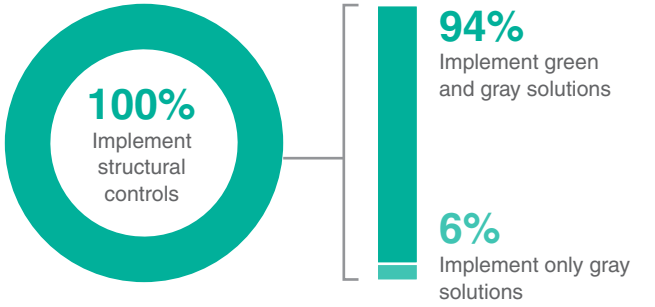
9.0 Structural Stormwater Controls

Structural stormwater controls are features such as detention basins, culverts, pipes, and streams that help the stormwater system function properly by providing conveyance, peak control, volume control, or water quality treatment. A structural stormwater control program either retrofits existing stormwater management features to enhance the existing feature or installs new stormwater management features. An effective structural stormwater control program helps reduce flood damage and restore the water quality of the waterbody.

Historically, the majority of projects constructed were gray infrastructure but green infrastructure projects are becoming more prevalent. Prior to the NPDES MS4 stormwater regulations, communities focused most of their efforts on projects that reduce flood damage. Many communities' focus changed after the NPDES MS4 stormwater regulations were implemented and now include considerations of water quality treatment. Subsequent NPDES permits and other regulatory initiatives have generally led to additional increases in water quality treatment goals.

The six minimum control measures listed in the NPDES MS4 permits typically do not require the construction of a stormwater feature and therefore, consider non-structural components. A public agency may complement the six minimum control measures with structural retrofits that enhance the water quality capabilities of existing flood control features. The structural retrofit approach is a cost-effective method to reduce urban watershed impacts. Newly installed structural stormwater controls can provide water quality improvements and be cost-effective, if the features are properly sited, designed, and maintained. All of these installations or retrofits are in addition to the structural control installations performed by the development community in response to the post-construction ordinance (Chapter 5.2).

100% of respondent communities implement a structural stormwater management program. Of these, 94% use a combination of green and gray solutions.



Hope Gardens bioretention in New York City, NY

Structural Program Drivers

Structural control program goals include many elements, including service requests, flood damage, system condition / asset management, watershed restoration goals, and regulatory requirements. All of the communities respond to multiple drivers when implementing their structural control programs.

Structural Program Implementation

Structural control program policies to effectively address watershed goals are needed. Some communities have numerous and diverse watershed goals and therefore implement structural control program policies to best meet those goals.

Extent of Service (Public versus Private Property)

Some communities take the approach that only storm drainage systems that are located in public right-of-way or on public property are the jurisdiction's responsibility. Other communities take a holistic approach that the entire drainage system is public responsibility and therefore, projects are constructed and maintained on both private and public properties.The holistic approach provides an advantage that drainage system improvements are performed comprehensively and therefore may be more effective. However, the holistic approach requires construction, inspection, and maintenance be performed on private property. Authority for the stormwater agency to enter the private property for these activities may require an instrument such as a right-of-access, easement, or even property purchase. Project implementation may be longer and require additional investment because of the negotiation with citizens to enter their property.

50% of respondent communities implement structural control programs on the entire system (public and private property).

50%
Implement structural controls onthe entire system (public and private property)

50%
Implement structural controls on public property only

Structural control of stormwater flow in the Staten Island Bluebelt in New York City, NY

Osborne green and blue roof in New York City, NY

Public Property Maintenance Responsibility

Communities may assign the maintenance responsibility to the agency on which the structural control is installed. For publicly-funded projects, the maintenance assignee may include the lead agency that oversees the stormwater program, or municipal agencies, such as the Department of Transportation and Parks and Recreation.

For implementation on public property, 45% of respondent communities require the public agency responsible for the installation site to maintain the facility.

45%
Maintenance assignee is agency the that owns the property

55%
Maintenance responsibility is lead stormwater agency

Private Property Maintenance Responsibility

For implementation on private property, 76% of respondent communities require the private property owner to maintain the facility.

76%
Maintenance assignee is property owner

12%
Maintenance responsibility varies depending on specific agreements

Staten Island Bluebelt in Construction in New York City *Source: Hazen and Sawyer*

Regulations

40 CFR Part 122 – EPA Administered Permit Programs: National Pollutant Discharge Elimination System describes the six minimum control measures that small MS4s must implement and are commonly found in medium and large NPDES MS4 permits, including structural stormwater controls. Permit requirements include a description of structural stromwater controls including operation and maintenance, a consideration of structural controls for post-construction management and pollution prevention/ good housekeeping for municipal operations.

CASE STUDY

Seattle, Washington

The City of Seattle, in response to its NPDES MS4 Permit, was required to set up a program for structural source controls and develop a plan to prioritize implementation and measure progress with effective metrics. The Structural Stormwater Control Program (SSCP) develops and prioritizes structural projects using assessments of receiving waterbody conditions, anticipated benefits of the project, regulatory compliance needs, and asset management principles.

Most of the structural stormwater control projects listed in the 2014 NPDES Stormwater Management Plan are new treatment facilities. The total cost estimate of these facilities is approximately $48 million. As part of the Plan, the City of Seattle identified 10 stormwater projects as candidates to treat stormwater and CSO pollution. The candidate structural stormwater projects include bio-retention facilities, biofiltration swales, cartridge media filters, active treatment through chitosan-enhanced sand filtration, and street sweeping and are planned to treat one or multiple receiving waterbodies. The expected cost of system-wide structural controls in the combined sewer areas required to comply with state standards for overflow per outfall was $500 millionas prioritized in the SSCP. The City has completed three structural control projects in the separate sewer areas for a total of $100 million. The projects include active stormwater treatment processes to mitigate flooding, a more robust street sweeping program, and infiltration and natural drainage swales.

Stormwater structural control in Seattle, WA

CASE STUDY

New York, New York

Staten Island boasts the last major stands of freshwater wetlands in New York City and, before the Staten Island Bluebelts were created, was the last large section of New York City lacking sanitary and storm sewerage infrastructure. The Staten Island Bluebelt program is an ecologically sound and cost-effective stormwater management solution to provide drainage infrastructure to mitigate flooding issues for approximately one third of Staten Island's land area. The program preserves natural drainage corridors, called Bluebelts, including streams, ponds, and other wetland areas. Preservation of these wetland systems allows them to perform their functions of conveying, storing, and filtering stormwater. In addition, the Bluebelts provide important community open spaces and diverse wildlife habitats. Not only does the Bluebelt program provide sustainable and ecologically friendly drainage solutions, it is also more economical, saving tens of millions of dollars in infrastructure costs when compared to providing conventional storm sewers for the same land area. This program demonstrates how wetland preservation can be economically prudent and environmentally responsible.

Rendering for a typical stone-faced headwall used throughout the Staten Island Bluebelt in New York City, NY

The New York City Department of Environmental Protection (NYCDEP) has completed new drainage plans for 19 watersheds. These plans connect conventional storm sewers in the streets with the natural drainage corridors for an integrated stormwater management system. Stormwater best management practices (BMPs) such as constructed wetlands, outlet stilling basins and stream restorations are located at these connections, providing water quality treatment and in some cases, extended detention to reduce erosive forces on downstream corridors due to urbanization of the upstream areas. Water quality improvements are achieved through a number of mechanisms: outlet stilling basins and sediment forebays capture sediment conveyed from the streets into the BMPs, removing the materials that often contain pollutants from downstream waters and eventually the Atlantic Ocean; vegetation is selected to provide nutrient uptake from nutrient laden stormwater runoff, helping to protect downstream waters from algal blooms; and extended detention within some of the BMPs slows down the runoff, helping to reduce erosive velocities in downstream drainage corridors, as well as providing additional opportunities for sediments to deposit in the BMPs rather than downstream.

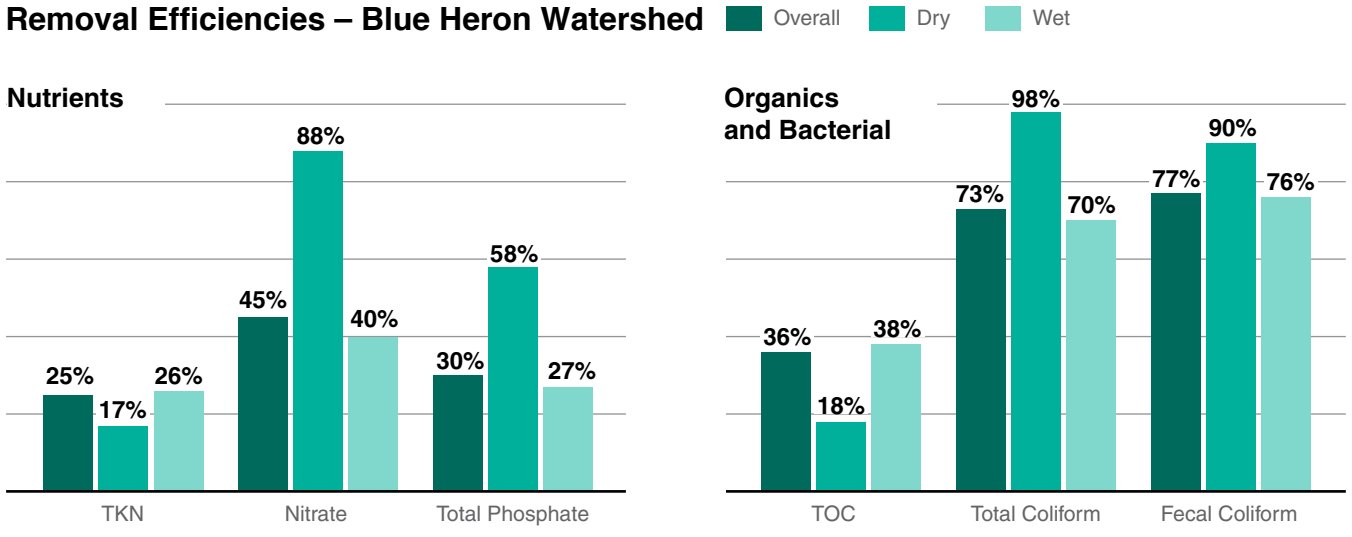
To date, 62 BMPs have been constructed out of a total of 124 planned BMPs, which are part of a capital program that extends to 2043. Many of the BMPs are constructed on New York City and State parkland, and other City-owned properties, but a large scale negotiated acquisition program of wetland properties has served as the backbone of the program.

Due to the success of the Bluebelt system in Southern Staten Island, the Bluebelt program expanded to the Mid-Islands area, where there are more unique challenges such as a combination of very steep topography at the upstream reaches, and very flat topography at the downstream ends, very low lying existing streets and homes, and significant tidal influence on the functionality of the drainage systems during high tide. The first capital project in this area is anticipated for completion in fall of 2017.

Natural habitat creation around structural stormwater controls.

Rough bottom culverts were used to maintain fish passage.

Removal Efficiencies – Blue Heron Watershed



10 Stormwater Monitoring

10.0 Stormwater Monitoring

A successful stormwater monitoring program helps understand stormwater pollution, constituents, concentrations, and particle size, based local conditions and increases the potential for management treatment effectiveness. A successful stormwater monitoring program helps determine BMP effectiveness and steers BMP refinements to ensure the receiving waterbody quality goal is achieved.

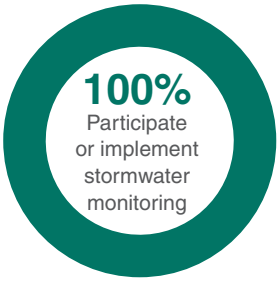
Pollutants originate from many diverse sources and exhibit diverse features such as concentration and size contstituents. Source pollutants can also originate from non-stormwater systems (leaking sanitary sewer systems, basement drains, etc.) or human activities (car washing, used oil disposal, etc.). Receiving waterbody impacts from stormwater pollution can be acute and due to high pollutant concentrations from intense storm events, or chronic and due to sustained pollutant loads.

For example, pollutants can originate from particulate wash-off during a storm event. Pollutant concentrations associated with the wash-off vary significantly based on many parameters including duration from the previous storm event, amount of particulate build up, storm event intensity and duration, population density, and land use. The variability is further amplified because particulates may come from vehicles, pavement materials, and waste.

Not only are pollution sources diverse, the concentration, particle size, constituents, and dilution varies widely.

Most NPDES MS4 regulatory requirements define compliance as “maximum extent practicable”. Implementation of the maximum extent practible standard typically requires the development and implementation of BMPs and the achievement of measurable goals to satisfy each of the six minimum control measures. Some NPDES MS4 compliance requirements direct that the six minimum control measures are assessed during the permit term to ensure that permit compliance and the desired improved water quality improvement is achieved. A comprehensive monitoring program that considers local conditions is needed and important for NDPES MS4 implementation. Each community’s stormwater monitoring program is developed so that specific community conditions are considered.

100% of respondent communities implement stormwater monitoring or are part of a regional stormwater monitoring effort.



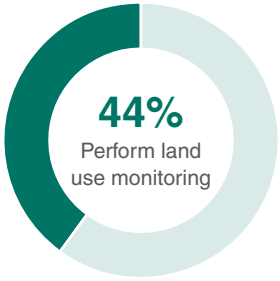
Sampling during a wet weather event in Queens, NY for the CSO LTCP Program

Stormwater Monitoring and Assessment Program

Land Use / Wet-Weather Monitoring

The land use sampling program typically collects runoff in response to a standard storm event (e.g. storm event greater than 0.5 inches after 3 dry days). A typical sample collects the first flush (first 30 minutes) and a composite sample throughout the storm event duration. The first generation of NPDES MS4 permits included land use monitoring requirements for relatively small contributing drainage areas with homogeneous land use. The sampling results were primarily used to understand land use specific pollution sources based on local conditions. Later generations of the NPDES MS4 permits focused the land use sampling program less on the small contributing drainage areas with homogeneous land use and more on larger drainage areas. The results were used to identify trends associated with storm event runoff. Key parameters assessed by the community to develop the land use sampling program include number of sampling locations, frequency of sampling, and sampling methods.

44% of respondent communities implement land use monitoring. The average number of monitoring sites is 5 and the average frequency of monitoring is 7 times annually.



Wet weather sampling for pollutant loadings and bacteria growth testing

Wet weather sampling at outfalls

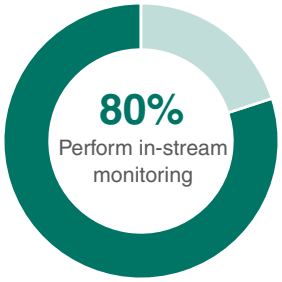
In-stream Monitoring

In-stream sampling programs may collect stream flow samples during ambient flow condition or and wet weather, typically using automated systems. Sample frequency can vary from a relatively frequent sampling period (15 minutes) to a relatively infrequent sampling period (weekly or monthly).

In-stream sampling can be used for two purposes. First, in-stream sampling can help understand the health of the receiving stream, to possibly refine the water quality initiatives and more effectively achieve water quality goals. The results, if collected with the appropriate sampling protocols, can supplement regulatory agency data and be used to support regulatory initatives such as 303(d) listing and TMDL compliance. Second, an in-stream sampling program can also help respond to spills or locate illicit discharges when high pollutant loads are detected.

Selection of the number and frequency of in-stream samples balances sampling collection and laboratory costs with the need for the results to identify spills/illicit discharges and understand the receiving stream health.

80% of the communities implement in-stream monitoring. The average number of monitoring sites is 30 and the average frequency of monitoring is 8 times annually.



In-stream monitoring assessments

Stream Geomorphology Assessment Data and Photo-Documentation
City of Raleigh Sampling and Monitoring Program Report

General Information			Site:
Sampling date:	Sampling time:		
Stream name:	County:	Stream order:	
Latitude:	Longitude:	Method location determined:	
Recent weather conditions:			
Site conditions at time of visit:			
Identify any special waterway classifications known:			
Is there a pond or lake located upstream of evaluation point? ☐ Yes ☐ No			
If yes, estimate the water surface area:			
Does channel appear on USGS quad map? ☐ Yes ☐ No			
Does channel appear on USDA Soil Survey? ☐ Yes ☐ No			
Bankfull width (ft):	Bank height (ft):	Water depth (ft):	
Channel slope down center of stream:	☐ Flat (0 to 2%) ☐ Moderate (4 to 10%)	☐ Gentle (2 to 4%) ☐ Steep (>10%)	
Channel sinuosity:	☐ Straight ☐ Very sinuous	☐ Occasional bends ☐ Braided channel	☐ Frequent meander

DWQ Stream Identification Form				Total Score:
Geomorphology	**Absent**	**Weak**	**Moderate**	**Strong**
Continuous bed and bank	☐ 0	☐ 1	☐ 2	☐ 3
Sinuosity	☐ 0	☐ 1	☐ 2	☐ 3
In-channel structure: riffle pool sequence	☐ 0	☐ 1	☐ 2	☐ 3
Soil texture or stream substrate sorting	☐ 0	☐ 1	☐ 2	☐ 3
Active/relic floodplain	☐ 0	☐ 1	☐ 2	☐ 3
Depositional bars or benches	☐ 0	☐ 1	☐ 2	☐ 3
Braided channel	☐ 0	☐ 1	☐ 2	☐ 3
Recent alluvial deposits	☐ 0	☐ 1	☐ 2	☐ 3
Natural levees	☐ 0	☐ 1	☐ 2	☐ 3
Headcuts	☐ 0	☐ 1	☐ 2	☐ 3
Grade controls	☐ 0	☐ 0.5	☐ 1	☐ 1.5
Natural valley or drainageway	☐ 0	☐ 0.5	☐ 1	☐ 1.5
Second or greater order channel on existing USGS or NRCS map or other documented evidence.	No ☐ 0		Yes ☑ 3	
Geomorphology Subtotal:	28			
Hydrology	**Absent**	**Weak**	**Moderate**	**Strong**
Groundwater flow/discharge	☐ 0	☐ 1	☑ 2	☐ 3
Water in channel and > 48 hrs since rain, or water in channel – dry or growing season	☐ 0	☐ 1	☑ 2	☐ 3
Leaflitter	☐ 1.5	☑ 1	☐ 0.5	☐ 0
Sediment on plants or debris	☐ 0	☐ 0.5	☑ 1	☐ 1.5
Organic debris lines or piles (Wrack lines)	☐ 0	☐ 0.5	☑ 1	☐ 1.5
Hydric soils (redoximorphic features) present?	No ☐ 0		Yes ☑ 1.5	
ology Subtotal:	8.5			
	Absent	Weak	Moderate	Strong

In-stream monitoring stream quality assessment worksheet

Regulations

The regulation that outlines the required NPDES MS4 monitoring is 40 CFR Part 122 – EPA Administered Permit Programs: National Pollutant Discharge Eliminated System.


Great Falls National Park

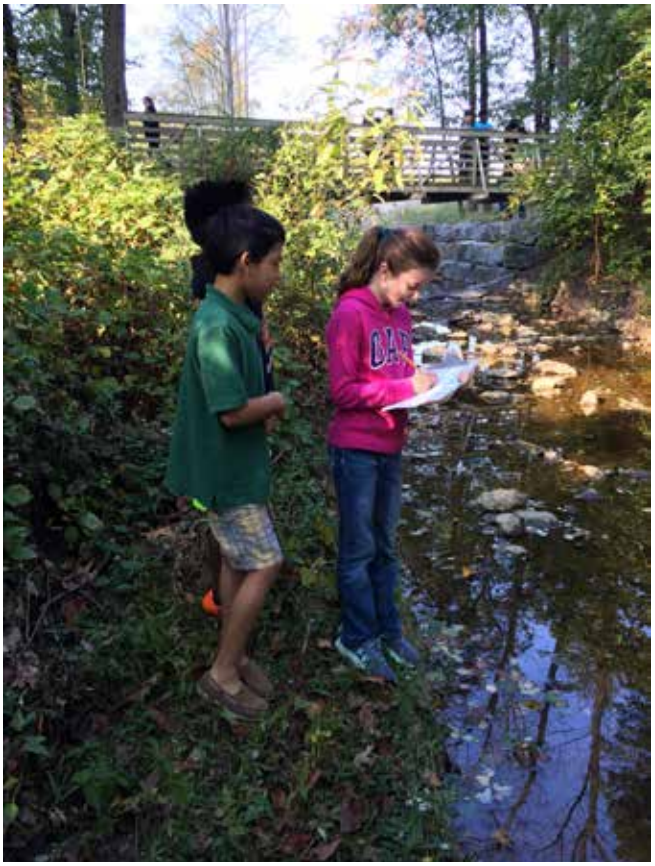
CASE STUDY

Fairfax County, Virginia

As part of Fairfax County's NPDES MS4 Permit, the County is required to implement a dry weather screening program, a wet weather screening program, a biological stream monitoring program, an in-stream monitoring program, and a floatables monitoring program. The County is also required to coordinate the USGS monitoring program.

The dry weather screening program requirements include monitoring areas of concern (such as commercial car washes, car dealerships, pet kennels, restaurants, areas with history of complaints, areas upstream of sensitive ecosystems) and screening at least 100 outfalls each year. The biological stream monitoring program requirements include collecting samples twice annually, once between January 1st and June 30th, and once between July 1st and December 31st, at five stream sites within the County. The in-stream monitoring program is also required at five sites within the county, but the sampling is required once every two months between January 1st and December 31st. The floatables monitoring program is required at five monitoring sites at MS4 outfalls and/or streams receiving MS4 discharges once per quarter and includes counting floatables visually observed and length or area of the sites assessed. The USGS program includes monitoring five sites of continuous TMDL, water quality, and water quantity monitoring.

Fairfax County's monitoring program assess the following: benthic communities, bacteria, pH, conductivity, and fish. Previously, 102 outfalls, 70 benthic monitoring locations, 23 fish containment monitoring locations, 176 bacteria monitoring locations, and 120 stream flow monitoring locations were screened. For the USGS monitoring program, 15 sites were monitored in addition to the original five to provide comparison for the five continuous monitoring sites. None of the additional 15 sites are outfalls. Fairfax also has a hot spot identification program.



Volunteer's performing stream sampling in Fairfax County, VA

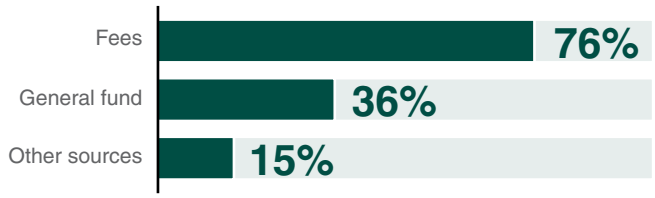
11 Funding Sources and Financial Incentive Programs

11.0 Funding Sources and Financial Incentive Programs

Funds needed to maintain a stormwater system are substantial, and capital improvements increase the required funding levels. Furthermore, NPDES MS4 regulations add compliance goals that also increase the needed funds. Communities are considering additional investments to implement comprehensive stormwater management programs.

Common funding mechanisms used are stormwater utility fees, water/sewer fees, general funds, grant funds, and municipal bonds. The most successfully comprehensive stormwater programs are typically funded using "dedicated" funds that are provided at a "steady" level. Funds that are "dedicated" and "steady" allow the stormwater manager to plan and implement stormwater projects and programs that have typical durations longer than one year. Water/sewer fees generate revenue based on each customer's use of the potable water and sewer system and typically are "dedicated" and "steady". A stormwater utility is a "dedicated" and "steady" fee, and is therefore a common funding source for many established stormwater programs.

All of the communities that have substantial budgets for stormwater management are primarily funded through water and sewer fees, stormwater fees, and/or general funds.



Funding Sources and Budget

Historically, the majority of communities funded operation of the stormwater system through the general fund (typically from property taxes) or the sewer utility. Most stormwater programs competed with other community programs such as police, fire, transportation, schools, etc. for general fund allocations because those programs were more visible to the customers/citizens. Stormwater systems were typically underground, not visible to the community, and only received attention when the system failed. Therefore, many stormwater program initiatives were a high priority only when the deficiencies were visible to the community such as after a large flood event or major infrastructure disaster. As a result, many stormwater programs were under-funded, and experienced funding levels that varied significantly from year to year.

A dedicated and steady funding source ensures that the community balances its interest in the stormwater management program with other community facilities and utilities programs such as streets, water/sewer, police, etc. Setting the annual funding levels so that the short- and long-term stormwater management program needs are addressed is critical to success of the program.

Private property has an impact on stormwater management and the associated impact to water quality. Stormwater fees are one potential source of funding to connect private property and fund community programs to mitigate negative impacts from stormwater runoff.

Stormwater Fee Basis

The concept of a stormwater utility is that each customer pays a fee based on the property's impact on the stormwater system. An undeveloped lot is typically not charged a stormwater fee. Factors that increase runoff and thereby the need for a storm drainage system include imperviousness, land use, soil type, land slope, zoning, and building type.

67% of respondent communities use an impervious-based stormwater utility.

67%
Impervious-based stormwater utility

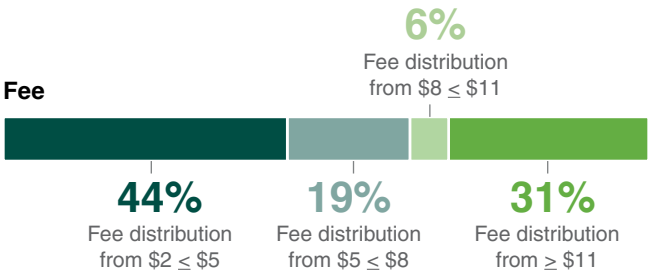
28%
Flat rate utility

6%
Development intensity-based stormwater utility

Average Monthly Residential Stormwater Fee

For residential property, stormwater fees are typically flat rate based on the impervious surface area, commonly using a single unit produced by the utility for the purpose of measuring fees, known as an equivalent residential unit. Residential stormwater fees can also be distributed in several tiers to increase the accuracy of the fee charged to the impact of the property without a substantial increase in the administrative effort. Monthly rates are determined based on two factors: needed stormwater investment and community's desire to address that needed investment.

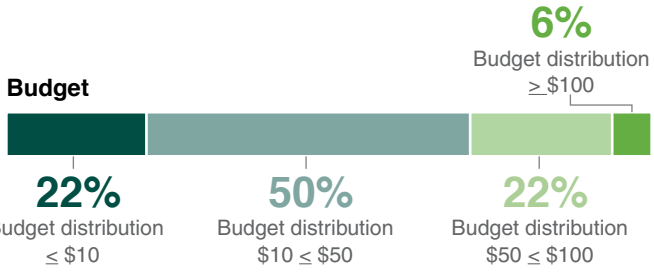
The average monthly residential stormwater fee is $8.79 for the communities that utilize a stormwater fee.



Annual Budget Per Capita

Annual budgets reflect the community's need and commitment to support the stormwater program. Some communities are large and/or have a significant backlog of projects and therefore have allocated relatively large budgets. Communities that are smaller or without a significant backlog allocate smaller budgets.

The average annual stormwater budget per person is $43.32 for the communities with a dedicated funding source.



Regulations

The regulation that outlines the required NPDES MS4 fiscal resources is 40 CFR Part 122 – EPA Administered Permit Programs: National Pollutant Discharge Eliminated System.

Financial Incentive Programs

Many communities implement financial incentive programs such as fee credits or grants to reward citizen actions that reduce stormwater impact to the drainage system and therefore reduce the needed public investment.

Stormwater Fee Credit Program

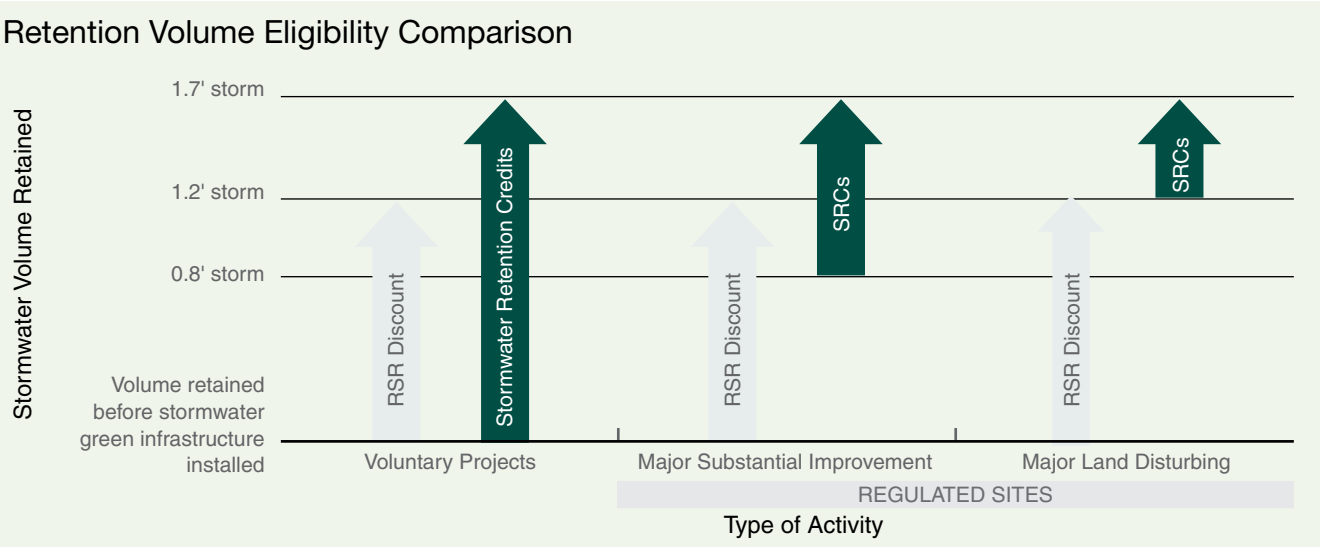
A fee credit or incentive program is used by communities to meet the basic utility tenet so customers can control their use of the stormwater system. A fee credit system increases awareness of stormwater infrastructure. The credit system typically requires the customer to install and maintain a stormwater control feature (rain garden, cistern, detention basin, etc.) that reduces the property's generation of stormwater and/or impact to the stormwater system. The fee credit system is typically developed so that a feature's ability to reduce the stormwater impact is proportional to the fee credit.

62% of the respondent communities with stormwater fees offer a stormwater fee credit program. The average maximum fee credit available is 70% of the stormwater fee.

Off-Site Mitigation and Fee-In-Lieu Of Programs

Development diversity influences the ease at which a project can comply with the post-construction stormwater ordinance. Ultra-urban areas with only opportunities for re-development projects contain sites where installation of structural BMP installation may be challenging. Mitigation and fee-in-lieu programs provide the owner flexibility to deal with challenging site conditions by installing structural controls off-site or paying into a fund for structural control installation in other areas. Some communities support mitigation banks that are funded by private organizations. The privately-funded mitigation bank constructs and maintains BMPs and sells the credits to developers.

Over 64% of respondent communities consider alternatives for post-construction stormwater management. The alternatives include offsite mitigation, mitigation banks, and fee-in-lieu of programs.

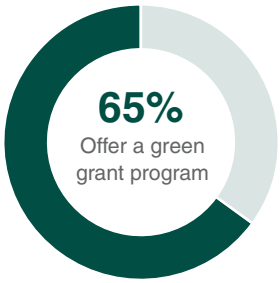


Washington D.C. Stormwater Retention Credits (SRC) and RiverSmart Rewards (RSR) comparison

Green Infrastructure Grant Program

Some communities utilize financial incentive programs and grant programs to motivate customers to install green infrastructure on their private property. These programs allow for utilities to provide financial assistance for the implementation of these practices and encourages private property owners to implement larger facilities that provide more benefit for the overall system. Typical grant programs are used to encourage the implementation of green solutions with multiple co-benefits as opposed to standard gray solutions such as detention basins.

65% of respondent communities offer a green infrastructure grant program.



Funds are awarded at two levels

	Medium Project	Large Projects
Award Size	$15,000–$40,000	$40,001–$100,000
Project Duration	9–12 months	12–18 months
Match Requirements	35% match	25% match and demonstrated history of successful project implementation

San Francisco has two green infrastructure grant programs, with one focused on implementation at public schools

The Brooklyn Navy Yard was the recepient of a green infrastructure grant to build its green roof.

CASE STUDY

Halifax Regional Municipality, Nova Scotia

The Halifax Regional Water Commission (HRWC) charges all customers a stormwater fee for site-related flow leaving their properties and a right-of-way charge to the Halifax Regional Municipality for stormwater leaving the right-of-way and entering the HRWC stormwater system. HRWC recently received approval to change the stormwater fee rate system for residential customers from a flat rate to a tiered system. The tiered system will be based on an equivalent residential unit (ERU) which is based on the median impervious area associated with residential properties.

The new fee system is proposed to reduce the majority of residential customers' annual site-related flow charge and to charge each unit based on the contribution it makes to the stormwater system. The non-residential customers are charged a fee based on an exact calculation of impervious area. All customers will be billed per ten square meters, as opposed to the previous legislation of per one square meter. This change has made to reduce the impact of small measurement errors and to prevent perceived precision associated with the one square meter. The current right-of-way charge is an annual flat fee of $42 (Canadian Dollars) used to help fund the municipality's share of the repairs and maintenance of the stormwater systems that control water runoff from municipal roads.

HRWC has received approval to implement a credit system for non-residential properties that control peak stormwater runoff from their sites with best management practices allowing them to reduce stormwater bills. The credit program requires that non-residential properties install BMPs designed by qualified professionals and provide stamped and signed documentation to receive a 30% to 50% credit on their stormwater bill. Residential properties do not qualify for stormwater credits. The credit must also be applied for annually and requires confirmation that the system was maintained and cleaned as per recommendations from qualified professionals or the manufacturer.

Mixed use area within the City of Halifax

CASE STUDY

Baltimore County, Maryland

The State of Maryland previously required 10 large communities to collect stormwater fees per State Legislation. The law applied to Baltimore City and Baltimore, Carroll, Hartford, Howard, Anne Arundel, Frederick, Montgomery, Prince George's and Charles Counties. The State Legislation repealed the requirement in recent years.

In addition to the general fund contributions, Baltimore County's stormwater program was previously partially funded by a flat rate fee for residential and impervious-base fee for Commercial/Industrial (Stormwater Remediation Fee). The initial single-family fee was $26/year. The Commercial/Industry fee was $23 per 1,000 square feet per year. The general fund contribution was approximately $10 million and the FY2016 stormwater fee generated approximately $16 million revenue. In addition, the County was successful in obtaining state and federally-funded grants for implementation of restoration projects.

Previously, fee credits were available as part of the stormwater fee program. The fee credit percentage was based on efficiency of total nitrogen and total phosphorus removal. The fee credits provided financial incentives for private property owners to implement stormwater best management practices. With a change in state legislation, Baltimore County has repealed their stormwater fee, effective at the start of Fiscal Year 2017/2018, with reductions in Fiscal Year 2017.

Residential property in Baltimore County

CASE STUDY

Philadelphia, Pennsylvania

The Philadelphia Water Department (PWD) charges a stormwater fee based on two parameters: the average Gross Area (GA) square footage and the average Impervious Area (IA) square footage for all residential properties. Non-residential and condominium properties are charged based on the property's specific GA and IA, while residential properties are charged based on the city-wide average GA and IA for a residential parcel.

All non-residential property owners and condominium owners associations can reduce their stormwater management fee by installing stormwater management controls and receiving stormwater credits. PWD offers three types of credits: impervious area credits, gross area credits, and NPDES credits for industrial stormwater discharge activities. The Impervious Area credit is a result of reducing the amount of impervious area through tree canopy cover, disconnected downspouts, pavement disconnections, green roofs, and porous pavement are eligible to customers who demonstrate compliance with PWD's Impervious Area Reduction criteria in managing the first inch of runoff.

The Gross Area credit is achieved by management of the first-inch of runoff for impervious area or by demonstrating a Natural Resource Conservation Service Curve Number that meets one of the values contained in the Curve Number Scale. This credit rewards high quality open spaces for infiltration. The NPDES Credit is given to active NPDES permit holders for industrial stormwater discharge and a history of compliance with the permit for the preceding twelve months.

PWD offers grant programs as financial incentives for qualified non-residential PWD customers and contractors to encourage stormwater best management practices implementation on private property. The Stormwater Management Incentive Program (SMIP) is a competitive grant for $100,000 or less per impervious acre to manage at least the first 1" of runoff. Recipients are chosen based on criteria including total volume of stormwater managed, cost competitiveness, and other environmental and educational benefits. The Greened Acre Retrofit Program (GARP) provides funding to companies or project aggregators who develop a stormwater management plan on properties that are 10 acres or larger within the combined sewer service area.

One year into the parcel-based fee for stormwater, the Stormwater Customer Assistance Program (CAP) was introduced. It limits eligible non-residential customer's accounts to no more than a 10% increase each rate period. This program helped abate high year-to-year rate increases that a customer would see as a result of the phase-in of parcel-based fees and the phase-out of meter-based fees for stormwater.

Apartment parking lot with pervious paving

CASE STUDY

Washington D.C.

Property owners in Washington D.C. (the District) pay stormwater fees based on the amount of impervious surface on their property. By installing runoff-reducing green infrastructure, a property owner can earn a discount on these stormwater fees.

Properties that voluntarily retrofit with GI can earn Stormwater Retention Credits (SRCs) that can be sold to properties that are subject to the District's stormwater management regulations. SRC-generating sites list their SRCs for sale on Department of Energy and Environment's (DOEE) SRC Registry, and regulated sites seeking credits contact SRC owners to negotiate a trade. To date, 11 trades have occurred, with a value of approximately $110,000.

In 2017, DOEE is rolling out a SRC Purchase Program whereby DOEE, working through a third party grantee, will agree to purchase SRCs from newly installed GI in priority areas of the District that maximize benefits to District waterbodies. The SRC Purchase Program will effectively establish an SRC price floor by providing greater certainty about the revenue that can be earned from new SRC-generating projects. As a result, DOEE expects the program to engage and leverage private capital investments in GI in priority areas of the District. This private investment has already begun in anticipation of the SRC Purchase Program, with Prudential Investments investing $1.7 million for GI projects with District Stormwater LLC, an SRC aggregator.

More information is available at
http://doee.dc.gov/riversmartrewards
http://doee.dc.gov/src

Washington D.C. also offers rebates for private property owners who install green roofs, rain barrels, newly planted trees, and stormwater management facilities to manage impervious surface. The rebates are as follows:

- $10 per square foot rebate for green roofs.
- $2/gallon rebate for rain barrels larger than 50 gallons.
- $50 per tree for small and medium canopy trees and $100 per tree for large canopy trees.
- $10 per square foot rebate for the replacement of impervious surfaces with pervious paving and a $5 per square foot rebate for the replacement of impervious surfaces with vegetation.
- $3 per impervious square foot treated by rain gardens on single-family properties.

Appendix 1: Utility Snapshots

Arlington County, VA
Atlanta, GA
Aurora, CO
Baltimore County, MD
Baltimore, MD
Boston, MA
Chicago, IL
Cincinnati, OH
Fairfax County, VA
Fort Lauderdale, FL
Houston, TX
Indianapolis, IN
King County, WA
Lincoln, NE
Los Angeles, CA
Milwaukee, WI
Minneapolis, MN
Nashville, TN
Northeast Ohio Regional Sewer District (NEORSD)
New Orleans, LA
New York, NY
Onondaga County, NY
Philadelphia, PA
Portland, OR
Richmond, VA
San Francisco, CA
Sanitation District (SD-1), KY
Seattle, WA
Washington D.C
Toronto, Canada
Copenhagen, Denmark
Melbourne, Australia
Halifax, Canada

Arlington County, VA

Sewer System Type

Separate
100%

Land Use

Residential
49%

Open space
30%

Other
21%

Participating Organization:
Arlington County – Department of Environmental Services

2010 Census Population	**208,000**
Population Density (per square mile)	**8,800**
Population Growth (2000-10)	**>5.0%**
Sanitary Sewer Pipes	**465 miles**
Storm Sewer Pipes (Separate system only)	**373 miles**

Regulatory Requirement

NPDES Phase I MS4 Permit

Administering Body

Arlington County

Impairments & TMDLs

Nutrients	Sediment	Bacteria	Metals	Trash	Other
●		●			●

Unique Features

- **Nutrient Trading Program:** Considers the reduced nutrient loads associated with Waste Water Treatment Plant improvements in conjunction with nutrient load reductions associated with stormwater improvement projects.
- **StormwaterWise Landscapes Program**: Provides financial incentives for homeowners to install green infrastructure on their property.
- **Stormwater Master Plan:** Recommends total phosphorus reduction in response to Chesapeake Bay requirements including:

  51 percent from stream restoration projects,
  6 percent from beaver pond refinements,
  25 percent from watershed retrofits,
  4 percent from street sweeping, and
  13 percent from re-development

Atlanta, GA

Sewer System Type

Combined **8%**

Separate **92%**

Land Use

Residential **32%**

Open space **12%**

Other **55%**

Participating Organizations:
City of Atlanta – Department of Watershed Management

2010 Census Population	**420,000**
Population Density (per square mile)	**3,300**
Population Growth (2000-10)	**>1.0%**
Sanitary Sewer Pipes (incl. combined)	**2,150 miles**
Storm Sewer Pipes (Separate system only)	**122 miles**

Regulatory Requirement	Administering Body
NPDES Phase I MS4 Permit	Department of Watershed Management
EPA CSO and SSO Consent Order	Department of Watershed Management

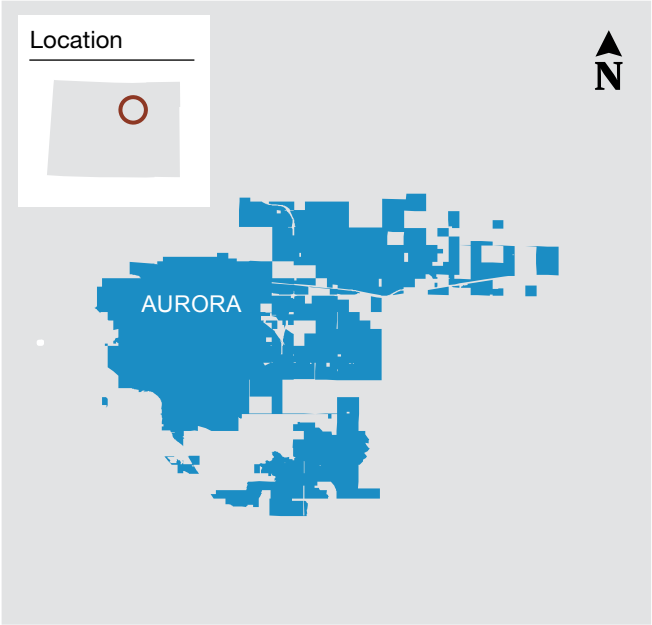
Impairments & TMDLs

Nutrients	Sediment	Bacteria	Metals	Trash	Other
	●	●	●		●

Unique Features

- **Greenway Acquisition Project:** Invests $25 million to acquire and protect properties adjacent to selected impaired rivers and creeks.
- **Upper Proctor Creek Watershed Action Plan:** Invests $50 million to improve water quality in an 18 square mile watershed through water and wastewater infrastructure improvements, combined sewer capacity relief, stormwater improvements, and community public space enhancements.

Aurora, CO



Sewer System Type

Separate
100%

Land Use

Residential **13%**
Open space **9%**
Other **78%**

Participating Organizations:
Aurora Water

2010 Census Population	**325,000**
Population Density (per square mile)	**2,300**
Population Growth (2000-10)	**>20%**
Sanitary Sewer Pipes	**NA**
Storm Sewer Pipes (Separate system only)	**NA**

Regulatory Requirement

NPDES Phase I MS4 Permit

Administering Body

City of Aurora

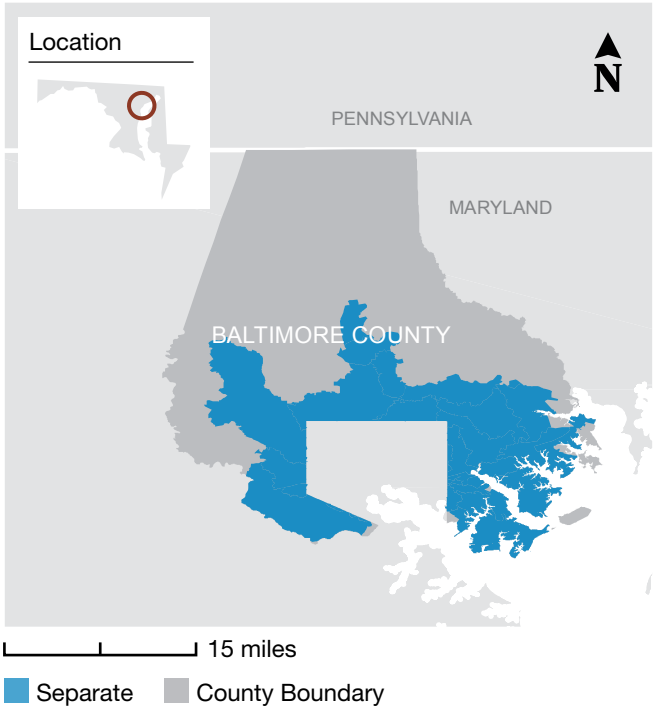
Impairments & TMDLs

Nutrients	Sediment	Bacteria	Metals	Trash	Other
		●			●

Unique Features

- **Watershed-Specific Fees**: Implements the Cherry Creek Basin fee as $60.00 per residential lot or $0.04 per square impervious foot for other land uses and the Center City Detention Pond fee as between $1,448 and $1,948, dependent on watershed location.
- **Regional Solutions:** Coordinates with the Urban Drainage and Flood Control District (UDFCD) to provide Stormwater design guidance, master planning services, floodplain management guidance, and flood warning for the region's 39 cities. UDFCD encourages regional approaches (watersheds larger than 130 acres) for flood reduction and distributed/on-site controls for water quality improvement.

Baltimore County, MD



Sewer System Type

Separate
100%

Land Use

Residential
16%

Open space
56%

Other
28%

Participating Organizations:
Baltimore County – Department of Environmental Protection and Sustainability

2010 Census Population	**805,000**
Population Density (per square mile)	**1,400**
Population Growth (2000-10)	**>5%**
Sanitary Sewer Pipes	**3,150 miles**
Storm Sewer Pipes (Separate system only)	**1,400 miles**

Regulatory Requirement	Administering Body
NPDES Phase I MS4 Permit	Department of Environmental Protection and Sustainability
EPA SSO Consent Order	Department of Public Works

Impairments & TMDLs

Nutrients	Sediment	Bacteria	Metals	Trash	Other
●	●	●	●	●	●

Unique Features

- **Floatable Monitoring Program:** Performs a floatable monitoring program that includes the monitoring of outfalls, land use, and percent imperviousness to determine large contributors to trash loads. Land use and imperviousness resulted in a better correlation than the outfall monitoring.
- **Fee-in-lieu:** Approved 30 fee-in-lieu projects which generated approximately $444,000 for the implementation of other projects.
- **Watershed Restoration:** Implemented a total of 3,233 stormwater treatment facilities (serving 35,470 acres/23 percent of the County).

Baltimore, MD

Sewer System Type

Separate
100%

Land Use

Residential **17%**
Open space **20%**
Other **63%**

Participating Organizations:
City of Baltimore – Department of Public Works (Bureau of Water of Wastewater)

2010 Census Population	**621,000**
Population Density (per square mile)	**6,800**
Population Growth (2000-10)	**>-4%**
Sanitary Sewer Pipes	**1,400 miles**
Storm Sewer Pipes (Separate system only)	**1,200 miles**

Regulatory Requirement	Administering Body
NPDES Phase I MS4 Permit	Department of Public Works (Bureau of Water and Wastewater)
EPA SSO Consent Order	Department of Public Works (Bureau of Water and Wastewater)

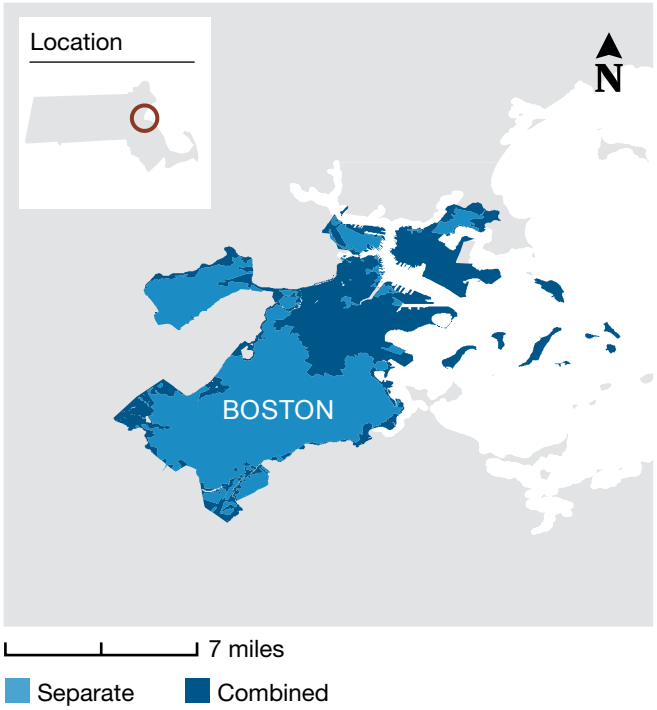
Impairments & TMDLs

Nutrients	Sediment	Bacteria	Metals	Trash	Other
●	●	●	●	●	●

Unique Features

- **Floatable Reduction Effort:** Performs an inventory of existing trash reduction programs, implementation of a trash reduction education program, and annual program effectiveness assessment. Installed 760 storm drain inlet screens and inserts to trap trash for storm events of smaller than 1-inch rain.
- **Tree Planting**: Reforests and plants trees to meet a goal of 40 percent tree canopy cover. Targets 4,000 lots for restoration over the next 10 years.
- **Fee Credit:** Provides single-family property fee credits based on participation in a public projects quality such as trash clean-up or tree planting. The owner receives a credit of $10/year for every 8 hours of participation.

Boston, MA



Sewer System Type

Combined **25%**

Separate **75%**

Land Use

Residential **18%**

Open space **10%**

Other **72%**

Participating Organizations:
Massachusetts Water Resources (MWRA), Boston Water and Sewer Commission (BWSC)

2010 Census Population	**617,000**
Population Density (per square mile)	**13,700**
Population Growth (2000-10)	**>1%**
Sanitary Sewer Pipes (incl. combined)	**700 miles**
Storm Sewer Pipes (Separate system only)	**665 miles**

Regulatory Requirement	Administering Body
NPDES Phase I MS4 Permit	Boston Water and Sewer Commission
EPA CSO Consent Order	Boston Water and Sewer Commission

Impairments & TMDLs

Nutrients	Sediment	Bacteria	Metals	Trash	Other
●					

Unique Features

- **Sewer Lateral Assistance Program:** Incentivizes leaking sewer lateral elimination through financial assistance for property owners.
- **Illicit Discharge Elimination:** Executed four consultant contracts to perform illicit discharge investigation and elimination ($7.8 million investment).
- **Illicit Discharge Elimination**: Tested numerous different methods to identify IDDE including dogs, televising, dye testing, fiber optic heat sensors, etc.
- **Industrial Facility Stormwater Pollution Prevention Program:** Enforces through identification, inspection, monitoring and enforcement of any industry that contributes a pollutant of concern. 90 percent of all industries are inspected once every 2 years.
- **Stormwater Design Manual:** Requires matching pre-development annual groundwater recharge volume, and 80 percent TSS removal for the 1-inch storm event. Requires special BMP designs for land uses with high pollutant load potential such as industrial, vehicle maintenance yards, and heavy equipment storage.

Chicago, IL

Sewer System Type

Combined **99.5%**

Separate **.5%**

Land Use

Residential **41%**

Open space **7%**

Other **52%**

Participating Organizations:
Chicago Metropolitan Water Reclamation District of Greater Chicago, City of Chicago – Department of Water Management

2010 Census Population	**2,696,000**
Population Density (per square mile)	**11,600**
Population Growth (2000-10)	**>-6.9%**
Sanitary Sewer Pipes (incl. combined)	**5,000 miles**
Storm Sewer Pipes (Separate system only)	**NA**

Regulatory Requirement	Administering Body
NPDES Phase I MS4 Permit	City of Chicago
EPA CSO Consent Order	City of Chicago

● Impairments & ● TMDLs

Nutrients	Sediment	Bacteria	Metals	Trash	Other
●		●	●		●

Unique Features

- **Tunnel and Reservoir Plan:** Constructs a deep tunnels and reservoirs for the purposes of capturing, conveying, and storing sewage and stormwater during CSO events. Altogether, the system will have a capacity estimated at 22.3 billion gallons upon completion.
- **Building a New Chicago Plan:** Replaces hundreds of miles of water mains and sewer mains and incorporate green infrastructure practices.
- **Green Programs:** Commits $50 million to:
  - Manage an inlet control system to relieve basement flooding and slow the flow of stormwater into the sewer system.
  - Install over 200 Green Alleys, which includes over 330,000 square feet of permeable pavement.
  - Plants over 70,000 trees along public roadways.
  - Install 350 green or vegetated roofs totaling over 5,500,000 square feet of surface area throughout Chicago.

Cincinnati, OH

Sewer System Type

Combined **40%**

Separate **60%**

Land Use

Residential **44%**

Open space **12%**

Other **44%**

Participating Organizations:
Metropolitan Sewer District of Greater Cincinnati – Storm Water Management, Hamilton County Storm Water District, City of Cincinnati – Stormwater Managment Utility

2010 Census Population	**297,000**
Population Density (per square mile)	**3,700**
Population Growth (2000-10)	**>-11%**
Sanitary Sewer Pipes (incl. combined)	**3,000 miles**
Storm Sewer Pipes (Separate system only)	**300 miles**

Regulatory Requirement	Administering Body
NPDES Small Municipal MS4 General Permit	City of Cincinnati
EPA CSO and SSO Consent Order	Hamilton County Board of Commissioners and the City of Cincinnati

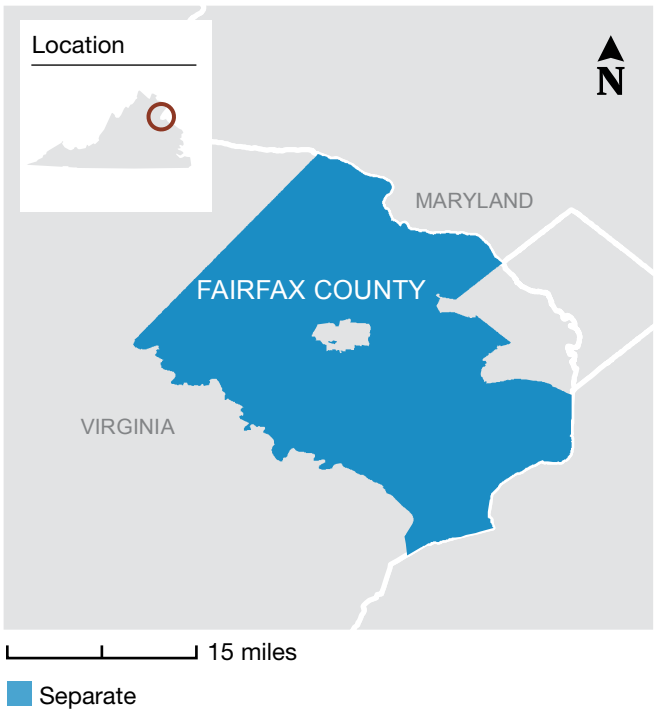
Impairments & TMDLs

Nutrients	Sediment	Bacteria	Metals	Trash	Other
		●			●

Unique Features

- **SSO/CSO Consent Decree:** Includes approximately 300 projects representing a total investment of $3.0 billion. Key stormwater projects include:
  - *Cincinnati Zoo* - pervious pavement, rainwater harvesting, green roofs, and bioswales.
  - *Cincinnati Public Schools* - pervious pavement, green roofs, urban planters, rain gardens, and bioswales.
  - *Red Cross Facility* - green roofs and bioswales.
- **Integrated Plan:** Implements the Lower Mill Creek plan which was developed using an integrated watershed-based approach. Revised the original plan (deep, large underground storage tunnel) with stormwater separation, green infrastructure, stormwater system day-lighting, and recreational/green space creation.
- **Septic Tank Program:** Reduces pollution from septic tanks through inspection and enforcement actions an as part of NPDES MS4 program.

Fairfax County, VA



Sewer System Type

Separate
100%

Land Use

Residential
50%

Open space
30%

Other
20%

Participating Organizations:
County of Fairfax – Department of Public Works and Environmental Services – Stormwater Managment Division, Wastewater Management Division

2010 Census Population	**1,082,000**
Population Density (per square mile)	**2,800**
Population Growth (2000-10)	**>10%**
Sanitary Sewer Pipes	**3,200 miles**
Storm Sewer Pipes (Separate system only)	**1,500 miles**

Regulatory Requirement

NPDES MS4 Permit

Administering Body

County of Fairfax

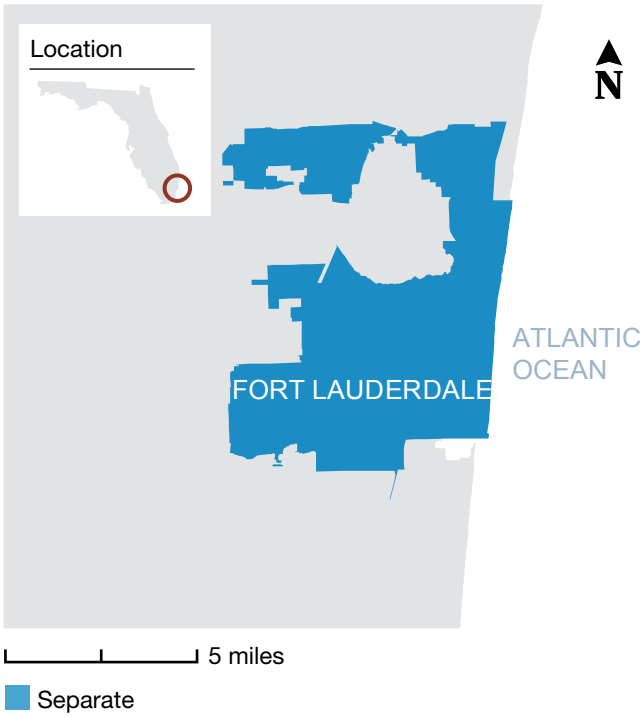
● Impairments & ● TMDLs

Nutrients	Sediment	Bacteria	Metals	Trash	Other
●	●	●	●		●

Unique Features

- **Watershed Plans:** Completed 13 watershed plans that recommend 1,700 structural and non-structural BMPs.
- **Regional Facilities:** Only implements wet ponds, extended detention ponds, and wetlands in residential developments as regional facilities (receiving drainage areas larger than 100 acres). Provides public maintenance for all regional ponds. Provides a fee-in-lieu of program by allowing developers to contribute a prorated amount.
- **Stream Restoration:** Recognizes stream restoration as one of the most cost effective methods of achieving compliance with the Chesapeake Bay TMDL.

Fort Lauderdale, FL



Sewer System Type

Separate
100%

Land Use

Residential **11%**
Open space **13%**
Other **76%**

Participating Organizations:
City of Fort Lauderdale – Department of Public Works – Sustainability Division

2010 Census Population	**166,000**
Population Density (per square mile)	**4,800**
Population Growth (2000-10)	**>3%**
Sanitary Sewer Pipes	**503 miles**
Storm Sewer Pipes (Separate system only)	**171 miles**

Regulatory Requirement

NPDES MS4 Permit

Administering Body

City of Fort Lauderdale

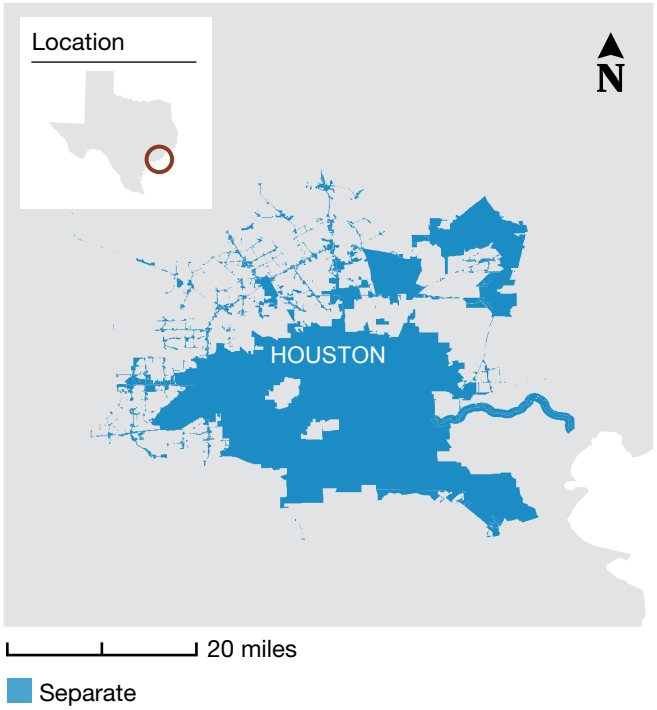
Impairments & TMDLs

Nutrients	Sediment	Bacteria	Metals	Trash	Other
●		●			●

Unique Features

- **Master Plan:** Updated the City-wide Stormwater Master Plan to assess climate change and sea level rise.
- **Illicit Discharge Elimination:** Performs illicit discharges testing in the receiving waterbody because many of the outfall elevations are below permanent pool elevation or tidal influence.
- **South Florida Water Management District (SFWMD):** The portion of the drainage system is operated by the SFWMD through a system of pump stations and spillways. SFWMD performs stormwater management and protects water supplies for more than 31 cities.

Houston, TX



Sewer System Type

Separate
100%

Land Use

Residential **19%**
Open space **1%**
Other **80%**

Participating Organizations:
City of Houston Department of Public Works - Street and Drainage Division

2010 Census Population	**2,099,000**
Population Density (per square mile)	**3,700**
Population Growth (2000-10)	**>7.5%**
Sanitary Sewer Pipes	**6,100 miles**
Storm Sewer Pipes (Separate system only)	**3,800 miles**

Regulatory Requirement

NPDES MS4 Permit

Administering Body

City of Houston

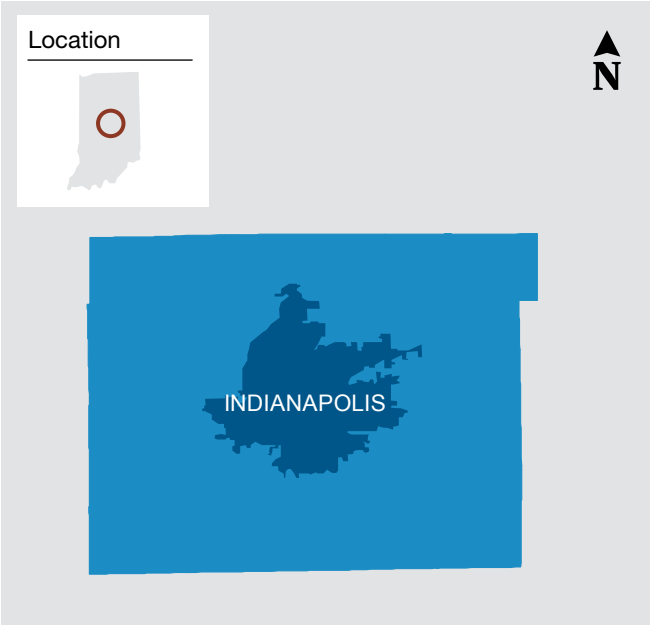
Impairments & TMDLs

Nutrients	Sediment	Bacteria	Metals	Trash	Other
		●			

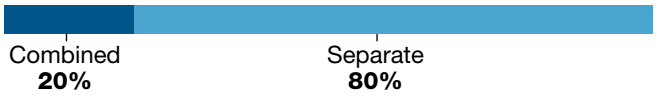
Unique Features

- **Local Drainage Projects (LDP) Program:** This program addresses localized stormwater drainage issues identified directly by property owners where "simple" solutions will resolve the problem. $25 million has been dedicated from 2015 to 2019 to resolve these problems.
- **Stormwater Capacity Availability:** Requires a certification that the downstream drainage system is available and has adequate capacity. Development is not allowed until existing drainage infrastructure is improved to sufficient capacity.
- **Clear Water Clear Choice:** Participates in a joint task force of the four co-permittees (City of Houston, Harris County, Harris County Flood Control District, and Texas Department of Transportation) on the Phase I NPDES MS4 Permit. The joint approach provides consistency and efficiency in stormwater management program implementation and management regionally.

Indianapolis, IN



Sewer System Type



Land Use

Participating Organizations:
City of Indianapolis – Department of Public Works, Citizen Energy Group

2010 Census Population	**820,000**
Population Density (per square mile)	**500**
Population Growth (2000-10)	**>1%**
Sanitary Sewer Pipes (incl. combined)	**3,000 miles**
Storm Sewer Pipes (Separate system only)	**NA**

Regulatory Requirement	Administering Body
NPDES MS4 Phase I Permit	City of Indianapolis
EPA CSO Consent Order	City of Indianapolis

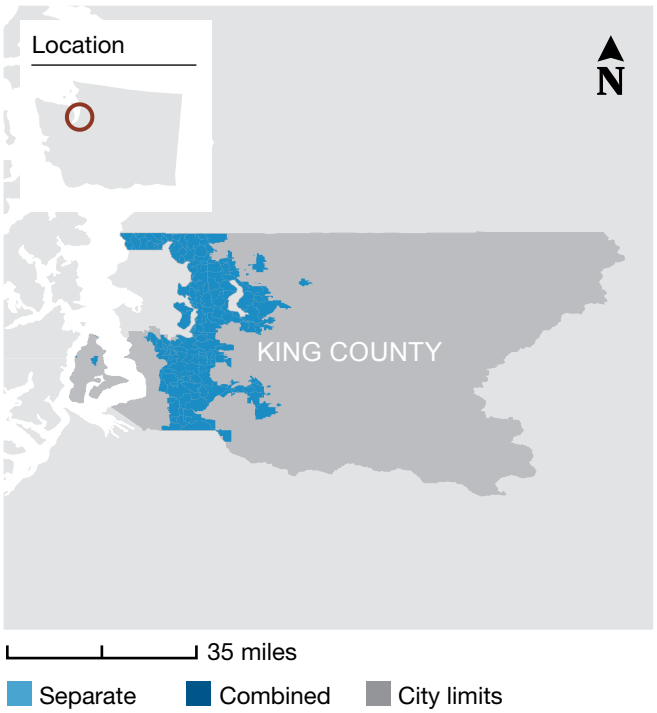
● Impairments & ● TMDLs

Nutrients	Sediment	Bacteria	Metals	Trash	Other
●		●			●

Unique Features

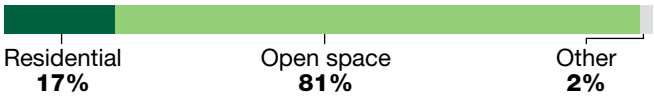
- **Gas Station and Restaurant Inspection Program:** Inspects ten facilities of each type per year to determine trends associated with frequency of trash, vehicle residue, and grease. Results are considered for managing the 1,421 gas stations and restaurant facilities throughout Indianapolis.
- **Green Infrastructure Grant Program:** Distributes $100,000 annually to organizations that utilize green infrastructure. The maximum grant award is $20,000 (with 20 percent matching contribution).

King County, WA



Sewer System Type

Land Use



Participating Organizations:
King County – Department of Natural Resources and Parks

2010 Census Population	**1,931,000**
Population Density (per square mile)	**1,000**
Population Growth (2000-10)	**>10%**
Sanitary Sewer Pipes (incl. combined)	**391 miles**
Storm Sewer Pipes (Separate system only)	**NA**

Regulatory Requirement	Administering Body
NPDES Phase I MS4 Permit	King County
NPDES Phase II MS4 Permit	King County
EPA CSO Consent Order	King County

● Impairments & ● TMDLs

Nutrients	Sediment	Bacteria	Metals	Trash	Other
	●				●

Unique Features

- **Post Construction Ordinance:** Includes three possible flood control targets and five possible water quality targets determined by an assessment of the receiving watershed.
- **Seattle and King County Long Term Control Plan:** Provides options for watershed plans to be developed by the development community so that regional improvements are implemented. Watershed plans can recommend improvements in adjacent watersheds.

Lincoln, NE

Sewer System Type

Separate
100%

Land Use

Residential
17%

Open space
75%

Other
8%

Participating Organizations:
City of Lincoln – Public Works and Utilities Department, Lower Platte South Natural Resources District

2010 Census Population	**259,000**
Population Density (per square mile)	**NA**
Population Growth (2000-10)	**>10%**
Sanitary Sewer Pipes	**1,000 miles**
Storm Sewer Pipes (Separate system only)	**NA**

Regulatory Requirement

NPDES Phase I MS4 Permit

Administering Body

City of Lincoln

Impairments & TMDLs

Nutrients	Sediment	Bacteria	Metals	Trash	Other
●		●	●		●

Unique Features

- **Fee Credit Transfers:** Allows fee credits based on volume (acre feet) that are greater than post construction stormwater management requirements. Such credits can be transferred, traded or sold; however, the credits must be used within the same watershed from which they were obtained.
- **Compensatory Floodplain Storage:** Requires preservation of floodplain storage at a 1 to 1 ratio for areas outside to the minimum floodplain corridor. Requires compensatory storage at a 1.5 to 1 ratio for areas inside the minimum floodplain corridor.
- **Watershed Management Plans:** Considers watershed-specific goals including strategically-located regional stormwater storage facilities. The regional facility sites are reserved before development occurs, when possible. Funding mechanisms are developed to allow joint

Los Angeles, CA

Sewer System Type

Separate
100%

Land Use

Residential
50%

Open space
27%

Other
23%

Participating Organizations:
City of Los Angeles – Bureau of Sanitation: Watershed Protection Program

2010 Census Population	**3,793,000**
Population Density (per square mile)	**7,800**
Population Growth (2000-10)	**>15%**
Sanitary Sewer Pipes	**4,700 miles**
Storm Sewer Pipes (Separate system only)	**1,800 miles**

Regulatory Requirement

NPDES Phase I MS4 Permit

Administering Body

Los Angeles County

Impairments & TMDLs

Nutrients	Sediment	Bacteria	Metals	Trash	Other
●		●	●	●	●

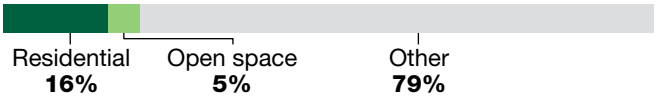
Unique Features

- **Fee Credit Trading:** Developing a credit banking system for larger properties (5,000 square feet) to exceed standard stormwater management requirements. The credit banking system allows projects to build all the stormwater management practices on-site or use the right-of way. If the right-of-way is used, the project is required to manage the additional runoff that would be normally managed in the right-of-way.
- **Base Flow Treatment:** Implemented a program that allows base flow to enter the sanitary sewer system and WWTP.
- **Floatable TMDL:** Requires 100 percent reduction over a 10-year period. Efforts include load assessment based on the amount of trash retrieved by the catch basin cleaning crews. Data indicates that the central part of the City contributes disproportionately more trash per unit area. This central part is targeted for priority installation of screens and inserts at catch basins

Milwaukee, WI

Sewer System Type

Land Use



Participating Organizations:
Milwaukee Department of Public Works - Environmental Section, Milwaukee Metropolitan Sewer District

2010 Census Population	**605,000**
Population Density (per square mile)	**6,200**
Population Growth (2000-10)	**>1%**
Sanitary Sewer Pipes (incl. combined)	**3,300 miles**
Storm Sewer Pipes (Separate system only)	**NA**

Regulatory Requirement

NPDES MS4 Phase I Permit

Administering Body

City of Milwaukee

Impairments & TMDLs

Nutrients	Sediment	Bacteria	Metals	Trash	Other
●	●	●	●		●

Unique Features

- **BaseTern™ Program:** The city of Milwaukee is currently studying the feasibility of repurposing the basements of abandoned homes slated for demolition as stormwater retention structures
- **ReFresh Milwaukee:** Proposes an annual 10% stormwater volume increase captured by green infrastructure
- **2035 Vision:** Develops a goal for zero combined sewer overflows, zero basement backups, and improving stormwater management. The key approach is Integrated Watershed Management and to seek a balance between gray and green infrastructure.

Minneapolis, MN

Sewer System Type

Land Use

Data not available

Participating Organizations:
Public Works Department – Sewer and Storm Drain Unit, Department of Public Works – Surface Water and Sewers

2010 Census Population	**383,000**
Population Density (per square mile)	**6,600**
Population Growth (2000-10)	**-0.001%**
Sanitary Sewer Pipes (incl. combined)	**830 miles**
Storm Sewer Pipes (Separate system only)	**556 miles**

Regulatory Requirement

NPDES Phase I MS4 Permit

Administering Body

City of Minneapolis

Impairments & TMDLs

Nutrients	Sediment	Bacteria	Metals	Trash	Other
●		●	●		

Unique Features

- **Green Roofs:** Implemented public green roofs at City Hall, Target Center Arena, and public library.
- **Local Surface Water Management Plan:** set the goals:
  - No net loss of tree canopy.
  - Plant at least 2,500 trees on public land every year.
  - Increase the number of Large Area Stormwater Amenities to 30 and Small Area Stormwater Amenities to 500.
  - Increase the number of Large Area Underground Stormwater Treatment Chambers to 150 and Small Area Underground Stormwater Treatment Chambers to 100.
  - Increase the number of Green Roofs in the City to 100.
- **Stormwater Volume Study:** Conduct a study of how stormwater volume reduction practices can support a performance based approach in lieu of a prescriptive requirement to provide site designers flexibility. For projects where it is determined that adequate stormwater volume reductions cannot be achieved on-site, a stormwater volume reduction crediting system must be developed.

Nashville, TN

Sewer System Type

Separate **7%**

Combined **93%**

Land Use

Data not available

Participating Organizations:
Metropolitan Government of Nashville and Davidson County, Metro Water Services – Stormwater Group

2010 Census Population	**627,000**
Population Density (per square mile)	**1,300**
Population Growth (2000-10)	**>5.0%**
Sanitary Sewer Pipes (incl. combined)	**2826 miles**
Storm Sewer Pipes (Separate system only)	**NA**
Combined Sewer Pipes	**224 miles**

Regulatory Requirement

NPDES Phase II MS4 Permit

Administering Body

Metro Nashville/ Davidson County

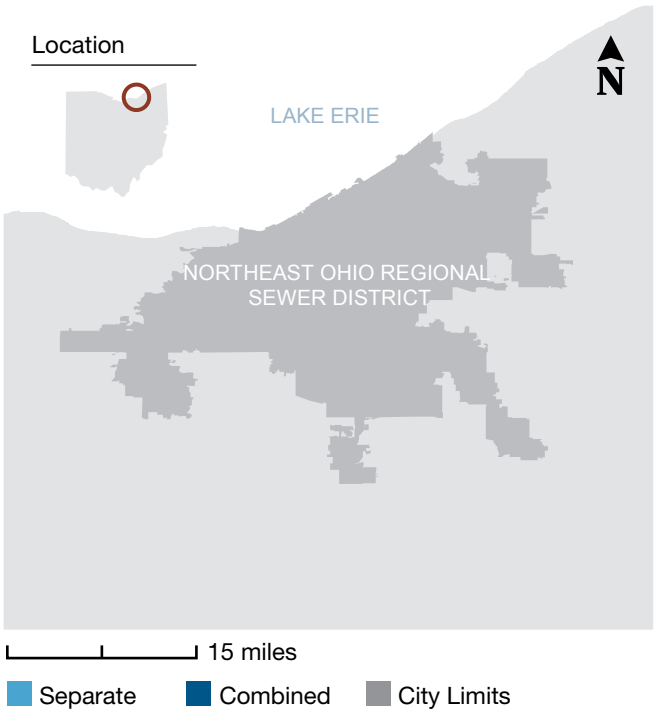
Impairments & TMDLs

Nutrients	Sediment	Bacteria	Metals	Trash	Other
●		●			

Unique Features

- **De-listing Goal:** Implements a plan to remove streams from the 303(d) list. Two stream segments have been de-listed. Multiple streams are in complaince for one pollutant
- **Floodplain Buy-Out:** Experienced an 18-inch flood event in 2010. The community responded by implementing a buy-out program for buildings located in the floodplain. 75% of the funding was provided by federal sources, 12.5% of the funding was provided by state sources, and 12.5% of the funding was provided by local sources.

Northeast Ohio Regional Sewer District (NEORSD)



Sewer System Type

Combined **23%**

Separate **77%**

Land Use

Data not available

Participating Organizations:
NEORSD

2010 Census Population	**1,427,000**
Population Density (per square mile)	**NA**
Population Growth (2000-10)	**-7.6%**
Sanitary Sewer Pipes (incl. combined)	**NA**
Storm Sewer Pipes (Separate system only)	**NA**

Regulatory Requirement

EPA CSO Consent Order

Administering Body

Cleveland, OH

Impairments & TMDLs

Nutrients	Sediment	Bacteria	Metals	Trash	Other
●	●	●			●

Unique Features

- **Community Cost Share Program:** Enables member communities to request funds from NEORSD to assist with maintenance and operation of local stormwater systems
- **Green Infrastructure Grant Program:** Includes $2 million per year funding of green infrastructure for the member communities.
- **Consent Decree Compliance:** Resulted in approximately 98% capture goal using gray infrastructure including a large storage tunnel (overall budget $3 billion dollars). Adopted a revised green infrastructure approach.
- **Regional Service:** Provides service to an area that covers 355 square miles, which includes 61 municipalities.

New Orleans, LA

Sewer System Type

Separate
100%

Land Use

Residential	Open space	Other
14%	**73%**	**13%**

Participating Organizations:
Sewerage and Water Board of New Orleans, City of New Orleans Planning Commission

2010 Census Population	**1,190,000**
Population Density (per square mile)	**1,000**
Population Growth (2000-10)	**>-11%**
Sanitary Sewer Pipes	**1,550 miles**
Storm Sewer Pipes (Separate system only)	**NA**

Regulatory Requirement	Administering Body
NPDES MS4 Permit	Sewerage and Water Board of New Orleans, City of New Orleans
EPA CSO Consent Order	Sewerage and Water Board of New Orleans, City of New Orleans

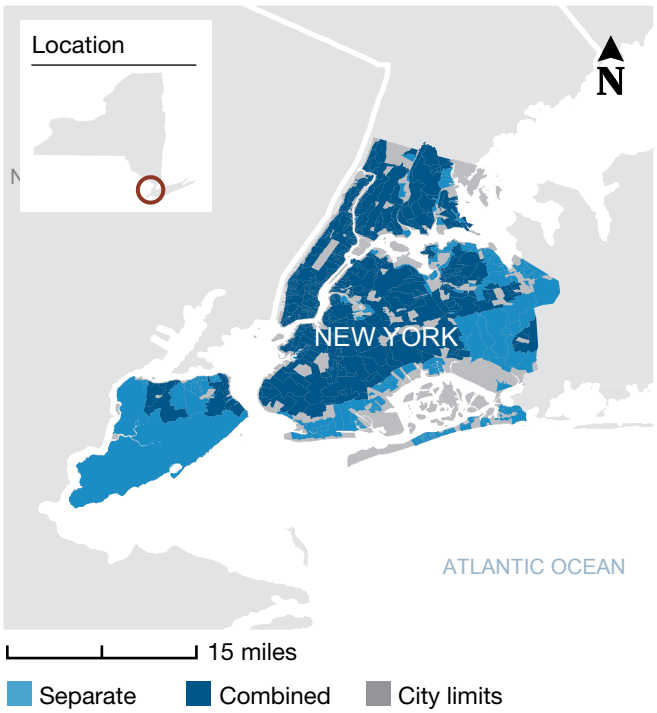
Impairments & TMDLs

Nutrients	Sediment	Bacteria	Metals	Trash	Other
	●	●			●

Unique Features

- **Drainage System – Sea Level:** Located at or below sea level elevation and is surrounded by flood protection levees. All stormwater (60 inches annual rainfall) is pumped and discharged over the levee systems. There are 22 stormwater pumping stations and 13 underpass stations with a pumping capacity over 29 billion gallons a day.
- **Coastal Impact Assistance Program:** Implemented a restoration and stabilization of shoreline. Funding is $15 million over the next four years through the Coastal Impact Assistance Program.
- **Wetlands Assimilation Project:** Partnership to restore 20,000 acres of wetlands lost to Hurricane Katrina.
- **Green Infrastructure Flood Mitigation:** Received a $140 million award from FEMA's Hazard Mitigation grant program to increase resiliency and includes green infrastructure elements.

New York, NY



Sewer System Type

Combined **60%**

Separate **40%**

Land Use

Residential **27%**

Open space **27%**

Other **46%**

Participating Organizations:
New York City – Department of Environmental Protection

2010 Census Population	**8,175,000**
Population Density (per square mile)	**18,100**
Population Growth (2000-10)	**>5%**
Sanitary Sewer Pipes (incl. combined)	**4,850 miles**
Storm Sewer Pipes (Separate system only)	**1,320 miles**

Regulatory Requirement	Administering Body
EPA CSO Consent Order	City of New York
SPDES MS4 Phase I Permit	City of New York

Impairments & TMDLs

Nutrients	Sediment	Bacteria	Metals	Trash	Other
●		●		●	

Unique Features

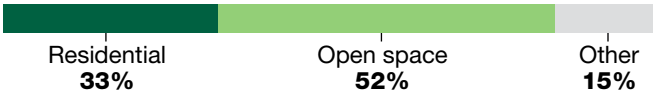
- **Municipal Good Housekeeping Pollution Prevention Program:** Prioritizes municipal facilities and off-site operations based on potential pollution risks to surface waters. Prioritization is performed using a quantitative process by assigning a ranking of high, medium, or low priority. Factors considered include operational area exposure to stormwater, type of material stored and used on-site, quantity of material, and others.
- **Southeast Queens Initiative:** Multiple city agencies are collaborating under the direction of the Mayor to reduce localized flooding in the area. Efforts include evaluating, phasing, and accelerating the capital plans for stormwater infrastructure; outreach to homeowners on what they can do to protect their properties; and adding green infrastructure as an interim support measure. The effort includes extensive inter-agency coordination and co-funding of program components.
- **Green Infrastructure Grant Program:** Provides funding for the design and construction of green infrastructure on private properties in NYC. The program was initiated to help address the CSO Consent Order, and was previously limited to combined sewer areas. NYC DEP recently obtained approval to expand the program citywide, to include the Separately sewered areas.

Onondaga County, NY

Sewer System Type

Data not available

Land Use



Participating Organizations:
Onondaga County – Department of Water Environment Protection

2010 Census Population	**467,000**
Population Density (per square mile)	**NA**
Population Growth (2000-10)	**>1%**
Sanitary Sewer Pipes (incl. combined)	**3,000 miles**
Storm Sewer Pipes (Separate system only)	**NA**

Regulatory Requirement

NPDES MS4 Phase I Permit

Administering Body

Onondaga County

Impairments & TMDLs

Nutrients	Sediment	Bacteria	Metals	Trash	Other
●		●			

Unique Features

- **Onondaga Lake Protection and Restoration:** Amended consent judgement to build green infrastructure to achieve specific, quantitative reductions in CSOs. Program budget is approximately $78 million. The program balances gray and green infrastructure to save as much as $20 million compared with traditional CSO mitigation programs.
- **Save the Rain Vacant Lot Program:** Conversion of publicly-owned empty lots into usable spaces for public benefit, including stormwater retention.
- **Onondaga Lake Sediment Dredging:** Removed 2.2 million cubic yards of sediment. Effort included capping about 450 acres of the lake bottom to provide a new habitat layer, prevent erosion, and isolate remaining contaminants. 44 acres of wetlands were restored. More than 110 species of fish, birds, and mammals returned to restored wetlands. About 1.1 million plants, shrubs, and trees were planted.

Philadelphia, PA

Sewer System Type

Combined **60%**

Separate **40%**

Land Use

Residential **14%**

Open space **23%**

Other **63%**

Participating Organizations:
Philadelphia Water Department

2010 Census Population	**1,527,000**
Population Density (per square mile)	**11,600**
Population Growth (2000-10)	**<1.0%**
Sanitary Sewer Pipes	**765 miles**
Storm Sewer Pipes (Separate system only)	**774 miles**
Combined Sewer Pipes	**1,461 miles**

Regulatory Requirement	Administering Body
NPDES Phase I MS4 Permit	City of Philadelphia
EPA CSO Consent Order	City of Philadelphia

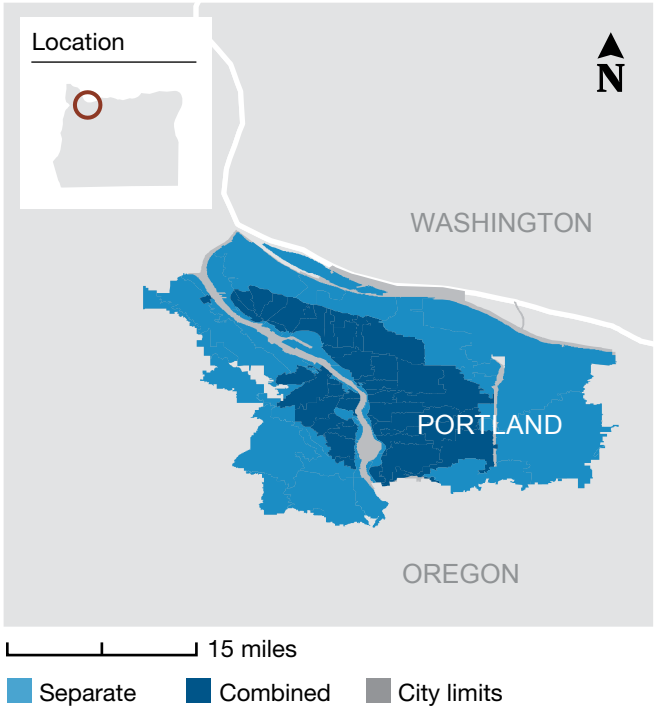
Impairments & TMDLs

Nutrients	Sediment	Bacteria	Metals	Trash	Other
●	●		●		●

Unique Features

- **Green City, Clean Waters:** Agreed to a long-term Consent Order compliance strategy based on the ad¬vancement of green infrastructure. Programmed to invest $1.2 billion over the next 25 years including an $800 million commitment for constructing green infrastructure, and $200 million for upgrading the City's water pollution control plants. The program includes a 25-year commitment to convert more than one-third of the impervious cover within the combined sewer area to green space.
- **Green Infrastructure Maintenance:** Compiled a nationwide review of green stormwater infrastructure maintenance programs and manuals (152 stormwater maintenance manuals). Original green infrastructure operation and maintenance cost was estimated to be 1 to 2% of capital expenditure. The current estimate of total green infrastructure operation and maintenance cost is 15 to 20% of capital expenditure.

Portland, OR



Sewer System Type

Combined **30%**

Separate **70%**

Land Use

Residential **37%**

Open space **20%**

Other **43%**

Participating Organizations:
City of Portland – Bureau of Environmental Services

2010 Census Population	**584,000**
Population Density (per square mile)	**4,300**
Population Growth (2000-10)	**>10.0%**
Sanitary Sewer Pipes	**1,003 miles**
Storm Sewer Pipes (Separate system only)	**443 miles**
Combined Sewer Pipes	**911 miles**

Regulatory Requirement

NPDES Phase I MS4 Permit

Administering Body

City of Portland

Impairments & TMDLs

Nutrients	Sediment	Bacteria	Metals	Trash	Other
●		●			●

Unique Features

- **Green City Grant Policy:** States that 1% of construction costs of all infrastructure improvement projects are contributed to a grant fund program that is used to install BMPs ($500,000 annually). Additional green policies include the Green Building Policy, Climate Action Plan and the Green Street Policy.
- **Separate Stormwater System:** The 70% includes >9,000 stormwater underground injection controls (UICs-drywells/sumps). In Oregon, UICs are regulated and permitted by the State (DEQ) under the Safe Drinking Water Act.
- **Industrial/Commercial Inspections:** Administers the General NPDES Industrial Stormwater Discharge Permit in Portland through an intergovernmental agreement with Oregon DEQ. Program staff conduct annual compliance inspections of permitted sites, provide technical assistance on BMP implementation, and issue enforcement referrals to DEQ for instances of noncompliance.

Richmond, VA

Sewer System Type

Combined **33%**

Separate **67%**

Land Use

Residential **13%**

Open space **78%**

Other **9%**

Participating Organizations:
City of Richmond – Department of Public Utilities

2010 Census Population	**204,000**
Population Density (per square mile)	**3,500**
Population Growth (2000-10)	**>1%**
Sanitary Sewer Pipes	**460 miles**
Storm Sewer Pipes (Separate system only)	**180 miles**
Combined Sewer Pipes	**520 miles**

Regulatory Requirement

NPDES Phase II MS4 Permit

Administering Body

City of Richmond Public Utilities - Stormwater

Impairments & TMDLs

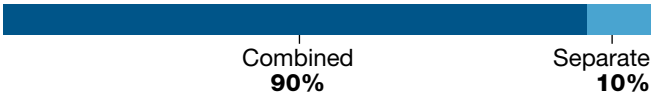
Nutrients	Sediment	Bacteria	Metals	Trash	Other
●		●	●		●

Unique Features

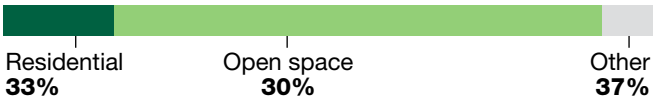
- **Integrated Planning:** Re-visited the 2006 CSO long-term control plan using the EPA Guidelines for Integrated Planning. Five independent agencies (Stormwater, Wastewater, Drinking Water, Gas, and Transportation) participated in the Integrated Planning process. EPA is also an active stakeholder. The goal includes the implementation of a coordinated Stormwater and Wastewater permit.

San Francisco, CA

Sewer System Type



Land Use



Participating Organizations:
San Francisco Public Utilities Commission, Port of San Francisco

2010 Census Population	**806,000**
Population Density (per square mile)	**18,200**
Population Growth (2000-10)	**>1.0%**
Sanitary Sewer Pipes (incl. combined)	**900 miles**
Storm Sewer Pipes (Separate system only)	**NA**

Regulatory Requirement

NPDES Phase II Small MS4 General Permit

Administering Body

City of San Francisco, Port of San Francisco

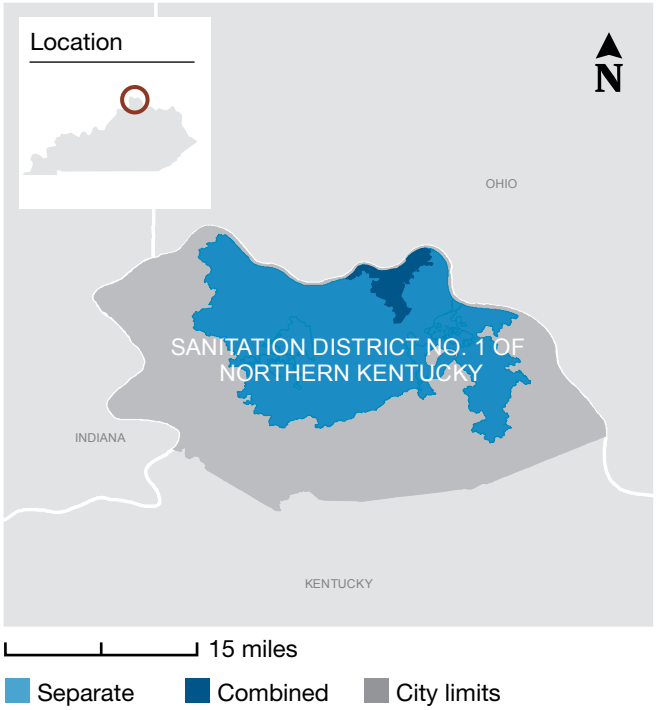
Impairments & TMDLs

Nutrients	Sediment	Bacteria	Metals	Trash	Other
●		●	●	●	●

Unique Features

- **Post-Construction Stormwater Ordinance:** For combined sewer areas, requires the peak flow rate and volume to be less than pre-development conditions for the 1- and 2-year 24-hour design storm for sites less than or equal to 50% imperviousness. And peak flow rate and volume shall be decreased by 25% from the pre-development conditions for the 2-year 24-hour design storm for sites greater than 50% imperviousness.
- **Watershed Assessment:** Started a collection system planning tool. The tool catalogs characteristics of each watershed and finds areas where problems may occur. The tool uses a detailed model to group packages of green and gray infrastructure projects.

Sanitation District (SD-1), KY



Sewer System Type

Combined **6%**

Separate **94%**

Land Use

Data not available

Participating Organizations:
SD-1

2010 Census Population	**284,000**
Population Density (per square mile)	**1,400**
Population Growth (2000-10)	**>1.0%**
Sanitary Sewer Pipes (incl. combined)	**1,600 miles**
Storm Sewer Pipes (Separate system only)	**440 miles**

Regulatory Requirement	Administering Body
NPDES Phase II MS4 Permit	SD-1
EPA CSO and SSO Consent Order	City of Erlanger

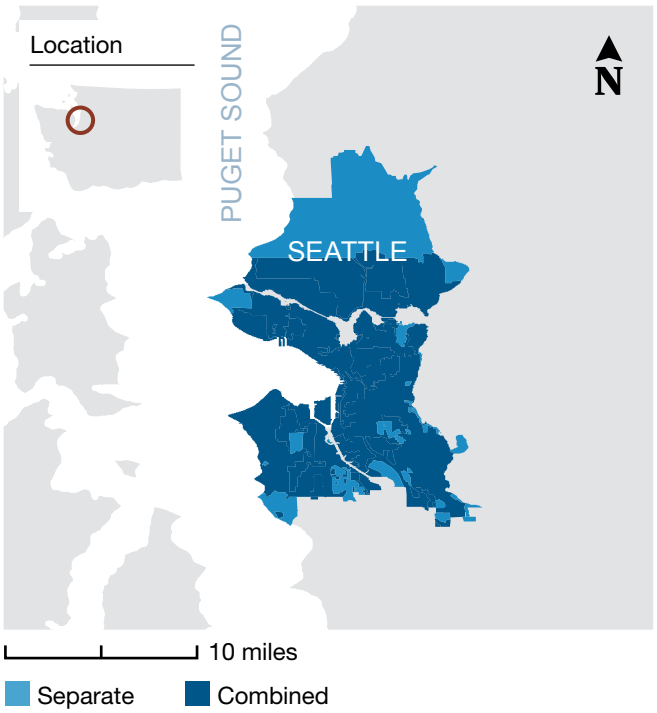
● Impairments & ● TMDLs

Nutrients	Sediment	Bacteria	Metals	Trash	Other
●	●	●			●

Unique Features

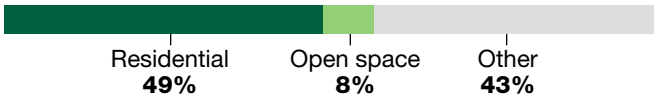
- **Integrated Planning:** Recommended by the consent decree and includes the development and implementation of watershed plans. Results indicated that runoff should be reduced by 80%.
- **Injection Wells:** Assessing injection wells to replenish groundwater.

Seattle, WA



Sewer System Type

Land Use



Participating Organizations:
City of Seattle – Public Utilities

2010 Census Population	**609,000**
Population Density (per square mile)	**4,700**
Population Growth (2000-10)	**>5.0%**
Sanitary Sewer Pipes (incl. combined)	**530 miles**
Storm Sewer Pipes (Separate system only)	**500 miles**
Combined Sewer Pipes	**1,020 miles**

Regulatory Requirement	Administering Body
NPDES Phase I MS4 Permit	City of Seattle
EPA CSO and SSO Consent Order	City of Seattle

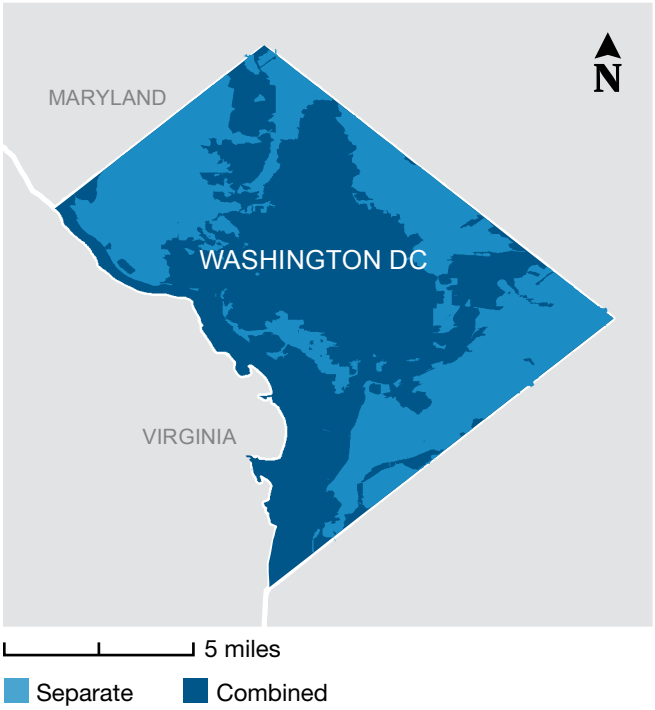
Impairments & TMDLs

Nutrients	Sediment	Bacteria	Metals	Trash	Other
●		●	●		●

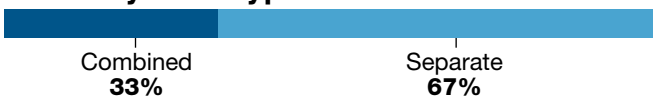
Unique Features

- **Integrated Plan:** Approved by the state and EPA as satisfying the requirements in the City's Consent Decree. The Integrated Plan defines structural stormwater control projects that will provide significant benefits beyond those achieved by the implementation of the approved CSO projects alone. The result includes a provision that some CSO projects will be deferred past 2025. Some of the Integrated Plan stormwater projects include:
  - Capitol Hill Water Quality Project – Four blocks of biofiltration swales ($11.3 million).
  - Venema Natural Drainage System – Five blocks of roadway to include natural drainage systems ($7.6 million).
  - South Park Water Quality Project – Regional stormwater quality facility ($30 million).
  - Street Sweeping – 560 lane miles per year ($2.0 million/year).
- **Catch Basin Inspection:** Inspected annually and fixed within six months if they do not pass inspection. Seattle has 22,000 catch basins in the MS4 areas.

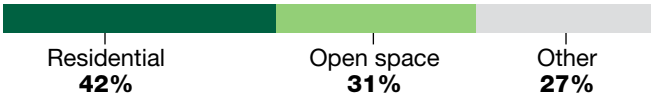
Washington D.C



Sewer System Type



Land Use



Participating Organizations:
Department of Energy and Environment (D.O.E.E.), DC Water

2010 Census Population	**602,000**
Population Density (per square mile)	**9,600**
Population Growth (2000-10)	**>5.0%**
Sanitary Sewer Pipes (incl. combined)	**1,800 miles**
Storm Sewer Pipes (Separate system only)	**600 miles**

Regulatory Requirement	Administering Body
NPDES Phase I MS4 Permit	Department of Energy and Environment
EPA CSO Consent Order	DC Water

● Impairments & ● TMDLs

Nutrients	Sediment	Bacteria	Metals	Trash	Other
●		●		●	●

Unique Features

- **Post-construction Ordinance Flexible Options:** Provides an option to meet a portion of the 1.2-inch retention requirement through Stormwater Retention Credits (SRCs) that are purchased in a private market or through payment of in-lieu fee (ILF). An SRC is worth one gallon of retention for one year.
- **Anacostia Trash Reduction Strategy:** Implemented a ban on the use of foam products by organizations that serve food.
- **Anacostia River Clean Up and Protection Act (Bag Law):** Requires all businesses selling food or alcohol to charge $.05 for each disposable paper and plastic carryout bag. The law allows businesses to keep $.01 (or $.02 if it offers a rebate when customers bring their own bag), and the remaining $.03 or $.04 is deposited into the Anacostia River Clean Up and Protection Fund which generates approximately $2,000,000 per year.

Toronto, Canada

Sewer System Type

Combined **23%**

Separate **77%**

Land Use

Data not available

Participating Organizations:
Toronto Water – Water Infrastructure Management

2010 Census Population	**2,615,000**
Population Density (per square mile)	**1,100**
Population Growth (2001-11)	**>1.0%**
Sanitary Sewer Pipes (incl. combined)	**2,318 miles**
Storm Sewer Pipes (Separate system only)	**3,095 miles**
Combined Sewer Pipes	**811 miles**

Regulatory Requirement

Data Not Available

Administering Body

Data Not Available

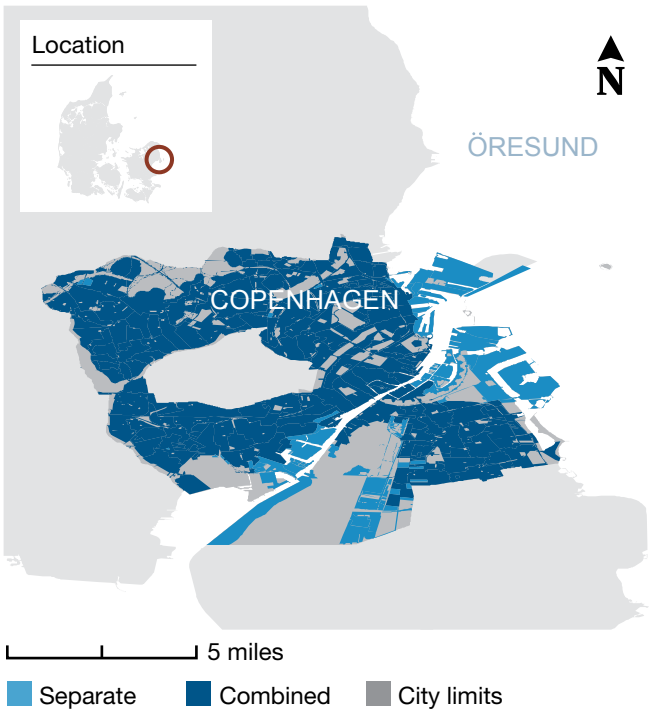
Impairments & TMDLs

Nutrients	Sediment	Bacteria	Metals	Trash	Other
		●			●

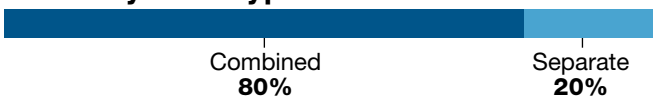
Unique Features

- **Wet Weather Flow Master Plan:** Adopted a 25-year plan to improve the watercourse and waterfront health. The plan was estimated to cost $1 billion over 25 years ($40 million per year). The plan includes:
  - Mandatory downspout disconnection program for combined sewer areas.
  - Basement flooding protection subsidy program that provides financial subsidies of up to $3,200 for implementing measures to prevent basement flooding.
  - Green standard establishes parameters for greening surface parking lots and constructing green roofs.
  - Don River and Central Waterfront projects include 51 combined sewer overflows and 41 storm sewer discharges.
  - Comprehensive waterfront improvements.
  - Stream restoration projects in all six watersheds.
  - Green roof policy stating that municipal buildings should have green roofs. To encourage property owners, a pilot incentive program to promote the construction of green roofs.
  - Tree planting strategy with a commitment to doubling the tree canopy in the next 30 years.

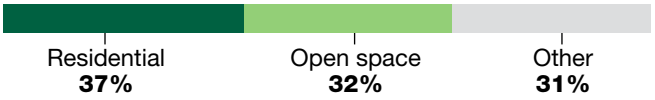
Copenhagen, Denmark



Sewer System Type



Land Use



Participating Organizations:
City of Copenhagen - City Development

2010 Census Population	**542,000**
Population Density (per square mile)	**17,700**
Population Growth (2001-11)	**>5.0%**
Sanitary Sewer Pipes (incl. combined)	**626 miles**
Storm Sewer Pipes (Separate system only)	**72 miles**

Regulatory Requirement

Data Not Available

Administering Body

Data Not Available

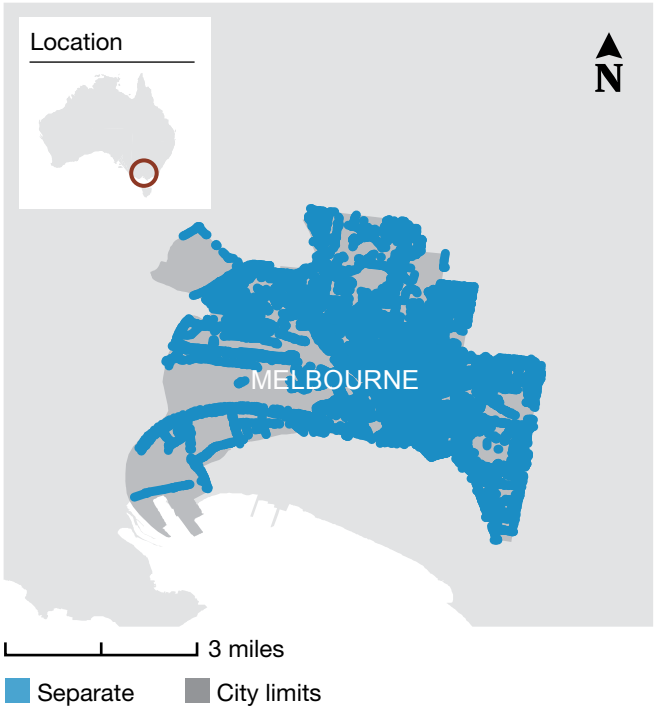
Impairments & TMDLs

Nutrients	Sediment	Bacteria	Metals	Trash	Other
			●		●

Unique Features

- **Climate Change Adaptation Plan:** Prepared innovative plan to adapt to climate change that considers:
  - Increasing precipitation (mainly as rain)
  - More intense weather (cloudbursts, storms etc.)
  - Summers with dry spells interspersed by heavy thunderstorms
  - More rain in the weather (expected about a 30% increase)
  - Rising sea levels
  - Rising ground water levels

Melbourne, Australia



Sewer System Type

Separate
100%

Land Use

Data not available

Participating Organizations:
Melbourne Water

2010 Census Population	**4,050,000**
Population Density (per square mile)	**1,100**
Population Growth (2001-11)	**>15%**
Sanitary Sewer Pipes (incl. combined)	**NA**
Storm Sewer Pipes (Separate system only)	**NA**

Regulatory Requirement

Data Not Available

Administering Body

Data Not Available

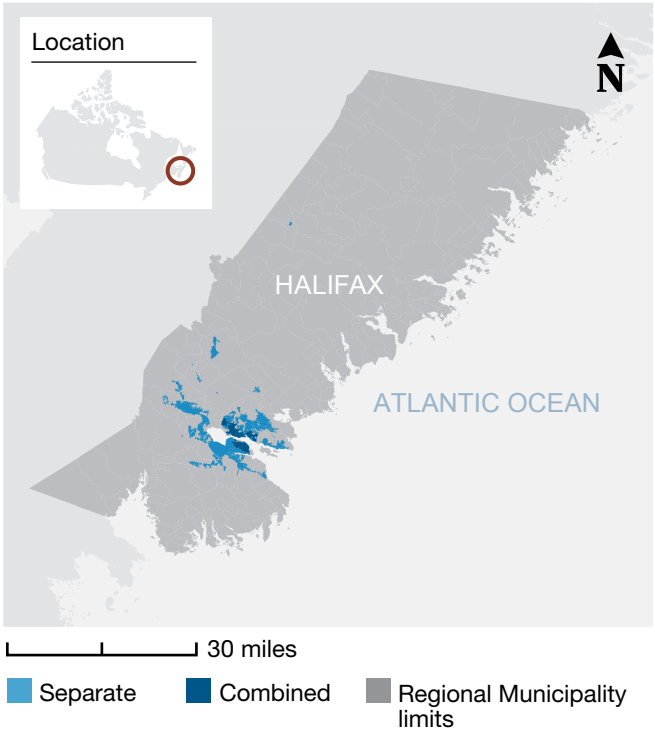
Impairments & TMDLs

Nutrients	Sediment	Bacteria	Metals	Trash	Other
●			●		●

Unique Features

- **Flood Management:** Led the preparation of a flood management strategy for the Port Philip and Western-port region of Victoria, with coordination between 38 organizations.
- **Stormwater Management Pollutant Removal Goals:** Council Land:
  - 20% Reduction in TSS by 2020 from 2005
  - 15% Reduction in TP by 2020 from 2005
  - 30% Reduction in TN by 2020 from 2005
  - 30% Reduction in Litter by 2020 from 2005
- **Water Sensitive Urban Design:** Requires integrated water management plans for private development projects to include a performance evaluation that assess the net environmental benefit of each site design.
- **Stormwater Management Pollutant Removal Goals:** Non-Council Land:
  - 20% Reduction in TSS by 2020 from 2005
  - 25% Reduction in TP by 2020 from 2005
  - 40% Reduction in TN by 2020 from 2005
  - 30% Reduction in Litter by 2020 from 2005

Halifax, Canada



Sewer System Type

Combined **15%**

Separate **85%**

Land Use

Residential **9%**

Open space **37%**

Other **54%**

Participating Organizations:
Halifax Water

2010 Census Population	**391,000**
Population Density (per square mile)	**3,500**
Population Growth (2001-11)	**>1%**
Sanitary Sewer Pipes (incl. combined)	**NA**
Storm Sewer Pipes (Separate system only)	**NA**

Regulatory Requirement

Data Not Available

Administering Body

Data Not Available

Impairments & TMDLs

Nutrients	Sediment	Bacteria	Metals	Trash	Other
					●

Unique Features

- **Integrated Resource Plan:** Involved a long-term planning framework and conducting scenario analysis to prioritize capital and operational programs needed to deliver water, wastewater, and stormwater services. A total cash expenditure of $108 million in stormwater expenditures is needed over the next 30 years.
- **Stormwater Discharge Limits:** Limits stormwater to not include floating debris, fuel, sewage, e-coli greater than 200 colonies per 100 milliliters, and wash water from concrete trucks. Stormwater must have a BOD of less than 15 mgl, pH between 6 and 9.5, phosphorus less than 0.4 mgl, and suspended solids less than 15 mgl.

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