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SUSTAINABLE STORMWATER MANAGEMENT PLAN 2008

A GREENER, GREATER NEW YORK

The City of New York
Mayor Michael R. Bloomberg

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SUSTAINABLE STORMWATER MANAGEMENT PLAN 2008

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* The complete set of appendices is available on the PlaNYC website at: www.nyc.gov/planyc2030

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New York City Agencies

Agencies listed in this Plan:

DCAS:	New York City Department of Citywide Administrative Services
DCP:	New York City Department of City Planning
DEP:	New York City Department of Environmental Protection
DDC:	New York City Department of Design and Construction
DOB:	New York City Department of Buildings
DOHMH:	New York City Department of Health and Mental Hygiene
DOT:	New York City Department of Department of Transportation
DPR:	New York City Department of Parks and Recreation
DSNY:	New York City Department of Sanitation
EDC:	New York City Economic Development Corporation
HPD:	New York City Housing and Preservation Development
NYCHA:	New York City Housing Authority
OEM:	New York City Office of Emergency Management
OLTPS:	New York City Mayor's Office of Long-Term Planning and Sustainability
OMB:	New York City Office of Management and Budget
SBS:	New York City Department of Small Business Services
SCA:	New York City School Construction Authority

Acronym Definitions

Organizations and and State and Federal government entities:

CENYC:	Council on the Environment of New York City
EPA:	United States Environmental Protection Agency
FEMA:	Federal Emergency Management Administration
NYRP:	New York Restoration Project
NYSDEC:	New York State Department of Environmental Conservation
NYSERDA:	New York State Energy Research and Development Authority
USFS:	United States Forest Service

Other acronyms used through this Plan:

BMP:	Best Management Practice
CEQR:	City Environmental Quality Review
CSO:	Combined Sewer Overflow
GIS:	Geographic Information Systems
HLSS:	High Level Storm Sewers
JBWPP:	Jamaica Bay Watershed Protection Plan
LEED:	United States Green Building Council Leadership in Energy and Environmental Design
LL5:	New York City Local Law 5 of 2008 on sustainable stormwater management
LL86:	New York City Local Law 86 of 2005 on green buildings
MMR:	Mayor’s Management Report
MS4:	Municipal Separate Storm Sewer System
WPCP:	Water Pollution Control Plant, i.e. wastewater treatment plant

THE CITY OF NEW YORK
OFFICE OF THE MAYOR
NEW YORK, NY 10007

December 2008

Dear Friends:

This Sustainable Stormwater Management Plan is a key step towards the *PlaNYC* goal of being able to use New York City's rich network of waterways as recreational resources. Our rivers, creeks, and coastal waters have always been critical to the City, and over the last twenty years we've made tremendous progress in cleaning them up.

Opening 90% of our City's waterfronts to recreation, though, will require several efforts, including new infrastructure that will prevent untreated discharge from entering our waterways during periods of heavy rainfall. This plan analyzes new approaches called "source controls" — such as greening our streets, expanding wetlands areas, and rainwater reuse – that will reduce stormwater runoff and prevent this kind of pollution.

The plan presented here is a major step forward, but by no means the final step. It calls for immediate actions that will require some types of source controls, but also outlines further study of different technologies and – critically – approaches to funding future needs. In all this, it continues us along the path of progress that will make New York an even better place live, work, and visit.

Sincerely,

Michael R. Bloomberg
Mayor

Executive Summary

This Sustainable Stormwater Management Plan is a key initiative of PlaNYC, the City's plan for a greener, greater New York. PlaNYC's water quality goal is to improve public access to our tributaries from 48 percent today to 90 percent by 2030.

The challenges to meeting that goal are rooted in our history of development. Over centuries, the cutting of our forests, filling of our wetlands, and construction of roads and buildings has upset the natural cycle of water. Instead of infiltrating into the ground and being soaked up by plants, water now runs off and can flood our sewers, subways and roads, and carry pollution to our waterways. These challenges are significant in New York City, which has the highest population density in the nation and depends upon a correspondingly dense man-made environment. For every inch of rain that falls on every acre of rooftops and other impervious surfaces, the City has to manage more than 27,000 gallons of water.

Stormwater runoff does not have to be an inevitable by-product of development. Building and landscape designs that mimic natural systems, and infiltrate, retain, or detain rainfall on-site, can reduce excess flows into our sewers, streets, and waterways.

This Sustainable Stormwater Management Plan is the product of an interagency task force. It is the City's first comprehensive analysis of the costs and benefits of those alternative methods for controlling stormwater. This Plan provides a framework for testing, assessing, and implementing small installations to control stormwater at its source, which are known by various terms – source controls, green infrastructure, low impact development, best management practices, or BMPs.

These source controls can complement the significant water quality gains from the City's long history of investing in its stormwater and sewage infrastructure. Street sewers were first installed in the 1600s, and today our network of over 6,600 miles of interceptor and street sewers leads to 14 water pollution control plants that treat 1.3 billion gallons of wastewater every day. Water quality today is better than it has been in over 100 years. Still, billions of gallons of combined sewer overflows (CSOs) are discharged to New York City waters each year when excessive levels of stormwater reach our combined sewers. In separate sewer areas, stormwater runoff can cause flooding and sewer backups. All of these effects will become more challenging to control as climate change increases the amount of annual rainfall and the severity of individual storms. The City has invested in large, expensive tanks to store combined flows by Flushing Bay and Alley Creek in Queens and Paerdegat Basin in Brooklyn for treatment after storms pass, and is planning to spend nearly $2 billion more on system upgrades to reduce our CSOs even further.

To complement and protect our investments and to forestall the need for further expensive infrastructure, this Plan explores the feasibility of source controls such as rooftops that store rainfall and slowly release it to the sewers; planted or "green" roofs that store rain in soil and use some of it in plants; roadway alterations that allow runoff to soak or infiltrate into the ground; and rain barrels or cisterns that can store water from downspouts. This Plan makes the preliminary finding that a network of source controls has the potential to significantly reduce pollution through incremental investments made over the next twenty years and into the future.

Since source controls would have to be distributed widely throughout the landscape, this Plan started with an analysis of land uses in the City that contribute most to stormwater runoff or that have the greatest opportunity for solutions. Buildings and developed lots, streets, and sidewalks have significant amounts of hard, impervious surfaces that shed rainfall immediately. And the city's remaining open space provides unique opportunities to locate source controls that can be hydraulically connected to surrounding impervious areas. In all these areas, successful implementation depends on finding opportunities where source controls will be widely adopted. The most cost-effective options are when stormwater controls can be designed as part of planned construction, such as new buildings, sidewalk replacements, and road reconstructions. Other cost-effective opportunities involve incremental changes in the way we plant street trees and install Greenstreets.

For these reasons, the City is already leading the way with many current and ongoing source control initiatives. Despite promising indications, there are outstanding questions about the feasibility of source controls in actual operating conditions in New York City that prevent their immediate implementation. Indeed, private landowners and developers have not widely adopted source controls. To resolve questions about the costs, benefits, and feasible implementation of source controls, the City is undertaking over 20 separate demonstration projects.

This Plan's focus on proven and cost-effective solutions is essential in light of the current financial climate. Mayor Bloomberg recently announced budget cuts to close a projected budget gap of $4 billion in fiscal years 2009 and 2010. And the City is always mindful that increasing the already high cost of construction in New York City could risk depressing new housing development or deferring maintenance of our existing building stock.

Our Plan

This Plan's analysis and other considerations have led the City to adopt an overall goal, short-term strategies to supplement existing stormwater control efforts, medium-term strategies to develop innovative and cost-effective source controls, and long-term strategies to secure funding.

Our Goal

PlaNYC's overall water quality goal is to improve the public's recreational use of and access to our tributaries from 48 percent today to 90 percent by 2030, through a series of water quality initiatives. This Plan is derived from one of those initiatives, a strategic planning effort to promote cost-effective source controls. As a consequence, this Plan focuses on management goals for stormwater.

This Plan adopts a goal of enacting policies in the next two years that, when fully implemented, will create a network of source controls to detain or capture over one billion additional gallons of stormwater annually. Through periodic evaluations, we will adjust our policies to meet that target number and, when appropriate, will set a new goal to drive policies further.

We will strive to meet our stormwater goal through the following three-part strategy.

Implement the Most Cost-Effective and Feasible Controls

In the short-term, there are significant opportunities, and few funding or operational barriers, to changing local codes to require stormwater detention in new developments. These changes will be implemented in 2009.

1. Capture the benefits of ongoing PlaNYC green initiatives

PlaNYC includes a number of greening initiatives that will absorb stormwater including the planting of a million trees, zoning amendments to require street trees and green parking lots, additional Greenstreets, a green roof tax abatement, public plazas in underutilized areas of the roadbed, additional engineered wetlands in our Bluebelt system, the conversion of asphalt fields to turf, the conversion of schoolyards to playgrounds, and the protection of natural wetlands.

2. Continue implementation of ongoing source control efforts

In addition to those PlaNYC initiatives, the City has many other ongoing efforts that will directly require, promote, or incentivize stormwater management. These include zoning amendments that prohibit the paving of front yards in private homes and require planted areas in privately owned public plazas, water conservation incentives and initiatives, interagency coordination of construction specifications, the use of High Level Storm Sewers, and measures to reduce flooding.

3. Establish new design guidelines for public projects

To continue its leading-edge stormwater management practices, the City will release the *Street Design Manual*, *Park Design for the 21st Century*, the *Sustainable Urban Site Design Manual*, and the *Water Conservation Manual*.

4. Change sewer regulations and codes to adopt performance standards for new development

The City will develop and finalize a performance standard for new construction that will be adopted as part of its sewer regulations and sewer code.

5. Improve public notification of combined sewer overflows

To inform more people about CSOs when they happen, the City will install new signs near every one of its 433 combined sewer outfalls, will develop a web notification system, and will incorporate this information into Notify NYC, a new service designed to enhance the delivery of information to the public through email, text, and phone alerts.

Resolve the Feasibility of Promising Technologies

Several other source control strategies have tremendous promise but require further technical validation in New York City's environment and the development of implementation plans. These scenarios include standards for sidewalks, road reconstructions, performance standards for existing buildings, green roadway infrastructure, and stormwater requirements and incentives for low- and medium-density residences.

6. Complete ongoing demonstration projects and other analysis

The City will test numerous source controls to determine if they can and should be implemented broadly or require changes in design and materials. To answer unresolved questions about feasibility, costs, maintenance, and performance of various source control techniques, the City is undertaking approximately 20 pilot projects and will carefully monitor the results and plan for the transition to long-term policy.

In addition, the City is conducting or tracking several other ongoing studies that will affect the feasibility of source controls generally, including modeling runs of CSO reductions from source controls, maps of permeable and impermeable surfaces throughout the city, and an updated soil survey by the New York City Soil and Water Conservation District.

7. Continue planning for the implementation of promising source control strategies

The City will continue planning for scenarios that our preliminary analysis indicates are promising. These include sidewalk standards, road reconstruction standards, performance standards for existing buildings, low- and medium-density controls, and green roadway infrastructure. Over the next year, the City will seek to develop consensus designs and identify funding mechanisms with the help of interagency working groups, outside experts, private landowners, and other interested stakeholders.

8. Plan for the maintenance of source controls

Maintenance and related costs must be considered when launching any new initiatives. Unless source control installations are properly maintained, the performance of the entire decentralized system will decline over time, undercutting the rationale for avoiding investments in large infrastructure and creating a backlog of work that will increase costs. To resolve these issues the City will seek to resolve the maintenance needed at the proper scale. There are several existing models for maintenance, including the public/private partnerships that help the City to maintain Bluebelts and Greenstreets.

Explore Funding Options for Source Controls

An adequate source of funding is a prerequisite to all potential source control strategies, whether in the private or public sectors.

9. Broaden funding options for cost-effective source controls

Currently, funding for stormwater-related expenses is embedded in water and sewer charges. Where source control initiatives require partial or full public subsidies, we must establish new sources of funding. We will explore the viability of five potential sources: (1) rate increases, stormwater charges, or a combination of the two approved by the Water Board, (2) the general municipal fund, (3) outside funding and other miscellaneous sources, (4) expansion of the federal role in financing infrastructure improvements, and, in the future, (5) funds that would otherwise go to building expensive storage tunnels and other conventional infrastructure.

10. Complete water and wastewater rate study and reassess pricing for stormwater services

The City's current water rate structure is comprised of a charge for consumption of water and an additional 159 percent for all sewer, stormwater, and wastewater services. Because this rate structure fails to reflect the true costs of stormwater generation and can lead to distortions, the City is currently undertaking a year-long study to consider improvements. The City is analyzing its current expenditures, reviewing the rate and credit programs of other municipal water systems, and estimating the impacts of alternative stormwater rate structures on ratepayers and revenues. This effort will be coordinated with other ongoing efforts to map impervious areas in the City and to overhaul the program for water bills.

Implementation and Milestones

To implement this Plan, the City is taking a variety of actions:

- The City will track, monitor, and report efforts to install source controls. This effort will involve the creation of a database to track sewer connection, building permits, and information about any detention or retention systems. Performance levels of source controls will be developed through pilots and studies of peer-reviewed or other literature. And in early 2009, the City will require reporting of additional sustainability indicators so that the public will be informed of the overall CSO capture rate, Bluebelt acres acquired, harbor monitoring stations meeting fecal coliform standards, and similar statistics.

- The City will develop a public outreach, education, and support program so that the public will understand the factors that contribute to water pollution, the economic and regulatory incentives for controlling stormwater, and the design and maintenance of source controls. These efforts will include the publication of a design and construction manual for source controls that will work in New York City conditions, for the use of private developers, homeowners, and public agencies.

- The City will take steps to encourage the development of existing and new local markets, job training, and employment opportunities to ensure an adequate skilled workforce for green initiatives. The City has already identified over 40 organizations with existing green collar jobs training programs in place in New York City and will continue to look for additional opportunities to address the development and support of a green collar workforce for the installation and maintenance of green infrastructure. The City is currently conducting a comprehensive study of green sector jobs to better understand the industry's current activity and to fill any unmet training needs.

- The City is enhancing its collection of water quality data in New York Harbor to determine whether our source control and other stormwater efforts are working.

- This Plan contains a series of discrete milestones for implementing initiatives and solutions to the funding, operational, and other challenges that would have to be overcome to achieve a successful, comprehensive program. The City will conduct periodic review of this entire Plan and its goals and update them accordingly.

Introduction

This Sustainable Stormwater Management Plan is one of the 127 initiatives in PlaNYC, our guide to creating a more sustainable New York City. PlaNYC's water quality goal is to improve water quality in the City and to open 90 percent of our waterways to recreation. The PlaNYC water quality goal provides a framework for improving water quality through various strategies, most of which are directed to reducing stormwater pollution.

PlaNYC called for the creation of an Interagency BMP Task Force to make the reduction of CSO volumes and stormwater a priority for all relevant city agencies and to develop a plan for source controls by October 2008. The Task Force is comprised of City agencies responsible for infrastructure or development that may have direct impacts on pollution in our waterways. It includes representatives from the Mayor's Office of Long-Term Planning and Sustainability (OLTPS), the Department of Environmental Protection (DEP), the Department of Design and Construction (DDC), the Department of Parks & Recreation (Parks Department), the Department of Sanitation (DSNY), the Department of Transportation (DOT), the Department of Buildings (DOB), the Department of City Planning (DCP), the Department of Citywide Administrative Services (DCAS), the Department of Housing and Preservation and Development (HPD), the Schools Construction Authority (SCA), the Department of Health and Mental Hygiene (DOHMH), the Office of Management and Budget (OMB), and the New York City Economic Development Corporation (EDC).

Since June 2007 the Task Force has met regularly to analyze ways to incorporate source controls into the design and construction of projects. Sub-groups focused on four specific focus areas: the public right of way, City-owned property, open space, and private development.

The Task Force developed an initial list of over 350 potential improvements for promoting stormwater source controls, and steadily reduced that list to the most feasible initiatives. Members of the Task Force also visited Washington, D.C., and Philadelphia to observe source controls first-hand and to discuss ongoing, and apparently unresolved, issues regarding the maintenance and reliability of those controls.

This Sustainable Stormwater Management Plan also builds on DEP's Jamaica Bay Watershed Protection Plan (JBWPP), which was issued in October 2007. The JBWPP analyzed the effectiveness of source controls in protecting the waters of Jamaica Bay. DEP estimated that source controls could reduce 6 percent to 24 percent of CSO, storm sewer, and direct discharges in 10 years. DEP proposed several pilot projects to address uncertainties associated with source control technologies within New York City's climatic and environmental conditions, including soil composition, depth to water table, depth to bedrock, the freeze-thaw cycle, and connections to existing sewer infrastructure. The pilot projects are intended to develop performance and cost data, with an emphasis on operational and maintenance requirements. To complement the pilot projects required by the JBWPP, DEP is separately planning to install additional pilots in the Flushing Bay, Gowanus Canal, and Bronx River watersheds. (A complete description of pilot projects is contained in Appendix E). In order to monitor source control implementation and growth on an aggregate scope, DEP will develop a source control design manual to assist private and public parties in building those installations, maps and data on pervious and impervious surfaces to help determine where to build them, and a citywide database to track information on any detention or retention systems used to manage stormwater in sewer connection and building permits.

DEP is also undertaking a study to model the effects of source controls upon CSOs, as well as a study of stormwater and wastewater rates.

PlaNYC was developed through an outreach program to solicit community concerns and suggest solutions. Similarly, the Interagency BMP Task Force held four public stakeholder meetings, convened working groups to discuss practical solutions, developed a list of potential source controls for inclusion in the plan, launched an on-line platform for sharing design specifications across agencies, and launched an online source control registry of current installations in New York City. After the draft plan was published, the City held a fifth stakeholder meeting to review the draft plan on October 7, 2008. Those meetings are described in Appendix C.

The public was able to submit written comments on the draft Sustainable Stormwater Management Plan through October 31, 2008, and over 30 stakeholders provided approximately 90 pages of detailed comments and suggestions. Those comments are included in Appendix K, and a response to comments is included in Appendix L.

This final Sustainable Stormwater Management Plan incorporates many changes suggested by members of the public and is much improved for their involvement. The City has added many details about our pilot programs and their transition to policies, costs and budget implications, the rate study, technological source controls, case studies, subsidiary planning efforts for promising scenarios and maintenance agreements, and the relationship of this strategic Plan to parallel regulatory efforts. The City has also explained the rationale for the goal of this Plan, its philosophy of adaptive management, and future milestones.

At the same time, many of the suggested changes could not yet be incorporated into this Plan. For example, many members of the public suggested that the City include a more complete discussion and quantification of non-stormwater benefits of source controls but the data required for such an analysis is not yet available. The City will refine the plan in the future as the data is developed, both through our pilots and other studies across the nation. Similarly, the costs and stormwater benefits of source controls are crucial preconditions for policy decisions, and basic cost and benefit information is still being developed, including from the demonstration projects mentioned in this Plan. The City is including the preliminary line-item cost estimates used in this Plan in Appendix D to advance the discussion as far as possible at this time. The City anticipates developing useful information from the pilots described in this Plan and from the experiences of outside partners, and then incorporating that information in future policy decisions.

This Plan is and will be a "living document" that reflects the City's philosophy of adaptive management. Our milestones include an update of the Plan on October 1, 2010, and every two years thereafter. At that time, the City will reevaluate all aspects of this Plan, including whether it is feasible to revise its stormwater capture goal upwards. In the meantime the City will continue to involve stakeholders in elements of the Plan, including in public review of the water and sewer rate study and new performance standards in the sewer regulations and code. In addition, the City will foster continuous civic engagement on this issue through public education and outreach.

Credit: NYC Economic Development Corporation

Context

New York City's 8.25 million residents, and the millions more workers and tourists who visit the city every day, are affected by stormwater in many ways. Stormwater can cause roadway flooding, back-ups of sewage into homes, discharges of pollutants from roads and other hard surfaces, and discharges of untreated sewage. Controlling these effects is important to the continued health, welfare, and overall quality of life in the city. This chapter provides an overview of stormwater problems, conventional solutions, alternative solutions, and the financial context for this Plan.

New York City's Investment in Water Quality

A long history of investments in sewers and treatment plants

New York City has managed water pollution since the late 1600s. Many of the early sewers simply collected sanitary sewage and discharged it directly to waterways. That was a significant improvement in public health at the time and protected people from exposure to pathogens and other pollutants by eliminating privies and the overflow of sewage into streets or into groundwater. Sewers also carried away stormwater, garbage, human waste, animal waste, and other refuse that collected on city streets. No discharges were treated.

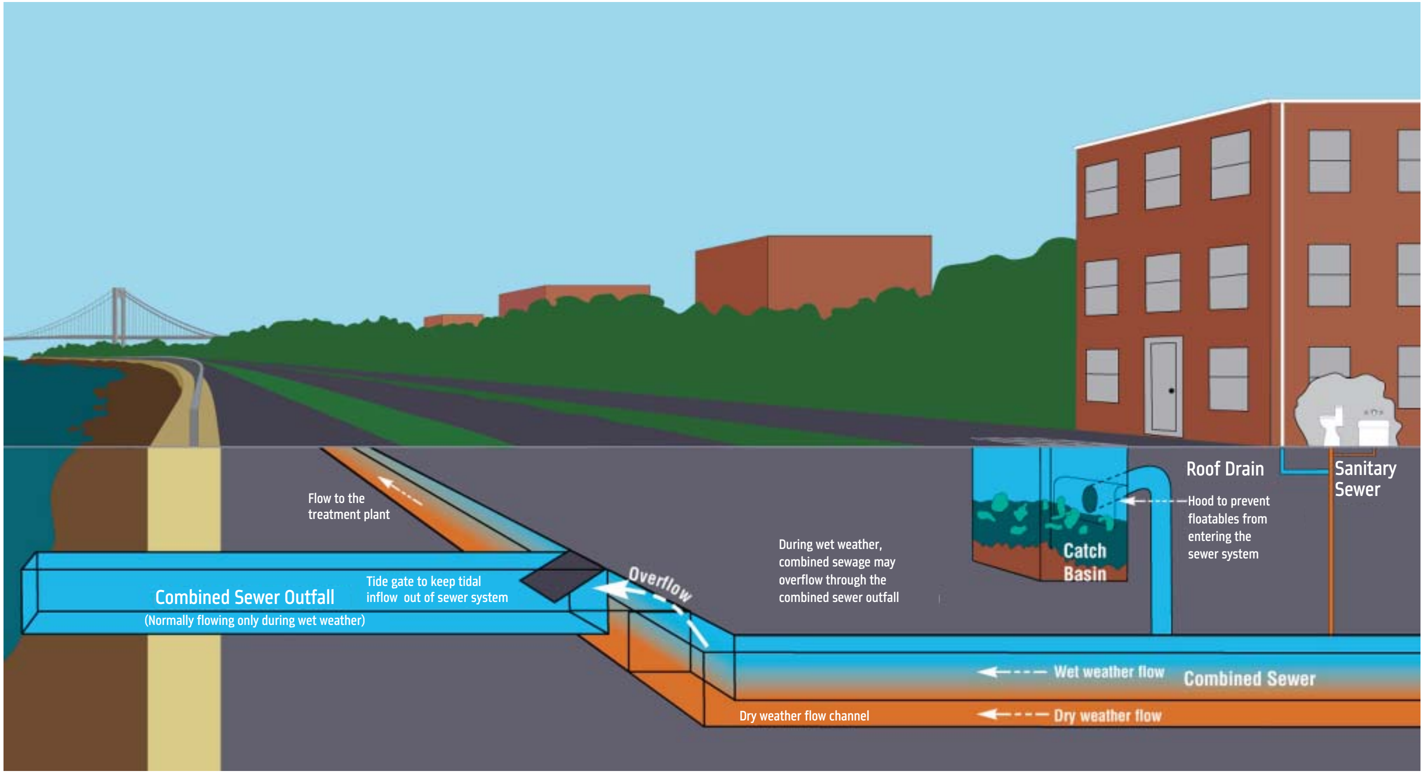
By the late 1800s, water quality conditions in New York Harbor and its tributaries were very poor because of the volume of untreated sewage discharged during dry weather. To address this problem, in the 1890s and early 1900s New York City began building wastewater treatment plants near bathing beaches, at the sites of the present 26th Ward and Coney Island water pollution control plants (WPCPs) in Brooklyn and the Jamaica WPCP in Queens. Existing street sewers were tied into these plants through "interceptor" sewers that collected flow at the end of street sewers, generally near the former point of direct discharge to water. To accommodate a growing population, the City built additional sewers and plants to treat the sewage collected by the combined system. Between 1935 and 1945 three new plants were constructed – Wards Island in Manhattan and Bowery Bay and Tallman Island in Queens. Between 1945 and 1965 five additional plants were built – Hunts Point in the Bronx, Oakwood Beach and Port Richmond in Staten Island, and the Rockaway and Owls Head plants in Brooklyn. The Newtown Creek WPCP was built between 1965 and 1979. By 1968, 12 wastewater plants were treating nearly one billion gallons per day of wastewater. New York City upgraded its plants to full secondary treatment and built two more treatment plants, the Red Hook plant in Brooklyn and the North River plant in Manhattan. The completion of the Red Hook WPCP in 1987 ended the last, permitted dry weather discharges of raw sewage into the harbor. The City's wastewater plants now have the capacity to treat 1.8 billion gallons of dry weather wastewater flows every day.

Wet weather flows

The WPCPs were designed to handle double the normal, dry weather sewage flow to account for high flows during rainstorms. However, the combined flow during storms is sometimes more than the treatment plants can accommodate and treat. The combined sewer systems were therefore designed to prevent flooding of the WPCPs or backup of sewage into streets and buildings through the use of regulators that shunt excess flow to local waterways (Figure 1). This type of system is not unique. Combined sewer systems are remnants of the country's early infrastructure

Rainfall in New York City

Figure 1: Combined Sewer System Diagram



Source: NYC Department of Environmental Protection

and are typically found in older communities. As a result, CSOs are a major water pollution concern for approximately 772 cities and 40 million people who are concentrated in the Northeast, Great Lakes, and Pacific Northwest.

The City began addressing the issue of CSO discharges in the 1950s. In 1972, New York City opened the first CSO control facility in the Harbor Estuary at Spring Creek, Jamaica Bay. This facility stores excess flow from CSOs until after the rainfall ends and then pumps it back to the WPCP for treatment. It was one of the first such facilities in the country. Other upgrades to our treatment plants increased wet weather capacity. By 2007, the City's WPCPs were treating 447 billion gallons of sanitary sewage and 35 billion gallons of stormwater water a year, at an operating cost of $379 million. Wet weather capture and treatment at WPCPs has increased steadily over time and currently averages over 70 percent. While these measures have improved overall water quality, they are often costly in terms of capital construction and ultimately do not "treat" all of the stormwater.

Current network of combined and separate sewers

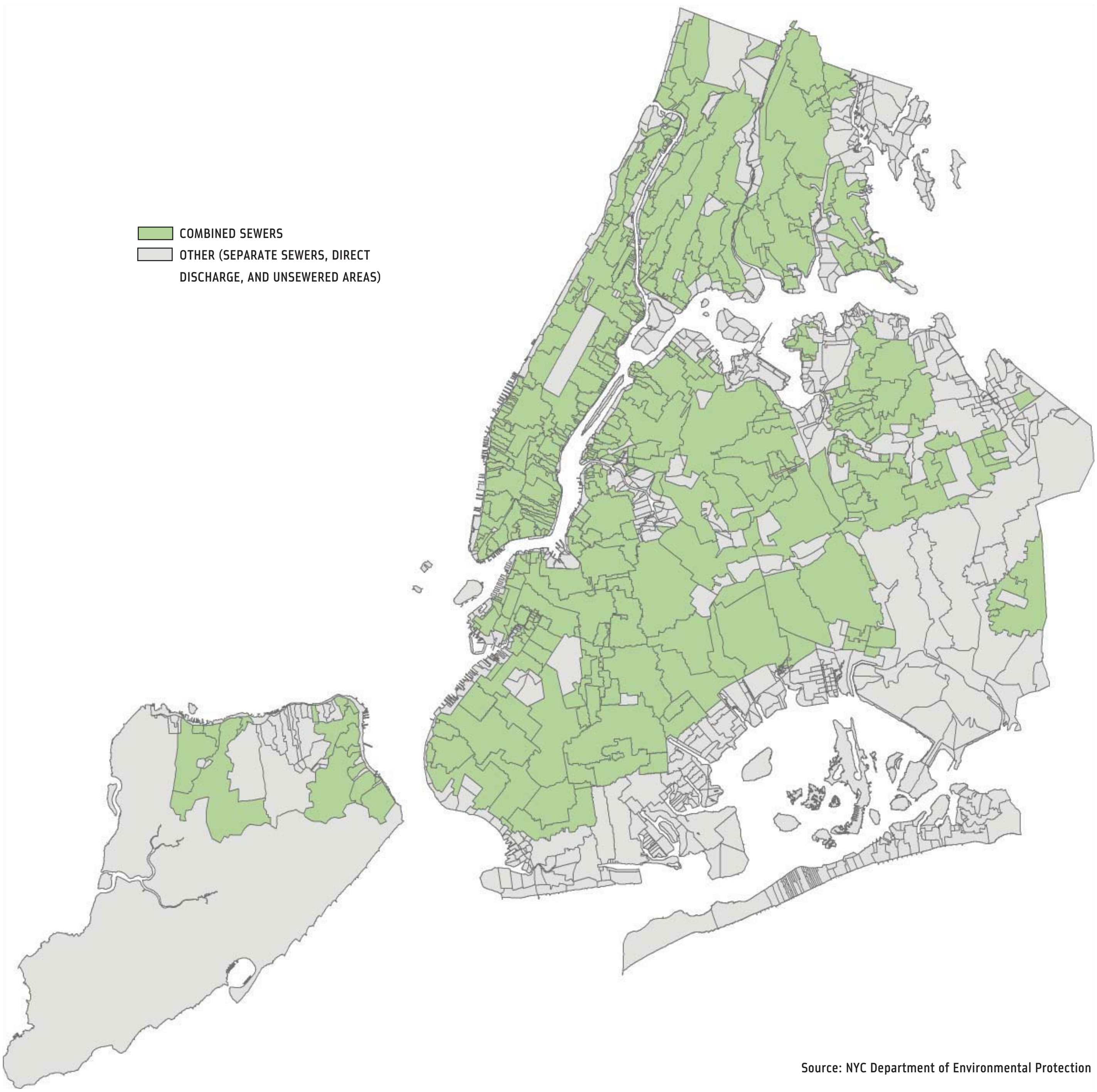
New York City's current infrastructure is comprised of an extensive network of over 6,600 miles of force mains and interceptor sewer pipes that collect sanitary sewage and stormwater, and the 14 WPCPs that receive the flow. This network is one of the City's most significant assets, and has improved the health of generations of New Yorkers.

Approximately 49 percent of the city's total land area and 65 percent of the city's sewered area is comprised of sewers that collect stormwater and sanitary sewage in the same pipes and then direct the combined flow to one of WPCPs for treatment before discharge (Figure 2). The City's 14th plant at Oakwood Beach drains a separate sewer system only. When stormwater threatens to overwhelm the WPCPs or exceeds the capacity of the sewer system, regulator structures with overflow weirs automatically divert flow through 433 outfalls that discharge CSOs to certain receiving waters in New York City. CSOs result in the discharge of coliform bacteria, organic matter, floatables, metals, and other hazardous substances from runoff, industrial discharges, or cleaning and other household products.

The remaining 51 percent of New York City's land area represents separate sewer areas, direct discharge areas, and unsewered areas. Of sewered areas, 35 percent have a separate sewer system for stormwater. There, sanitary sewers direct sewage to WPCPs, while separate storm sewers direct runoff to waterbodies. Separate sewers avoid the problems of CSOs; however, stormwater runoff picks up oil, grease, litter, sediment, pesticides, fertilizers, animal waste, and other pollutants from land and other surfaces. These pollutants are not treated before they are discharged to waterbodies by separate sewers, except for some settling. The "first flush" of runoff from impervious surfaces can contain particularly high levels of these pollutants, especially if there has been a long period of accumulation between rainstorms.

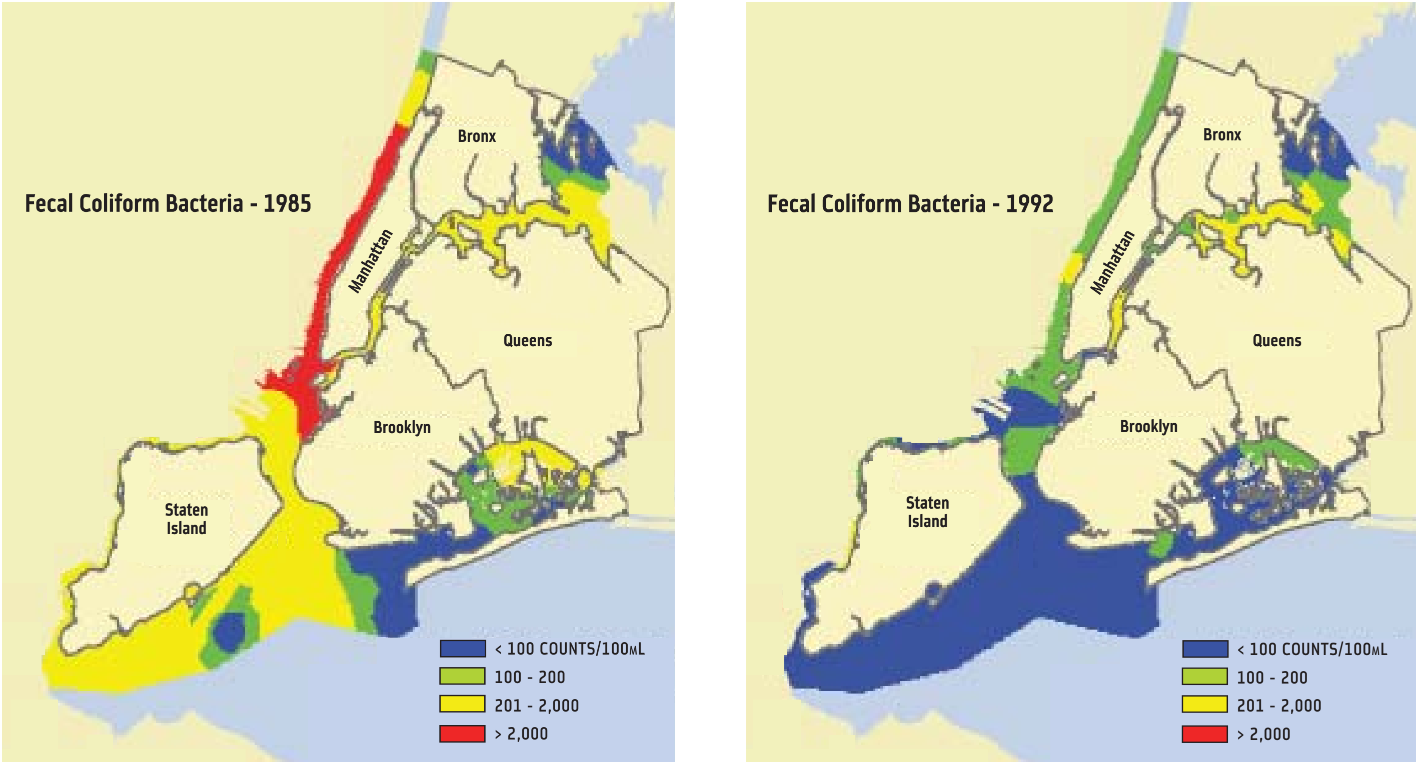
The stormwater management measures described in this Plan have potential benefits in both CSO areas and separate sewer areas. In connection with its ongoing long-term CSO planning efforts, the City has undertaken extensive modeling, focusing on stormwater in CSO areas. This document refers to model results in relation to CSOs because of the availability of this information. The City intends to determine the cross-applicability of source controls between combined and separate sewer areas.

Figure 2: Combined Sewer Areas and Other Areas



Source: NYC Department of Environmental Protection

Figure 3: Trends in Water Quality - 1985 and 1992



Source: NYC Department of Environmental Protection

Ongoing investments in New York City's sewer system

As part of the CSO program, DEP is building detention tanks to store wet weather flow for gradual release to wastewater treatment plants after storms have abated. One, located underneath Flushing Meadows Park, cost $291 million and has the capacity to store 800 millions gallons of combined sewage and stormwater flow annually. It began operating in May 2007. A tank at Paerdegat Basin in Canarsie cost $318 million and will have the capacity to store 1.3 billion gallons of combined flows annually. That tank is scheduled to be in operation by 2011. Finally, in Alley Creek, construction is still ongoing for a $131 million project to construct a 5 million gallon tank and upgrade area sewers.

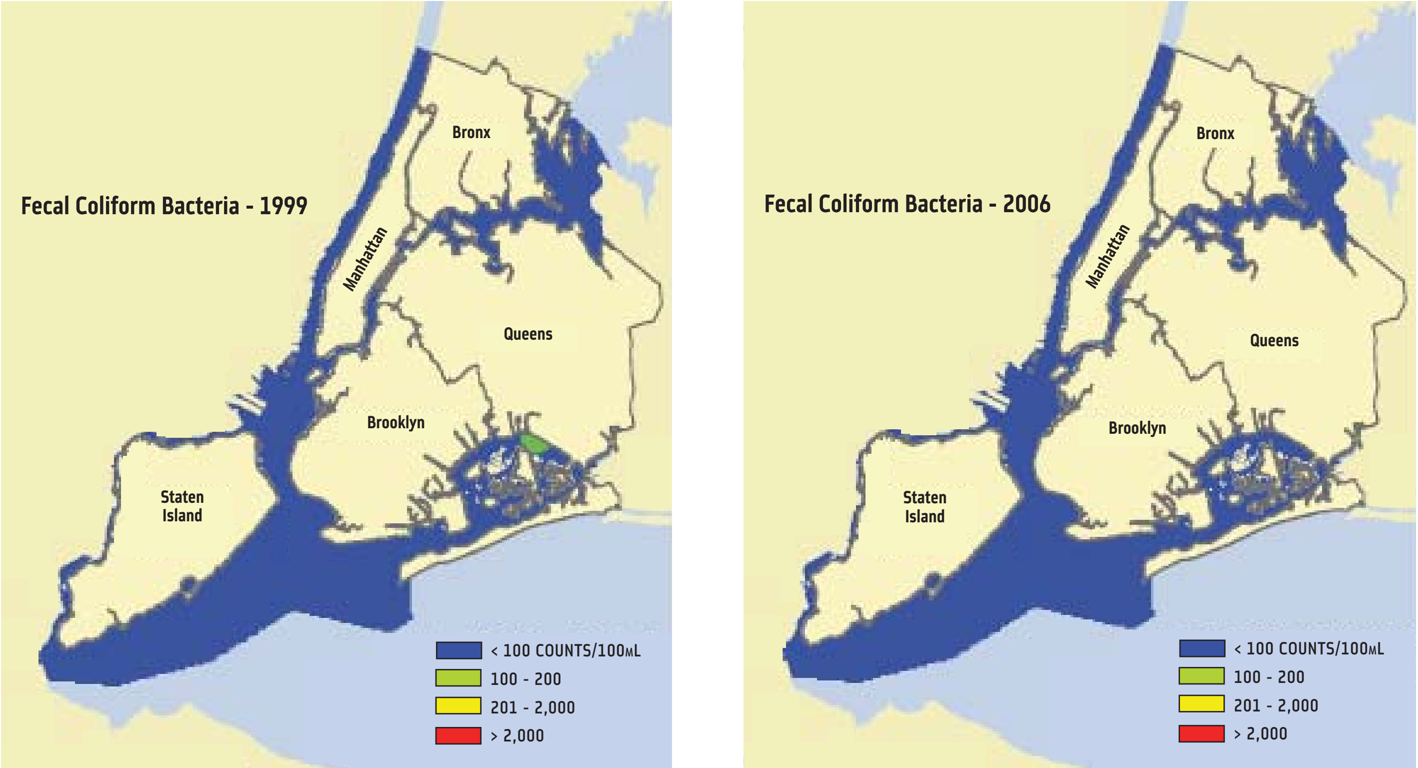
The City also anticipates spending over $1.9 billion on other "end of the pipe" projects over the next ten years to reduce CSOs even further. These projects include facility upgrades, dredging, floatables control, and aeration projects at the Newtown Creek WPCP; pumping upgrades at Gowanus Canal; multiple facility upgrades, dredging, and aeration at Jamaica Bay; floatables control projects at Bronx River; dredging and facilities upgrades at Flushing Bay; and CSO modifications at Westchester Creek. With all of these investments, the City is projected to reach a CSO capture rate of 75 percent.

These investments are the result of a national policy to control CSOs that is being implemented by states and municipalities under the direction of the EPA and the New York Department of Environmental Conservation (NYSDEC). Given the intractable nature of the problem, the size and complexity of the infrastructure involved, and the long lead times for modeling, design, and construction, this policy will be realized nationally over several decades. Municipalities have to file Long Term Control Plans (LTCPs) for controlling CSOs to the states for approval; the EPA requires LTCPs to evaluate a range of controls to eliminate up to 100 percent of CSO volume and to meet applicable water quality standards. New York City's LTCP is due in 2017. In the meantime, the City has worked with NYSDEC to develop plans for sewer and treatment plant investments to achieve existing water quality standards and fulfill the requirements of a CSO Consent Order. These are based on the results of detailed modeling and analysis of the water quality impacts of various alternatives that are required to justify the enormous public expense of infrastructure costs. Facility Plans detailing these investments have been submitted to NYSDEC for approval. The Facility Plans contain all of the EPA required elements of a LTCP. These Plans will form the basis for the 2017 Citywide LTCP.

This Plan is a separate effort and is informed by, and ultimately will inform, those regulatory efforts, but it does not replace them. The City is undertaking modeling for source controls in the coming years. The City will work with NYSDEC to evaluate existing information about the effectiveness of source controls and to review the results of those modeling runs. Source controls may prove sufficiently effective to justify reductions in scale or other reconsiderations of storage tunnels and other hard infrastructure set forth in the Facility Plans. Other municipalities have incorporated source controls in lieu of infrastructure as CSO controls. Portland's Downspout Disconnect program was included in its LTCP, has been adopted by 49,000 households, and reduces annual flow to the combined sewer by over 1.2 billion gallons per year, allowing that city to avoid certain infrastructure investments.

As in many large cities, the entirety of New York's water and sewer infrastructure is funded by revenue it collects through water and sewer rates. To support past and current investments in infrastructure, the Water Board has increased water rates in the City significantly since 1999, yet New York City's rates are still lower than the national per household average. With each increase, the Water Board has to consider the impacts of rates on the overall cost of living and competitiveness of New York City.

Figure 4: Trends in Water Quality - 1999 and 2006



Source: NYC Department of Environmental Protection

Current Water Quality and Stormwater Issues

Water quality improvements over the past 20 years and remaining challenges

Water quality in New York City has greatly improved in recent years. Fecal coliform levels have steadily trended downwards from the 1980s to the present in the open waters of New York Harbor, towards compliance with standards. From 1985 to 2006, monitoring has shown that the average concentration of fecal coliform colonies has dropped dramatically (Figures 3 and 4), which means that our harbor is cleaner than it has been in over 100 years. These improvements took decades of work, and billions of dollars for sewer systems, WPCPs, and storage tanks.

One of the biggest remaining water quality challenges today is stormwater runoff, which contributes to CSOs and other untreated discharges. Stormwater runoff is one reason that many of our tributaries still do not meet standards for recreational use (Figure 6). These waterbodies are Bergen Basin, Bronx River, Coney Island Creek, Flushing Bay, Flushing Creek, Fresh Creek, Gowanus Canal, Newtown Creek, Paerdegat Basin, Thurston Basin, and Westchester Creek (secondary contact recreational use) and Hutchinson River (primary contact recreational use). In New York City, approximately 433 outfalls discharge CSOs during wet weather to the receiving waters of the New York Harbor complex (Figure 5). These discharges result in localized water quality problems such as periodically high levels of coliform bacteria, nuisance levels of floatables, depressed dissolved oxygen, and, in some cases, sediment mounds and unpleasant odors. CSOs are considered to be the largest single source of pathogens to the New York Harbor.

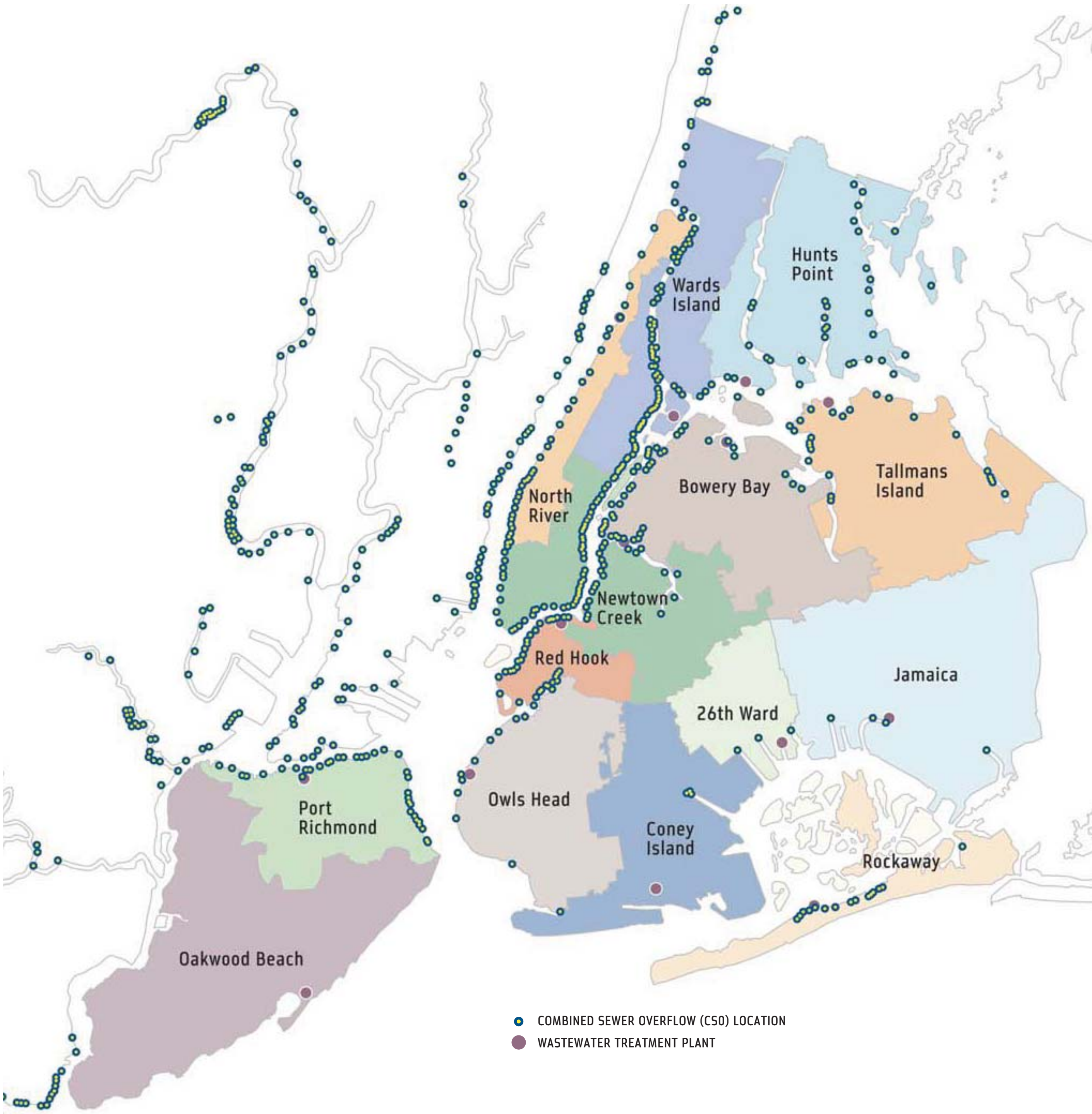
There are four basic strategies that the City is implementing to improve water quality in these tributaries: removing remnant pollution by dredging, increasing the capacity or throughput at our WPCPs, reducing CSOs, and reducing other untreated runoff. The last two strategies focus on capturing or detaining stormwater before it reaches our sewer system or waterbodies.

Stormwater controls and surface water quality

Many waterbasin-specific factors affect water quality, not just CSOs and untreated discharges from New York City. Some waters in the New York Harbor are listed as impaired because of sediments that are contaminated with dioxins, cadmium, polychlorinated biphenyls (PCBs), and other remnants of our industrial past. Contaminated sediments from stormwater runoff either in separate or combined areas contributes to water quality impairments in the vicinity of outfalls and creates impediments for achieving water quality. Contaminated sediments are problematic because they introduce toxic substances into waterways that affect marine life and the food chain, and may require costly and extensive dredging and disposal in the future.

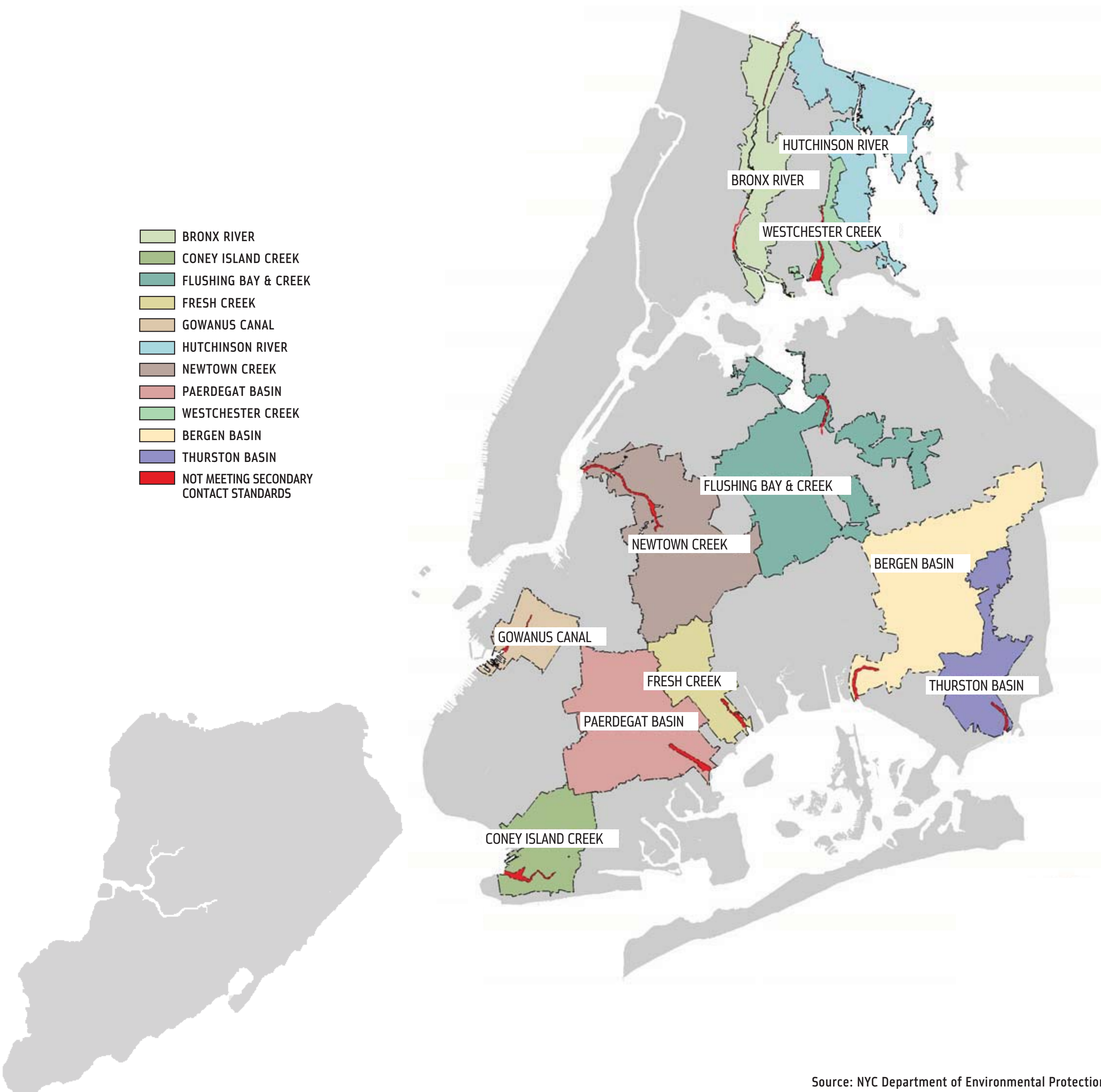
Other factors create water quality issues. The Hudson River in New York City is listed as "impaired" for fish consumption because of elevated levels of PCBs, dioxin, and cadmium from past industrial discharges, particularly in the Upper Hudson River. Indeed, nearly the entire Hudson north of New York City is impaired for fish consumption. In addition, there is ongoing pollution of upstream Hudson River tributaries with oil, grease, fecal coliform, and other pollutants in stormwater runoff, from discharges from other municipalities' wastewater treatment plants, and from small industrial dischargers. And the upper Bronx River in Westchester County is "impaired" for aquatic life and recreational use because neither dissolved oxygen nor coliform standards are met in the upper Bronx River. In that segment upstream of New York City, aquatic life support, recreational uses and aesthetics are restricted by low dissolved oxygen, floatables, debris, organic inputs and pathogens from stormwater discharges and various other urban nonpoint runoff sources that degrade the waterway.

Figure 5: Drainage Areas to Water Pollution Control Plants and CSO Outfall Locations



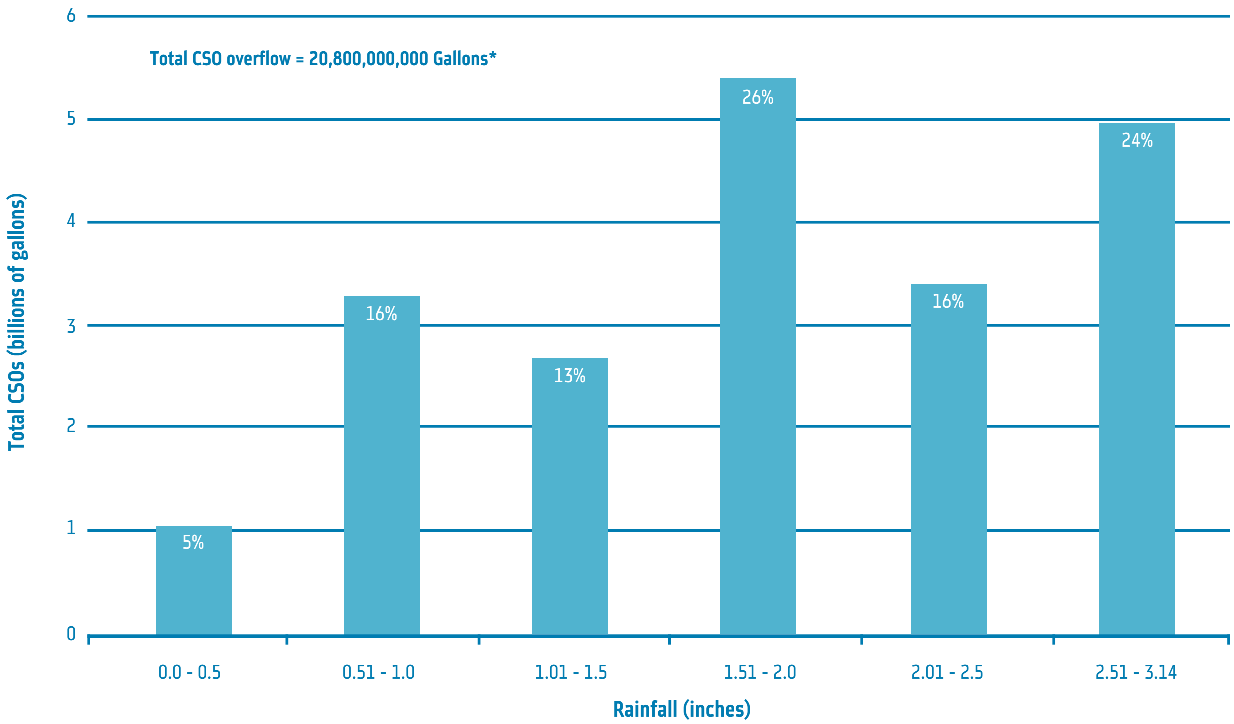
Source: NYC Department of Environmental Protection

Figure 6: Waterbodies Out of Attainment with Water Quality Standards



Source: NYC Department of Environmental Protection

Figure 7: Rainfall and CSO Volume



* "Total CSO overflow" reflects the projected overflows when all planned upgrades and elements of the Waterbody/Watershed Facility Plans are online, with the exception of the Newtown Creek and Flushing Bay CSO storage tunnels. See Appendix D.

Source: NYC Department of Environmental Protection

While it is important to recognize that CSO reductions from New York City alone will not solve our remaining water quality problems, that fact is not an excuse for inaction. If policies were limited to only "magic bullet" sources, then little action would be taken and few improvements would be made. PlaNYC's approach is to implement many incremental improvements. Therefore, this Plan is intended to start limiting the contribution of the City's CSOs to poor water quality.

Pollutant loading and rainfall

New York City has a wet climate, receiving approximately 44 inches of precipitation every year. The connection between precipitation and CSO discharges is not a fixed ratio, nor is the effect of rainfall the same in each watershed. We do know that rainfalls of less than one inch cause most of the CSO events citywide, while larger rainstorms cause most of the CSO discharges by volume. (Figures 7 and 8 are based upon modeled CSOs after planned upgrades are built; waterbody-specific charts of CSO volumes are found Appendix I).

As with the frequency of overflows, the level of pollutants is not proportional to rainfall. Rather, smaller CSO events will have more concentrated pollutant levels than larger CSO events because they contain a smaller amount of diluting stormwater and a larger amount of the first, concentrated flush of pollutants from impermeable surfaces. This characteristic of smaller CSO events is particularly true for fecal coliform and other pathogens; sanitary sewage flows stay relatively constant while stormwater flows are lower during smaller rainfalls, so CSOs during small rainstorms contain a greater percentage of sanitary flow.

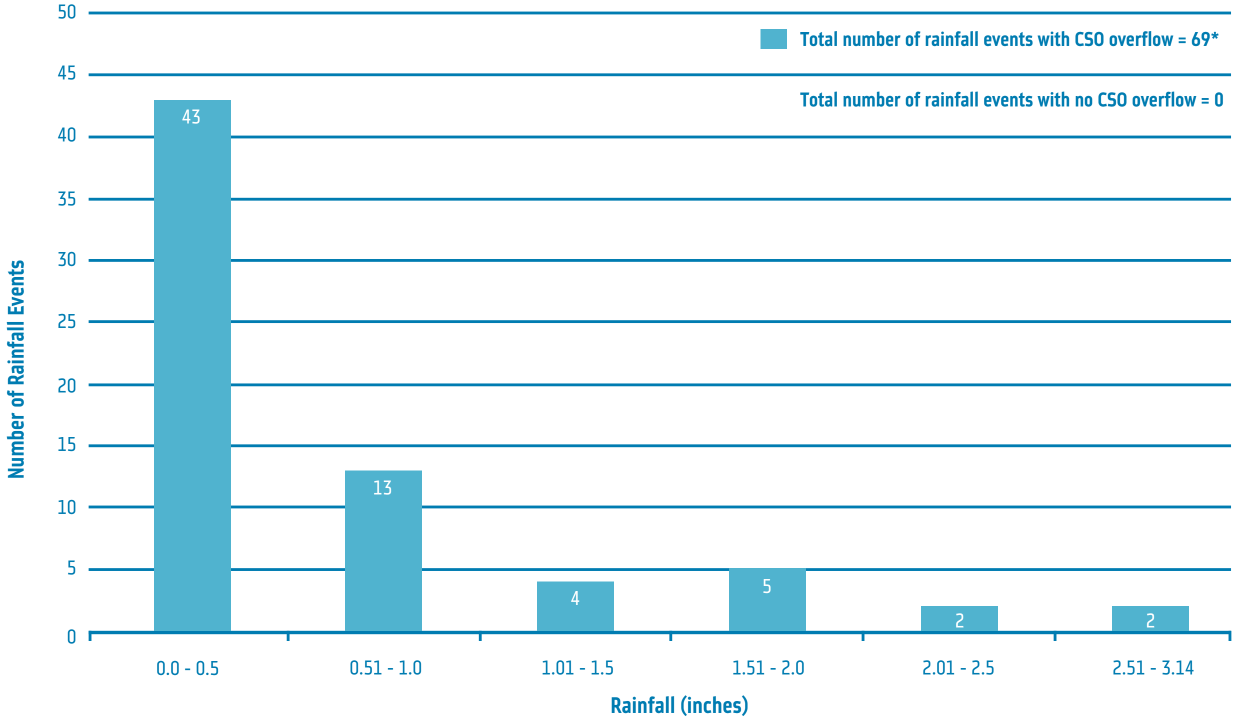
These characteristics mean that the frequent but smaller CSO events may be more of a water quality concern than overall CSO volumes. The dilution factor also means that focusing solely on CSO volumes produces diminishing water quality benefits, since larger rainstorms produce most of the CSO volume, but in highly diluted form. Attempting to control runoff from the largest and most infrequent storms would increase costs significantly but would achieve smaller incremental water quality benefits than controlling the lower CSO volumes from more frequent, smaller storms.

Flooding and sewer back-ups

New York City has intense storms that cause flooding and other problems. For example, in the summer of 2007, rapidly-moving, localized, and intense rain storms – peaking at 1.93 inches in one hour on July 18th, and more than 3 inches of rain in a two-hour period on August 8th – caused severe flooding throughout the city, focused in Queens. Many people could not get to work because subways and bus routes were flooded. The City responded by creating a Flood Mitigation Task Force, which issued recommendations to mitigate the problem on April 28, 2008 (the recommendations are described in a later chapter).

A decentralized source control strategy would attempt to capture runoff from the more frequent, smaller storms that contribute to localized, nuisance flooding. Flooded sewers can also cause sewer back-ups in homes and other buildings. Sewer back-ups occur when the level of sewer water rises to the level of fixtures that are below street grade. As the water seeks its own level, it will rise through the fixtures unless they are above the surcharge height or unless protective measures, such as backwater valves, are in place. Finally, and fortunately rarely, when a surcharged combined sewer encounters a bottleneck or a counter-flow, the internal pressure in the sewer may become so great that it will push up through the catch basins and manholes.

Figure 8: Rainfall and CSO Frequency



* "Total number of rainfall events with CSO overflow" reflects the projected overflows when all planned upgrades and elements of the Waterbody/Watershed Facility Plans are online, with the exception of the Newtown Creek and Flushing Bay CSO storage tunnels. See Appendix D.

Source: NYC Department of Environmental Protection

DEP data shows that flooding and sewer back-ups are widespread across the city, not just in combined sewer areas (Figures 9 and 10). In each of the last five fiscal years, DEP has received over 21,000 complaints of sewer back-ups. During that same period, complaints about clogged catch basins, which can lead to localized flooding, increased from over 13,000 in fiscal year 2004 to over 18,000 in calendar year 2007, a year when several intense storms occurred. Sewer backups can be caused by many different issues, including storms that exceed system capacity, improper protections on below grade fixtures, clogged catch basins, or localized blockages from grease or other debris that restrict flow in the system.

Climate change and increased rainfall

Climate change could exacerbate the effects of stormwater runoff. Climate change has already caused an increase in the amount, intensity, and variability of precipitation in New York City. At the Central Park rainfall station, for example, only 11 of the 100 years before 1970 recorded rainfall of more than 50 inches per year; in the 38 years since then, 15 years have exceeded 50 inches of rainfall (Figures 11 and 12). Most climate change models predict that average regional precipitation will increase by 5.7 percent by the 2050s, and 8.6 percent by the 2080s. In addition, models predict an increase in the intensity of rainfall events, which would increase flooding and stormwater runoff. As with any modeled predictions, there is a range of uncertainty about the magnitude and timing of any changes that will affect our drainage system, but all models predict that precipitation will increase.

Sea level rise, the loss of natural wetlands, and coastal flooding

Expert predict that New York City can expect a sea level rise of 4.3 to 7.6 inches by the 2020s, 6.9 to 12.1 inches by the 2050s, and 9.5 inches to three feet by the 2080s.That increase will exacerbate coastal flooding and will have other negative effects on stormwater management.

In response, the City has convened the New York City Climate Change Adaptation Task Force of city, state, and federal agencies and private companies that operate, maintain, or regulate critical infrastructure in New York City. The Task Force is creating an inventory of roads and other infrastructure that could be at risk from the impacts of climate change.

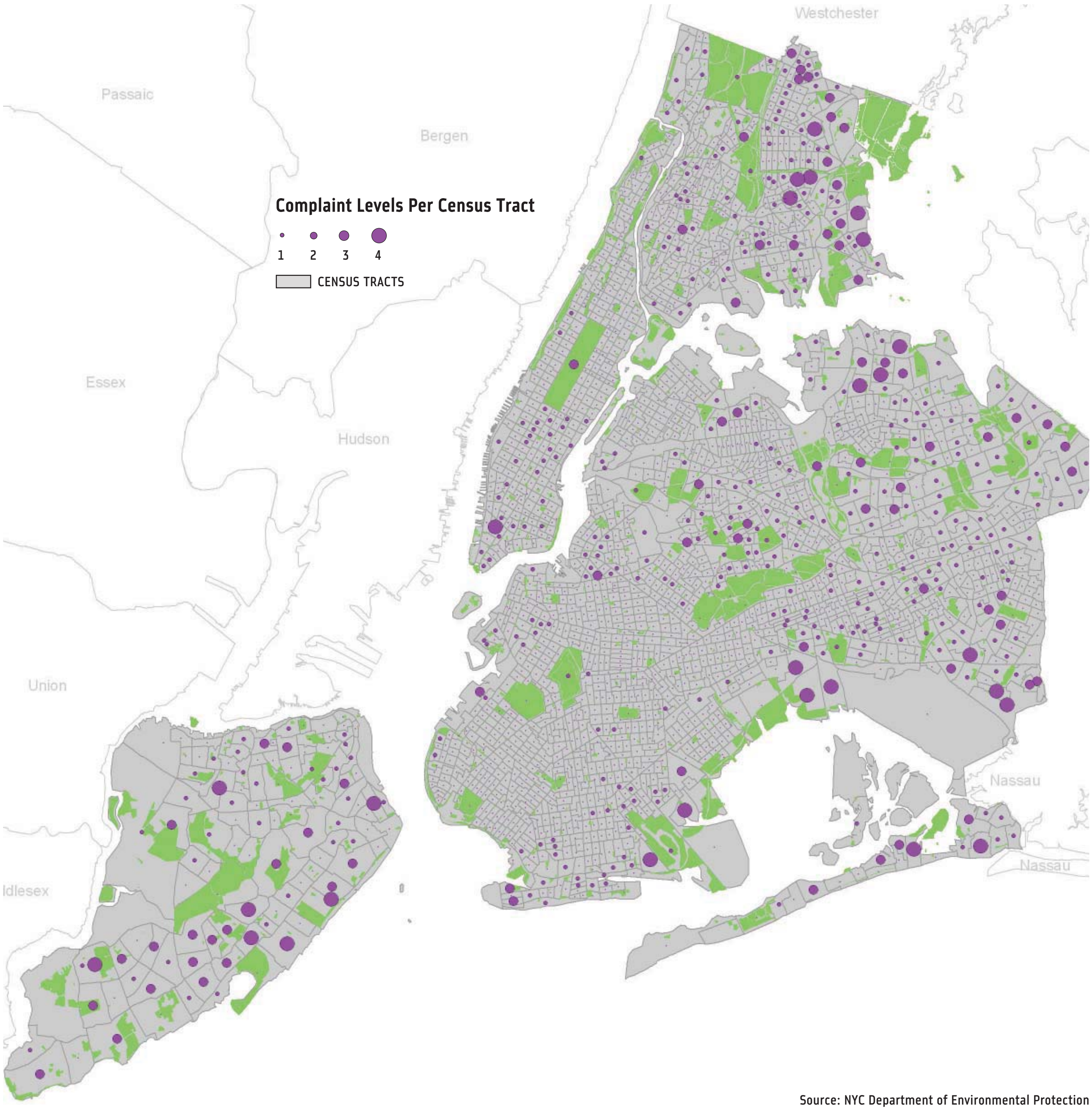
By December 2009, the Task Force will develop initial adaptation strategies to protect the City's critical infrastructure. As part of that effort, the City is developing information about potential in-land migration areas for tidal wetlands. And PlaNYC's chapter on climate change and adaptation committed to update the Federal Emergency Management Agency (FEMA)'s floodplain maps for New York City, which were last revised in 1983 based on even earlier data. The updated maps will reflect changes to the shoreline and elevations, rising sea levels, and the increased severity of storms. The information in those maps will inform our understanding of low-elevation, potential flooding areas.

Future Investments in Source Controls

Complementing hard infrastructure

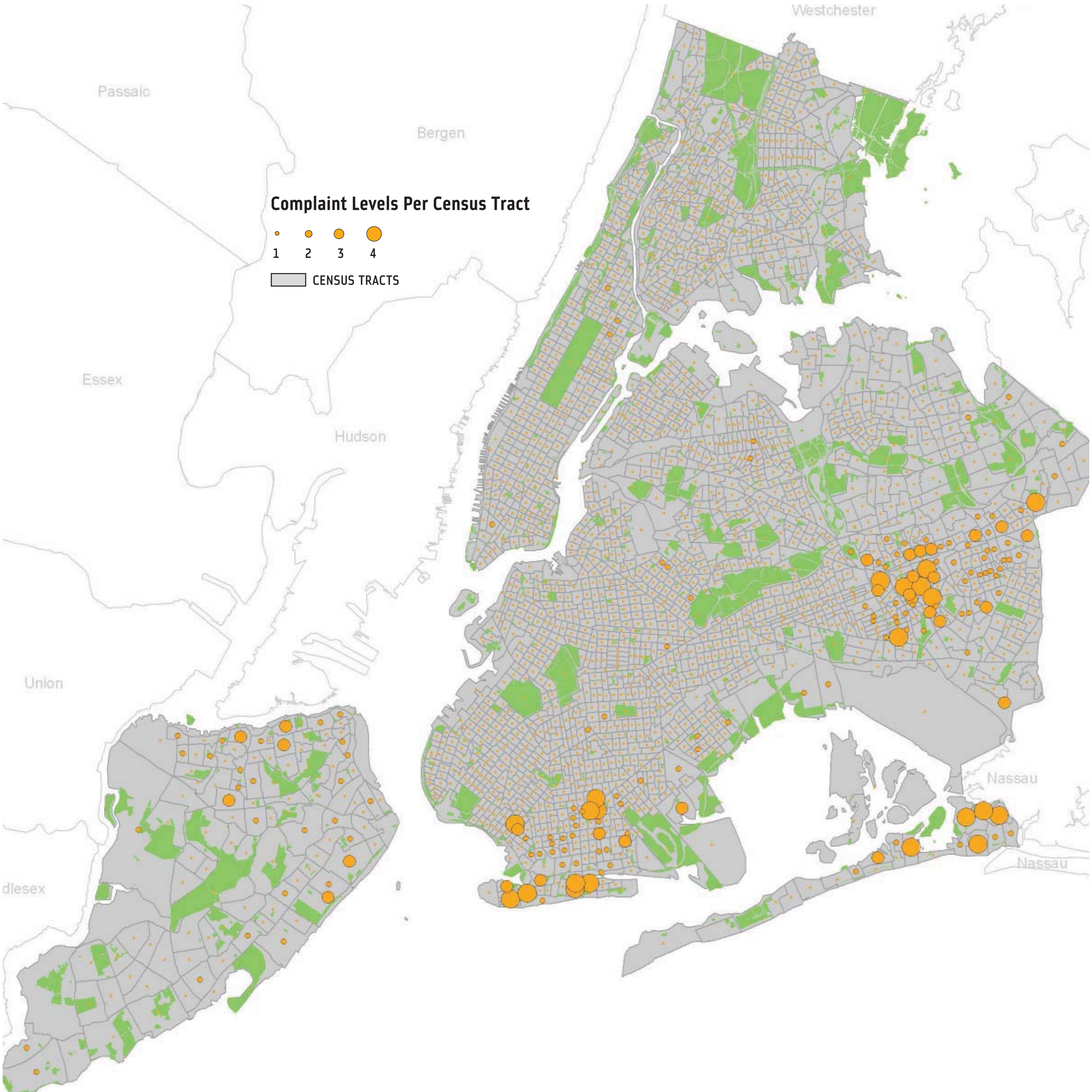
While effective, the "end of the pipe" solutions that the City has built or will build will not completely eliminate untreated discharges. These large installations are costly to construct, operate and maintain, take years to complete, and are ultimately limited by physical constraints in the sewers that lead to the WPCPs.

Figure 9: Flooding



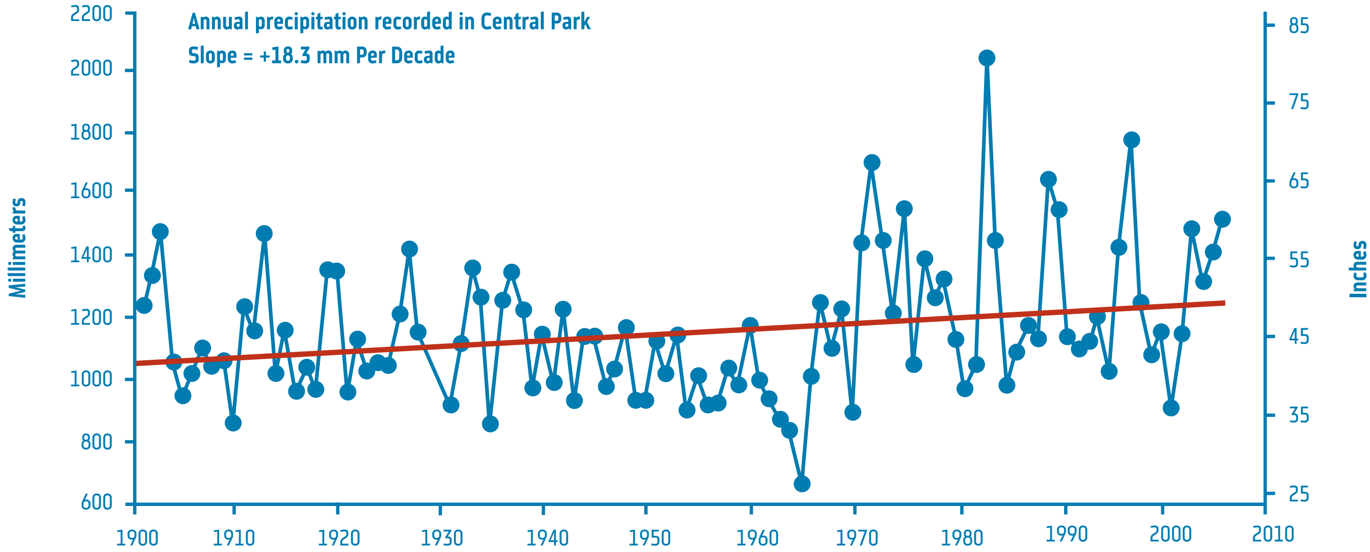
Source: NYC Department of Environmental Protection

Figure 10: Sewer Backups



Source: NYC Department of Environmental Protection

Figure 11: Trends in Precipitation



Source: Columbia Center for Climate Systems Research

Some future storage facilities are expected to be very expensive on a per gallon basis. Big infrastructure projects have long lead times for planning, design, bonding and construction, leaving them vulnerable to escalating costs from external market conditions for material, labor, and financing.

A recent report by the New York Building Congress found that general contractors in New York City experienced a 5 to 6 percent increase in construction costs in 2004, an 8 to 10 percent increase in 2005, a 12 percent increase in 2006, and an 11 percent increase in 2007, due in part to rising global demand for essential commodities like steel and concrete for booming economies in India and China. Other reasons for the rise in costs for large DEP projects include the small number of firms that can build such projects, the unavailability of sites for large storage tanks or, in the alternative, the expense of excavation for deep storage tunnels.

Distributed source controls have the potential to reduce some of these costs. At sufficient scale, distributed controls may free up enough sewer capacity and reduce enough combined flows to reduce the costs of treatment at WPCPs and related greenhouse gas emissions.

Retention source controls that reduce potable water consumption could help to offset demand for drinking water. Distributed source controls also have the potential to provide non-stormwater benefits through synergies with trees and other landscape elements that can perform other functions.

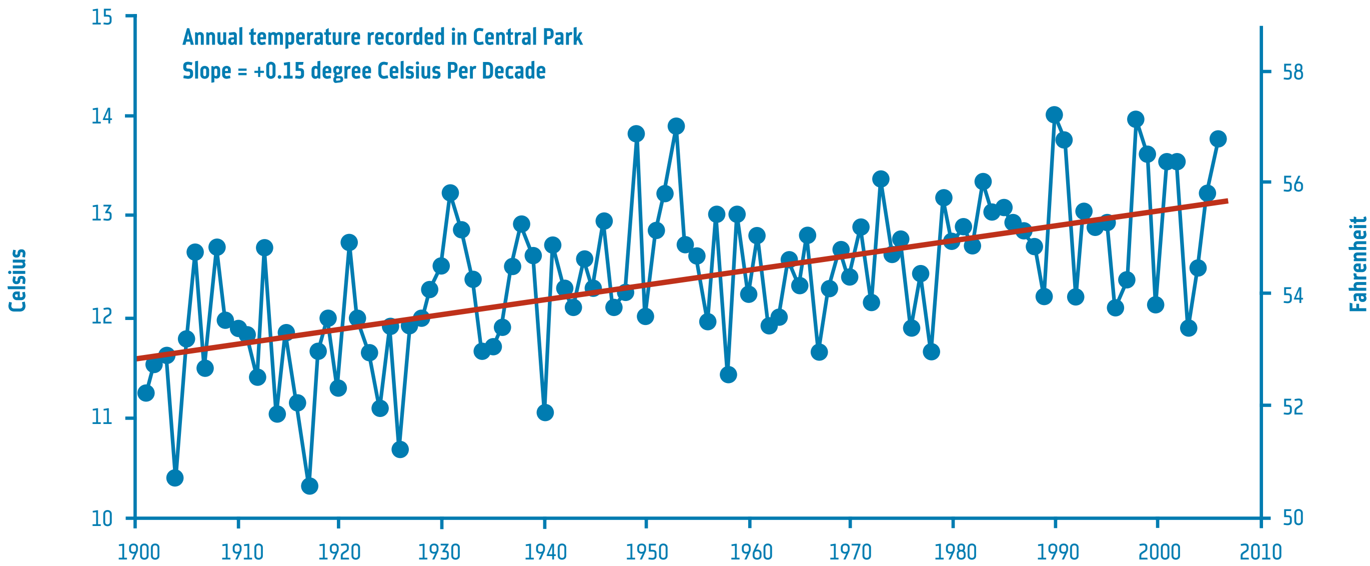
The City is undertaking modeling for source controls in the future as promised in the Facility Plans. The questions to be answered are whether existing information about the effectiveness of source controls is adequate for that modeling effort and whether the results of those modeling runs will be sufficiently reliable to make decisions. These are important questions as the City and NYSDEC together decide whether investments in source controls could justify the redesign or other reconsideration of storage tunnels and other hard infrastructure set forth in the Facility Plans. This modeling effort is part of a contract to be initiated in early 2009, and analysis is expected to be complete in 2012.

A nationwide movement toward source controls

The EPA has recently endorsed source controls or "green infrastructure" as a way that municipalities can control stormwater. (See Appendix H for more details). The agency actively encourages regulated municipalities to reduce runoff volumes and sewer overflow events through the wide-spread use of management practices that capture and treat stormwater runoff before it is delivered to ambient waters.

The EPA has provided guidance for constructing source controls, including an *Urban Stormwater Retrofit Practices Manual* and an *Urban Best Management Practices Performance Tool Kit* with studies covering a variety of traditional and low-impact source control types.

Figure 12: Trends in Temperature



Source: Columbia Center for Climate Systems Research

The EPA has also published several reports suggesting that source controls can be less expensive than conventional stormwater controls, with potential capital cost savings of 18 to 80 percent. Whether those estimates hold true in New York City is one of the key questions that would have to be answered before source controls can be widely adopted here.

Several municipalities have pioneered stormwater source controls for new development. For example, Minneapolis requires source controls to treat the first 1.25 inches of rainfall and requires system-wide downspout disconnection from its combined sewer system. Philadelphia requires all new developments over 15,000 square feet, and redevelopments that increase impervious area, to manage the first inch of rainfall on-site through infiltration or other techniques that improve water quality. It also has a program to convert vacant lots in the city to stormwater parks that infiltrate stormwater into the ground. Portland, Kansas City, Baltimore, Seattle, Chicago, Atlanta, Milwaukee, and other cities have taken similar approaches to mitigate adverse impacts from new development or redevelopment that increases impervious areas. Retrofitting existing development is more difficult, but these cities have successfully implemented pilot programs to test the viability of source controls and have also adopted some source controls on city-owned property and in the public right of way.

Municipal Budget Considerations

This Plan also takes place within a financial context that controls the available choices for the City. In early November 2008, Mayor Bloomberg declared that the City faces a cumulative $4 billion budget gap for fiscal years 2009 and 2010, despite prudent efforts followed in previous years to use budget surpluses to stabilize the City's future and to pay down over $1 billion of debt.

To reduce the deficit, the Mayor announced a series of difficult spending reductions and other measures to achieve $1.5 billion in savings, including a reduction in the City workforce by over 3,000 employees and a cut in City funds to the Department of Education by $181 million in 2009 and $385 million in 2010. The City will also save $20 million – and further reduce the City's carbon footprint – through maintenance efficiencies, inventory review, lifecycle management, joint fuel purchasing agreements, and "right sizing" of the City's vehicle fleet. The Mayor's proposals will substantially reduce the budget deficit. Nevertheless, even if those proposals are implemented New York City faces budget gaps of approximately $1.3 billion in fiscal year 2010, $5.0 billion in fiscal year 2011 and $4.9 billion fiscal year 2012. The initiatives in this Plan are and will be tempered by that fiscal reality.


Credit: NYC Economic Development Corporation

Land Use Considerations

New York City is a challenging environment for stormwater management. Our population density is 27,000 residents per square mile, far higher than that of any other American city. This density is supported by aboveground development that generates a significant amount of stormwater runoff, thus requiring the creative design and placement of controls in space-constrained areas. For these reasons, the source control plans of other cities can be informative for New York City but cannot be adopted wholesale.

Development Patterns in New York City

Our stormwater challenges began with the changing land use and development patterns in New York City. Before development, surface runoff was insignificant because the environment absorbed most precipitation as undisturbed soils stored water for plant evapotranspiration and infiltration to groundwater. Over time, natural permeable areas in New York City were developed (Figure 13). Now more than three-fourths of our land is covered with impervious surfaces (Table 1). Over the last century the city's wetlands shrank by almost 90 percent. And in the last 25 years, as the city has regained population, more than 9,000 acres of vacant land were converted to impermeable buildings, parking lots, and roadways. In our separate sewer areas, developments have been built or increasingly retrofit to convey stormwater as quickly as possible from roofs, driveways, parking lots and roads. The increased volume and frequency of runoff is associated with higher elevations of pollutants, altered and eroded channels, and pollution-tolerant invasive species. Even some of our heavily-used grass athletic or recreational fields have compacted soil that generates substantial runoff.

In contrast to natural permeable areas, rain does not soak into impermeable surfaces. Instead, runoff occurs almost immediately and peaks quickly, effectively forming flash flood conditions during intense rain storms.

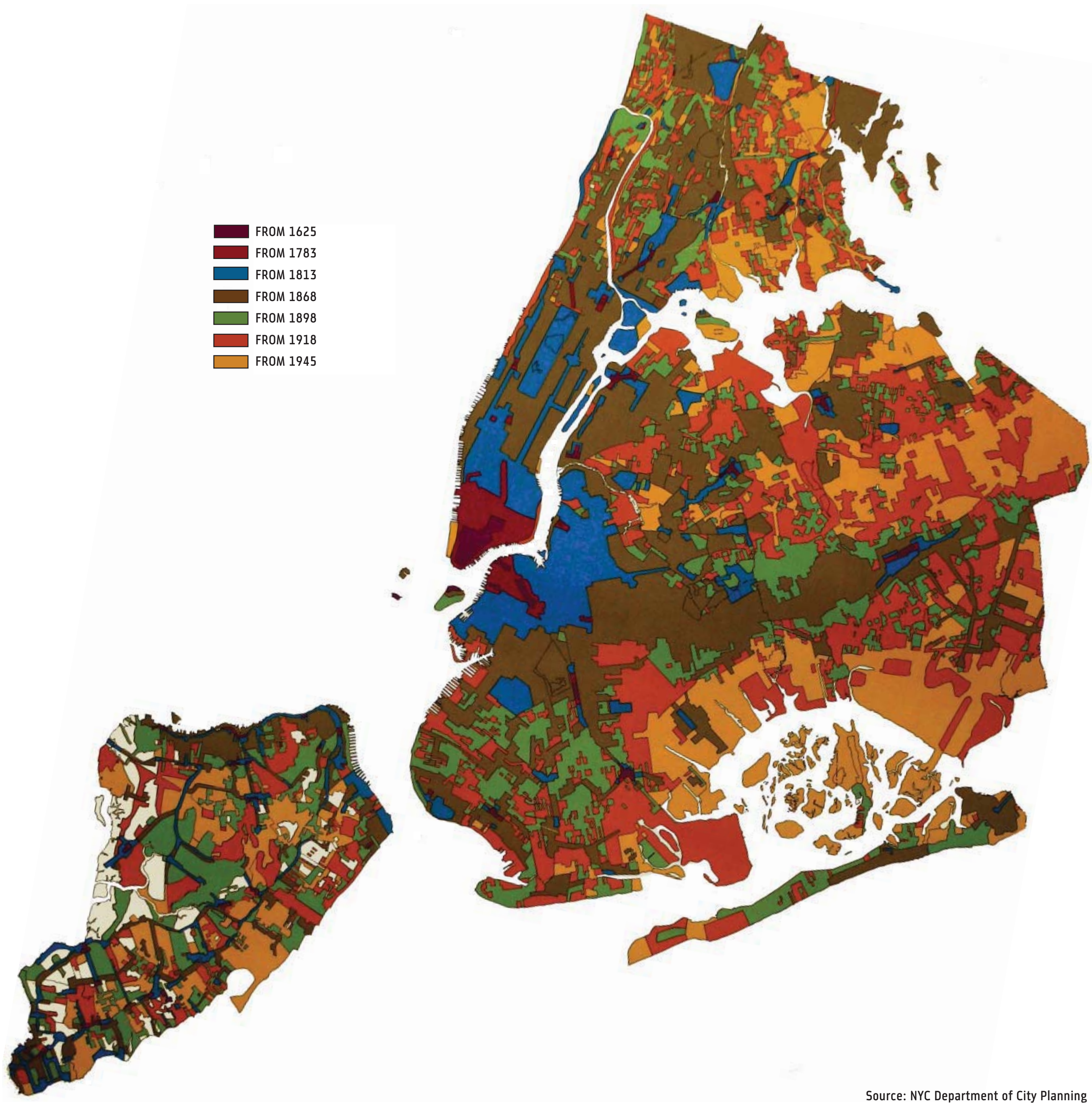
Designing source controls in urban areas presents different engineering challenges than designing source controls in rural or suburban areas. Where we still have low-density areas, we still have used natural drainage corridors to convey, treat, and detain stormwater, such as the network of wetlands that comprise the 10,000-acre Staten Island Bluebelt system. But the feasibility of various source controls technologies in ultra-urban environments is limited by space and design requirements, as recognized in a U.S. Department of Transportation in a 2002 study, *Stormwater Best Management Practices in an Ultra-Urban Setting: Selection and Monitoring*.

Since buildings occupy a significant percentage of the New York City's land surface, there is little undeveloped space left over within lots to place source controls. And the space between lots is dedicated to impervious sidewalks and road surfaces; underneath it all is much of our infrastructure – subways, tunnels, steam pipes, water and sewer pipes, electrical and telecommunications lines – which precludes the infiltration of stormwater in many areas.

These land use constraints will become more challenging over time. Development will create additional demand for the capture or treatment of stormwater and CSOs. Population growth will add to sanitary sewage flows in the city, and higher levels of rainfall will increase stormwater flows. Yet as more people live in new developments built along the shoreline, and as other New Yorkers continue

Residential Development in Manhattan

Figure 13: Development of New York City from 1625 to 1988



Source: NYC Department of City Planning

Table 1: New York City Land Area Weighted by Impervious Surfaces

			ALL CITY LAND		IMPERVIOUS SURFACES		
SECTOR	LAND USE CATEGORIES*	NET LAND AREA (ACRES)	% OF TOTAL LAND AREA	GROUP % OF TOTAL LAND AREA	IMPERVIOUS RATIO	% IMPERVIOUS	% OF IMPERVIOUS AREA
	Multi-family residential	18,273	9.5%		75%	9.7%	
	One- and two-family residential	41,542	21.5%		65%	19.2%	
	Mixed residential and commercial	4,137	2.1%		75%	2.2%	
	Commercial and office	5,648	2.9%		85%	3.4%	
BUILDINGS & LOTS	Industrial or manufacturing	5,532	2.9%	45.5%	85%	3.3%	45.8%
	Government buildings	4,641	2.4%		85%	2.8%	
	Institutional buildings	5,988	3.1%		85%	3.6%	
	Garages	1,052	0.5%		95%	0.7%	
	Parking lots	1,113	0.6%		95%	0.8%	
RIGHT OF WAY	Sidewalks	15,455	8.0%	26.6%	85%	9.3%	33.6%
	Street surfaces	35,933	18.6%		95%	24.3%	
	Parks	18,512	9.6%		25%	3.3%	
OPEN SPACE	Recreational buildings	1,445	0.7%	13.3%	85%	0.9%	5.2%
	Other open space	5,797	3.0%		25%	1.0%	
VACANT LAND	Public vacant land	6,950	3.6%	4.5%	60%	3.0%	3.7%
	Private vacant land	1,727	0.9%		60%	0.7%	
	Airports	4,416	2.3%	2.3%	95%	3.0%	3.0%
	Private utilities	3,640	1.9%	1.9%	90%	2.3%	2.3%
	Cemeteries	4,201	2.2%	2.2%	60%	1.8%	1.8%
	Other transportation facilities	2,216	1.1%	1.1%	95%	1.5%	1.5%
	Other public facilities	1,930	1.0%	1.0%	95%	1.3%	1.3%
	Miscellaneous lots	2,078	1.1%	1.1%	75%	1.1%	1.1%
	Gasoline stations	988	0.5%	0.5%	95%	0.7%	0.7%
	TOTAL	**193,214**	**100%**	**100%**	**78%**	**100%**	**100%**

* Analysis by the Mayor's Office of Long Term Planning and Sustainability, based on MapPLUTO data and other City information, and following the methodology set out in Appendix D

to discover our waterfront through public and private esplanades, parks, and other access points, the need to improve water quality will become ever more urgent.

Land Use Framework

This Plan was partially determined by an analysis of New York City's land use. In order to identify the most promising technologies for widespread adoption, the City identified the types of public and private properties that contain impervious surfaces and cause stormwater runoff pollution. The overall breakdown of land uses provides the framework for developing source control strategies.

The geographic sources of stormwater

This Plan's geographic analysis shows that it is possible to focus on a few broad land use categories and still address most of the stormwater sources in the city. That finding is based on a preliminary analysis of the current state of land use in the city, corrected for imperviousness (Table 1).

The two largest land use categories that contribute to the city's high level of impermeability are buildings and lots and the right of way, which combined account for approximately 80 percent of non-permeable areas. The city's third largest land use category, open space, contains a smaller percentage of impervious area but could capture additional stormwater from surrounding impermeable surfaces.

The impervious land area ratios were derived from many sources, including sources outside of New York City. They are therefore subject to change when better information is available, including information we expect from an ongoing DEP project to use satellite imagery to map impervious surfaces across the city.

Buildings and lots

Buildings and developed lots represent 45 percent of the land area in the city. This is a diverse category comprised of one- and two-family homes, multi-family residences, public facilities, commercial or office buildings, industrial and manufacturing facilities, and mixed residential and commercial developments.

There are over 900,000 existing buildings in New York City. The highly fragmented ownership and management of buildings, and their unique configurations, presents challenges to implementing any policy. However, some strategies cut across these subcategories, such as strategies for roofs, driveways, and other impervious areas. By some estimates, there are approximately 944 million square feet of roof surfaces in the city, and approximately 75 percent of that total is comprised of roofs with a flat or shallow slope.

When adjusted to account for the degree of imperviousness, the relative contribution of the buildings and lots category accounts for approximately 46 percent of the impervious surfaces in the city. This reflects the fact that several of the major land use subcategories – multi-family residential, commercial and office buildings, industrial or manufacturing buildings, government and institutional buildings, and garages and parking lots – are almost entirely covered by impervious surfaces such as roofs and asphalt. The exception is one- and two-family homes, where existing yard areas provide some pervious surfaces that may reduce stormwater runoff. But as noted in other contexts by DCP and the Flood Mitigation Task Force, runoff from low-density developments like single and two-family homes has increased 50 percent since 1950, as some residents paved over their yards, often in an effort to obtain more parking spaces. A DCP zoning amendment adopted in 2008 established front yard planting requirements that limit the amount of paving in front yards.

Right of way

Roads and sidewalks comprise approximately 27 percent of the city's land area and approximately 34 percent of its impervious surfaces. The public right of way is under the general jurisdiction of one agency, DOT, which reconstructs roadways and sidewalks, repaves roads, maintains bridges and tunnels, and regulates the geometry and specifications of roadbeds and sidewalks, street furniture, and lighting. However, many other agencies are active in the right of way. DDC designs and oversees construction of projects for DOT; the Parks Department plants street trees, regulates private tree plantings, and builds and maintains Greenstreets installations; DCP establishes requirements for private development of roads and sidewalks; and DEP builds and maintains catch basins, sewers and water mains and regulates sewer and water connections. In addition, DSNY cleans the streets and picks up litter and garbage, which is sometimes supplemented by business improvement districts and other community-based organizations. Finally, private landowners now must maintain sidewalks in front of private property. Each of these actors has the potential to contribute to stormwater management in the right of way.

Open space

Open space represents approximately 13 percent of the land area in the city, but only 5 percent of our impervious surfaces. These figures reflect the fact that parklands contain significant pervious surfaces that absorb rainwater. Despite the limited opportunity to improve existing open space areas, they can be hydraulically connected to a much larger land surface that is generally impervious. Therefore, we have identified new strategies to address roadways and other impervious surfaces surrounding parkland. The City's experience with the Bluebelt program shows that natural areas can be harnessed to absorb and filter stormwater that would otherwise go into the sewer or flood our roads. Preserving open space can constitute a significant source control measure in its own right.

Other areas

The remaining land area in the city is comprised of diverse uses that include vacant lots, airports, gas stations, transportation facilities, and other land uses. Vacant lots are one of the categories that may have potential for stormwater control, as they represent 5 percent of land area and 4 percent of impervious surfaces. However, the City expects that many vacant lots will be developed to accommodate our growing population. Some of the other areas contain crucial infrastructure, soil contamination, or other factors that may limit infiltration techniques or other source controls. Other significant impervious areas, such as the vast areas of paved runways and taxiways at the LaGuardia and John F. Kennedy International airports managed by the Port Authority of New York and New Jersey, are outside of City control.

Geographic Strategies for Stormwater Capture

A citywide approach to stormwater controls

This analysis indicates that the City must seek some policies that promote the uniform and widespread adoption of source controls. Stormwater controls are needed in all areas of New York City, regardless of whether they are served by combined sewers, separate sewers, or direct discharge systems. Source controls address many stormwater-related challenges, including CSOs, discharges of polluted runoff from separate sewer and direct discharge areas, local nuisance flooding, sewer backups, and the strain on our sewers of handling increased sanitary flows from additional development. A geographic overlay of these issues confirms that the need for source controls is widespread, and is not limited to specific areas.

In addition to analyzing citywide land use and sectors that contribute to impervious surfaces, the City also examined the sub-watersheds that produce high CSO volumes. That analysis indicated that the majority of the city's combined sewer areas contribute to CSO volume at a uniform level. When maps of CSO outfalls are normalized by the land area of their contributing sewersheds, it becomes apparent that, on an average basis, large swaths of the city contribute to CSOs at a similar rate (Figure 14). In fact, the outfalls with the largest CSO volumes receive runoff from the largest land areas. That finding is not surprising given the high levels of impervious surfaces that exist throughout most of our combined sewer areas.

The City has concluded that a non-targeted citywide approach to source control policies is the most logical foundation for the initial stages of our stormwater policy. Many of the short-term potential source control strategies under consideration are best implemented on a citywide basis since they would capitalize on incremental investments, expand existing citywide programs, or adjust regulations that already apply throughout the city.

A targeted approach to stormwater controls

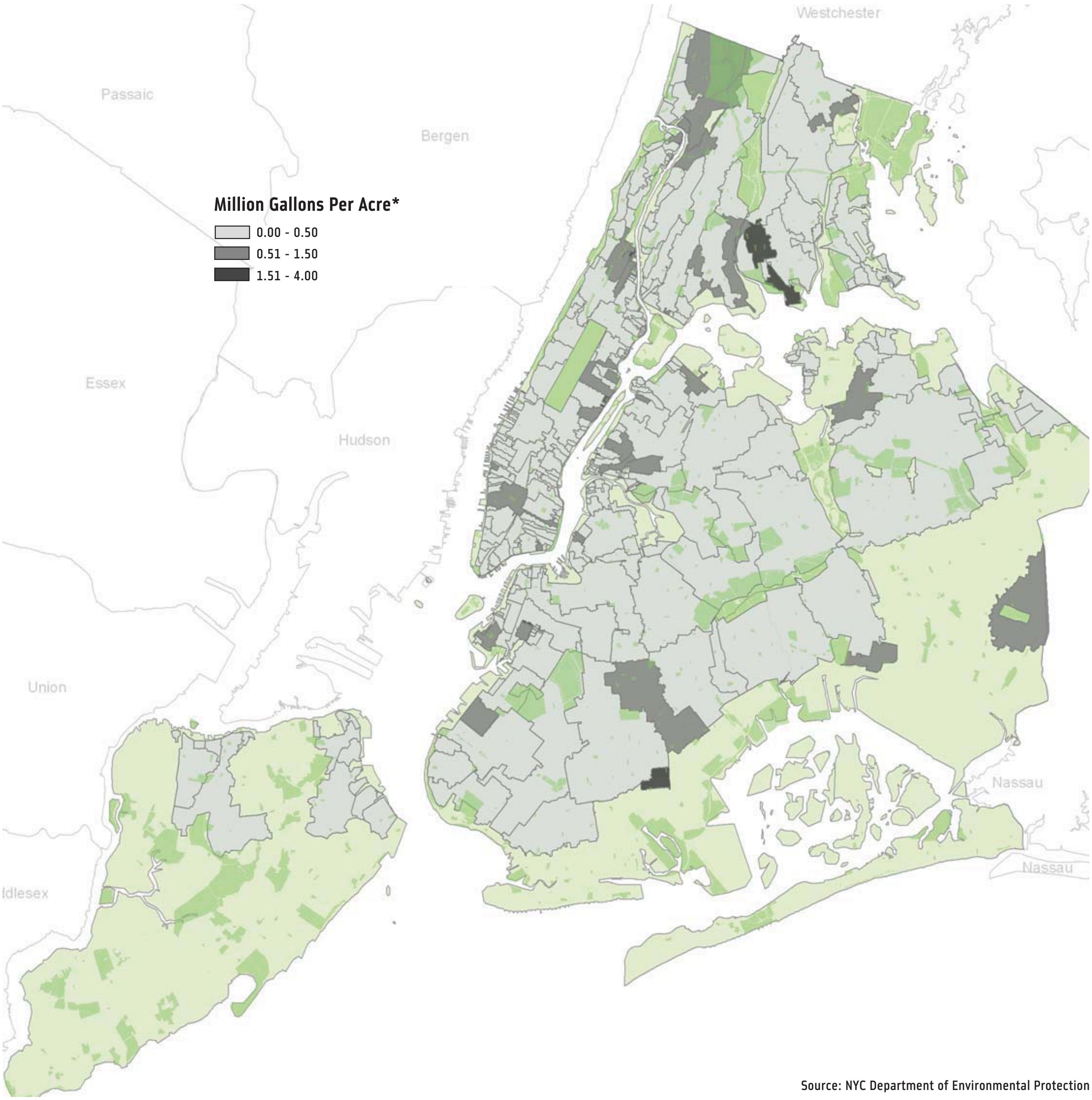
While a citywide set of policies is needed to address the wide range of challenges facing all areas of the city, certain areas could benefit from a targeted approach to stormwater capture. Targeted approaches can provide benefits more quickly to areas that have greater discharges than average, can allow for faster landscape penetration and success, and can be less costly to implement. These are important considerations as the City seeks to implement initiatives that will complement the initial citywide performance standards that we will implement in the first year following this Plan. Initiative 9 in this Plan contains a discussion of targeted approaches and hypothetical budgets that are dedicated to certain watersheds.

When choices have to be made about how to prioritize implementation of certain source control projects such as Greenstreets, street trees, or right of way improvements, the City can consider the relative effectiveness of these measures at different locations. Source controls may have a greater potential for protecting or restoring stream health in watersheds that have relatively low impervious areas. Also, neighborhoods in areas with a very high level of impervious areas may benefit the most from the non-stormwater benefits of vegetated controls. When the potential impacts of non-stormwater benefits such as improved air quality and reduced urban heat island effect are better quantified in the future, then those parameters will be additional factors that help determine site selection for source control projects.

The Trees for Public Health component of the MillionTreesNYC initiative serves as a model that can be considered in future stormwater planning efforts. MillionTreesNYC is a citywide program that provides benefits to all areas of New York City, but the program recognizes that some areas deserve focused attention. Under that approach, the neighborhoods of Hunts Point, Morrisania, East New York, East Harlem, Rockaways, and Stapleton were selected as priority planting areas. These six areas contain fewer than average street trees and higher than average asthma rates. Despite that targeted approach, the Parks Department will continue to respond to individual requests for street trees, while the New York Restoration Project and other public and private partners engage community-based organizations and volunteers in every neighborhood throughout New York City's five boroughs to plant and care for new trees.

Efforts to target specific areas for stormwater management are already underway. DEP has focused attention on the Jamaica Bay watershed through the creation of the Jamaica Bay Watershed Protection Plan. The JBWPP identifies opportunities for source controls in the watershed and calls for several demonstration projects in order to determine the feasibility for local adoption. Other private and public efforts are focused on the Bronx River watershed. DEP also intends to create watershed plans for up to four additional waterbodies that receive substantial CSO or stormwater discharge volumes. These planning processes will be modeled on the JBWPP and separate from plans developed for the LTCP process. These watershed plans will identify source control, restoration, and other low-impact strategies for addressing multiple water quality and ecosystem goals for high-priority areas.

Figure 14: CSO Volume to Area Ratio



Source: NYC Department of Environmental Protection

* CSO volumes reflect the projected overflows when all planned upgrades and elements of the Waterbody/Watershed Facility Plans are online, with the exception of the Newtown Creek and Flushing Bay CSO storage tunnels. See Appendix D.


Credit: Martina Frey

Source Controls

This chapter introduces a new and evolving approach to stormwater management that involves "source controls", "green infrastructure," "low impact development," "best management practices" or BMPs. This Plan uses the term "source controls" throughout this report to emphasize their location at the place where runoff is generated, that is, where rain falls on impervious surfaces. This chapter provides an overview of general source control techniques, technological source control measures, non-technological source control measures, and prerequisites to their adoption.

A Decentralized Approach to Stormwater Management

To supplement conventional end-of-the-pipe solutions – and to protect multi-billion dollar investments in sewage infrastructure – hydrologists, engineers, landscape architects, and policy makers have begun to introduce systems that temporarily store or permanently remove stormwater near where rain falls on impervious surfaces.

Potential benefits and risks of source controls

Compared to centralized infrastructure, decentralized infrastructure is built gradually, often by non-municipal actors on private property. The effectiveness of such decentralized systems depends upon the aggregate, cumulative effects of many small-scale source control measures. Since it takes many years of adoption to achieve significant numbers of installations, a decentralized infrastructure program requires the public, regulators, and the municipality to have a decades-long commitment to a comprehensive source control program. Just as the city's surfaces were paved and developed over time, they can only be modified gradually.

Green Parking Lot in Portland, Oregon

Source controls express an underlying philosophy of pollution prevention, i.e., that it is more cost-effective to prevent pollution than to treat it. And unlike the large step change reduction in stormwater that occurs when a single centralized infrastructure installation is brought on-line, a network of source controls would provide gradual relief from the effects of stormwater. The incremental construction of source controls can also require more level cash flows and demands upon labor and material markets.

Source controls may have diminishing effectiveness over time or failure if not maintained properly. Septic systems and drywells (different types of decentralized controls that are not discussed in this Plan) have a long track record of failure in New York City and nationwide that shows that individual homeowners do not always properly maintain their installations. For example, the EPA reports that between 10 and 20 percent of on-site and septic wastewater treatment systems fail each year, creating the second greatest threat to groundwater quality in the United States. It is necessary to ensure that there are sufficient numbers of people that are trained to install source controls properly and to maintain them.

Potential Technological Source Control Measures

This subsection describes general source control measures. There are three major source control techniques – detention, retention, and bioretention/biofiltration – and each provides certain benefits that can be matched to the city's needs. Available technological source control measures include blue roofs, rainwater harvesting, vegetated controls, permeable pavements, and green roofs. These technologies have varying levels of feasibility,

Table 2: Benefits and Limitations of Source Control Techniques

BENEFITS AND LIMITATIONS	BIOFILTRATION	RETENTION	DETENTION
Reduces CSOs	X	X	X
Reduces treatment costs	X	X	
Reduces potable water consumption		X	
Reduces flooding	X	X	X
Reduces sewer backups	X	X	X
Reduces separate/direct discharges	X	X	
Reduces strain on sewers	X	X	X
Provides a community asset	X		
Improves air quality	X		
Reduces urban heat island effect	X		
Limited by high groundwater and bedrock	X		
Higher capital expense than standard construction	X	X	X
Higher maintenance expense than standard construction	X	X	X

costs, and benefits. Non-technological source control measures include design guidelines, performance measures, zoning requirements, and economic incentives.

To develop the best understanding of source controls possible, the City commissioned an expert to review the available peer-reviewed literature and other sources about costs, performance, site conditions, and other aspects of source controls. The expert's report is provided in Appendix F to this Plan.

The City also developed detailed cost and benefit estimates with assistance from industry experts and others. That information is contained in Appendices to this Plan, including Appendices D, F, and J. As the City's experience grows and as the industry matures we will be able to obtain more accurate information about performance, installation costs, and operating costs. In particular, estimates of maintenance costs have not been based on actual experience over time and should be taken as preliminary at best.

Source Control Techniques

Detention

One control technique is the temporary detention of stormwater at the source while the peak runoff from storms dissipates. Detention systems include rooftop detention systems ("blue roofs") and underground storage tanks. By slowly releasing stormwater to the system, detention controls free up capacity in the sewer system, thus allowing WPCPs time to process and treat combined sewage and stormwater flows. Essentially, detention source controls function as smaller versions of the large storage tanks that are located at the end of the pipe.

Detention source controls are less effective than bioretention source controls in addressing pollution in separate sewer areas, where stormwater does not flow to WPCPs. In those areas, however, detention techniques would help address storm sewer constraints and, over time, localized nuisance flooding. As an island city with broad areas where infiltration is limited, detention makes sense as a primary strategy for New York City. This is also a strategy that has a track record in New York City and can be implemented in new development immediately.

Retention

Retention techniques remove stormwater permanently from the system for use or infiltration on-site. Retention systems include rain barrels, cisterns, gravel beds that infiltrate runoff into the ground, and systems that collect rainwater for use in cooling towers, truck washes, drip irrigation, toilet flushing, and other non-potable uses. Some levels of treatment may be necessary for non-potable uses.

Retention strategies would help improve water quality in both separate sewer and direct discharge areas. Retention can help restore the natural hydrology and improve water quality by reducing the volume and frequency of flows that cause pollution and physical disturbance. Retention strategies that reuse water also provide benefits by reducing the consumption of potable water; however, outdoor reuse systems may require disconnection during colder months to prevent freezing and, therefore, would not be functional year-round.

Bioretention or biofiltration

Bioretention or biofiltration vegetated source control techniques work through the infiltration of water to the soil and the transpiration of water by plants. The combination of these two mechanisms most closely mimics pre-development hydrology. They therefore have the potential to withhold significant amounts of water from the sewer system. In addition, biofiltration systems filter out pollutants through physical properties or eliminate pollutants altogether through microbial process and therefore can act as a network of distributed pre-treatment plants. Biofiltration strategies are subject to a number of site constraints, including soil characteristics, bedrock, high water table, and underground utilities. Where feasible, biofiltration strategies could help improve water quality in both separate sewer and direct discharge areas.

Due to the concerns about flooding and sheeting of water across property lines, infiltration techniques with overflow drains and control structures to the sewer system are often the most practical and easily approved for use in New York City. Other source controls discussed will require site specific analysis or further piloting prior to widespread application.

These techniques are found in many different kinds of approaches. Appendix F sets forth a somewhat different framework, dividing source controls between conventional controls (e.g., subsurface detention tanks), rooftop controls (e.g., blue roofs and green roofs), downspout controls (e.g., rain barrels and cisterns), and vegetated controls (e.g., tree pits and green walls). There are overlaps and cross-connections between techniques and technologies. For example, depending on whether a vegetated control has an overflow pipe near the surface or an underdrain, it can use retention or detention techniques. It is also common to have "treatment trains" of different techniques. For example, a rooftop control can be connected to a cistern or to a rain garden. Appendix F contains more detail about these technologies including downspout disconnections, but not all are discussed in the body of this report or analyzed further, especially where there are additional obstacles to be overcome. For example, the City does not presently approve of complete downspout disconnections because of the lack of certainty about infiltrating rainwater into soils. When the City collects more detailed information about soils and other factors that are necessary for infiltration, this restriction will be assessed. Similarly, this Plan does not separately analyze some of the source controls such as green walls that were singled out in LL5 if they are not well known or accepted. Instead, those technologies are considered elsewhere in this Plan; green walls are considered in a general way as a variation of vegetated controls in Appendix F; greywater systems and rainwater harvesting systems are under consideration by the Green Codes Task Force described in a later chapter; wetland preservation and creation is discussed in connection with the ongoing Bluebelt expansion program and certain demonstration projects; and subgrade storage chambers are discussed in connection with the City's proposed performance standard for new buildings.

Physical and Other Limitations

Technological source controls have physical limitations depending on the stormwater technique used. The most significant limitation in dense urban areas is space. Source controls such as detention ponds are a staple of systems in suburban areas but require too much area and are therefore not considered in this Plan. Size constraints affect source controls that rely on all three techniques – detention, retention, and infiltration. Other physical constraints limit the effectiveness of infiltration techniques, such as steep slopes, bedrock close to the surface, poorly infiltrating soils, and a high water table (Figures 15 and 16). These constraints are generally described in many sources, including the NYSDEC's *Stormwater Management Design Manual*. The current assumption is that wide areas of the city have these limitations. Retention or re-use techniques are likely to be more successful in those areas, as well as technologies that rely upon rooftop detention systems or cisterns.

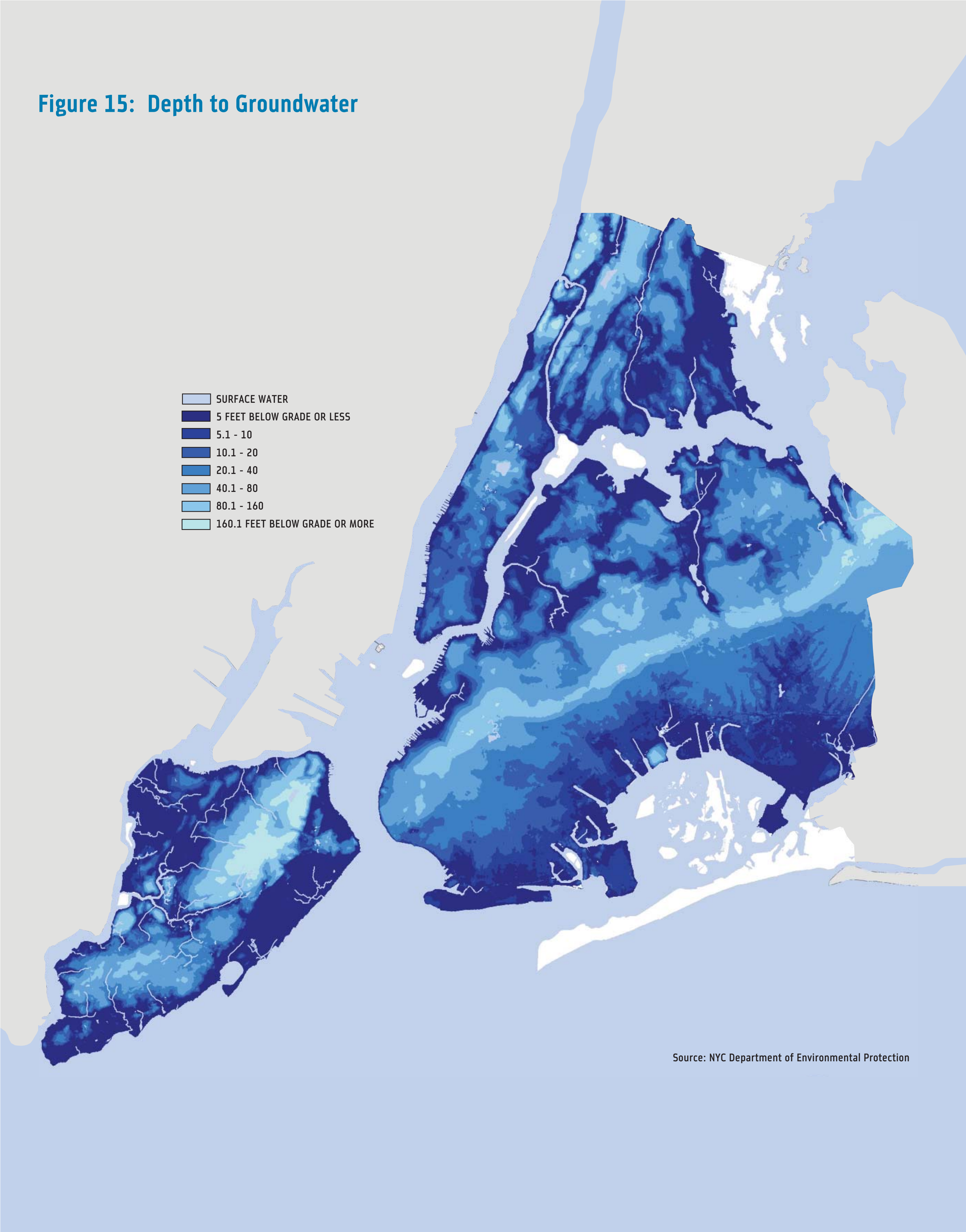
Other constraints relate to the impact of infiltrating stormwater. Since runoff from urban areas contains pollutants it is important to prevent it from reaching sensitive aquifers. The aquifer under Brooklyn and Queens is designated a sole-source aquifer. The City plans explore development of that aquifer to diversify the drinking water portfolio and to serve as a strategic in-city resource.

In areas over sole source aquifers, the *NYSDEC Stormwater Management Design Manual* recommends at least a four-foot separation between the bottom of an infiltration source control and the seasonally high water table. In addition, infiltration should not occur in "hotspot" areas such as gasoline stations or manufacturing areas where soils are likely to be contaminated with hazardous materials. Many areas of New York City were used for manufacturing in the past two centuries, including the areas around Newtown Creek and Gowanus Canal, which were themselves widened and hardened to serve manufacturers. There are significant overlaps between these potentially constrained areas and the areas that generate CSOs. There it may be appropriate to require detention or, in the alternative, a site-specific analysis of soil conditions and site history to ensure that infiltration does not pollute groundwater.

Initial results of the source control research conducted for this Plan are promising but not conclusive. As discussed elsewhere in this Plan, additional time is necessary to fully determine the effectiveness and restrictions of each source control, particularly those that rely on infiltration or retention, before they can be recommended for widespread implementation by the city or private developers for use as reliable stormwater management techniques. However, strategies like detention tanks, blue roofs, and green roofs that have proven performance records in NYC will continue to be those recommended for widespread adoption and the City will actively encourage awareness and use of these.

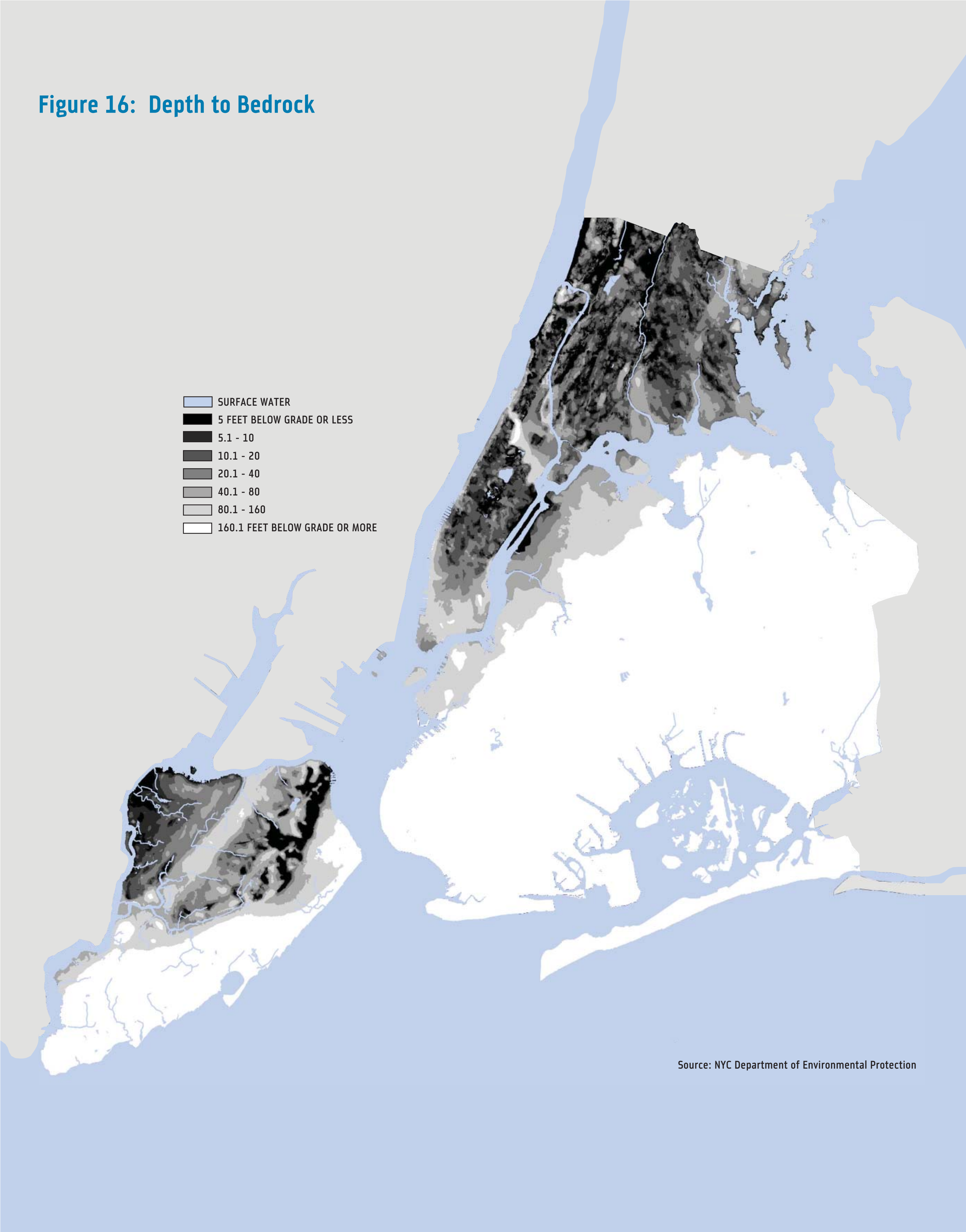
When the results of pilot programs are known, the City will then be able to formulate design requirements for the application of this more diverse menu of source controls for stormwater management on private properties and in the right of way. The City has developed rigorous pilot studies to determine recommendations and inform the creation of design guidelines for efficient and effective use of source controls. A discussion of demonstration projects can be found later in the Plan, and a full description of pilot projects can be found in Appendix E.

Figure 15: Depth to Groundwater



Source: NYC Department of Environmental Protection

Figure 16: Depth to Bedrock



Source: NYC Department of Environmental Protection

Blue Roofs

General Description
Blue roofs, or rooftop detention systems, are a detention technique where a flow restriction device around drains holds back water until the storm surge passes. If the ponded water depth exceeds the established threshold amount, the water flows over the collar into the roof drain.

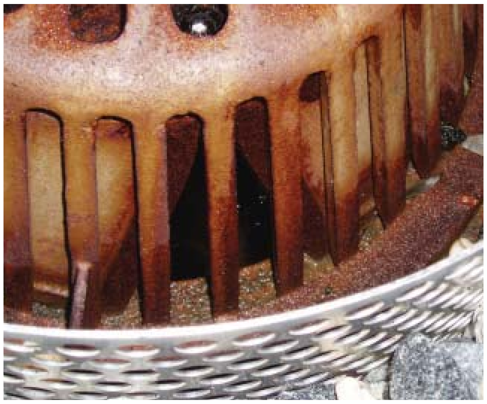
Costs
Blue roof systems cost approximately $4 per square foot above a standard roof. The primary expenses associated with blue roofs are labor, flow restriction collars, and a secondary waterproof membrane.

General Site Conditions Required
Blue roof systems require a flat, watertight roof with enough load-bearing capacity to support the weight of ponded water and an appropriate number of drains to support desired water flow. Small "walls" known as dams can be constructed around the roof perimeter (if there is no parapet) to hold water on the roof.

Feasible Properties and Areas
Blue roofs can be used in all areas of the city that contain properties that meet required site conditions. Blue roofs are most appropriate for areas with large commercial, multi-family residential, industrial, and institutional buildings with flat roofs. Low-density areas featuring residential properties with pitched roofs are not feasible for widespread adoption of blue roofs.

Stormwater Performance
The quantity of runoff detained from blue roofs depends upon the slope of the roof, the configuration of the flow restriction device, the load-bearing capacity of the roof, and the designed release rate. Depending on the diameter of the roof drain and the height of the collar, average maximum flow from rooftops fitted with a flow restrictor can be reduced by up to 85 percent compared to a conventional roof drain.

SCA Blue Roof on PS 12
Credit: NYC Department of Environmental Protection



Blue Roof Weir on PS 12
Credit: NYC Department of Environmental Protection

Green Roofs

General Description
Green roofs treat stormwater through retention or bioretention. Green roofs are comprised of a structurally sound roof, a waterproofing and root barrier, a drainage layer, a permeable fabric, a growing medium, and vegetation. Extensive green roofs are lightweight, typically featuring hardy succulent plants. Intensive green roofs are heavier and feature a thicker growing medium to support deep-rooted vegetation.

Costs
Green roof costs vary widely. Extensive green roof costs range from $5-35 per square foot. Intensive green roofs range from $15 to $70. Costs also depend on whether the roof requires structural support or other repairs.

General Site Conditions Required
Green roofs require a watertight rooftop with enough load-bearing capacity to support the weight of plants and waterlogged soils. Green roofs can be installed on roofs with a slope up to 40 percent, although stormwater performance is better for shallow or flat roofs.

Feasible Properties and Areas
Green roofs can be used in all areas of the city with properties that meet required site conditions. Green roofs are appropriate for areas with large commercial, multi-family residential, residential brownstone, industrial, and institutional buildings. Low-density areas featuring residential properties with steep pitched roofs are not ideal for green roofs.

Stormwater Performance
The performance of green roofs as a stormwater control measure depends upon the depth of the growing medium, soil, slope, and vegetation. Reported runoff reduction ranges from 29 percent to 90 percent of the total rainfall volume; most studies of extensive green roofs report runoff reductions between 50 percent and 70 percent. Performance of green roofs in droughts and winter conditions are variable and are not yet extensively documented in New York City.

Green Roof on the Five Borough Building
Credit: NYC Department of Parks and Recreation

Green Roof on the Five Borough Building
Credit: NYC Department of Parks and Recreation

Homeowner participating in DEP Rain Barrel Program
Credit: NYC Department of Environmental Protection

Rain Barrels from DEP Rain Barrel Program
Credit: NYC Department of Environmental Protection

Rain Barrels

General Description
Rain barrels harvest rainwater from building downspouts into a small above-ground barrel. A first flush pipe diverts the initial pulse of runoff from the roof, and an overflow pipe diverts runoff in excess of barrel capacity to the sewer.

Costs
Rain barrels typically cost between $3 to $9 per gallon of capacity, plus the costs of hoses and special connection materials. Installation may also include the costs of labor, site preparation, and construction of a concrete pad.

General Site Conditions Required
Generally, rain barrels may be placed on-sites with sufficient space to locate the barrel near readily-accessible downspouts. Disconnecting building downspouts is not currently allowed in New York City. For DEP's Rain Barrel Giveaway Program, connecting the rain barrels to downspouts was allowed for parcels in which the volume of roof runoff generated could be appropriately managed on-site and safely discharged back to the sewer system in case of overflows.

Feasible Properties and Areas
A typical rain barrel holds approximately 50 gallons. Rain barrels are appropriate for parcels with landscaped areas. Reuse of captured or stored water is limited to irrigation for on-site landscaped areas only.

Stormwater Performance
The quantity of runoff retained in rain barrels depends on relationship between storage volume, the area of the roof, the depth and duration of the rain event, and whether the tank was emptied between storms. Homeowners must disconnect rain barrels and reconnect to the sewer system in the winter to prevent freezing. Therefore, rain barrels manage stormwater for only half a year.

Cistern
Credit: Council on the Environment of New York City

Cistern
Credit: Council on the Environment of New York City

Cisterns

General Description
Cisterns harvest stormwater in large above- or below-ground tanks to store water from downspout. The installation of cisterns requires an overflow pipe that diverts excess rainwater to the sewer system.

Costs
Cistern costs range from $0.50 per gallon of capacity for a large galvanized steel tank to $2 per gallon for certain plastic tanks. Additional costs include labor, site preparations, and plumbing retrofits.

General Site Conditions Required
Cisterns can be placed underground or inside buildings. The appropriate location of a cistern depends upon the configuration of roof drains and the routing of plumbing infrastructure.

Feasible Properties and Areas
Any commercial, residential, institutional, or industrial property that meets site conditions and can appropriately manage the flow of stormwater. Cistern sizes are typically between 300 and 1,000 gallons, although some cisterns can be as large as 10,000 gallons. Research indicates that in other cities, cisterns are best used in medium-density residential properties, buildings adjacent to open space, or any property with sufficient space on-site for underground or internal installation.

Stormwater Performance
The quantity of runoff retained depends on the relationship between storage volume, the area of the roof, the depth and duration of the rain event, and whether the tank is emptied between storms.

Permeable Pavements

General Description

Permeable pavement technologies, including permeable pavers, porous asphalt, or porous concrete, allow water to pass through the paved surfaces into a specially-designed subgrade gravel bed or other porous medium. Permeable pavement systems can act as a detention or retention technique since water stored in the subgrade medium can percolate into the ground, evaporate, or leave the system laterally through an overflow pipe or underdrain.

Costs

The installed cost of permeable pavement systems typically ranges from $10 to $15 per square foot, largely dependent on surface type (paver, concrete, or asphalt) and the depth and type of the porous medium or structural soil installed underneath. Operation and maintenance costs also vary and depend on the frequency and level of effort involved in any regular street sweeping, vacuuming, and power washing that is performed.

General Site Conditions Required

Permeable pavements generally are used on surfaces that are subject to low-speed, low-impact use by vehicles. To prevent clogging of pore spaces, permeable pavements are generally not designed to receive runoff from disturbed soil areas, sparsely vegetated upland areas, or areas prone to erosion.

Permeable pavements are typically not installed over underground utility vaults, subways, underground parking lots, on sites with a history of intense soil contamination, or on sites that are treated with sand or salt during winter months, as these substances can clog pores and cause chloride to migrate into underground aquifers. Typically, permeable pavements can be separated from building foundations and other underground utilities with an impermeable liner.

In general, a minimum depth to the seasonally high water table is recommended so as to maintain the ability of the porous medium to exfiltrate, to avoid floatation problems, and to protect against damaging freeze/frost cycles. The load bearing capacity of permeable pavers varies from about 1800 to 2400 pounds per square inch (psi) for porous concrete, to 5700 to 8000 psi for concrete grid pavers.

Feasible Properties and Areas

New York City has extensive areas of sidewalks, driveways, parking lots, plazas, bike lanes, and other low-traffic areas that represent potential permeable pavement sites. Permeable pavements could also potentially be used in recreation areas such as basketball courts or around ballfields.

Porous pavements are generally not recommended in areas of the city with high water table, high levels of bedrock, and former manufacturing areas without a percolation test or a soil sample. Porous pavements are not appropriate for use on commercial nurseries, auto recycling facilities, vehicle maintenance areas, fueling stations, industrial parking lots, hazardous material generators, outdoor loading facilities, and public works storage areas.

Stormwater Performance

Water can percolate into the ground, evaporate, or leave the system through an overflow pipe or underdrain, which may be required dependent on location and site conditions. Performance depends on depth of the storage media, with typical depth ranging from 18 to 24 inches. Clogging of pore spaces may inhibit performance over time. If properly sited, designed, and maintained, most permeable pavement installations produce virtually no runoff from the vast majority of storms.

Porous Concrete
Credit: City of Olympia Public Works

Porous Pavement Parking Lot
Credit: The Low Impact Development Center

Permeable Pavement Parking Lane
Credit: Franco Montalto

Permeable Pavers
Credit: Aaron Koch

Sidewalk Biofiltration
Credit: Martina Frey

Highway Swale
Credit: The Low Impact Development Center

Sidewalk Vegetated Control
Credit: Vaidila Kungys

Stormwater Neckdown
Credit: Abby Hall

Vegetated Controls

General Description

Vegetated controls include tree pits, rain gardens, Greenstreets, green walls, planters, and swales. They can be designed as bioretention, biofiltration, or contained source controls. Soil systems in vegetated controls usually contain a high-infiltration, organic layer underlain by more typical planting soils and gravel or crushed stone. In systems such as tree pits or grassy swales, engineered structural soils can be used to maximize load bearing capacity while also facilitating root growth and aeration.

Costs

Installation costs for vegetated controls vary greatly and are a function of type, design depth, and whether certain features such as fences, grates, and retaining walls are required. The installed cost per square foot of vegetated source controls can range from $30 to $100, with typical sidewalk biofiltration and Greenstreets installations in the $35 to $45 range. These costs typically include labor, site demolition, soil preparation, site grading, underdrains, overflows, curbing, paving, materials, and landscaping. Street trees cost approximately $2,000 per tree for installation.

Operation and maintenance costs for vegetated controls vary greatly based upon design, location, and type of plants. Proper maintenance for vegetated controls can cost in the range of $3 to $4 per square foot per year. Specific maintenance activities can include cleaning clogged underdrains, removing accumulated debris and plant material, weeding, and replanting when necessary.

General Site Conditions Required

Vegetated controls that use biofiltration are most appropriate in areas without bedrock or seasonally-high water table constraints, where soil contamination does not exist, or where soil percolation rates are low. Where there are sufficient soils and depth to groundwater tables, vegetated controls can be designed as bioretention facilities to maximize on-site retention.

Street tree pits must be sited so trees do not interfere with adjacent buildings, overhead utility lines, underground utility lines, building easements, and vertical retaining walls. They must also not obstruct traffic lights and signs.

Feasible Properties and Areas

Vegetated controls are appropriate in all areas of the city where there are appropriate site conditions. Because of their numerous design variations, vegetated controls can be retrofit into many street and parking lot medians, street/sidewalk modifications such as curb extensions and neck downs, yards, plazas, parks and building and lot perimeter boundaries.

Stormwater Performance

The quantity of runoff retained or infiltrated by vegetated controls depends on depth of gravel or structural soil substrate, the presence of overflow drains, and the percolation rates of underlying soils. Surface discharge only occurs as overflows (either through the inlet or an overflow drain) when the bioretention facility's total storage capacity is exceeded. The reduction in annual runoff from catchments served by bioretention and biofiltration facilities is often 80 to 99 percent compared to prior conditions. Performance of vegetated controls can be compromised by clogged inlets or outlets, eroded soils, or compacted soils.

Vegetated controls also provide numerous non-stormwater benefits related to improvements in air quality, reduction in Urban Heat Island Effect, and animal habitat. These benefits are discussed elsewhere in the Plan and in Appendix F.

CASE STUDY
Greenstreets

The Greenstreets program of New York City's Department of Parks and Recreation was launched in 1996 and has evolved into an indispensable component in greening the right of way. There are now over 2,300 Greenstreets in New York City.

The initial goal of Greenstreets was to convert unused concrete islands into planted areas for urban beautification and traffic calming. In the past 12 years, however, the City has become aware of other environmental benefits, particularly the potential for stormwater capture and detention. Greenstreets can use curb cuts and trench drains for stormwater capture. In some parts of the city, bioswales can be used to capture and filter water to irrigate Greenstreets plantings. The Parks Department has a thorough understanding of soil and plant types best suited for the variety of geographies in the city. For example, in Far Rockaway the best soils to use in Greenstreets contain slightly higher levels of sand and are planted with native shore plants that thrive in sandy soils.

Greenstreet project

Credit: NYC Department of Parks and Recreation

With committed funding from PlaNYC for 80 new Greenstreets each year for the next 10 years, the Parks department is considering how the program can be expanded in the future. To better understand its impacts, the Parks Department has begun a comprehensive two-year study on the effectiveness of Greenstreets in addressing urban environmental concerns. Using high-tech sensors and conventional measuring techniques in five Greenstreets, technicians will be looking at how much water enters planted areas, whether water contamination has adverse effects on the plants and soil, how soil changes over time, and plant health and longevity. The purpose of the study is two-fold: to document the stormwater management capacity of Greenstreets, and to understand how well they achieve water self-sufficiency. The study will help establish the best design standards for Greenstreets, thus decreasing the need for constant visits from watering trucks, reducing costs, shrinking our ecological footprint.

Non-Stormwater Benefits

The benefits of source controls are not limited to CSO reductions. In fact, source controls are embraced by many municipalities around the country that have separate sewer systems and do not have CSOs. Retention, bioretention, and biofiltration source control techniques have the potential to provide non-stormwater benefits. The potential environmental, water quality, public health, aesthetic, and economic benefits of source controls include cooling and cleansing the air, reducing energy demand, sequestering and reducing emissions of greenhouse gases, beautifying neighborhoods and potentially raising property value, providing habitat for birds and other wildlife, stream health benefits, and developing new local markets that can stimulate job growth.

Following PlaNYC's framework of leveraging cross benefits to achieve multiple sustainability goals, this Sustainable Stormwater Management Plan identifies opportunities to achieve complementary benefits. These include creating an attractive public realm of tree-lined streets, public plazas, playgrounds, and other planted areas that would transform the everyday life of city residents, reduce the urban heat island effect, and help us adapt to climate change.

It is difficult to quantify these non-stormwater benefits, as the EPA recognized in its recent strategic plan for green infrastructure (Appendix H). Several attempts have been made to quantify the non-stormwater benefits of hypothetical source control policies in New York City. A 2006 Columbia University study, *Green Roofs in the New York Metropolitan Region*, attempted to quantify the benefits of covering 50 percent of all flat roofs in New York City – i.e., over 144,000 buildings, 7,698 acres, or 4 percent of the city's land area – with sedum-planted, extensive green roofs. At that extraordinarily high level of landscape penetration, the study predicted that the overall effect on temperature would be between 0.1° F to 1.4° F, with an average value of 0.8° F. That temperature reduction would correspond to a 5 percent reduction in energy demand for cooling, or $213 million citywide. The total cost of design, installation, and maintenance was estimated to be $8.2 billion, with an annualized cost of $664 million. (Those cost figures vary from the estimated costs of green roofs in this Plan.)

The same Columbia research team conducted a 2006 study for the New York State Energy Research and Development Authority (NYSERDA), *Mitigating New York City's Heat island with Urban Forestry, Living Roofs, and Light Surfaces*. That study concluded that impacts on megawatts consumed during peak load periods was modest, even at high penetration rates of 50 percent of roofs with green roofs and 100 percent of sites planted with trees. The study did not attempt to quantify benefits for air quality and public health or greenhouse gas emissions. It suggested that such non-energy benefits should be the subject of further research.

A DDC study of the costs and benefits of "cool" roofs (i.e., light colored) and green roofs calculated a lower energy benefit of $82 million a year for every 1° F reduction. If greening half of New York City's roofs produces a 1.2° F savings (a number the authors derived from an earlier draft of the Columbia report), then the energy savings would be approximately $149 million a year, at a cost of $4.72 billion. (Those cost figures vary from the estimated costs of green roofs in this Plan.) The report calculated that tree planting is a more cost-effective strategy than green roofs, because trees provide additional cooling through shade and evapotranspiration.

The overall benefits of trees alone have been better quantified than for vegetated source controls generally. A 2007 study by the U.S. Forest Service (USFS) attempted to quantify the benefits of the New York City urban forest. The study concluded that average benefits per tree were $48 in energy savings, $1 in carbon dioxide sequestration and emission reductions, $9 in air pollutants removed, released and avoided through cooling and interception,

$61 in stormwater reduction, and $90 in aesthetics, property value increases, and other less tangible improvements. The average benefits of $209 per tree annually is greater than the $37 per tree that it costs to plant new trees and maintain existing trees.

Given the limited information that is available, at this time, it is difficult to use non-stormwater benefits to drive source control policy except as a deciding factor in the cases where stormwater costs are essentially "tied." Some non-water quality benefits will be meaningful only if vegetated source controls are adopted on a wide scale, such as the overall energy savings if the city's ambient temperature is reduced. Other benefits such as improved property values, aesthetics, and habitat can arise from the localized impact of targeted source controls.

Potential Non-Technological Source Control Measures

Non-technological source control measures – design guidelines and technical manuals, demonstration projects, public outreach and education, pricing and other incentives – are vehicles to promote the voluntary adoption of technological source control measures beyond those that would be required under the NYSDEC Municipal Separate Storm Sewer System (MS4) permit program. Existing open space and other pervious areas already provide stormwater services, and measures that preserve those areas could be considered non-technological source control measures as well. The extent of compliance is highly dependent upon the structure of those programs; mandatory zoning amendments and performance standards, for example, achieve uniform and predictable adoption rates. These non-technological source control measures are introduced in this chapter. The City's ongoing and future implementation of these measures, where applicable, is discussed in greater detail in later chapters.

Education and Training

The most basic non-technological measures simply enable the adoption of source controls by those members of the public who are ready and willing to build and maintain them. These measures might include the dissemination of trusted and reliable information and training. The coordination of efforts across communities or agencies is one form of training about best practices that will augment the limited design capabilities and experience of most community members, agencies, and designers.

Route 9A
Credit: Mathews Nielsen

Route 9A
Credit: Mathews Nielsen

CASE STUDY
Plantings along Route 9A

Healthy trees are a vital component of managing water. Their root systems absorb water and transpire cooling moisture through their leaves. In an urban environment trees are part of the landscape of the right of way and must be integrated with sidewalk and paved surfaces, which are obstacles to tree health.

Finding the right soil to help trees thrive in the right of way was the challenge of the redesign of Route 9A, or the West Side Highway, in Manhattan. In 1998, landscape architects from the firm Mathews Nielson began to look for the best possible soil to use along Route 9A and discovered a new type of soil designed and piloted by experts at Cornell University. The soil, now known as C-U Soil®, or structural soil, is a stony mix similar to a road base material with a unique hydrogel coating on the stone designed to retain water. It can be compacted to the weight-bearing requirements of streets and sidewalks, but still allows water and air to infiltrate to the tree roots. Structural soil was used all along the 4.5 mile corridor of route 9A, including the median and bikepaths.

Since the introduction of its use over ten years ago, there has been no loss of trees. Because of the composition of structural soil the tree roots do not become saturated with too much water, which would cause them to become unstable and topple. And structural soil does not become overly-compacted, which restricts water and air circulation. Paired with structural soil, continuous tree pits, which are excavated deeper and are long enough for groups of trees to be planted in the same area, offer room for tree roots to absorb more water and nutrients, and planted medians provide more permeable surface to absorb rainfall and prevent it from draining into the city's sewer. The thriving trees also provide important traffic calming benefits and above all help make the West Side Highway the vibrant and beautiful urban boulevard it is today.

Homeowner with rain barrel
Credit: NYC Department of Environmental Protection

CASE STUDY
DEP Rain Barrel Pilot Program

In its effort to reduce stormwater runoff in the delicate ecosystem of Jamaica Bay, DEP initiated a pilot program to encourage homeowners to capture and store rainwater with rain barrels. Through the program, DEP distributed 250 rain barrels to residents of Queens Community Boards 12 and 13, which are low-density, residential neighborhoods in the Jamaica Bay watershed. Participants in the program also received a diverter to connect the barrel to their home's downspout, accessory parts, and complete instructions for installation. Homeowners were required to install the rain barrels themselves and disconnect the barrels in the winter. Free training sessions were given by DEP to facilitate these actions.

As a source control method, the program is promising because the simple nature of the design makes it very accessible to homeowners. The rain barrel is connected to the existing downspout from the roof gutter. The barrel itself remains completely sealed, and a spigot allows homeowners easy access to water for lawn care and landscaping. When the barrel is full, excess stormwater is directed back into the city's sewer system. The program is designed to understand more fully the benefits of rain capture to communities and the ease of installation, operation, and maintenance of on-site BMPs by individual homeowners. In addition, homeowners have an economic incentive, as some households allocate as much as 40 percent of their total water usage to lawn and garden care. DEP is in the process of collecting completed surveys from participating homeowners to assess the effectiveness of the program. Early response has been overwhelmingly positive. With continued success, DEP hopes to expand the program in the future.

Design guidelines

Guidelines that are consistent with, and may enhance, NYSDEC design standards can be adopted to control the design of capital projects by a public agency. They generally provide flexible, context- and site-specific designs. The process of creating design guidelines is important to making the management of stormwater part of the mainstream mission of capital agencies and can produce significant benefits. As a result of design guidelines, some public agencies and private individuals in the city have already installed technological source controls, and these early adopters have helped pave the way for others. For example, SCA's adoption of roof detention as a design standard in 2003 has led that agency to design and construct approximately 14 schools with that stormwater control feature.

Design guidelines can be strengthened through the addition of internal accountability measures to ensure binding targets or other accountability measures to make sure that guidelines are implemented.

Pricing

Voluntary adoption of source controls can also be induced through pricing. The recent connection between higher gas prices and consumer's responses in driving less and buying more efficient vehicles underscores the power of price signals to implement behavioral change. Washington, D.C., Seattle, scores of municipalities in Florida, and many other cities nationwide have adopted separate stormwater rates that are closely linked to stormwater generation. There, runoff pricing allows ratepayers to understand the costs associated with impervious surfaces and provides funding for the construction and maintenance of source controls.

In theory, stormwater charges could vary depending on the impervious surface coverage of each lot or equivalent unit, and would encourage developers to install more pervious areas. Many municipalities have included credit programs that use proxies for pervious surfaces, such as the installation of easily-documented retention devices. The purpose of credit programs is to provide an incentive for homeowners to follow stormwater management measures. If stormwater rates are not set high enough, however, other incentives may be necessary to promote source controls.

Tax incentives

Tax incentives generally take the form of an abatement for certain actions, such as for relocation of a business to empowerment zones or the purchase of hybrid cars. As described in later chapters, the City is implementing a partial tax abatement of the costs of constructing green roofs to encourage the adoption of that source control. As with all tax incentives, the government is donating money by foregoing tax collection. However, only taxpaying entities can receive this incentive and it arrives after expenditures.

Expedited permitting

More immediate relief can be provided through expedited permitting. This is potentially valuable because developers follow the maxim that "time is money" and permitting is a key determinant in whether projects are completed on time and on budget. Significant delays can result in increased construction costs or poor market timing. Therefore, expedited permitting can induce desired behavior by saving costs up front. This incentive is not favored in New York City. There are so many potential triggers for expedited permitting across a range of social programs that wide adoption would transform this class of permits from special category to the expected type of permit, thereby undercutting the inducement of going to the front of the line or requiring a significant expansion of permit reviewers. For these reasons the City does not favor expedited permitting programs.

Low-interest financing

Low-interest financing is another method of incentives that is particularly useful when there are significant capital costs that will lead to operational savings. If the initial financial hurdle can be passed, then beneficiaries can use operational savings to pay back the loan or other method of capital financing. These characteristics have made this a popular technique for inducing the adoption of energy efficiency measures. However, there must be a lending facility set up initially. In this time of tight municipal budgets and a shrinking financial sector, this is currently not a promising technique.

CASE STUDY

Rainwater Harvesting in NYC

CENYC Community Garden

Credit: Council on the Environment New York City

The ancient practice of rain harvesting can be seen across cultures as far back as 3000 B.C. when agrarian societies began collecting rainwater in ditches to use for crop irrigation. While rain harvesting has become forgotten in modern societies with centralized municipal water supplies, this practice is being implemented once again in community gardens around New York City, spearheaded by the Council on the Environment for New York City (CENYC).

At 39 community gardens, rain harvesting allows gardeners to collect rainfall in large, enclosed cisterns made of polyethylene and PVC piping from rooftop rain gutters. In some gardens a small shed or shade structure is built with an attached gutter draining into the cistern. Other gardens tap into downspouts from adjacent buildings to collect larger amounts of rain water. CENYC has made design guidelines available in its online how-to manual. Their guide, "How to Make a Rainwater Harvesting System," gives recommendations for effective installation as well as a formula to determine how much water a garden needs and how much can be expected from the roof.

Cisterns typically have the capacity to contain 300 to 1,000 gallons of water. Water quality in the cisterns is tested and monitored, and the opening must be screened to prevent mosquitoes. While not suitable for drinking, the water is safe for irrigation and the cisterns can be configured to fill watering cans or for a hose hook-up allowing convenient access to water throughout the growing season. Maintenance is minimal, but cisterns must be drained down in the late fall to prevent freezing.

Urban gardeners, otherwise dependent on street hydrants for watering community gardens, have welcomed these rain harvesting practices. In the past year, the use of captured rain water in just 39 gardens has saved over 500,000 gallons of the city's drinking water from being used for irrigation, and prevents stormwater from entering sewers.

Zoning

Voluntary measures may not always be sufficient to achieve the landscape penetration that is necessary to reduce untreated discharges or to meet State requirements. It may be necessary to amend laws, rules, and regulations. Zoning is a key tool for carrying out planning policy, along with the City's power to budget, tax, and condemn property. Zoning determines the size and use of buildings, where they are located and, in large measure, the densities of the city's diverse neighborhoods. New York City has been a pioneer in the field of zoning policy since it enacted the nation's first comprehensive zoning resolution in 1916. Since then, the creation and use of incentive zoning, contextual zoning, and special district techniques have made zoning a more responsive and sensitive planning tool.

Zoning can also be used to facilitate the creation of source controls. For example, the City has already enacted amendments to the zoning resolution that require vegetated areas in parking lots, street trees, and planting in front yards. Those amendments are discussed in greater detail in later chapters.

Performance standards in sewer and construction codes

Quantitative standards, such as the NYSDEC Design Standards, can require that a specified amount of stormwater be retained, detained, infiltrated, and/or reused on-site. Other types of performance standards attempt to control sediment and other pollutants from construction and other activities.

A standard that specifies performance rather than methods can create a parallel incentive to develop the most cost-effective source controls. However, the initial level of performance must be set at a level that is ambitious but achievable so as not to dampen otherwise desirable development and redevelopment.

As described in later chapters, this Plan anticipates a performance standard for new developments that will result in significant stormwater capture– beyond those set forth in the NYSDEC Design Standards– and thus the reduction of CSOs, and stormwater mitigation in separate sewer areas, at low cost.

Over time performance standards can have a significant effect on CSOs. For example, Philadelphia changed its codes to require new developments and significant alterations over 15,000 square feet to manage the first inch of precipitation through infiltration or other techniques. The 1-inch standard is sufficient to capture roughly 82 percent of the rain events every year, or 35 of the 42 inches that fall there annually. Following the standard's adoption in 2006, Philadelphia officials estimate that over 900 acres of new or altered development have met the standard and now manage and reduce over a billion gallons of stormwater every year. (Philadelphia has about 15 billion gallons of CSO discharges annually). The standard has saved that city over $300 million in avoided infrastructure costs.

Credit: NYC Department of Parks and Recreation

Scenarios

This chapter analyzes the benefits of feasible source controls, strategies and scenarios to determine their likely landscape penetration, stormwater capture, and costs.

The City developed these potential strategies through a year-long process. Starting with a list of 350 possible initiatives, the BMP Task Force focused on key land use categories. Working groups identified opportunities for high landscape penetration in those categories. And with the help of stormwater experts, the City has developed detailed plans for those opportunities, conducted an exhaustive search of the literature to develop life-cycle costs and benefits of individual source controls, and estimated the benefits at certain adoption rates in individual sewersheds.

Considerations for Developing and Assessing Strategies and Scenarios

Geography

The City has focused on three main land use areas: buildings and lots, the right of way, and open space. As discussed in the chapter on land use, the buildings and lots and right of way categories contain most of the city's impervious surfaces. Open space is another important category since stormwater runoff can be directed into existing permeable areas under appropriate conditions where topography, soil type, and groundwater conditions are appropriate.

Landscape penetration

The most important factor is landscape penetration or the adoption rate of source controls and their concentration in the landscape. Only at significant scale will the aggregate affect of small installations approach that of large storage tanks and other centralized infrastructure. For example, full roadway reconstruction – which involves excavation of the entire right of way, laying new foundations for sidewalks and the roadbed, installing new curb reveals, and placing new paving and plantings – will apply to only 5 percent of the city's road surface at the end of our 20 year planning horizon, or 0.25 percent of our road surfaces annually. On the other hand, sidewalks generally last about 30 years, so it is conceivable that new design standards will achieve high landscape penetration by 2030 and make a significant contribution to stormwater management.

There are practical limitations to full landscape penetration. As with any policy, there will be early adopters, mainstream adopters, and holdouts. The mere announcement of a program, or the provision of partial incentives, may be sufficient to affect the behavior of early adopters. Mainstream adopters are likely to respond to more complete economic incentives or performance standards. Holdouts may respond only after the creation of a vigorous, and potentially expensive, compliance program.

There are also financial limitations to full landscape penetration in the private sector. The level of acceptance or resistance tracks the relative cost of initiatives. Also, early and mainstream adopters are even more likely to install source controls if they were already planning on construction, and therefore only have to incur incremental costs to add source controls. Higher landscape penetration rates might be achieved only through retrofit programs, which come with a higher cost, because retrofits destroy useful life and the economic value of what they replace.

Greenstreet at 110th and Amsterdam

Table 3: Costs of Source Control Technologies

SOURCE CONTROL	INCREMENTAL CAPITAL COST (PER SQ. FT. OR UNIT)	NET PRESENT VALUE (PER SQ. FT. OR UNIT)	LIFESPAN (YEARS)	COST PER YEAR	GALLONS* (PER SQ. FT. OR UNIT)	COST TO CAPTURE GALLON	ANNUAL COST PER GALLON
Blue Roof (2-inch detention)	$4.00	$4.00	20	$0.20	1.25	$3.21	$0.16
Rain Barrel (55-gallon tank)	$200	$200	20	$10.00	55	$3.64	$0.18
Sidewalk Biofiltration	$36.81	$39.68	20	$1.98	8.60	$4.61	$0.23
Porous Asphalt Parking Lane	$8.13	$10.33	20	$0.52	2.18	$4.74	$0.24
Porous Concrete Sidewalk	$6.83	$8.67	20	$0.43	1.82	$4.77	$0.24
Swale	$18.73	$22.50	40	$0.56	1.82	$12.39	$0.31
Blue Roof (1-inch detention)	$4.00	$4.00	20	$0.20	0.62	$6.42	$0.32
Cistern (500-gallon tank)	$3,700.00	$3,700.00	20	$185.00	500	$7.40	$0.37
Greenstreet	$42.67	$82.79	30	$2.07	5.24	$15.81	$0.53
Sidewalk Reservoir	$98.48	$110.41	20	$5.52	3.74	$29.52	$1.48
Green Roof	$24.45	$62.39	40	$1.56	0.47	$133.37	$3.33
REFERENCE CASES	**INCREMENTAL CAPITAL COST (PER SQ. FT. OR UNIT)**	**NET PRESENT VALUE (PER SQ. FT. OR UNIT)**	**LIFESPAN**	**COST PER YEAR**	**CSO GALLONS (PER SQ. FT. OR UNIT)**	**COST TO CAPTURE GALLON**	**ANNUAL COST PER GALLON**
Newtown Creek Tunnel	$1,299,000,000	$1,300,000,000	50	$26,000,000	40,000,000	$32.50	$0.65
Flushing Bay Tunnel	$1,038,000,000	$1,039,000,000	50	$20,800,000	25,000,000	$41.56	$0.83

* "Gallons" in the source control fields refers to gallons of stormwater runoff that can be retained or detained in those source controls. The exact relationship between those quantities and the corresponding reduction in CSOs is not yet established. See Appendix D.

Finally, there are physical limitations to full landscape penetration. As described in a previous chapter, many areas of the city are not suitable for controls that rely on infiltration, because of a high water table, bedrock, or underground structures or utilities. And many structures are not suitable for detention controls because of space limitations or insufficient structural support; the creative use of in-building re-use or retention systems may be required in those areas.

Cost-effectiveness

Finally, costs matter. The City seeks to keep the incremental costs of stormwater management low for at least two reasons: to achieve high landscape penetration rates and to minimize unintended, adverse effects on the amount of new housing and other development or on the regular maintenance of the existing building stock. In order to evaluate the true costs of source controls, we have developed life-cycle cost estimates that reflect the present value of installation, operation, and maintenance over the expected lifespan. The City has also developed different estimates for full and incremental costs. The full costs of construction are appropriate for source control installations that are part of an accelerated retrofit program that would install source controls or that replace impermeable surfaces on a schedule that is not coordinated with other construction. Incremental costs are appropriate for source controls that are installed when roofs, sidewalks, roads and other impermeable surfaces are already being replaced (e.g., the additional costs of a blue roof over a conventional roof replacement.) Our cost analysis is set forth in more detail in Appendix D.

Source Control Strategies

We evaluated the impacts of several promising strategies in 24 CSO watersheds. As explained in more detail in Appendix D, these estimates of runoff capture are based upon spreadsheet calculations of the number of potential source controls, the cumulative capacity of source controls in 2030 for any one storm, and the number of storms of varying intensity in each watershed that cause CSOs. The translation of runoff detention in source controls to CSO reductions depends upon the controlled release rate, duration, and intensity of the rainfall, and sewer capacity. We have not analyzed non-stormwater benefits by conducting a comparative embodied energy analysis or other quantitative comparison of environmental benefits.

Readers should recognize that these estimates are not based on actual CSO measurements or modeled calculations. While the City will not

Summary of Potential Source Control Strategies:

Buildings and lots

1 Performance standards for new development
2 Performance standards for existing buildings
3 Low- and medium-density residential controls

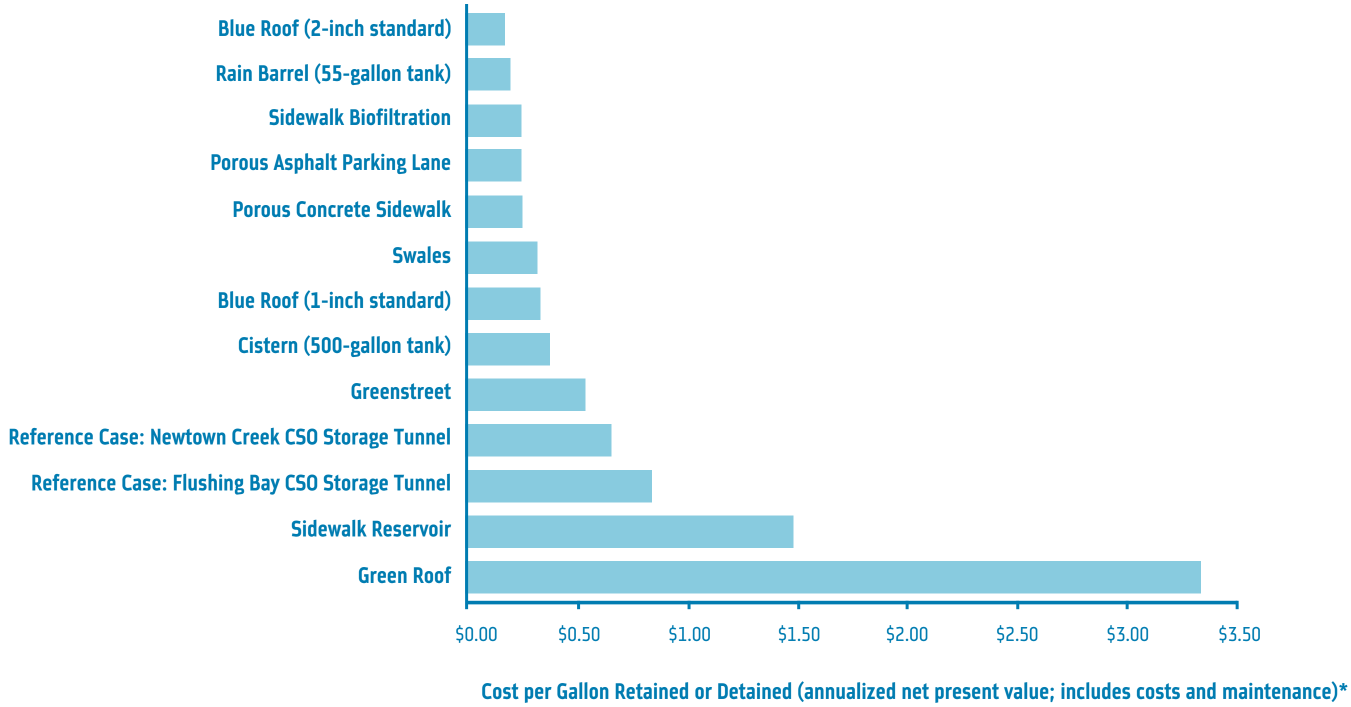
Right of way

4 Road reconstruction design standards
5 Sidewalk design standards
6 Right of way buildout

Open space

7 Green infrastructure: Greenstreets and swales

Figure 17: Costs of Source Control Technologies



* "Gallons" when used with source controls refers to gallons of stormwater runoff that can be retained or detained in those source controls. The exact relationship between those quantities and the corresponding reduction in CSOs is not yet established. See Appendix D.

have the final results of source control modeling runs until 2012, the direction of this Plan's findings is supported by at least one peer-reviewed study of the potential effects of source controls on a CSO outfall in New York City, F. Montalto et al., *Rapid assessment of the cost-effectiveness of low impact development for CSO control*, Landscape and Urban Planning 82: 117-131 (2007). That study modeled CSO reductions of 10 to 26 percent for various technological source controls.

The City is also conducting a spreadsheet analysis of the impacts of the scenarios outside of the 24 CSO watersheds in separate sewer areas and will publish the results of that study online in a separate technical paper.

Performance standards for new developments

One potential strategy is to require new developments to detain or retain stormwater beyond levels currently required under DEP rules and regulations. Performance standards for new construction approaches have been adopted by Chicago, Philadelphia, Seattle, Portland, and other major cities.

The current sewer code and drainage plan regulations require property owners to pipe stormwater directly from their lots into municipally-operated sewers, where available. When a developer applies for a sewer connection permit for new construction or major alterations, DEP requires on-site detention of stormwater in many instances, for example, when there is no nearby sewer, or when the proposed project flow exceeds the flow that the sewer was built to accommodate from a particular parcel. As a result of these rules, rooftop detention and subsurface detention tanks have been and continue to be installed in the city.

In consultation with agency and outside experts, the City has determined that new developments will be able to detain a 10-year design storm with a gradual release rate through proven, cost-effective technologies such as rooftop detention. The 10-year design storm is based on 50 years of rainfall data in New York City, and equates to approximately 2.35 inches in one hour.

For the purposes of analyzing the potential benefits that performance standard would provide, our initial analysis of new developments studied the costs and benefits of applying the standard to lots over 10,000 square feet. This threshold was chosen for study and testing because it is used by other U.S. cities. The City is actively evaluating whether performance standards for smaller buildings would provide significant, additional CSO reductions. This Plan's analysis projected future construction without regard to existing or future zoning regulations. Any future efforts to model the impacts of source controls for particular watersheds should take zoning and other restrictions into account.

Based on an analysis of building permit applications from DCP and DOB for the period from 2000 to 2006, this Plan projects that over 52 million square feet of new developments over 10,000 square feet will be built between 2010 to 2030. Citywide, the proposed performance standard could capture over 1 billion gallons of runoff during CSO-causing rain events when fully implemented in 2030. (These volumes are source control detention volumes, not CSO reductions, as noted in the methodology section of Appendix D.) These estimates must be interpreted with caution. The recent and drastic slowdown in construction nationwide and in New York City starting in 2008 may undercut projections based on data from 2000 to 2006. For a further discussion of this issue, see Appendix D.

The City intends to require developers to implement stormwater detention or retention practices that are consistent with, or equivalent to those set forth in the *NYS Stormwater Management Design Manual*. Requiring on-site detention or retention for new construction will significantly reduce the peak discharge rate of stormwater runoff and would more closely mimic pre-development conditions. The City's research has shown that there are cost-effective solutions for detaining water on larger flat

Table 4: Potential Landscape Penetration for Source Controls

STRATEGIES	FEASIBILITY	POTENTIAL LANDSCAPE PENETRATION BY 2030	RUNOFF CAPTURE (GALLONS)*
Performance standard for new development	Proven in NYC	100%	1,174,000,000
Performance standard for existing buildings	Unproven	25%	1,664,000,000
Low-density residential controls	Proven outside of NYC	25% (of homes)	783,000,000
Medium-density residential controls	Proven outside of NYC	25% (of homes)	333,000,000
Greenstreets	Proven in NYC	Opportunistic (at least 9 acres)	98,000,000
Swales	Proven in NYC	Opportunistic (up to 438 acres)	126,000,000
Sidewalk standards	Unproven	50% (of all sidewalks)	4,222,000,000
Road reconstructions	Unproven	5% (of right of way)	1,468,000,000
Right of way buildout	Unproven	50% (of right of way)	14,224,000,000

* "Runoff capture" refers to gallons of stormwater runoff that can be retained or detained in those source controls. The exact relationship between those quantities and the corresponding reduction in CSOs is not yet established. See Appendix D.

roofs. That finding is largely based on SCA's experience in constructing new schools with roofs that detain water. This feature is possible because new school roofs are very flat. Indeed, SCA guidelines for roof detention call for a maximum 2-inch rise from a high point at the intersection of the roof and the parapet wall to a low point at the roof drain. This specification recognizes that storage capacity will be limited on steeper roofs because the release rate will have to be set at a high level to avoid excessive ponding at drains. New roofs can be built flat enough to detain water, but buildings with multiple setbacks roofs may not be suitable for detention.

Alternatively, it is possible to detain stormwater in above-ground or below-ground storage tanks or in subsurface gravel beds, which have the additional benefit of facilitating infiltration if the soils under the gravel bed have a sufficient percolation rate. DEP has developed a subsurface gravel bed design with underdrains to the sewer system that will work whether or not site conditions allow infiltration.

The cost of source controls that could meet new construction standards is modest. Rooftop detention, one of the measures most likely to be used to comply with the performance standard has low incremental costs. Compared to average costs of $18 per square foot for a typical four-ply roof, the costs of a blue roof are only $4 per square foot more. We assumed no additional maintenance costs above those incurred for a standard roof. When we consider lifecycle costs, the economics improve further, because the thicker membrane of blue roofs mean that they last longer than standard roofs; the warranty provided by manufacturers is 20 years, compared to 10 to 15 years for standard roofs. With approximate construction costs of $300 per square foot for new buildings, the cost of this strategy is little more than 1 percent of construction costs.

Other relatively low cost source controls are also available to meet the proposed performance standard. Subgrade storage chambers are a proven technology that has long been used for stormwater management to detain water on-site for controlled release to the sewer system. A subsurface gravel bed can also serve the same function, and can be enclosed with geotextile fabric on the sides and top to protect voids below the gravel from becoming clogged while preserving the opportunity for infiltration through the unenclosed bottom. Site configuration is the key driver of costs. Many different chamber and gravel bed dimensions are available to achieve the necessary storage volume; generally, shallower ones require less excavation and are less expensive but require a larger lot area that is not taken up by a building. However, costs also depend upon on-site soil conditions, tank materials, and ease of site access. While it is difficult to generalize, the constructions costs of chambers or gravel beds can be comparable to blue roofs on a per gallon or per square foot basis. These underground systems also work on a year-round basis.

Performance standards for existing buildings

Existing buildings present an even greater opportunity than new construction. The buildings that exist today represent 85 percent of the buildings that will exist in 2030. If considering only existing rooftops over 10,000 square feet, there are over 302,000,000 square feet of rooftops on such buildings across the city. A significant percentage of the owners of these buildings are likely to repair their roof or undertake major modifications at some point in the next 20 years.

If roofs are replaced about every 20 years, by 2030 a performance standard for existing buildings could, in theory, capture nearly all of the rooftops in the city. However, the City's research and discussions with rooftop drain and materials manufacturers has revealed significant challenges to a strategy of using existing roofs for detention. As discussed above, the pitch of roofs is the most important limiting factor and existing buildings have greatly varying pitches. Indeed, there were few standards for roof pitches until recently. These facts mean that the City would have two options if it decided to impose a detention or retention standard for existing buildings: it could require that owners submit an individual engineering analysis for every roof replacement to ensure that the structure could accommodate ponding at the drain, or it could set a performance standard at a level that would create minimal ponding on most existing roofs. The first option is expensive and may deter needed roof replacements, and the second option may produce minimal stormwater benefits.

Nevertheless, the potential benefits of a strategy of rooftop detention for existing buildings are significant because of the sheer number of existing rooftops. This Plan assessed the impacts of a policy for this sector, we have assessed the impacts of a 1-inch detention standard for buildings of 10,000 square feet or greater, and assumed that 25 percent of such structures can meet the standard by 2030. The City estimates that such a strategy has the potential to capture over 1.6 billion gallons of runoff a year during events that cause CSOs on a citywide basis, when fully implemented. This would represent nearly 8 percent of baseline CSO volumes from our citywide baseline case.

The cost of that benefit would still be relatively low if blue roof technology could be used, since it has only a $4 per square foot incremental cost over conventional roofs. The City notes that the relative per gallon costs of blue roofs are more expensive than for new construction on a per gallon basis because the standard we assessed is half that for new roofs (1 inch of detention compared to the 2 inches). Because the

CASE STUDY
Blue Roofs on New York City Schools

In 2003, the New York City School Construction Authority adopted a new design standard requiring blue roofs, or roofs structurally capable of detaining water, on all new schools built citywide. In the past five years since adopting the requirement, SCA has built 14 new schools featuring the blue roof system. Essentially a blue roof is a drainage system that slows the rate water enters the public sewer system. Four aspects of the blue roof system determine its function: the structural integrity of the roof, the amount of water allowed to flow into the sewer, waterproofing of the roof, and the drain itself.

Blue roof drain installed by the SCA on PS 12

Credit: NYC Department of Environmental Protection

In the SCA's blue roof design, the roof drain detains up to three inches of water on the roof behind an adjustable weir valve. Any water in excess of three inches flows over the open top of the valve and into the sewers, but the detained water remains on the roof while being slowly filtered down the drain pipe.

For SCA, the decision to incorporate blue roofs in its design standard was driven by economics. DEP sets standards on the allowable flow of water to enter the public sewers from buildings, based on the local drainage plan and sewer capacity. To meet these drainage plan standards, any excess water must be stored on-site for delayed release into the sewer. SCA eliminated the need to build costly underground storage tanks at newly-built schools and additions by using a resource that was basically free: the roof. Since the engineering and design are already budgeted for in a new construction project, an integrated design to accommodate a blue roof adds very little or no additional upfront cost. And the maintenance and upkeep is no different than with a roof with a standard drain.

SCA has been very satisfied with the cost-savings blue roofs afford them in building new schools and will continue to follow the standard in future projects.

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viability of blue roofs on existing buildings is unproven, our cost estimates must be viewed as the low end of a range.

Low- and medium-density residential developments

Another strategy is to retrofit smaller, existing buildings. Collectively, low- and medium-density residential land uses comprise over 30 percent of our city's land area, and represent over 25 percent of our impervious surfaces, or nearly half of the impact of all buildings and lots in the city. (These land uses correspond roughly to one- and two-family homes and multifamily residences, respectively.)

Reaching the hundreds of thousands of lot and building owners in this category would require systematic and widespread programs and policies. The City's assumptions about landscape penetration by 2030 are premised on the successful use of non-technological source controls. For example, the City could reach early adopters through public education efforts that include the publication of guidelines, technical manuals, and other resources that would allow building owners to learn how to manage stormwater on their property. A policy could reach mainstream owners through economic incentives that encourage voluntary adoption. Finally, we could adopt performance standards for smaller buildings. This Plan has assumed a landscape penetration of 25 percent by 2030, or a little over 1 percent a year for 20 years.

The smallest, detached homes generally have pitched roofs, and even existing townhouses have a pitch that would rule out rooftop detention. Cisterns or rain barrels are the appropriate technologies for that situation, but both are effective only during a six-month period from April 15th to October 15th, when there is no danger of freezing. The City has assessed the impacts of a 500-gallon cistern which has a greater storage capacity than possible through 55-gallon rain barrels. The City assessed the impacts of cisterns only for multi-family residences even though other technologies could detain or capture more stormwater runoff; some multi-family residences with flat roofs may have the potential to employ a wider range of source control technologies, including rooftop detention and green roofs. In the prototypes we assessed only rainfall generated from rooftops, which we assumed to average 1,250 square foot roof in lower density residential areas, and 1,340 square foot roof for multi-family residential areas. Capture would be greater if technologies were adopted to control the runoff from driveways, pathways, and other impervious areas in low- and medium-density residential developments.

This Plan estimates that a low-density residential strategy could capture over 780 million gallons of runoff a year during events that cause CSOs on a citywide basis when fully implemented in 2030. We estimate that a medium-density residential strategy could capture over 330 million gallons of runoff a year during events that cause CSOs on a citywide basis when fully implemented. Together, the 1.1 billion gallons of runoff detained would represent about 5 percent of citywide CSO volumes from our baseline case.

Incorporate source controls into roadway reconstruction projects

Because our right of way generates so much runoff, we analyzed opportunities to incorporate source controls in that land use. A significant opportunity for installations occurs during scheduled road reconstruction projects, which involve extensive excavation and sub-grade work. The incremental costs of installing stormwater source controls at that time are relatively low compared to overall project costs.

To estimate the possible penetration of these source controls, we analyzed DDC records for road constructions that have occurred or are planned from 2004 to 2014. Initially, we assumed the same rate of construction in each watershed per decade, and doubled that rate in order to obtain the expected reconstructions from 2010 to 2030, adjusted for the expected

CASE STUDY

Permeable Pavement in Cold Climates

Porous pavement technology offers great potential to capture large volumes of stormwater runoff. However, those who are cautious about testing the technology cite a number of concerns about its application in New York's climate, particularly its long-term performance through the freeze/thaw cycle and the cost of maintenance. Fortunately, the technology of porous pavement is well-documented and there are numerous examples of successful implementation in cold climate locations such as the University of New Hampshire in Durham, NH, Philadelphia, Chicago, and Ithaca, NY. The University of New Hampshire Stormwater Center piloted a four-year study of porous pavement specifically to address the concerns of their use in cold weather climates. They had unexpectedly positive results that displayed excellent performance year round. Using data from monthly infiltration rates for three years, University of New Hampshire researchers found surface infiltration actually improved in winter months, even with more than twelve inches of frost penetration.

Porous pavers at the new Mets stadium

Porous concrete parking lot

The basic design of porous pavement involves a surface layer of porous concrete or asphalt, with a subsurface layer of stones and crushed gravel. In the New Hampshire study, a third underlying layer of fine sand and gravel for further filtration was also used. Because this design involves a well-drained sub-base, empty spaces in the gravel layer and in the pavement remain open even when the material is frozen. In the summer, infiltration was slightly less than in the winter probably due to a petroleum-based binder material in the asphalt, which is sticky and swollen in hot weather, slightly reducing the pore size. A separate study at Cornell observes that a minimum of 24 inches of structural soil under porous asphalt prevents heaving or cracks due to freeze/thaw cycles.

Porous pavement has also been used very successfully in Chicago's Green Alley Program to prevent sewer backups and basement flooding. What started as a pilot study in 5 alleys has now been adopted in alley retrofits citywide. Maintenance is being carefully monitored, and early feedback indicates that regular vacuuming is needed. Data from the New Hampshire study shows surprising results about maintenance: well-designed porous pavement may actually have a longer life-span and require up to 25% less salt for winter maintenance due to lack of standing water and black ice on the surface. Additionally, during the New Hampshire study, there was no instance of surface runoff, even during two 100-year storms that occured during the monitoring period.

width of roadway in each watershed. As we plotted the results, we discovered significant distortions from our initial data set; watersheds that had no projects in the 2004 to 2014 capital plan showed no projects until 2030 under that initial methodology. To reduce the variability among watersheds, we assumed that the same overall rate of reconstructions would apply citywide, approximately 5 percent of the total road and sidewalk surface length in each area over a 20-year period. Using the recent past as a guide, we can expect that 2,740 acres or 5.33 percent of our road surfaces citywide, will undergo full road reconstruction by 2030. These areas represent just 1.42 percent of the city's land area.

To calculate the potential stormwater diverted, we used two prototype designs. For narrower right of ways such as one-way streets and adjacent sidewalks, we considered the impacts of permeable pavement in the parking lane that would accept runoff from streets and sidewalks. For broader rights of way such as two-way streets with wider sidewalks, we considered the impacts of sidewalk biofiltration cells that are connected to the street through curb cuts. We also analyzed and then rejected two other scenarios that were less cost-effective. Details of our methodology and assumptions are set forth in Appendix D.

We estimate that some combination of these designs could capture over 1.4 billion gallons of runoff a year during events that cause CSOs on a citywide basis, when fully implemented in 2030. This would represent more than 7 percent in baseline CSO volumes from our baseline case.

The cost of these strategies would involve the incremental costs of incorporating source controls into road reconstruction projects that already involve excavation. A permeable asphalt parking lane costs approximately $17.00 per square foot, compared to approximately $6.00 per square foot for a typical asphalt parking lane. A sidewalk biofiltration installation costs approximately $48.00 per square foot compared to approximately $7 per square foot for a typical sidewalk. Because the biofiltration installation has a greater storage capacity and would accept stormwater from wider streets, the cost per gallon of these two prototypes ends up being nearly equal.

Some of the prototype designs are unproven. The City has reservations about the feasibility of building and maintaining permeable pavement parking lanes and biofiltration, and whether their performance would remain stable over time. While some preliminary information indicates that asphalt parking lanes could last for approximately 20 years before resurfacing, there has been no experience with that application over that time period. All of these unresolved concerns preclude the immediate implementation of this strategy. However, we will add to or amend our pilots to test those applications in reconstruction projects and to resolve lingering concerns about their performance, costs, reliability, and maintenance. The results of pilot projects will allow us to develop standard designs.

Another challenge to implementation is the uncertainty about funding for the operation and maintenance of stormwater controls in the right of way. Currently, the division of responsibility for maintenance in the right of way is governed by a 1983 directive that was adopted to resolve an impasse over cleaning city-owned properties in the right of way. It gives DSNY responsibility for sweeping the streets and cleaning non-landscaped traffic islands, medians, and other areas; the Parks Department responsibility for cleaning landscape areas; and DOT responsibility for cleaning areas along arterial highways. These agencies are all funded out of general tax revenues. The issue has become more complicated since then, as intervening laws have allocated responsibility for sidewalks to adjoining landowners. As stormwater source

Greenstreet at Furmanville Road and E 80th Avenue

Credit: NYC Department of Parks and Recreation

Higway swale in Maryland

Credit: Low Impact Development Center

controls become more widespread, resolving maintenance responsibilities will be critical to successful implementation. This matter is discussed in more detail in Initiative 8 below.

Sidewalk design standards

Sidewalks represent another opportunity in the right of way. The potential for landscape penetration is significant because sidewalks are repaired on a more frequent basis than roads are fully reconstructed. We estimate that the lifespan of concrete sidewalks varies considerably across the city, from a low of 13 years to a high of 50 years, based on information from DOT, DCP, and business improvement districts. Over the last four years, DOT has followed a 13-year replacement cycle (repairing 41 acres each year out of the approximately 537 acres of sidewalks adjacent to city-owned properties), a pace that would repair 100 percent of all city-owned sidewalks by 2030. This activity may represent an unusually productive period or the need to catch up on deferred maintenance.

A more significant opportunity is presented by sidewalks adjacent to private property, which represent 95 percent of all sidewalks and a total area of approximately 15,000 acres. Private sidewalks are replaced at a slower rate than the City's. The lifespan can be as low as 20 years in heavily trafficked central business districts and as high as 50 years in low-density residential districts. Useful life is often extended through patchwork repairs. Even so, if we assume an average life of 30 years, then approximately two-thirds of all the sidewalks in the city will be replaced by 2030. This high rate of turnover means that a sidewalk strategy has the potential to keep an enormous volume of stormwater from reaching our sewers.

To estimate the possible impact of sidewalks that are designed to capture stormwater, we assumed that the sidewalks in CSO watersheds would be repaired at the same rate as the citywide average (i.e., two-thirds by 2030), and that most of those repairs could follow infiltration or detention design standards. After considering limitations posed by vaults, subways, and other underground obstacles; poorly drained soils; landmark restrictions; and the possible regulatory requirement that all installations connect to catch basins, we have scaled back our assumptions about overall landscape penetration rate to 50 percent.

The prototype sidewalk design assessed in this Plan was a five-foot strip of permeable pavement adjacent to the road. That location was selected to minimize the risk of seepage to basements and buildings. The drainage area was assumed to be a 10-foot wide sidewalk area, which is the average sidewalk width in the city.

Our calculations show that this strategy could nonetheless divert over 4 billon gallons of runoff a year during storms that cause CSOs, when fully implemented in 2030. If there is a direct, one-to-one relationship between stormwater captured and CSOs, that volume represents over 20 percent of citywide CSO volumes in our baseline case.

The cost of these strategies would involve the incremental costs of permeable pavement and deeper excavation over the costs of regular sidewalk reconstruction. Regular replacement already requires removal of the old sidewalk and substrate and the placement of new substrate. The additional costs would include deeper excavation, additional gravel, and permeable concrete or other pavement for the half of the sidewalk that would be permeable under our assumed prototype. The lifecycle cost of permeable concrete sidewalks, including additional subgrade excavation and installation and annual maintenance, is $15.67 per square foot, compared to $7 per square foot for a regular concrete sideway. The additional, incremental cost would average $8.67 per square foot for the half of the sidewalk that would be permeable if this strategy were implemented.

This strategy has significant potential for cost-effective stormwater management. However, there are many details to be analyzed before the City could amend applicable sidewalk standards to require stormwater controls. For example, the prototype design assessed in this report included an 18-inch deep gravel bed that would hold a large quantity of stormwater, and a catchment area that encompassed only the sidewalk. That conservative design may capture more stormwater than necessary for the cost, and may not be optimum. Indeed, the data suggest that the prototype we modeled is probably too large for the limited catchment area because its capacity is rarely exceeded. Opportunities for value engineering and other design changes include a shallower gravel bed, structural soil, and other configurations. In addition, we would need to resolve questions about the effects of salt and other pollutants in sidewalk runoff upon street trees and other vegetation, as well as questions about basement flooding. These issues will be addressed through the planning process mentioned in Initiative 7.

Green infrastructure: Greenstreets and highway swales

Additional retrofit programs may be required to lower the overall impermeability of the right of way. The Greenstreets program of small plantings in the right of way is one of our most successful retrofit programs. PlaNYC has already committed the funding and planning for 80 new Greenstreets every year for the next decade, with the goal of bringing the total number to 3,000 by 2017. The Parks Department is experimenting with new design standards that would allow for more storage of street runoff. We have evaluated the impacts of a strategy of expanding the Greenstreet program, either

Portland Green Street sidewalk biofiltration source control

Stormwater capture swale in Eugene, Oregon

by doubling the number built every year, or extending the commitment from 2018 to 2030, an additional 12 years.

To estimate the impact of an extended Greenstreets program, we assumed that the additional installations would be allocated in proportion to the road area represented by each of our CSO watersheds. (In reality, the location of installations is driven by a number of non-stormwater factors, including opportunities presented by roadbed configurations, community requests, and other factors.) We further assumed that half of these would be the new design that accepts stormwater, that is, would be built with an additional foot of gravel fill, and curb cuts that allow the inflow of stormwater from the street.

Our projections show that a mere extension of the Greenstreets program would not have a significant impact on stormwater capture on a citywide basis, and would provide capture of runoff at a rate that compares to less than 1 percent of CSO volumes citywide when fully implemented in 2030. Yet in some watersheds an extended Greenstreets program could make significant contributions to runoff control.

Greenstreets are pure retrofit installations, and therefore would bear full costs. (We assume that any incremental cost opportunities presented by road reconstruction would be achieved through that separate initiative.) Nevertheless, based on our projection that Greenstreets installations can last 30 years, the lifecycle costs over 20 years would be approximately $42.00 per square foot.

Despite the modest overall benefits, the City could use this strategy to target intersections prone to nuisance flooding or sub-watersheds with specific CSO problems. Greenstreets are also desirable for other, non-stormwater reasons. They provide community amenities and a positive impact on real estate values, quality of life, and cooling. And their highly-visible presence in the right of way, adjacent in many cases to pedestrian areas, means that Greenstreets installations could provide a unique opportunity for public outreach and education about stormwater impacts and controls.

Highways can generate a significant amount of stormwater runoff. Our analysis of GIS data shows that there are approximately 1,900 acres of land owned by the Parks Department that are adjacent to highways and that are suitable for swales. Of this area, approximately 430 acres are in combined sewer areas and approximately 1,460 acres are in separate sewer or direct discharge areas. Highway swales have been used for decades to manage stormwater and any retrofit program could take advantage of that technology.

In assessing the potential stormwater impacts of engineered swales, we made certain assumptions in the absence of applicable design guidelines. We have assessed the impact on CSOs of retaining and detaining 1 inch of rainfall from the highway areas that are directly adjacent to potential swale areas.

Our projections show that swales would not have a significant impact on runoff capture on a citywide basis, representing runoff capture of less than 1 percent of citywide CSO volumes, when fully implemented in 2030. But in some watersheds – where combined sewer areas intersect with concentrations of highways – highway swales can make significant contributions to runoff capture and could be used to supplement other reduction efforts as needed.

We recognize that our projections undercount the potential water quality benefits, as most of the potential swale areas are in separate sewer or direct discharge areas. A full build-out of swales would reduce untreated discharges in those areas. Indeed, separate sewer or direct discharge areas contain three times the potential area available for swales.

The costs of constructing swales are highly variable, because site geometry, elevation, and roadway characteristics would lead to unique grading, excavation, and culvert configurations. To estimate costs, we have used the cost estimates from DEP's pilot programs at Paerdegat and Rockaway Bridges on the Belt Parkway. There, preliminary estimates range from $2.58 to $10.32 per gallon of design storage with infiltration of 0.5 inches per hour to $4.64 to $18.69 per gallon of design storage with no infiltration. The variation is due to different designs, with a deep, oblong swale at Paerdegat storing more water than the shallow, linear swale at Rockaway.

Right of way build-out

The above strategies address most of the opportunities presented in the major land use categories of buildings and developed lots and the right of way. One of the few remaining options is to expand beyond the portions of the roadway that will be reconstructed over the next 20 years. Any such retrofit program would be motivated by stormwater capture rather than roadway improvement.

To assess the impacts of such a strategy, we have used the biofiltration and parking lane permeable pavement designs described in the reconstruction sub-section above for 50 percent of the right of way. We estimate that some combination of these strategies could, in theory, capture over 14 billion gallons of runoff a year during rain events that cause CSOs, when fully implemented by 2030. But these reductions would be capped well beforehand, due to the distorting effect of having storage capacity that exceeds CSOs.

The cost of this theoretically effective strategy would be proportionally higher because of three phenomena. First, we would be destroying significant useful life in our roadways, and would therefore have to bear the full costs of reconstruction. We have assumed that retrofits would destroy 100 percent of remaining useful life; as some commenters have pointed out, that assumption does not match existing conditions and the remaining useful life will range from 0 percent (scheduled or overdue replacement) to 100 percent (new roads), depending on the age of the street in question. (Our future planning efforts for this scenario, as detailed in Initiative 7, will attempt to refine this assumption through a sensitivity analysis if data exists.) Second, widespread road reconstruction would involve significant indirect costs, as construction creates detours and roadway congestion, slows commutes, and causes pollution from slower-moving traffic. Third, there are diminishing returns in controlling stormwater; capturing the last possible gallon would involve overbuilding on a massive scale. Accordingly, our projection is that a roadway strategy would cost over $18 billion over 20 years. On a per-gallon basis, this would be an order of magnitude greater than any other strategy.

Reference cases: Newtown Creek and Flushing Bay CSO retention tunnels

We also evaluated the costs and benefits associated with the construction of two proposed CSO storage tunnels for Newtown Creek and Flushing Bay. The cost of these tunnels provides an additional benchmark to assess the cost-effectiveness of source controls. These traditional CSO controls are projected to be expensive – some of the most expensive alternatives assessed in the City's Waterbody/ Watershed Facility Plans submitted to the NYSDEC – because they involve deep tunneling. If the City can build sufficient source controls, it could work with NYSDEC to seek opportunities to either reduce the design capacity or eliminate the need to construct these tunnels, and thereby create significant cost savings in future budgets and reduce the negative impacts to the environment that are associated with large construction projects. Since these projects are not in the City's current 10-year capital budget, there are no earned savings to redirect to source controls even if data existed to make the case for that trade-off.

We calculated the impacts of these two tunnels by modeling their effect during different rain intervals and in different watersheds. On an annual basis, these tunnels are estimated to reduce CSO by over 1.9 billion gallons annually when built, or about 9 percent of the annual CSO volume in the baseline case.

Queens Botanical Garden
Credit: Jeff Goldberg/ESTO

Queens Botanical Garden
Credit: Jeff Goldberg/ESTO

CASE STUDY
Queens Botantical Garden

Water is the central feature of the fresh new face of the Queen's Botanical Gardens. The newly-designed Visitor and Administration Center highlights the significance of water as a vital natural resource by incorporating rainwater and greywater systems throughout the building and its surroundings. The ambitious design won NYC's first Green Building Design award in 2004, and is the first public building in New York City to achieve the rarely-awarded LEED® Platinum certification.

The Visitor's Center is a significant example of effective stormwater management packaged in an elegant design. A rainwater recycling system collects rainwater for use in a large-scale water feature that welcomes visitors to the garden and is a focal point of the newly designed visitor's center. All excess stormwater is contained on-site, with no connection to the City's storm sewer system. A 24,000-gallon cistern stores captured rainwater for reuse in the fountain at the garden's entrance. Stormwater overflow drains into a bioswale that effectively sustains the surrounding native landscape without using any additional irrigation. During wet weather, rainwater cascades from a folded roof canopy and flows through a water course and a cleansing biotope, or man-made stream. The stream filters the water using the natural processes of sand, gravel, and native wetland plants. During dry seasons and drought, the channel becomes a dry riverbed, and a reminder of the vital role water plays in the intersection of natural and built environments.

In addition to stormwater management, the Center also has installed a greywater filtration system that cleans and reuses 4,000 gallons of greywater each week. Greywater from the kitchen and lavatory sinks, showers, and washing machines is collected and sent through a constructed sand-based wetland, planted with sedges, grasses, rushes, and ferns that naturally purify the water. Cleansed greywater is then recycled for toilet flushing. The Center's entire greywater system helps reduce potable water consumption by 82 percent.

Table 5: Feasibility Considerations for Source Control Strategies

STRATEGY	OPERATIONAL PREREQUISITES	FUNDING PREREQUISITES
Performance Standard for New Development	None	Costs would be incrementally incurred by owner
Performance Standard for Existing Buildings	Design of policy, determination of feasibility, and outcome of pilots	Costs would be incrementally incurred by owner
Sidewalk Standards	Design of policy, determination of feasibility, and outcome of pilots	Source of public incremental funding and maintenance
Road Reconstruction Standards	Design of policy, determination of feasibility, and outcome of pilots	Source of public incremental funding and maintenance
Swales	Determination of available sites and outcome of pilots	Source of public funding and maintenance
Greenstreets	Determination of available sites and outcome of pilots	Source of public funding and maintenance
Medium-Density Residential	Design of policy and outcome of pilots	Source of public funding for incentives
Low-Density Residential	Design of policy and outcome of pilots	Source of public funding for incentives
Right of Way Buildout	Design of policy, determination of feasibility, and outcome of pilots	Source of public funding for full costs and maintenance

The large reductions come at a high cost – over $1 billion for the Flushing Bay Tunnel, and over $1.2 billion for the Newtown Creek Tunnel. If built, these tunnels are predicted to last about 50 years, longer than many source controls on roofs or in the right of way. But on a per gallon basis these controls will still be more expensive than most source controls, with the notable exception of green roofs.

Potential Source Control Scenarios

It makes sense to implement strategies that are more feasible or have lower costs, or, ideally, both, before turning to less feasible or more expensive strategies. Our research and discussions with industry, agency and other stakeholders has revealed several issues that must be resolved before implementation (Table 5).

Accordingly, we have ranked the available strategies in seven tiers (Table 6).

Our preliminary findings demonstrate that we can reduce CSOs substantially by making incremental investments over the next 20 years. However, there is an upper limit to stormwater runoff reductions, and diminishing returns to cumulative investments in control options. These rankings may change in the future as demonstration projects and other developments allow us to refine our stormwater analysis or include other environmental benefits such citywide cooling and energy savings.

These preliminary findings have led us to identify three tiers of options.

First, in the short-term, there are significant opportunities, and few funding or operational barriers, to adopting changes to local regulations or codes or both to require stormwater detention in new developments. These changes could be implemented in 2009.

Second, in the medium-term, there are several source control scenarios that could be implemented once funding and operational prerequisites are satisfied. These scenarios – sidewalk standards, road reconstruction standards, green roadway infrastructure, and stormwater requirements and incentives for low- and medium-density residences and other existing buildings – present significant opportunities for source controls. However, we must first satisfy preconditions for each of these strategies, including analyzing the results of pilot projects, completing studies of economic incentives, resolving funding and maintenance issues, and settling on consensus designs.

Third, in the long-term, the City should assess stormwater controls at regular intervals to determine the need for additional measures. Some control options should await future needs assessments before they are implemented. Based on current information, for example, we cannot recommend the implementation of a widespread road reconstruction program for the sole purpose of stormwater control. That would incur enormous up-front costs and indirect costs in increased delays, traffic, air pollution, and construction costs, for a diminishing benefit in stormwater reduction.

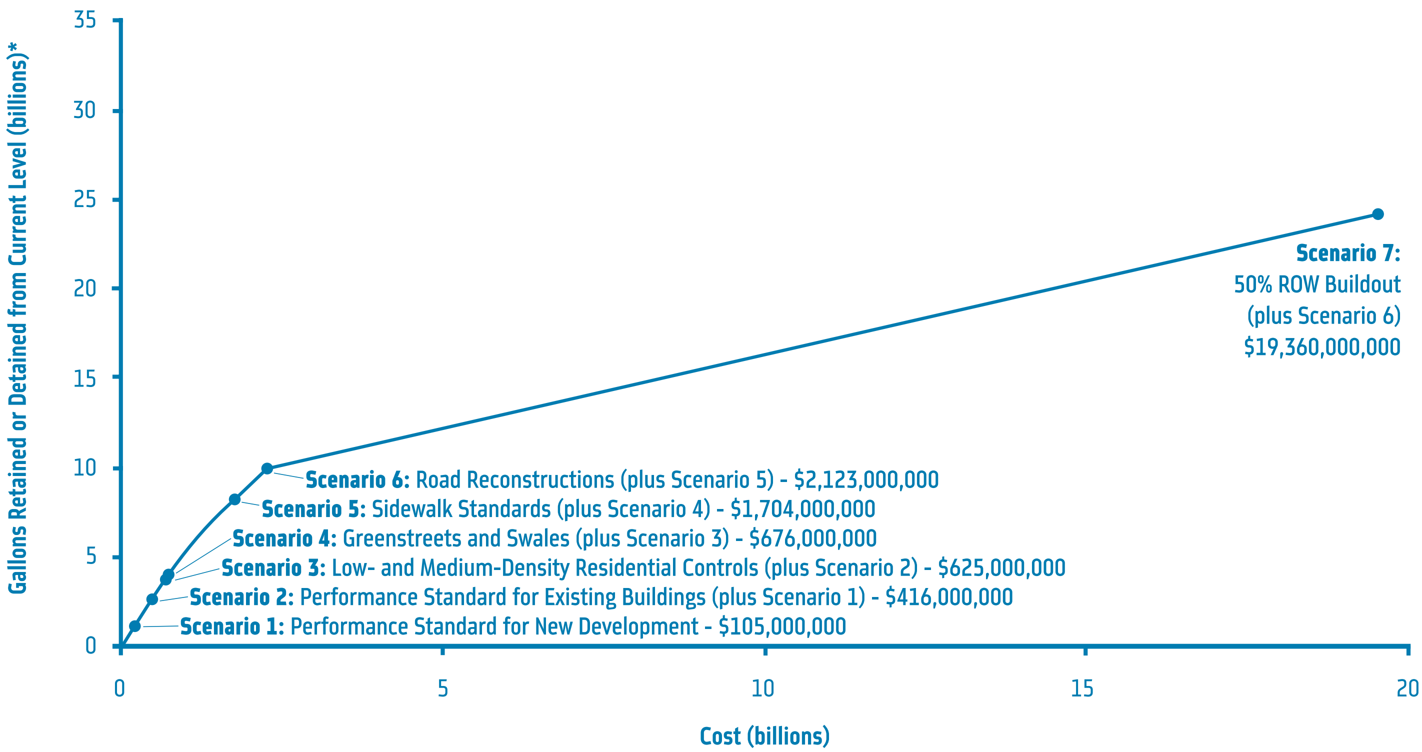
A future performance assessment of the effectiveness and broad implementation of source controls could also affect current projects that are mandated through various mechanisms. Based on such an evaluation, the plans to build expensive hard infrastructure such as deep storage tunnels for stormwater in Newtown Creek and Flushing Bay could be downsized or eliminated.

Table 6: Cost-Effectiveness of Different Source Control Scenarios

SCENARIOS	CUMULATIVE RUNOFF CAPTURE* (GALLONS)	CUMULATIVE COST (2010-2030)	COST/GALLON
Performance Standards for New Development	1,174,000,000	$105,000,000	$0.09
Performance Standards for Existing Buildings (Plus Above Strategy)	2,838,000,000	$416,000,000	$0.15
Low- and Medium-Density Residential Controls (Plus Above Strategy)	3,954,000,000	$625,000,000	$0.16
Greenstreets and Swales (Plus Above Strategy)	4,178,000,000	$676,000,000	$0.16
Sidewalk Standards (Plus Above Strategy)	8,400,000,000	$1,704,000,000	$0.20
Road Reconstruction Standards (Plus Above Strategy)	9,868,000,000	$2,123,000,000	$0.22
50% Right of Way Retrofits (Plus Above Strategy)	24,092,000,000	$19,360,000,000	$0.80
REFERENCE CASE	**TOTAL CSO REDUCTION**	**TOTAL COST**	**COST/GALLON**
Potential Future CSO Detention Facilities	2,266,000,000	$2,337,000,000	$1.03

* "Cumulative runoff capture" with the source control scenarios refers to gallons of stormwater runoff that can be retained or detained in those source controls. The exact relationship between those quantities and the corresponding reduction in CSOs is not yet established. See Appendix D.

Figure 18: Cost-Effectiveness of Different Source Control Scenarios



* "Gallons retained or detained" refers to gallons of stormwater runoff that can be retained or detained. The exact relationship between those quantities and the corresponding reduction in CSOs is not yet established. See Appendix D.

Credit: NYC Department of Parks and Recreation

Our Plan

Our Goal: Within two years, the City of New York will enact policies that will create a network of source controls to detain or capture over one billion additional gallons of stormwater annually when fully implemented

Implement the Most Cost-Effective and Feasible Controls

1. Capture the benefits of ongoing PlaNYC green initiatives
2. Continue implementation of ongoing source control efforts
3. Establish new design guidelines for public projects
4. Change sewer regulations and codes to adopt performance standards for new development
5. Improve public notification of combined sewer overflows

Resolve the Feasibility of Promising Technologies

6. Complete ongoing demonstration projects and other analysis
7. Continue planning for the implementation of promising source control strategies
8. Plan for the maintenance of source controls

Explore Funding Options for Source Controls

9. Broaden funding options for cost-effective source controls
10. Complete water and wastewater rate study and reassess pricing for stormwater services

New York City Greenstreet installation

Our Goal

When PlaNYC was released in April 2007, it adopted the goal of increasing access to our tributaries from 48 percent today to 90 percent by 2030 for recreational use. That goal is designed to guide the City's water quality policy and build on the City's ongoing efforts to improve our waterways.

This Sustainable Stormwater Management Plan is focused on ways to promote cost-effective source controls throughout the City and requires appropriate management tools to guide the creation and implementation of policies. The City will work towards enacting policies in the next two years that will create a network of source controls to detain or capture over one billion additional gallons of stormwater annually when fully implemented. In determining the goal of capturing one billion gallons of stormwater, the City is setting a goal that can be met after implementing aggressive policies that have not yet been attempted in New York City. Through the periodic updates required by LL5, the City will adjust its policies to meet the target number of one billion gallons captured. If there is adequate funding to implement the initiatives and the City is otherwise on track to meet that number, then the goal can be increased.

Both PlaNYC's water quality goal and this Plan's goal are consistent with LL5, which requires a goal to "reduce the volume of stormwater flowing into the city's sewer system, to improve water quality in the city's waterbodies and to protect the public health through the restoration and protection of the ecological health of the city's waterbodies, and to enhance use and enjoyment of the city's waterbodies for recreational activities." These discrete elements reflect the different benefits of reducing CSOs from our waterbodies and capturing stormwater throughout the City. Captured stormwater means that less stormwater will flow into the sewer system, starting a virtuous cycle of lower volumes of CSO and other untreated discharges, improved water quality, better ecological health of the waterbodies, more boating and other recreational uses, and improved public health.

Implement the Most Cost-Effective and Feasible Controls

INITIATIVE 1

Capture the benefits of ongoing PlaNYC green initiatives

PlaNYC includes a number of groundbreaking greening initiatives, including planting street trees in all possible locations, creating 800 new Greenstreets, and reforesting 2,000 acres of parkland. Mayor Bloomberg has dedicated $391 million over ten years for those initiatives. Other PlaNYC greening initiatives include the NYC Plaza Program, a new tax abatement for green roofs, zoning requirements for green parking lots, an expansion of the Bluebelt program, and the conversion of asphalt surfaces and schoolyards. For a complete list of PlaNYC green initiatives, see Appendix E.

Street trees

As part of PlaNYC, the Parks Department has launched a citywide, public-private program with the ambitious goal of planting and caring for one million new trees by 2017. MillionTreesNYC is divided into three separate programs – street trees, privately-held land, and public open space reforestation.

The Parks Department will plant 220,000 street trees in the right of way. Another 400,000 trees will be planted by private and community partners, and many of these will be in the right of way. To guide these plantings, the Parks Department has revised its standards for tree pits to require minimum, standard pit dimensions of five feet by five feet, which represents a significant increase over typical pit dimensions of three feet by three feet. The larger pits and additional soil requirements will increase the permeability of tree pits, and ensure that trees receive the water and oxygen they need to live. The Parks Department calculated the potential canopy interception of proposed plantings over the next 10 years could intercept an additional 220 million gallons per year of rainfall in 24 CSO tributary watersheds.

In addition, the City Council recently adopted a DCP zoning text amendment that requires street tree planting in all zoning districts, and planting strips between the sidewalk and the curb in lower-density residential zoning districts.

These trees are protected in two ways. First, new street trees are covered by detailed contracts that contain a two-year guarantee for the maintenance of live trees or the replacement of failed trees. Second, all existing street trees and other trees under the jurisdiction of the Parks Department are protected by existing city regulations that limit construction or other activity around trees and their root zone and that provide for the replacement of damaged trees. Proposed new regulations would tighten permit requirements and require a certified arborists' report.

Reforestation

The PlaNYC Reforestation program is targeted to plant 2,000 acres throughout the five boroughs with over 400,000 trees by 2017. The goals of the initiative are to decrease stormwater surges, reduce the urban heat island effect, improve air quality, and increase species diversity, and improve habitat quality. Although the planting areas are mostly permeable already, there are many opportunities to improve stormwater management, such as reforestation of parkland that is adjacent to the right of way, reforestation of river- and stream-banks to prevent erosion and improve the buffering capacity of pervious areas, and reforestation along coastal areas to prevent erosion and buffer the city from storm surges.

Greenstreets

Launched in 1996, Greenstreets is a citywide program to convert paved, vacant traffic islands and medians into green spaces filled with shade trees, flowering trees, shrubs, and groundcover. Since 1996, the Parks Department has planted 2,341 Greenstreets sites throughout the five boroughs.

As part of PlaNYC, the Parks Department is increasing the number of Greenstreets by an additional 80 new installations per year, or more than 3,000 additional installations by 2017. About half of the Greenstreets built in the past year were designed to accept greater amounts of stormwater, by the simple method of excavating an additional foot of material, from 2 feet deep to 3 feet deep. Curb cuts surrounding the installations allow runoff from the streets to flow into the planted areas, and infiltrate into the soil or pore spaces in the gravel subsurface. Although additional materials and excavation increased the costs of installation, Parks believes that it will realize savings because of fewer visits by watering trucks.

Table 7: Summary of PlaNYC Green Initiatives

STRATEGY	DESCRIPTION	EFFECT
Street Trees	MillionTrees NYC is a public/private initiative to plant one million trees citywide. New DCP zoning amendment requires street tree plantings	Parks Department and NYRP will plant 220,000 street trees by 2017, while private parties will plant many more
Greenstreets	PlaNYC calls for increasing Greenstreets by 40 projects per planting season for 10 years, resulting in 800 new Greenstreets by 2017	Increase Greenstreets from 2,200 in 2007 to 3,000 by 2017
Green Roof Tax Abatement	New law will allow NYC property owners to receive a tax abatement for installing a green roof on their building	Provides $4.50 per square foot up $100,000 in costs for all green roofs built in NYC between August 2008 and 2013
Greening of Parking Lots	DCP zoning changes require vegetation and stormwater controls in new parking lots	300 acres of new parking lots over the next 20 years will capture 8 million additional gallons of rainwater per storm
NYC Plaza Program	The NYC Plaza Program is a DOT initiative to create public plazas from underutilized roadway areas	Potential to add one plazs in each of the 59 community board areas
Bluebelt Program Expansion	The Bluebelt Program is a successful initiative to utilize open space to capture stormwater and control flooding	Goal established in PlaNYC to increase Bluebelt program by 4,000 acreas over the next 25 years
Asphalt to Turf	Parks is converting asphalt surfaces into permeable play surfaces	24 sites will be retrofitted at a total cost of $38 million
Schoolyards to Playgrounds	PlaNYC established an initiative to open all playgrounds for recreation use	290 playgrounds will be opened to the public; many will be retrofitted with trees and green space

Green roofs

The City has developed a pilot tax abatement program for green roofs. The program will result in the building of green roofs, and will also help develop information about the costs and likely acceptance rate. The abatement from City property taxes provides $4.50 per square foot of green roof, up to $100,000 in total costs. In order to qualify, property owners must install a green roof on at least 50 percent of a roof, and must prepare a maintenance plan to ensure the viability of the plants and the expected stormwater benefits. The program is currently scheduled to run until 2013.

Greening of parking lots

New York City is the first major city in the United States to require stormwater controls on private parking lots. In April 2008, the City enacted zoning amendments that require commercial and community facility parking lots to plant street trees and perimeter and interior landscaping that will detain water or infiltrate to the soil as feasible. The parking lot design standards apply to commercial and community facilities with parking lots that contain 18 or more parking stalls or are more than 6,000 square feet. If similar development trends continue for the next twenty years, then the new zoning rules will apply to 300 acres of otherwise impervious surfaces.

Plaza program

Another key PlaNYC strategy to greening the right of way is the Plaza Program, which will create non-transportation-related public uses in the right of way. DOT has identified at least one potential plaza site in each of the 59 community board areas, and 31 new projects are scheduled for completion as early as 2009. Many of the existing plazas are DOT pilot projects. These sites are areas of the right of way that include amenities like benches, tables, and planters. DOT is developing high performance guidelines to make these plazas greener, and to inform the professional design teams for each uniquely-designed plaza. Part of these guidelines will come from the existing zoning resolution for privately-owned public spaces, which include vegetation and permeability requirements. The Plaza program guidelines are scheduled for adoption in June 2009. Subsequent projects under the Plaza Program are expected to feature grading, permeable surfaces, and vegetation, all of which will increase the opportunities for infiltration.

Bluebelts

For more than a decade, DEP has managed and maintained one of the largest municipal systems of stormwater source controls in the country. DEP's "Bluebelt" system on Staten Island has connected storm sewers to streams, ponds, wetlands, and other natural drainage systems to create an integrated solution that preserves open space while controlling pollution and flooding. The system currently consists of 50 completed source controls with 40 more in planning, design, or construction, including extended detention wetlands, outlet stilling basins, sand filters, and pocket wetlands. The Bluebelt's source controls have saved tens of millions of dollars by avoiding the costs of installing conventional storm sewers. This system also provides ancillary benefits and is widely desired as a community amenity that increases recreational and green space and, as a result, quality of life and property values.

The Bluebelt experience is especially relevant to PlaNYC's effort to promote sustainable storm water management. PlaNYC calls for the expansion of the Bluebelt system, and over the last year, the City has acquired or is acquiring 70 additional acres. In addition, the Wetlands Transfer Task Force recommended that the City transfer 76 additional small wetland parcels to the Bluebelt Program. At this time, the implementation of the Bluebelt program expansions may slow due to funding constraints.

Asphalt to turf

The last expansion of the parks system included multi-purpose asphalt fields that could accommodate a range of recreational uses. To meet new and more varied demands, PlaNYC committed the City to accelerate the conversion of at least two-dozen asphalt multi-purpose fields to synthetic turf that can better absorb frequent and intensive use. At the same time, the most advanced design and technology will be used to make these fields as environmentally friendly as possible, including infiltration and retention of stormwater to the maximum extent possible. A first phase of five sites is in design right now. The general plan is to preserve as many trees as possible, remove an average five inches of asphalt, and excavate drainage and infiltration trenches before installing permeable artificial turf layers surrounded by planting beds. Rain falling on the sites will infiltrate to the soil, or flow over flush curbs to surrounding planted areas.

Table 8: Summary of Ongoing Source Control Initiatives

STRATEGY	DESCRIPTION	EFFECT
Local Law 86	Local Law 86 requires LEED certification for all new public buildings. Stormwater management is a component of the LEED system	All new buildings must meet basic green building standards
Residential Yards Zoning	DCP zoning changes limits residential property owners from paving over their entire front yards	Requires a minimum percentage of planting for all front yards in R1 to R5 Zoning Districts
Waterfront Standards	DCP is exploring updated zoning standards to improve planting and green space in waterfront development	Potentially incorporates increased permeability into new waterfront developments
High Level Storm Sewers	DEP evaluates opportunities to install HLSS in previously-developed areas where it is not feasible to separate existing combined sewers	High Level Storm Sewers have the potential to capture 50% of runoff where feasible, which results in less flooding
Sewer Separations	DEP requires the installation of separated sanitary and stormwater sewer systems in new developments when feasible	Sewer separations are occurring at major projects such as Battery Park City, Bronx Terminal Market, and Hudson Yards
Water Conservation	DEP provides incentives for building water reuse reduction and has proposed a fixture rebate program that is currently deferred due to budget constraints	New fixture rebate program would potentially result in savings of 60 million gallons per day
Coordination of Construction Specifications	The BMP Task Force is coordinating the planning and implementation for source controls in the right of way and open spaces	All agencies will use the same specifications for tree plantings and other common source control components

Schoolyards to Playgrounds

The Parks Department launched an initiative to convert underutilized school playgrounds to more multi-purpose playgrounds in neighborhoods like East Flatbush where they are most needed. Of the 290 underutilized schoolyards in neighborhoods that lack open space, 69 have already been opened. The other sites require new investments—such as play equipment, greenery, or sports fields—to make them attractive as play space, and $111 million is set aside for that purpose. The City will enliven these spaces by reducing or eliminating asphalt where possible. In May 2008, the first new Schoolyard to Playground project opened at P.S. 138 in the South Bronx. The new playground includes a larger play area for older children, a smaller play area for younger children, and several features that double as stormwater controls, including a small grassy area that was transformed to a Butterfly Garden with native flora, continuous tree pits, and natural areas. These areas will absorb most of the rainfall at the site.

Wetlands

Preserving wetlands is an important part of the City's goal to open 90 percent of its waterways for recreational use by 2030. PlaNYC includes an initiative to assess existing gaps in wetlands protections and to explore options for filling those gaps. A wetlands working group is completing that assessment. It is also producing detailed maps of wetlands. The assessment maps will be used to recommend whether it is necessary for the City to adopt local wetlands laws to fill gaps left by changes in Federal and State wetlands laws. Any local protections of wetlands adopted through that initiative will enhance the City's ability to manage stormwater.

In the meantime, the City retains management control over wetlands held in its portfolio. The New York City Park System includes 7,000 acres of undeveloped forest, tidal and freshwater wetlands, and meadows. In addition, Jamaica Bay is one of the largest coastal ecosystems in New York State. Recently, a Wetlands Transfer Task Force reviewed all City-held property that contains wetlands. It recommended the transfer of 82 wetlands parcels to the Parks Department and further evaluation of an additional 111 properties. The Parks Department has a "hold" on all other wetlands held by DCAS, and all City-owned properties that may contain wetlands will be reviewed by the Parks Department before sale or transfer for a use other than open space. The City will continue to pursue these management protections.

INITIATIVE 2

Continue implementation of ongoing source control efforts

In addition to the new PlaNYC initiatives, the City has many ongoing efforts that directly require, promote, or incentivize successful stormwater strategies. These efforts generally fall into the categories of sustainable water management policies, public design standards, recent zoning code amendments, and interagency coordination.

Public design standards

The City has also led the way through innovative strategies for the design of public projects. In 2005, Mayor Bloomberg signed into law Local Law 86 (LL86), which is New York City's Green Buildings Law for most public capital projects over $2 million. LL86's performance standards are based upon the United States Green Building Council's LEED (Leadership in Energy and Environmental Design) requirements, which include several credits for reducing impervious cover, increasing on-site filtration, reducing or eliminating pollution from stormwater runoff, and eliminating contaminants.

Some of the City's agencies have created guidelines and policies that guide the design and construction of capital projects. DDC has a series of sustainable design manuals including the *High Performance Building Guidelines* and the *High Performance Infrastructure Guidelines*. These publications promote innovative strategies such as harvesting rainwater, installing green roofs, recycling greywater, capturing runoff, using pervious pavements, and building vegetated source controls. SCA formalized its use of rooftop detention systems or "blue roofs" in 2003, and then developed the NYC Green Schools Guide and Rating System to guide the sustainable design, construction and operation of new and remodeled schools. Finally, HPD is implementing sustainable stormwater strategies to guide the design of the Gateway Estates II project. We will work with additional agencies that have responsibility for design and construction to ensure that all public buildings and developed lots meet and exceed any generally-applicable standards.

Recent zoning code amendments

The City recently amended zoning laws relating to yard regulations for residential developments in low-density zoning districts. Before the amendment, zoning required minimum front yards, but not planting. Since front yards were not required to be planted, in many new developments the yards were completely paved over, and similar conversions were occurring in the front yards of existing homes. The new zoning provisions now require a minimum percentage of planting in front yards in R1 to R5 zoning districts.

The City also recently changed zoning regulations related to the design and operation of privately-owned, publicly-accessible plazas. Recent design changes require trees, planters, planting beds, accessible lawns, and other planted areas. As a result of these changes, new privately-owned public spaces will contain more planted areas that will absorb stormwater rather than direct it to our sewers.

Finally, DCP is also assessing the zoning rules that apply to waterfront areas and the esplanades that have to be created for public access adjacent to the shoreline. DCP is considering design requirements for plantings and buffer areas in public access areas that would improve the quality of plantings and encourage permeability in new developments in the waterfront area. Additional permeable surfaces would reduce pollutant loadings from areas that otherwise discharge directly to waterbodies or through separate sewer systems.

Water conservation programs

Water conservation efforts reduce the flow of wastewater to WPCPs, therefore freeing up capacity for plants to treat additional stormwater during storms. Water reuse and other conservation measures have been implemented in New York City (see sidebar on the Remsen Yard facility). These projects are especially attractive for areas where high groundwater tables, bedrock, or underground utilities limit the use of infiltration or other in-ground source controls.

DEP already reduces water and wastewater rates in buildings that recycle much of their water and reuse it for toilet flushing, irrigation, and make-up water for evaporative cooling towers. The lower rate applies to new construction or substantial renovations that can demonstrate 25 percent less use of potable water through water conservation, reuse, or stormwater reuse than comparable buildings of similar size and use. DEP has also designed citywide fixture rebate programs to reduce water use. These programs include a rebate program for water-efficient toilets, urinals, and clothes washers, the replacement of inefficient plumbing fixtures in public buildings, and other water efficiency projects with the private sector, including the replacement of once-through water-cooled equipment, steam condensate reuse, and reuse for irrigation. At this time the implementation of this program is on hold because the City's revenue has fallen off dramatically, leading to budget cuts.

Remsen Yard
Credit: Kiss + Cathcart Architects

Remsen Yard
Credit: Kiss + Cathcart Architects

CASE STUDY
Remsen Yard

Remsen Yard is a DEP maintenance facility for trucks in its water and sewer operations. The 2½-acre property accommodates DEP vehicles, their equipment, storage and material piles, and personnel support facilities such as locker rooms, bathrooms, and administrative offices.

On-site water management was a major goal in the Remsen Yard design, which is slated to be completed in 2009. The Remsen Yard is a heavy water-use operation, using an average of 6,600 gallons per day for internal building consumption, as well as for yard activities such as washing trucks and misting piles for dust control. Rainwater from the roof will be collected in a tank, treated per NYC health guidelines, and reused for site-related water needs, providing 51 percent of the water required for these site activities and saving 1.4 million gallons of potable water a year.

Table 9: Summary of New Citywide Design Guidelines

STRATEGY	DESCRIPTION	EFFECT
Street Design Manual	DOT will release a new manual to govern street geometriess, materials, and lighting	Will recommend standards and pilot configurations for all roadway projects
Park Design for the 21st Century	Initiative of DPR and Design Trust for Public Space to establish guidelines for progressive open space design projects	Will promote source controls and sustainable stormwater management for all Parks capital projects
Sustainable Sites Manual	This DDC manual will provide strategies for maximizing vegetation, minimizing site disturbances, and managing stormwater	Will address the landscaped areas associated with all DDC capital building projects
Water Conservation Manual	This DDC manual will describe and evaluate best practices for reduction of potable water use and capture of precipitation for re-use	Will promote water conservation to designers and building managers for new projects and existing buildings

Coordination of construction specifications

Through the work of PlaNYC's Interagency BMP Task Force, it became evident that there was an opportunity for better coordination between the agencies that undertake construction work in the right of way. In balancing all of the specifications and design requirements promulgated by different agencies, city construction managers did not always apply the most recent regulations. To begin to resolve this problem, the Interagency BMP Task Force established an online website using Sharepoint software as a pilot solution. Using this system, agency personnel can share electronic versions of regulations while they are still under development so that other agencies can anticipate changes. In addition, the DDC is updating its "specification book" in an electronic format and is including the most recent version of agency specifications. The Task Force will continue to work to implement agreed-upon changes, including ensuring that all relevant draft and final specifications and State design standards are posted, hosting issues, and developing connections for contractors and other users that are outside of city government.

High Level Storm Sewers

Recent initiatives by DEP have led to the implementation of High Level Storm Sewer (HLSS) installation in targeted areas where they would be beneficial. In developed combined sewer areas where the replacement of existing old combined sewer systems with separate storm and sanitary sewers is not feasible, the city introduced High Level Storm Sewers.

Normally utilized for areas near water bodies, HLSS systems are designed to capture stormwater runoff from the street and side walk area which is 50% of the total storm runoff and resulting in significant reductions in street flooding, sewer backups into houses, and CSOs frequency. When feasible, DEP also requires the installation of completely separated sanitary and stormwater sewer systems in new developments, as it has done or is doing at Battery Park City, Queens West, Hunters Point, Bronx Terminal Market, Hudson Yards (partial installation) and Columbia University's Manhattanville expansion (partial installation). At these areas, stormwater is diverted directly to adjacent waterways and never reaches the combined sewer system.

Flood Mitigation Task Force

In response to severe flooding and storms in the summer of 2007, Mayor Bloomberg launched an interagency Flood Mitigation Task Force to coordinate and enhance the City's response to such events from multiple agencies. The Task Force's efforts supplement the maintenance activities that DEP undertakes on a regular basis, including inspections and cleaning of catch basins on a programmatic cycle and in response to 311 calls. The Task Force identified mitigation strategies for application in the right of way, including the development of a new emergency plan to guide city agency coordination and operations during severe wet weather. The Task Force also implemented several short-term mitigation measures including targeted system inspections by DEP engineers to identify maintenance needs and investigations by DOT to heighten curbs during street resurfacing projects in flood-prone areas in order to re-direct the flow to new catch basins. DEP also modified the standard catch basin design to enhance its ability to capture debris with fewer instances of clogged grates.

INITIATIVE 3

Establish new design guidelines for public projects

To continue to promote leading-edge design practices, the City will release four new documents that will have direct impacts on stormwater management. These publications include DOT's *Street Design Manual*, the Park Department's *Park Design for the 21st Century*, and DDC's *Sustainable Urban Site Design Manual* and *Water Conservation Manual*.

Street Design Manual

DOT is establishing new standard street materials and guidelines for street geometric design. The *Street Design Manual* emphasizes context-sensitive designs that can improve traffic safety; encourage sustainable traffic modes such as walking, transit, and biking: improve the visual quality of streetscapes; and streamline the project design and approval processes. The revised manual will reduce stormwater runoff from the right of way through two principal mechanisms. First, the materials palette will include options for the use of permeable surfaces such as cobblestones and paving blocks, which will facilitate the infiltration of stormwater. Second, the geometry handbook will encourage use of stormwater source controls including expanded sidewalk "bulbout" swales, landscaped medians, and other vegetated geometric treatments. Stormwater controls are also incorporated into DOT's agency strategic plan, which was unveiled in the spring of 2008. DOT's strategic plan, *Sustainable Streets*, brings a green approach to transportation that will simultaneously ease travel conditions in our growing city while squarely facing the problem of climate change.

Park Design for the 21st Century

The Parks Department is developing a new design manual, *High Performance Landscape Guidelines - Park Design for the 21st Century*, with the Design Trust for Public Space. *High Performance Landscape Guidelines* is the third installment in a series of design manuals for public projects, including city-owned buildings (DDC's *High Performance Building Guidelines*) and the public right of way (DDC's *High Performance Infrastructure Guidelines*). Parks' design manual will provide an in-depth approach to systems-based park design, including best management practices, site typology systems and extensive case studies. The *High Performance Landscape Guidelines* will specify a number of sustainable practices for parklands that improve stormwater management, with the goal of minimizing or recycling stormwater runoff and incorporating green infrastructure source controls. The *High Performance Landscape Guidelines* is scheduled for release in July 2009. Once these design tools are in place, the Parks Department will work to translate the guidelines to agency standards and specifications.

Sustainable Sites Manual

DDC will publish the *Sustainable Urban Site Design Manual* in early 2009. The manual will address landscaped areas associated with building projects, and it is a companion project to other DDC manuals on green buildings and high performance infrastructure. It highlights practical recommendations for site land uses, maximizing vegetation, minimizing site disturbances, managing stormwater, and landscape planting. The manual is conceived as a resource handbook, featuring chapters that marry the unique site conditions encountered on many City projects with appropriate sustainable design strategies. Though created to address City projects, this manual will also serve as a resource for architects, construction managers, contractors, and facility personnel.

Water Conservation Manual

Another effort in the DDC's sustainable design and building operation handbook series will be the *Water Conservation Manual*, which is scheduled for completion in March 2009. The manual will describe and evaluate best practices for potable water use reduction and a hierarchy for implementing the methods weighted on costs, code compliance and environmental reward. It is intended for DDC staff and consultants, but may also serve as a reference for anyone interested in water conservation in building construction and operation. Topics covered include domestic plumbing efficiencies, reduced water landscape irrigation, precipitation capture for re-use, graywater, heat recovery, cooling tower make-up water, and efficient appliance and fixture selection. Innovative system monitoring will be fully illustrated and integrated by a comprehensive reference matrix crossing building types with techniques.

INITIATIVE 4

Change sewer regulations and codes to adopt performance standards for new development

Over the next year the City will develop and finalize a performance standard for new construction that will be adopted as part of its sewer regulations or code or both. Some of the considerations include finalizing specifications for an approved gravel bed to be used for detention or retention and developing standards for crediting the use of source control technologies such as green roofs, consistent with the NYSDEC Stormwater Management Design Manual. These specifications and credits will be contained in a BMP manual for use in the city that will be prepared by DEP after the completion of certain pilot projects. Until that time, specifications and credits will have to be determined in case by case, detailed reviews. The City is currently reviewing the feasibility of a proposed standard with engineering and architecture firms and other outside experts in the Green Code Task Force of the New York Chapter of the U.S. Green Building Council. That process is expected to be complete by April 2009. Following this initial vetting of the performance standard, the City will develop regulatory and code language that will undergo a public notice and comment period.

INITIATIVE 5

Improve public notification of combined sewer overflows

Our analysis shows that it is almost impossible to eliminate CSOs, despite the expenditure of billions in conventional infrastructure solutions and, possibly, on source control measures as well. This upper boundary on our source control efforts has led us to re-examine our system of notifying the public of inevitable CSOs.

In developing this Plan, the City assessed its protocols for notifying the public of the location and occurrence of combined sewer overflow events. Specifically, we examined whether it was feasible to alert potential users of the waterbodies affected by CSOs through the use of radio, print media, internet, 311, e-mail alerts or similar modes of communication, of the estimated nature and duration of conditions that are potentially harmful to users of such waterbodies. We also assessed the need to notify non-English speakers and people without access to computers or the internet.

CASE STUDY

Beach Closure Notification

At present, the DOHMH operates a beach water quality monitoring and analysis program that notifies the public of the latest water quality information and classifies beaches as "Open," "Wet Weather Advisory", "Advisory" and "Closed – Temporarily Restricted for Bathing."

The Wet Weather Advisory is a preemptive standard based upon a threshold level of precipitation that, when exceeded, can lead to elevated levels of bacteria due to CSOs and stormwater runoff, and may pose a public health risk. The City does not recommend swimming and bathing in any area identified as under a Wet Weather Advisory, especially for people with underlying medical conditions and for young and elderly people who may be more susceptible to illness if beach water is swallowed. The triggers for Wet Weather Advisories are listed in the adjacent chart.

When DOHMH issues an advisory or closure, notification signs are posted by the beach facility until the status changes. Advisories due to wet weather conditions or increased pollution levels are also available on DOHMH's web site and by calling the City's 311 service system. DOHMH also publishes an annual report on water quality near beaches.

BEACH	RAINFALL LIMIT	DURATION
South Beach, Staten Island	1.5 inches in 6 hours	12 hours
Midland Beach, Staten Island	1.5 inches in 6 hours	12 hours
Manhattan Beach, Brooklyn	1.5 inches in 6 hours	12 hours
Kingsborough Community College, Brooklyn	1.5 inches in 6 hours	12 hours
All Private Beaches, Bronx	0.2 inches in 2 hours	48 hours
Douglaston, Queens	0.2 inches in 2 hours	48 hours
Gerritsen Beach, Brooklyn	0.2 inches in 2 hours	72 hours

Table 10: Summary of Ongoing or Planned Pilot Studies and Demonstration Projects

PILOT	AGENCY	EXPECTED COMPLETION	DESCRIPTION
Green Roof/Blue Roof Pilot Study	DEP	2011	Construct different roof treatments on adjoining buildings, comparing results
Blue Roofs on Existing Buildings	DEP	2012	Construct 20,000 square feet of blue roofs on existing buildings
Rain Barrel Give-Away Pilot Study	DEP	2012	Distribue 1,000 rain barrels to homeowners in Queens
Parking Lot Pilot Study	DEP	2011	Retrofit two 1.5 acre parking lots in the Jamaica Bay watershed to meet new DCP zoning requirements
NYCHA or HPD Property Retrofits	DEP	2012	Retrofit publicly-owned property with infiltration and detention source controls
Porous Pavement Pilot Study	DEP	2012	Install and monitor porous pavement on publicly-owned parking lots
Green Roofs on Five Borough Building	DPR	2010	Install 4,800 square feet of green roofs consisting of five different systems
Domestic Sewage Treatment Pilot Study	DEP	2012	Analyze the benefits and opportunities of the decentralization of sanitary wastewater treatment
Flushing Bay and Gowanus BMP Grant Program	DEP	2013	Grant program for local stakeholder groups to submit proposals for effective stormwater management projects and pilots
DEP Tree Pit Pilot Study	DEP	2011	Install and monitor five street trees that have pits enhanced with subsurface detention
DPR Tree Pit Pilot Study	DPR	2010	DPR is working with Gaia Institute and Youth Ministries for Peace and Justice to cut curbs around existing tree pits
Enhanced Greenstreets Pilot Study	DPR	2010	Evaluate 5 new Greenstreets designed to accept greater amounts of stormwater
Bronx Block Saturation Pilot Study	DEP	2013	Monitor expanded tree pits on a two-block section of 172nd Street during 6-8 storm events
Astor Place/Cooper Square Renovation	DDC/DOT	2012	Increase green space, porous pavements, infiltration swales, and continuous tree trenches
Albert Road Reconstruction	DDC/DOT	2012	Install vegetated controls and other source controls where feasible to manage runoff
East Houston Street Reconstruction	DDC/DOT	2012	Widen center median, infiltrate sidewalk runoff in planted areas, and install continuous tree trenches
Atlantic Avenue Reconstruction	DDC/DOT	2011	Plant native trees in structural soil and direct the center median's runoff towards the planted area
Constructed Wetlands Pilot Study	DEP	2011	Construct wetlands to capture runoff from a roadway
Belt Parkway Bridges Roadside Swales	DEP/DOT	2014	Construct vegetated swales adjacent to bridges and roadway to mitigate direct discharges of stormwater
Streetside Infiltration Swales Pilot Study	DEP/DOT	2011	Install vegetated swales to capture stormwater runoff from smaller roads
Ballfield Source Controls Piot Study	DPR	2012	Install source controls within parks and baseball fields within the Bronx River watershed
Bronx River Pilot Study	DPR	2010	Install downspout disconnections, trench drains, rain gardens, swales, and other innovative source capture methods

First, DEP has committed to install more informative signs near every one of its 433 combined sewer outfalls at a cost of $1 million. The existing signs have detailed information regarding the discharge point and the applicable discharge permit, and request that the public notify the City of any dry weather discharges by calling 311. The new proposed signs include a graphic image that conveys the risk of wet weather discharges and that swimming should not occur in those circumstances. The symbols are designed to convey the substance of the message to non-English speakers and people without access to computers or the internet. The new signs will be installed in 2010 after they are approved by DEC.

In addition, DEP will develop a web notification system located on its homepage (http://www.nyc.gov/dep). Predictions of significant rain events will trigger website alerts containing information about predicted precipitation amounts and modeled CSO impacts. A hypothetical notice may state, for example, that:

According to the National Weather Service 2.5 inches of rain will fall in the New York City area between midnight Tuesday and 6:00 a.m. Wednesday. This amount of rain may result in combined sewer overflows and impact local waterways. Click here for more information.

DEP's website will also feature a chart of waterbodies that identifies the rain amounts that cause elevated pathogen concentrations as a result of CSOs. After rain events, website notifications will incorporate more specific information as needed.

Second, the City will incorporate this information into Notify NYC, a new service designed to enhance the delivery of information to the public, and to help members of the public make decisions relating to fast-breaking developments. Citizens voluntarily sign up on the Notify NYC website (www.nyc.gov/notifynyc) to receive information through different media, including email, text messaging, and telephone. Currently in a pilot phase, the service provides information on emergency events in four communities. There are two levels of information, "notifications" of basic information about emergencies that affect one of the four pilot areas and status updates, and "alerts" of major emergencies that will interrupt routine behavior and instructions on how to respond. Messages sent to all pilot communities are to be distributed to 311 and 911 and posted to this page.

In early 2009, the service will be launched on a citywide basis, and in mid-2009 it is scheduled to expand its coverage to certain non-emergency events. It is the City's intention to include CSO alerts as one of the non-emergency events in the program. The content of these alerts will be generated by DEP and other interested agencies.

We expect these services to reach critical audiences. People near outfalls will see the new signs. Recreational users can check the DEP website and sign up for Notify NYC. And marinas and other commercial interests in water-related activities are likely to obtain information and will be in a position to inform the public.

Resolve the Feasibility of Promising Technologies

INITIATIVE 6

Complete ongoing demonstration projects and other analysis

Not all potential source controls can be adopted and promoted immediately in New York City. The availability of stormwater source controls for implementation is highly variable, with some controls in transition between research, demonstration, and proven and available off-the-shelf technology.

To answer unresolved questions about feasibility, costs and performance of various source control techniques, the City is undertaking approximately 20 pilot projects. A complete description of the pilot projects is included in Appendix E. Table 10 summarizes these pilots.

Table 11: Criteria for Assessing Demonstration Projects

PILOT	COSTS	OPERATIONS & MAINTENANCE	FEASIBILITY	STORMWATER PERFORMANCE	CRITERIA TO ASSESS WHETHER DEMONSTRATION PHASE IS OVER AND TECHNOLOGY CAN BE INCORPORATED INTO COMPREHENSIVE COST-BENEFIT ANALYSIS
	PARAMETERS TESTED				
Green Roof/Blue Roof Pilot Study	X	X	X	X	Cost-effective storage or removal of runoff from new rooftops in side-by-side comparison
Blue Roofs on Existing Buildings			X	X	Feasibility of retrofitting an existing rooftop to detain water given variable slope
Rain Barrel Give-Away Pilot Study		X	X	X	Reliability of homeowner operation and maintenan
Parking Lot Pilot Study	X	X		X	Cost-effectiveness of swales absorbing parking lot runoff
NYCHA or HPD Property Retrofits	X			X	Feasibility of retrofitting landscaped areas in public housing to control stormwater
Porous Pavement Pilot Study	X	X	X	X	Maintenance of open pore space and performance and reliability over time
Green Roofs on Five Borough Building	X	X		X	Performance and cost-effectiveness of different green roof designs
Domestic Sewage Treatment Pilot Study	X	X	X		Effectiveness of technology and feasibility of a distributed sewage treatment plant in a large building
Flushing Bay and Gowanus BMP Grant Program	X	X		X	Effectiveness of each project in its local setting after construction or installation
DEP Tree Pit Pilot Study	X	X	X	X	Costs, stormwater performance, and survival of vegetation with storage space for water under roots
DPR Tree Pit Pilot Study			X	X	Survival of trees when curbs around tree pits are opened to accept stormwater from the street
Enhanced Greenstreets Pilot Study		X		X	Plant survival and cost-savings from avoided watering when opened to stormwater
Bronx Block Saturation Pilot Study			X	X	Effectiveness of concentrated, low-technology developments on the level of a block
Astor Place/Cooper Square Renovation			X	X	Feasibility of source controls, especially small infiltration swales
Albert Road Reconstruction			X	X	Feasibility of source controls, especially area-wide vegetated areas
East Houston Street Reconstruction			X	X	Feasibility of source controls, especially permeable pavers and biofiltration areas
Atlantic Avenue Reconstruction			X	X	Feasibility of source controls, especially structural soil and porous pavement around median trees
Constructed Wetlands Pilot Study	X			X	Cost-effectiveness of constructed wetlands
Belt Parkway Bridges Roadside Swales	X	X		X	Cost-effectiveness of different swale designs near major highway and bridges
Streetside Infiltration Swales Pilot Study		X	X	X	Performance of retrofitted streetside swales
Ballfield Source Controls Piot Study			X	X	Effectiveness of source controls under and around artificial turf fields
Bronx River Pilot Study	X	X		X	Feasibility of a package of source controls and reliability of community maintenance

A pragmatic approach to public policy requires the testing of source controls on a small scale before turning to the question of whether and how they can be implemented broadly. Accordingly, each pilot is designed to address a unique series of technology-specific questions that currently prevent widespread implementation (Table 11). Nearly all of the 20 pilots are designed to test whether a particular technology can be built, whether it will be properly maintained, and whether it will capture stormwater. The pilots are also designed to quantify the benefits of stormwater capture and the costs of construction, operation, and maintenance. While none of the City pilots are designed to quantify non-stormwater benefits of source controls such as cooling and energy savings, academic institutions in the City are studying and modeling those effects. For example, Columbia University is studying the effect of green roofs on roof temperatures.

The pilots will be designed to provide basic data. The Jamaica Bay pilots, for example, will be designed to capture a given design storm (e.g., 90th percentile) after a survey of the areas surrounding each project location to characterize the precise scale, land uses, and quantity of water generated by each sub-watershed. These design elements will be tested throughout the course of each project.

Pilots must be monitored carefully. Monitoring is designed to assess many factors: the stormwater quantity reduction and quality improvements that each provides; the survival of vegetation given fluctuating water levels and intense urban pressures; the ability to remain functionally effective for long periods with infrequent but intense storms, community acceptance; low maintenance requirements; and low cost per unit of stormwater control. These are not the same across pilot programs. The Jamaica Bay pilots, for example, will be monitored to refine the specific capture rates and pollutant removal rates for nitrogen and other nutrients and pollutants. That data will be collected and analyzed in monthly, quarterly and annual reports, as well as a final report at the end of the three year monitoring. Specifically, the following parameters will be monitored:

- Meteorological conditions from nearby certified weather locations and actual precipitation data and stormwater flow data;
- Estimated evapotranspiration rates of various plant species utilizing meteorological conditions data from a nearby certified weather station;
- Weather conditions (precipitation, cloud cover, wind, temperature, etc.);
- Incidental wildlife observations;
- Summary of sub-watershed characteristics and estimated flow volume rates;
- Estimated and actual soil infiltration rates;
- Percent volume capture with respect to drainage area total; and
- Estimate of pollutant and sediment load reductions.

The City is seeking to integrate the monitoring controls for all City projects as much as possible. For example, the Greenstreets pilot is designed to assess the effect of infiltration of street stormwater on operating and maintenance costs that depend on watering and plant survival. The Parks Department is creating a modeling tool that will be calibrated through continuous monitoring of stormwater capture and infiltration. That pilot is also testing the residual toxics left in the soil by runoff and plant survival. The goal is to develop a model can be used on a system-wide basis.

The variety of source controls being piloted, site conditions, and parameters studied mean that there is no "bright-line" measure of success. The City's approach is more akin to true research than to product development; the pilots are designed to develop information about

CASE STUDY
Green Roofs on the Five Borough Building

Green roofs can be effective in reversing urban environmental problems such as stormwater runoff and the urban heat island effect. With the announcement of PlaNYC, the New York City Department of Parks and Recreation understood the opportunities for building sustainable best management practices into the city's infrastructure and took initiative to understand the variables in green roof design. Employees of the Five Borough Technical Services Division on Randall's Island researched current green roof designs and began an experiment on the roof of the division's headquarters in Spring 2007. Their strategy was to build a system of green roofs, featuring various growing mediums, plant types, planting depths, and installation designs, as a type of experimental station to determine the best practices in green roof technology.

Green Roof on the Five Borough Building

Green Roof on the Five Borough Building

Several innovative green roof designs are featured on the Five Borough roof. Two of the green roofs are planted in removable aluminum trays, offering the benefit of easy access to the roof if necessary. These two modular systems feature two and four inches of growth medium, respectively, with sedum and succulent plants that require very little water during the hottest summer months. Another system uses a newly-patented growing medium called GaiaSoil that is designed specifically to be lightweight for green roof use. In that system, native plants provide rich texture and color to the rooftop garden. In another modular system, biodegradable trays are installed individually, but over time the internal walls will decay, creating a continuous growing space. Another new innovation, Green Paks, offers convenient installation of woven polyethylene bags prefilled with heat-treated shale and planted with sedum. With each system, the Parks Department is monitoring the green roof for water absorption, urban heat island offset, and energy conservation. Installation and maintenance of each system is also compared, and factors such as ease of planting, weight of materials, and labor time and cost are recorded. Today, the roof features over 7,000 square feet of vegetation and is truly a working laboratory for green roof design practices, providing knowledge and experience to the rest of the Department and other agencies, as well as contributing to the effort of conservation and stewardship in New York City.

performance in a neutral way rather than to answer a pre-conceived notion that source controls must be installed throughout the city. The strategic object of the project is to test those source controls that have the most promise of reducing stormwater flow into the combined sewer system, increasing soil infiltration and pollutant removal, providing urban ecological restoration opportunities, and increasing overall green spaces within watersheds. As part of the pilot studies, stormwater capture volume and pollutant removal rates of each of the technologies will be documented. The results of the pilot studies and monitoring data will resolve the need for consistent and specific stormwater quality information and efficiency related to New York City. Once this information has been gathered, it can be used to develop an effective source control stormwater strategy.

Once these technologies are proven to be effective on a pilot scale, a much wider application of the technologies can be evaluated. Each source control technology cannot be assessed or implemented in isolation. If we are to develop a reliable network of decentralized controls, then each technology must be assessed in relation to alternative approaches and as part of a citywide system. The completion of each pilot will mark a new phase in our comprehensive stormwater planning in which the costs and benefits of each source control determines its relative position in our municipal program. It may be that green roofs are not cost-effective stormwater controls compared to blue roofs in CSO areas or infiltration technologies in non-CSO areas, as our review of existing literature suggests. Or it may be that green roofs are a viable option in non-CSO areas where infiltration technologies are ineffective because of a high water table or bedrock near the surface.

That is not to say that all pilots must be completed before we can start implementation. The City intends to follow adaptive management principles whereby we refine our approach as information becomes available on a rolling basis. The milestones at the end of this Plan reflect that approach. The next major planning milestone is the revision of this Plan. That public process should begin in the spring of 2010, at a time when the pilots will have generated preliminary or final results. Before then, we will establish interim milestones to ensure that any preliminary information on performance gathered from the pilots is put into practice as soon as possible.

At that time, we will have information from several other ongoing studies that also affect our confidence about the feasible operation of source controls on a citywide basis. These three studies will help us predict the success of infiltration and other source control technologies and whether a targeted approach is appropriate. They are:

First, the New York City Soil and Water Conservation District is updating its survey of soils across New York City to provide information on a 1-foot contour scale. This survey is scheduled to be completed by December 2009. The soil maps will provide general information to landowners and regulators about the soils that may be suitable for infiltration technologies. Applicants for sewer connections would still need to provide site-specific soil surveys to DEP.

Second, DEP is modeling CSO reductions from source controls. The completed model will allow us to adopt appropriate policies. As discussed in Appendix D, current projections are based upon spreadsheet analyses. The model will seek to determine street-level hydraulic conditions, CSO reductions and other water quality benefits that could be achieved through source control implementation. The model will consider the performance of individual source controls as well as the effects of rezoning and growth projections, alternative drainage modification, and other climate adaptation strategies. The modeling will incorporate DEP's most recent impervious surface data developed from remote sensing and other sources, and will be calibrated accordingly.

Third, DEP is creating maps of permeable and impermeable surfaces throughout the city from satellite images. These maps will be based on aerial flyovers in April 2009, the optimal "leaf-

Street in New York City without street trees

Street in New York City with mature street trees

off" period to take infrared images of vegetated areas, and are scheduled to be completed by December 2009. These maps will provide precise locations where source controls are needed most and where bioinfiltration techniques will best succeed.

INITIATIVE 7

Continue planning for the implementation of promising source control strategies

The City will continue planning for the promising strategies analyzed in the previous chapter: sidewalk standards, road reconstruction standards, performance standards for existing buildings, low- and medium-density controls, and additional vegetated controls in the right of way. These strategies have significant potential, but also face obstacles that prevent immediate implementation, such as the absence of consensus designs, funding mechanisms, and maintenance agreements. Over the next year, the City will seek to resolve those concerns. We will convene interagency working groups, confer with outside experts, reach out to private landowners, seek knowledge from leading organizations, promote implementation of stormwater reduction practices that are consistent with the State Stormwater Management Design Manual, consider additional design standards, and continue to analyze best practices from other municipalities. As much as possible, we will involve interested stakeholders and other members of the public.

City agency coordination

Since May 2007, the City's Interagency BMP Task Force has met to analyze strategies to incorporate source controls into public policies. The City intends to build on the foundation established by this group by continuing to convene stakeholders from City agencies to plan for promising sustainable stormwater management policies and resolve challenges that cut across agencies. The City is also committed to ensuring that staff members within agencies are better informed of source control practices and new policies through an emphasis on intra-agency coordination and outreach.

Planning for right of way strategies

The Mayor's Office of Long-Term Planning and Sustainability will continue to convene working groups of City agency staff to investigate the potential to adopt sidewalk standards and roadway reconstructions. These groups will further analyze prototype designs of source controls, potential materials, and issues related to scoping, design, construction, and maintenance. Specifically, the working groups will be asked to consider the appropriate application of porous pavements; the proper application of certain street geometry configurations; the impacts of stormwater on urban vegetation; maintenance requirements for source controls in the right of way; and the financial implications of enacting specific source control design standards as required construction specifications. These efforts will consider the results of the demonstration projects, learn from other innovative projects completed within the city, and analyze projects and studies from outside of New York City. These working group meetings will include staff from multiple city agencies, including DOT, the Parks Department, DEP, DDC, DOB, and DCP.

Planning for source controls on buildings and lots

The City will also continue to plan for promising scenarios that could be incorporated into existing buildings. The OLTPS will work closely with DEP, DOB, and outside experts to continue to study the feasibility of utilizing the rooftops of existing buildings for rooftop detention systems. Many questions remain about the potential to use the rooftops of existing buildings for detention due to issues of requiring additional structural and plumbing analysis, setting appropriate permitting requirements, and addressing issues related to the slope of older roofs. The City will consider opportunities to further provide incentives for green roofs for existing buildings as funding becomes available, as pilots resolve outstanding questions, and as we learn lessons from the City's green roof tax incentive.

The City will consider additional programs and financial incentives to promote the use of rain barrels, cisterns, and rainwater harvesting systems, as funding options become available. Future policies to explore include: providing incentives for source controls by providing discounted water rates, subsidizing the purchase of these systems through City partnerships with vendors, and outreach and education initiatives to inform citizens about the benefits of residential controls.

The City will convene an interagency working group to explore issues related to installing green roofs on public buildings. The City will determine the efficacy of installing green roofs by examining the results of demonstration projects such as the green roof on the Parks Department's Five Boroughs Building. The City will also consult the lessons learned by green roof projects by groups such as the Queens Botanical Gardens, Columbia University, Consolidated Edison, and the Gaia Institute. Specific analysis will explore costs, benefits, maintenance requirements, and design elements such as plant species, soil depth, and soil types. The OLTPS will convene the working group that will include agencies such as the Parks Department, DEP, DDC, DOB, DCAS, HPD, NYCHA, EDC, and SCA.

Protocols for public projects

The City will develop a stormwater management program that is consistent with State and federal standards, and will also continue to

PS 138 playground, before

PS 138 playground, today

analyze potential policies that encourage the inclusion of source controls during the scoping, design, and preliminary and final budget approval process, beyond applicable State or federal standards.

The City recognizes the need for the incorporation of stormwater management at the design stage, according to well-thought out standards. These standards should reflect our understanding of construction, operation and maintenance costs, as well as the effects, if any, on property damage, business loss, damage to infrastructure, and economic vitality. Such standards should also reflect our understanding of the applicability, cost-effectiveness, efficiency, and durability of different source controls, and we will be more certain after the results of demonstration projects and additional research.

Due to the difficult economic conditions and the unknowns regarding source control performance, the City believes that it is premature to impose a blanket standard now on capital projects of a certain size. Where such standards exist, such as for federal facilities of a certain size beyond any State permitting requirements, they have taken the form of narrative exhortations to "reduce stormwater to the maximum extent feasible" or some similar command that is very general because it must cover a broad range of uses.

We believe that it is more useful to adopt quantitative performance standards. The proposed performance standard for new development would apply to city-owned and city-financed projects as the new regulations will be enacted as part of a citywide sewer code. Any new policy establishing a performance standard for the renovation or major alteration of existing buildings would also apply to city-owned properties.

The Parks Department is also considering additional design directives for its capital projects. Many sustainable stormwater management design strategies can be implemented into the design of Parks projects with no additional cost or maintenance, while other design strategies will require additional capital expenses or maintenance costs. The forthcoming *High Performance Landscape Guidelines* will identify cost-effective design strategies for including source controls in Parks projects. Once this set of guidelines is released, the Parks Department will consider formalizing specific strategies into design standards, scoping procedures, and construction specifications.

DOT will also consider design directives for future capital projects in the right of way. The DOT Strategic Plan, Sustainable Streets, already calls for incorporating source controls into street designs, and the new Street Design Manual will further establish prototypes and geometries that are recommended for future exploration. Any design protocols mandating source controls would require additional funding for capital construction costs as well as for long-term maintenance. In the next year, DOT will further analyze the costs and benefits of enacting additional standards.

New Demonstration Projects

In addition to planning for promising technologies in the right of way and for buildings and lots, the City will identify the need for new demonstration projects and will seek to launch those pilots as funding becomes available.

DEP is currently piloting porous pavement on a parking lot, but there are still additional needs to test the application of porous materials in sidewalks, parking lanes, and other right of way conditions. The City's understanding of source control effectiveness would also benefit from additional prototypes of vegetated controls and sidewalk biofiltration beds that capture stormwater from the right of way. Finally, demonstration projects could also test innovative systems that would retain water from the rooftops of existing buildings. The City will continue to explore opportunities to add demonstration projects as an incremental expense to ongoing or upcoming capital projects. We will also examine opportunities to seek outside partnership and private funding to assist in these efforts.

Green Codes Task Force

The City is also reviewing all relevant aspects of its building and sewer codes in partnership with the New York Chapter of the U.S. Green Building Council, which has launched a Green Codes Task Force at the behest of Mayor Bloomberg and Speaker Quinn. The Green Codes Task Force seeks to tap into the city's deep bench of talent by enlisting the help of technical experts from the engineering, architecture, landscape architecture, and construction fields, as well as members of the real estate industry and other stakeholders, to develop code reform proposals. Their objective is to remove impediments or add improvements that will encourage leading-edge conservation and environmental practices.

There are two committees of the Green Codes Task Force that are relevant to this Plan. A committee on water efficiency and buildings has reviewed a wide range of opportunities to suggest methods to conserve potable water and capture stormwater within the City. The committee is exploring ideas to increase water efficiency, reduce energy consumption, provide greater potable water security through reduced demand and appropriate water use, and reduce CSOs by capturing and re-using stormwater in building systems.

The Green Codes Task Force also has a committee focusing on stormwater management on developed sites. This group of outside experts has played an active role in reviewing ideas for establishing stormwater capture performance standards for new development and existing buildings. The goal of this committee is to examine issues related to site design that could potentially capture stormwater, increase permeability, and improve the ecological health of the city.

The Task Force's report will include proposed code language for each of the finalized proposals. Enactment of proposed changes will involve public review and comment. The USGBC aims to present their package of proposals to the Mayor and the Speaker by Spring 2009. Our milestone is for code changes to be enacted by the end of 2009.

INITIATIVE 8

Plan for the maintenance of source controls

Purpose and need

Source controls require maintenance to remain effective. Unless source control installations are properly maintained, the performance of the system will decline over time, undercutting the rationale for avoiding investments in large infrastructure and creating a backlog of work that will increase costs. For centralized stormwater infrastructure this requirement is simpler because a single agency plans, designs, permits, constructs, manages, and maintains the installations. In a decentralized system, these roles will be spread amongst various City agencies and private actors. Most if not all source controls will be located on property that is owned or controlled by entities whose primary mission is something other than stormwater control, and it is not realistic to expect that they will place a high priority on maintaining stormwater infrastructure.

Reliability can be assured in many ways. For residential structures, the need to avoid leaks from roof controls or other adverse impacts may be sufficient. This is especially true if homeowners are educated about the importance of maintenance and given tasks that are relatively straightforward, such as keeping drains free of debris, disconnecting rain barrels and cisterns during the winter, and using or emptying their contents after rainfall. In the public realm, however, we cannot rely on enlightened self-interest.

Schmul Park Permeable Basketball Court
Credit: NYC Department of Parks and Recreation and Field Operations

Schmul Park Permeable Playground
Credit: NYC Department of Parks and Recreation and Field Operations

CASE STUDY

Schmul Park

Schmul Park is being redeveloped as part of the larger development plan for the Fresh Kills Landfill area. Renovation of Schmul Park will provide a direct link between the surrounding neighborhoods on the western portion of Staten Island and the future Fresh Kills parkland. This small, four-acre park, of which 70 percent is currently impervious surface, will incorporate low-impact development strategies to improve permeability on the site.

The proposed park redevelopment consists of demolition of the existing park facility, regrading, and construction of a new playground, restroom facility, basketball, and handball courts. The 1,000-square foot roof of the new comfort station will collect rainwater and channel it through a waterfall feature into ground-level rain garden sized to collect runoff. The entire area will be regraded to allow rainwater to shed to plant beds surrounding the park with hearty native plants. The playground will feature a porous safety surface which allows water to infiltrate and absorb into the soil. The site will also add two hand-ball courts and a basketball court paved with a rubber aggregate porous pavement called FlexiPave. Walkways will also include use of porous concrete or permeable pavers, and permeable, stabilized stone walkways along some paths through the park. The plan decreases the amount of impervious area by approximately 60 percent and showcases the Parks Department's commitment to effective stormwater management practices.

Printer's Park
Credit: NYC Department of Parks and Recreation

CASE STUDY
Printer's Park

Printer's Park receives its name from the site's early history as the location of the estate of Richard March Hoe, inventor of the rotary printing press. His mansion in the Bronx was torn down at the turn of the 20th Century and developed into 5-story brick apartment buildings. After falling into disrepair by the late 1970's, the buildings were condemned by the city and turned over to the Parks Department in 1979. The property was designated Hoe Park and consisted of asphalt tennis courts. By the mid 1980's the asphalt surface began to subside leaving gaping cracks and potholes and causing unsafe conditions. It has been closed to the public ever since.

Currently, the Parks Department is implementing a new design for this long-abandoned and degraded property. A new playground and 'greeting garden' for use by community groups, senior citizens, and families with children will open in Summer 2009 and will feature sustainable water management strategies and innovative green design practices. In conventional playgrounds, the spray shower runoff is directly drained to the sewer system. At Printer's Park playground, however, the runoff water from the spray shower becomes a resource. After potable water is used to provide cool, refreshing activity for children in the playground, spray shower runoff is directed by underground pipes to surrounding planting beds, irrigating a lush and water-efficient landscape.

Strategies to address stormwater are also incorporated into the playground design. In addition to the lush native plantings that surround the play area and absorb stormwater, permeable protective play surfaces and permeable pavement are used throughout the playground for water infiltration. Excess stormwater flows through a granite cobble swale to a continuous tree pit of Ginkgo trees. All other runoff is directed into planting beds. Overflow catch basins send rainwater from extremely large storm events into the sewers. For average rainfall, however, this park is an excellent example of reducing the burden on the city's sewers by creating a safe, fun, sustainable, and rejuvenating public space from what was once an abandoned blighted area.

Maintenance costs must be considered when launching any new initiative. PlaNYC's Million-Tree and Greenstreets initiatives, for example, are supported with funding for an additional 156 staff and $4.6 million in new forestry and horticulture maintenance funds. Our limited experience with source controls – especially the types that will be used outside of the Bluebelt – means that we do not have accurate numbers for budgeting and planning purposes. That is why one purpose of the pilot programs discussed in Initiative 6 is to develop more accurate maintenance costs.

Public maintenance

While we develop that basic information, we will have to create appropriate maintenance mechanisms for source controls. We cannot simply extend the default rule that the sponsors of capital projects are responsible for maintenance. The right of way provides an instructive example. DOT controls the right of way and would be responsible for designing and constructing source controls located there. Those tasks can be incorporated into existing agency processes, as contemplated by Initiative 7 of this Plan. Post-construction involvement is another matter. DOT is set up to maintain hard surfaces. Vegetated controls or infiltration areas require knowledge and training about plants and soils; pruning and removal of litter during the planting season; and replanting and replenishing soil on a regular basis. DOT has neither the expertise nor the manpower to do those tasks. That is why all Greenstreets are maintained by the Parks Department, which hires many seasonal employees and has established working agreements with community groups that assume maintenance responsibility.

The relative strengths and weaknesses of different agencies form the basis of the current division of responsibility in the right of way, which is governed by a 1983 memorandum of understanding. Under that agreement, DOT maintains hard surfaces, the Parks Department maintains vegetated medians and similar areas, and the Sanitation Department removes litter, leaves, and snow from the roadway and grates at least weekly. Each agency has appropriate personnel and equipment to fulfill those duties. In addition, DEP has specialized vacuum trucks and is responsible for cleaning out sediment and debris from within catch basins on a regular schedule or when alerted to a problematic intersection. DEP also funds certain functions conducted by other agencies to achieve stormwater management objectives;

Vacuum machine used on porous concrete sidewalk

Credit: City of Olympia Public Works

Porous concrete sidewalk after vacuuming

Credit: City of Olympia Public Works

for example, a portion of the income from water rates is transferred to the Sanitation Department's budget to support street cleaning efforts. If source controls in the right of way are adopted at sufficient scale, however, that would strain the current structure to the breaking point. Starkly put, the current budgets of DOT, the Parks Department, or the Sanitation Department are not large enough to support significant work on source controls.

Indeed, there are many current reconstruction projects for which there are significant opportunities for source controls but that cannot go forward for lack of maintenance funding or agreements. The City's ongoing attempts to resolve these matters on an ad hoc basis are made difficult by the current budget situation and the necessary across-the-board cuts of agencies' budgets. In the current environment, it is challenging to arrange for agencies to take on responsibilities that are outside of their core programs.

To resolve this recurring problem the City will undertake an interagency planning process to provide for maintenance at scale. The maintenance challenge is similar to other natural areas programs such as the creation of parkland and wetlands that require ongoing stewardship, where agencies turn to community organizations to make up for budget and personnel shortfalls. An interagency group will evaluate potential maintenance models such as an alteration of the 1983 memorandum of agreement, a partnership with Business Improvement Districts and community groups that provide other maintenance services in the right of way, funding transfers between agencies, creation of a stand-alone agency with sole responsibility for maintaining public source controls, or a mix of all of these methods. This initiative is intertwined with the following two initiatives on funding (Initiatives 9 and 10).

Public/private partnerships as a possible model

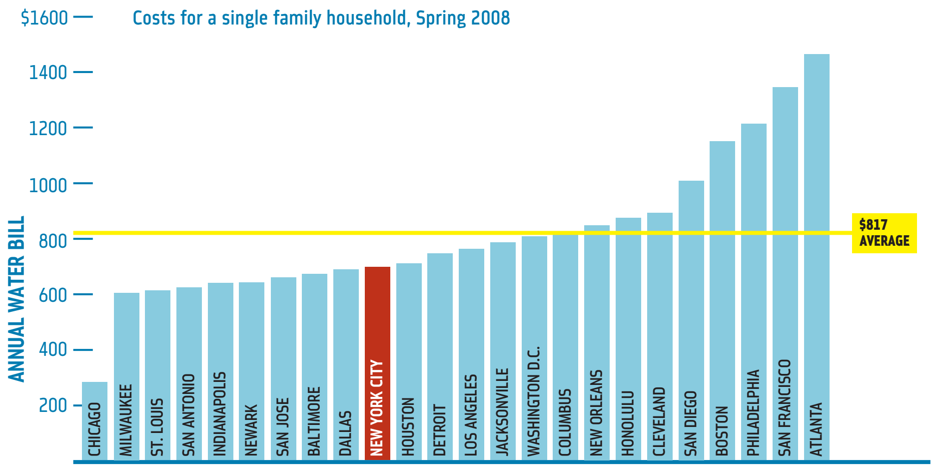
There are several existing models for maintenance that will inform that planning process. The most relevant is the decade-long strategy employed by DEP's Staten Island Bluebelt team to successfully maintain and manage New York City's only source control network. Related models include the Parks Department's use of community volunteers to maintain Greenstreets and the Department of Small Business Services (SBS)'s new Clean Streets initiative to develop the capacity of neighborhood-based economic development organizations in commercial districts.

Bluebelt maintenance starts with the planning, design, and construction stages. Through consultation with a four-person field management staff, these installations are made as "maintainer-friendly" as possible. In fact, the philosophy of the Bluebelt Office is that the field management staff is the client for all those who work on planning, design, and construction of Bluebelt facilities. Once Bluebelt facilities are constructed, laminated 8½ by 11 inch cards are created which present all the maintenance requirements of each facility. These cards can be easily used by the field staff and list all the maintenance tasks and important information about the features at the site, such as valves, weirs, and access ways. With those maintenance cards in hand, the DEP field management group periodically monitors the condition of all the Bluebelt properties and drainage facilities. Such monitoring is especially important before and after major storms. Once a problem is identified, the field staff calls on a contractor to repair certain problems that can not be resolved by in-house forces. The goal is to resolve small problems quickly before they become big problems.

Bluebelt private contractors are under the direct supervision of DEP field management staff. The field management staff has developed detailed scopes of work for specific maintenance activities: landscape maintenance, vacuum truck (vactor) services, and debris removal. The landscape maintenance contract includes grass cutting, snow removal, emergency tree removal, and rodent control tasks. Wetland and upland source control plantings are also maintained through the landscape maintenance contract. The vactor services contract involves the use of a vactor vacuum truck to remove sediment and other water soluble material from outlet stilling basins, sand filters, and the forebays and micropools of extended detention storm water wetlands. The vactor services contract is also used to clean in-stream culverts, riser boxes, and tributary catch basins. The debris removal contract provides for the removal of illegally dumped refuse, including abandoned automobiles, large appliances, and building debris. The tasks in this contract are used to remove heavy debris from the perimeters and interiors of DEP drainage properties.

The contracting strategy that DEP has developed for its maintenance program has been highly successful over the years. Coupled with community outreach programs to local school groups, high school, and college volunteers and the very successful Adopt-A-Bluebelt program, DEP's Staten Island Bluebelt program has developed a unique storm water management system that is not only effective in restoring some of Staten Island's environmental integrity, but is also efficient and extremely well run. DEP also relies on probation labor, which has saved the City approximately $700,000.

Figure 19: Average Annual Water Rate



Source: NYC Water Board

The Greenstreets program follows a similar model to maintain over 2,300 planted areas in the right of way. The Parks Department currently waters, weeds, and cleans these sites regularly by hiring seasonal employees. To supplement those basic efforts, since 2000 the Parks Department has formed partnerships with private entities to provide additional care and to relieve some of the financial burden on the agency. It seeks private citizens, businesses, and corporations to join the City of New York and its communities through the Adopt-a-Greenstreet Program. Parks' follows a four-pronged recruitment effort:

- Grassroots efforts to recruit community groups, homeowners, individuals, and Friends of Parks to assume the care of a neighborhood Greenstreet, supported by workshops;
- Adoption by local businesses who hire an outside contractor or provide care directly;
- Corporate sponsorship to pay for the maintenance of many sites; and
- Foundations and government grants.

To date, over 76 Greenstreets have been adopted.

Another model is the Department of Small Business Services' (SBS) Clean Streets Program. That is a new initiative to develop the capacity of neighborhood-based economic development organizations in commercial districts throughout the city. Through Clean Streets, SBS offers a comprehensive sanitation and maintenance program to selected local neighborhood organizations and engages those organizations in a capacity-building relationship so that they will be able to independently manage and finance the program after two years. Under the program, the cost for supplemental sanitation and maintenance services will be provided entirely by the City in the first year of the program and on a matching basis in the second year, with the City contributing 75 percent of the sanitation and maintenance program costs and selected organizations contributing 25 percent. Over the course of the second year of the program, selected organizations will be required to raise 100 percent of the cost for supplemental sanitation services in the third year.

Explore Funding Options for Source Controls

In this Plan, the City is not making any specific recommendation about funding, but is laying out certain general considerations that should be considered in future assessments. We are unable to make any new commitments for capital or operational funding due to budget projections in New York City, which are declining because of local, regional, national, and international economic conditions.

INITIATIVE 9

Broaden funding options for cost-effective source controls

An adequate source of funding is a prerequisite to all potential source control strategies. Some of the scenarios envisioned in this Plan will be borne almost entirely by the private sector and can be justified as an incremental cost of a new building or parking lot. Those privately-funded stormwater control measures will require additional City engineers, permit reviewers, inspectors, and others to ensure adequate construction and maintenance. Most of the initiatives in this Plan will be implemented only with partial or full public subsidies. For example, public stormwater controls in the right of way will require capital and maintenance funding. At present, there is no separate, dedicated source of revenue for municipal stormwater-related expenses, either for general support services or for the maintenance of source controls in the public right of way or on public buildings.

There are at least five potential types of sources for funding stormwater initiatives: (1) rate increases, designated stormwater rates, or a combination of the two types approved by the independent Water Board, (2) the general municipal fund, (3) outside funding and other miscellaneous sources, (4) expansion of the federal role in financing infrastructure improvements, and, in the future, (5) funds redirected from conventional infrastructure to more cost-effective solutions.

First, the most established and important funding source are the rates paid by water users, who already pay for stormwater management. There are limits to the amount of additional funding that can be generated through rates. To support past and current investments in water and sewer infrastructure, including the $1.9 billion that the City is paying for ongoing CSO abatement projects, the Water Board has increased water rates in the City significantly since 1999, yet New York City's water rates are still lower than average.

Future increases will have to occur to cover the increased costs of constructing and maintaining sewers, CSO storage facilities, water supply projects, and treatment plants. However, there are political and practical constraints on the amount of increases that can be expected as the Water Board attempts to strike a balance between water needs, the impacts on ratepayers, and the economic competitiveness of the City. Indeed, this Plan and other innovative stormwater management efforts, including the potential performance standard for new development, are intended to implement the most cost-effective solutions and therefore to keep down rates as much as possible.

Table 12: Potential Costs for Targeted Watershed Source Controls

	Bronx River		Flushing Bay		Flushing Creek		Gowanus Canal		Newtown Creek	
Initiative	**Stormwater Captured**	**Cost**	**Stormwater Captured**	**Cost**	**Stormwater Captured**	**Cost**	**Stormwater Captured**	**Cost**	**Stormwater Captured**	**Cost**
PlaNYC Street Trees	4,180,000	$11,000,000	2,120,000	$5,600,000	n/a	n/a	n/a	n/a	7,500,000	$19,700,000
PlaNYC Greenstreets	220,000	$2,300,000	170,000	$1,800,000	180,000	$1,900,000	200,000	$2,200,000	30,000	$300,000
Performance Standards for New Construction	23,800,000	$4,600,000	23,900,000	$4,100,000	41,400,000	$6,500,000	44,300,000	$8,000,000	53,200,000	$8,500,000
Road Reconstructions	33,900,000	$7,300,000	147,500,000	$25,300,000	128,800,000	$18,300,000	21,800,000	$3,800,000	78,600,000	$13,000,000
Low- and Medium-Density Residential Controls	21,200,000	$4,900,000	63,600,000	$12,900,000	103,700,000	$15,400,000	24,100,000	$4,800,000	118,200,000	$15,000,000
Green Infrastructure: Greenstreets and Swales	16,500,000	$4,300,000	6,000,000	$1,500,000	35,200,000	$6,500,000	1,700,000	$400,000	8,900,000	$1,400,000
Sidewalk Standards	116,100,000	$29,800,000	222,200,000	$53,800,000	341,500,000	$71,300,000	75,500,000	$18,400,000	302,600,000	$62,000,000
Performance Standards for Existing Buildings	40,000,000	$13,200,000	87,600,000	$27,300,000	76,200,000	$20,700,000	25,500,000	$8,300,000	116,300,000	$33,200,000
TOTAL	**255,890,000**	**$77,400,000**	**553,100,000**	**$132,300,000**	**726,980,000**	**$140,600,000**	**193,100,000**	**$45,900,000**	**685,330,000**	**$153,100,000**

* "Stormwater captured" refers to gallons of stormwater runoff that can be retained or detained. The exact relationship between those quantities and the corresponding reduction in CSOs is not yet established. See Appendix D. All cost figures are for a 20-year period.

The City is studying the current water and wastewater rate structure under supervision of the Water Board. That study is explained in detail in the following section. One of the possible outcomes is a stormwater charge that is calculated by various methods. Another possible example is an additional charge dedicated for financing new or alternative technology modeled on the systems benefit charges levied by electrical utility regulators upon ratepayers, which provides a stream of income used to pay for entities that promote research, demonstration, and demand-side management installation projects. A similar charge could fund pilot projects and analogous initiatives.

Second, general municipal funds could be used to pay for certain stormwater mitigation projects through tax abatements or other incentive structures. The pilot green roof tax abatement will provide useful lessons to the City about the efficacy and practicality of this method of financing source controls.

Third, we can continue to rely upon outside funding and other miscellaneous sources for one-off funding of identified projects. In the past these have included grants from the New York State Department of State, New York State Environmental Protection Fund, and private foundations. Settlement funds from pollution or permit cases have also been used to finance projects, including some of the ongoing pilots in Jamaica Bay and the Bronx River using money held in escrow in the New York State Environmental Facilities Corporation. Those funding mechanisms could be formalized so that incoming funds are directed to green infrastructure projects that are agreed upon ahead of time or are selected through a competitive bidding process. For example, many natural resource damage actions in New Jersey are resolved by contributions to a pre-approved mitigation bank in which site stormwater is filtered and infiltrated to replenish groundwater aquifers. In the future, other sources such as City Council member items could also be used to finance green infrastructure projects. These sources do not provide a reliable, long-term solution to funding source controls but can support demonstrations of technology untested in New York City, new applications of source control technology, or the construction or maintenance of projects of special importance or that have an identified local partner.

These types of penalty or other dedicated funds are often tied to particular waterbodies. Using our estimates of the costs of PlaNYC green initiatives and the scenarios outlined above, and the opportunities that we know about, it is possible to develop specific budgets for some of the watersheds that would benefit the most from source controls (Table 12).

Fourth, the Federal role in financing infrastructure improvements may be expanded. The present version of the Clean Water Act was passed in 1972 because it was accompanied by significant Federal grants and loans to municipalities to build sewage treatment plants and sewers. These funded mandates complemented the new permitting systems and were responsible for much of the improvement in water quality over the past 30 years. That compact has shifted to one of unfunded mandates on municipalities. There are more stringent obligations under the Clean Water Act to reduce pollution from difficult-to-control non-point sources such as stormwater on roads. Yet the federal government has reduced funding for water and wastewater infrastructure by 70 percent over the past 20 years, shifting the burden to local governments. The unmet needs are now so large that they overwhelm municipal financing. The EPA estimates that $202 billion is needed to keep pace with aging sewer infrastructure needs over the next 20 years nationwide, which would required an average commitment of $10 billion per year. In New York State alone, the NYSDEC estimates that $36.2 billion is needed to pay for wastewater infrastructure over the next 20 years.

Staten Island Bluebelt

Staten Island Bluebelt

Mayor Bloomberg has led the way by forming the Building America's Future coalition with Governor Arnold Schwarzenegger of California and Governor Edward Rendell of Pennsylvania. It advocates for restoring America's competitiveness through investing in infrastructure. Several economic stimulus bills, including the Economic Recovery Act of 2008, have accepted the premise that the Federal government will support environmental infrastructure projects. However, these short-term stimulus bills are likely to use existing federal program funding mechanisms.

The Clean Water Collaborative is a parallel effort organized by NYSDEC with members that include New York City, other municipalities in New York, environmental groups, and engineer organizations. Its purpose is to urge the federal government to increase funding for grants and loans on a more predictable and regular cycle. For example, several bills have been introduced to increase federal financing through grants to state revolving funds, including the Water Quality Financing Act of 2007 and the Water Infrastructure Financing Act of 2008. The draft Senate bill authorizes $20 billion for the clean water state revolving fund for fiscal years 2008-12; The House bill, approved in 2007, authorizes $14 billion for fiscal years 2009-11. The Senate bill includes incentives for municipalities to use green infrastructure, and states may be allowed to forgive up to 5 percent of loans used for green infrastructure. In 2007 the House authorized $1.8 billion in grants for fiscal years 2008-12 to prevent sewer overflows in a separate measure; the draft Senate bill authorizes $2 billion for sewer overflow grants for fiscal years 2008-12.

The City believes that there are additional opportunities for grants directly to municipalities or more generous loan forgiveness programs that will relieve municipalities of the burden of repaying even low-interest loans. New York City will continue to pursue these outside sources of funding for sewage infrastructure and green infrastructure.

Fifth, the City may be required to construct deep storage tunnels in Newtown Creek and Flushing Bay, at a cost of over $2.3 billion. This money is not in the existing 10 year capital plan and cannot be shifted to pay for source controls. But in the future, if the City's upcoming modeling shows the potential for significant impacts and the implementation of source controls proves successful, then the City could discuss redesign or elimination of those projects with State regulators. Any such resolution would involve closer coordination between two distinct processes: the strategic planning process that led to this Plan and which is able to initiate untested, new approaches and the LTCPs that are binding commitments negotiated between regulators and municipalities that require a higher degree of certainty than currently exists.

INITIATIVE 10

Complete water and wastewater rate study and reassess pricing for stormwater services

The general public, residents, visitors and taxpayers alike bear the burdens caused by stormwater runoff. As with most large cities, however, the entirety of New York's water and sewer infrastructure is funded by revenue it collects through water and sewer rates paid by land or building owners only. Stormwater-related infrastructure and other program costs incurred by DEP are paid out of rate charges. Costs incurred by other agencies – such as advanced design standards directly related to stormwater controls or the costs of planting that have ancillary stormwater benefits – have been paid out of general municipal revenues or have been compensated by DEP on an ad hoc basis. Therefore, if we choose to fund more stormwater controls, then taxes may have to be increased to enhance the general fund or the Water Board may have to raise rates.

Currently, the City charges 159 percent of the rate for potable water for sewer, stormwater, and wastewater services, meaning that ratepayers are charged for stormwater costs depending on the quantity of potable water that is used. This rate structure fails to reflect the true costs of stormwater generation and can lead to distortions. Lots that do not use potable water but that generate substantial amounts of stormwater runoff, such as parking lots, receive significant public stormwater services but are not assessed a comparative rate; high-density housing developments can use significant amounts of potable water, but may generate lower volumes of stormwater per capita.

To address these issues and others with regard to water rates, in July 2008 the Water Board selected a consultant to study alternative stormwater, water and wastewater rate structures, and the underlying expenditures and revenue sources. DEP is managing the study and has begun an analysis of its current expenditures including a classification between its water, sanitary sewer, and stormwater-related costs. The study will survey municipal water, wastewater, and stormwater utilities with stormwater rate structures, and the variables that define these rate structures such as imperviousness, land area, and property classifications. The study will also review credit programs being implemented by other stormwater utilities to incentivize the installation of stormwater source controls and water conservation measures. Based on the results of the survey, the study will analyze the impact of different stormwater rate structures on ratepayers and revenues over 2-year, 10-year, and other budget planning scenarios. The study is scheduled to end in mid-2009. One of the many possible outcomes is providing credits and incentives for property owners who adopt certain substantive source controls.

The rate study will involve significant public participation even before any new rate structure is proposed to the Water Board. DEP has started preliminary outreach with stakeholders, the collection of rate information from 25 peer cities, an analysis of its budget to disaggregate water, sanitary wastewater, and stormwater-related expenses, an analysis of potential impacts of rate changes on revenue, ratepayers, and budgets for long-term scenarios, and an evaluation of regulatory, administrative and enforcement requirements for alternative rate structures. This data collection phase will conclude in March 2009. DEP will describe its progress on the study on an ongoing basis in public meetings before the Water Board and will present its preliminary findings at the April 2009 meeting. Those meetings are open to the public.

In April 2009, while ground vegetation is starting to "green out" but trees do not yet have the full leaves that obscure the ground, the DEP will conduct fly-overs of the city to obtain infrared images that will show detailed impervious cover. Mapping impervious cover onto lot and block lines is a key element to determining the viability of a stormwater charge. In addition, DEP is continuing to overhaul its billing software and database, which is another precondition to a stormwater charge or rate.

The City's reevaluation of its rates is part of a national trend. The draft Senate Water Quality Financing Act of 2008 calls for the National Academy of Sciences to study how municipal drinking and wastewater systems meet the costs associated with operations, maintenance, capital replacement and regulatory requirements. The bill contemplates that the EPA will use the study to help municipal systems determine whether they can establish a rate structure that adequately addresses the true cost of services.

Queens Botanical Gardens Visitor Center

Credit: Jeff Goldberg/ESTO


Credit: NYC Department of Environmental Protection

Implementation

This chapter discusses available options for tracking and monitoring source control projects and the milestones necessary to implement this plan. In addition, this chapter covers our options for informing, engaging, and supporting the public, including the creation of informational tools to support adoption of source controls, public education and training, and the City's plan to monitor ambient water quality.

Tracking, Monitoring, and Reporting

The key to quantifying the impact of source controls on a citywide basis is developing a system to track the number and location of individual source controls. We know from our experience with voluntary registrations such as prototype BMP Registry launched as part of the public outreach in developing this Plan, that they are not sufficiently reliable to serve as a basis for projecting CSO or other reductions.

Source controls have to be comprehensively and consistently tracked through permit databases and other mechanisms. Permits issued by DEP and DOB are currently tracked on agency databases, and any required source controls would be captured on new fields created in those databases. In the right of way, source controls installed would have to be tracked and monitored by the responsible construction agencies; DOT and DDC already have tracking systems for capital projects in the right of way, and we will add fields to record the construction of source controls. And the Parks Department already maintains an inventory of plantings done by the agency and outside groups in connection with PlaNYC's MillionTrees initiative. The databases and certifications could be patterned on the tracking systems that were established in other cities. Milwaukee, for example, has an on-line database that contains pertinent information from stormwater permits, including the type and size of source controls by type. And the Center for Neighborhood Technology, together with Chicago, Milwaukee, Evanston, and Fort Wayne, is developing a Permeability Index that includes registering existing and new source controls on public and private land, and is nested in a GIS-based view of overall impermeable land cover. The City is working with national experts on this issue and their collection of best practices from around the country is contained in Appendix G.

The DEP is also working with a consultant to develop a database to track sewer connection and building permits. The database will include existing information about detention or retention systems used to address sewer capacity restrictions in sewer connection and building permits issued over the last two years, and will include any requirements in future permits. The database will provide for GIS mapping of all such detention and retention systems, and other existing public and private stormwater source controls throughout the city.

Performance of typical source controls will have to be established through ongoing and future pilots and, where necessary and appropriate, by reference to studies in scientific literature. Once performance levels are established, the overall reliability of each element of the distributed network becomes a matter of proper maintenance, so that source controls perform up to their expected levels. We will design an inspection system for public and, where appropriate, private installations, to ensure compliance with maintenance standards and commitments. For example, sewer and construction codes that require source

East River and the New York City Skyline controls will also require certifications of reliability and maintenance by property owners, and will authorize inspections by City officials. The current green roof tax abatement law has similar requirements.

Agencies already report performance indicators as part of the Mayor's Management Report. Existing indicators that are relevant to stormwater include:

- Number of Greenstreets
- Greenways (miles added)
- Street Trees planted

In January 2009, these indicators will be expanded to include sustainability issues, as part of an initial phase of PlaNYC reporting. The sustainability indicators will include:

- CSO capture rate
- Bluebelt acres acquired
- Bluebelt total acreage
- Harbor monitoring stations meeting fecal coliform standards (percent)
- Saline waters classified for secondary contact recreation (percent)

Information to Support Source Controls

Members of the public will have to be important partners in implementing many of the identified source control initiatives. For the public to understand the factors that contribute to water pollution, economic and regulatory incentives for controlling stormwater, and the code and other incentives for minimizing stormwater runoff and how to design, build and maintain source controls, a strong public outreach, education and support program would be needed.

Design Manual

DEP is developing a source control design manual that will contain approved designs and design considerations for use in New York City to comply with applicable codes and economic incentive packages. Many cities and states have recently published design manuals, but these do not describe New York City regulatory requirements and New York City-specific climate, geologic, hydrologic, and built conditions. In 2009, DEP will begin development of a source control design manual that will identify how to design and install effective source controls in New York City for public and private land uses. The Design Manual will address different land use and building classifications; soil, bedrock, and groundwater conditions specific to different areas of New York City; climate conditions specific to New York City; and Administrative Code and permitting requirements for installing source controls, using examples from pilot and demonstration projects in New York City. The Design Manual will also include minimum maintenance requirements and procedures that will ensure effective source control performance over their design life. Maintenance requirements will take into consideration the sedimentation that can cause source controls to fail or perform less effectively over the years.

A list of existing source control installations

As part of the JBWPP, DEP is developing a database to track sewer connection and building permits, including information on any detention or retention systems used to address sewer capacity restrictions, and will provide for GIS mapping of that information shall provide for mapping with GIS. The database and map will also identify known public and private stormwater source controls throughout the city.

Other public outreach materials

Other potential outreach materials include laws that relate to source controls (e.g., sewer and construction codes, green roof tax abatements, green parking lot zoning amendments, street tree zoning amendments, yards zoning amendments, and sidewalk and tree planting requirements and specifications), maps of relevant information (e.g., pervious and impervious surfaces, high groundwater, bedrock, areas prone to flooding, soil percolation rates, and elevation contours, lists of suppliers, installers and other industry participants (e.g., following the model of DSNY's NYCWastele$$ site) and links to information resources about source controls (e.g., EPA's Green Infrastructure web site, the Water Environmental Research Foundation's BMP Database, and design competitions run by professional organizations).

Public Education and Outreach

To support source control initiatives, the City will also consider adapting existing programs or developing new public education programs to increase awareness about the need to reduce the flow of stormwater into the City's sewer systems and waterbodies, and about specific methods and practices for reaching that goal. The specific needs for an outreach program cannot be determined until we begin implementation of source control strategies, but any program will attempt to achieve several goals.

Role of education and outreach programs

Educational programs increase general public awareness of New York City's combined sewer system, combined sewer overflows, and stormwater management issues. The importance of public involvement is demonstrated by the BMP Task Force Public Wiki site created during the development of this Plan to keep the external stakeholders informed about source control policy developments and the relevant facts from stakeholder meetings. Most New Yorkers are not familiar with stormwater runoff, its interaction with the wastewater that leaves their homes every day, or the causal connection with floatables and other litter or beach closures – at least until sewer lines back-up into basements or there is street flooding. Informing city residents of their relationship to the sewer system and the urban-hydrological cycle is an important first step in promoting solutions to the problem that we all create. The City will consider including case-studies, water conservation and stormwater management tips, state-of-the-sewer system news features, and education source controls on the back of water bills. Finally, the City will consider engaging the public by prominently highlighting public demonstration and other source control projects underway in New York City with accompanying interpretive signage. In that way, every park, open space, or right of way source control would become an educational site. Highly visible source controls in public spaces could educate property owners, and will make manifest the distributed network.

CASE STUDY

Green Apple Corps

Green Apple Corps project

Credit: Green Apple Corps

Since 2004, the GreenApple Corps has been an active public service initiative of the Parks Department. The Corps program seeks to educate and equip its members with technical skills, practical, hands-on experience, and opportunities for personal development. Paid interns work for 9 months in three areas: environmental education, ecological restoration, and urban forestery.

The GreenApple Corps has identified stormwater management benefits in several of its key initiatives. The Corps is active in installing green roofs around the city. They work to promote green roof use and educate students on their environmental benefits. In one case, the GreenApple Corps installed a green roof on top of St. Simon Stock elementary school in the Bronx, where GreenApple Corps members continue to work in the school as environmental educators, using the green roof as a living laboratory of sustainablility, water capture, and gardening.

GreenApple Corps members also contribute to urban stormwater management through urban forestry practices by maintaining the health and vitality of street trees. Neighborhoods that have been identified as having a combination of high asthma rates by Department of Health standards and the least amount of tree canopy are targeted by the Parks Department as Trees for Public Health neighborhoods. These neighborhoods receive priority tree plantings, and the Green Apple Corps works extensively with school groups in these neighborhoods to care for newly planted trees. By removing leaves and debris from tree pits and aerating the soil, the Green Apple Corps teaches students how to increase the soil's ability to absorb rainwater. Students receive the benefit of learning firsthand the importance of street trees in alleviating a multitude of urban environmental problems as well as understanding the need to become stewards of their urban forest.

Outreach programs must inform property owners and others about the requirements of applicable sewer, construction and other codes, and to educate the designers, landscapers, and others who will help owners meet those requirements. If there are a limited number of consulting companies with required expertise to advise developers on the implementation of sustainable stormwater management practices, then an increased demand for their services will increase consultant costs and, therefore, raise the already-high costs of development.

Adaptation of existing outreach programs

DEP has a wide array of programs in place to educate the public about stormwater and water conservation. DEP has recently hired a new Public Outreach and Education Marketing Manager whose primary focus is to coordinate outreach at community based fairs, festivals, and concerts, conducted at City parks, beaches, and trade shows. At the Newtown Creek Wastewater Treatment Plant, DEP is opening a Visitor's Center will be an education forum that will have regularly scheduled tours, workshops, and special events to educate the public about the wastewater treatment process and its importance to water quality. In the spring of 2008, DEP initiated a Rain Barrel give-away program. Primarily designed to gather data on their effectiveness it also serves as an opportunity to educate homeowners on stormwater best management practices.

DEP also has an active outreach to schools, from elementary through college students and educators. Through this program, DEP increases awareness of New York City's combined sewer system, stormwater management programs, CSOs, and the importance of disposing of waste properly and using less water. Lessons and materials are designed to align with New York State and New York City Standards for science, mathematics, social studies and language arts and to include hands-on and inquiry-based activities. Education resources include classroom presentations, assembly programs, field trips, curriculum development, student research assistance, written material, professional development workshops and special programs, such as the annual Water Conservation Art and Poetry program. Presentations are made at least twice a week, often to multiple classes, throughout the school year. Recent hands-on education programs have been conducted at PS 78 (a Queens elementary school), Baruch College Campus High School, and New Explorers High School. DEP's 22nd annual Water Conservation Art and Poetry program encouraged fourth through sixth grade students to express themselves creatively about water, and some of the winning art and poetry from the 2008 contest are displayed on the agency's website.

In addition to the direct outreach performed by DEP staff, a wealth of materials is available on the agency's website. The DEP website will continue to provide support for City-wide environmental education. Consumers and businesses can find water conservation information through the "Ways to Save Water" page.

Evaluation of new programs

In the process of creating relevant city ordinances and the source control design manual, the City will develop an active outreach and training program to reach relevant audiences, patterned on the proposals in other cities. Many seminar and training programs fulfill continuing education requirements for individuals in a number of related fields (civil engineering, construction, contracting, real-estate, landscape architecture, general architecture and design, city planning) as well. For example, Washington State's Department of Ecology allows individuals to train for stormwater management fieldwork in classes sponsored by private companies that have designed programs compliant with the state or city technical manuals. Chicago's Green Tech University provides training to the general public at its Center for Green Technology, which is a showroom for an array of green initiatives. Chicago has also facilitated the work of contractors, engineers and designers by maintaining a website with a list of companies who have designed and installed source control installations. Similarly, DSNY maintains a "NYCWastele$$" site with lists of suppliers, installers, and other participants in the recycling industry. Finally, California's CALTRANS Division of Construction provides online and video resources for stormwater management training at construction sites.

Volunteer opportunities for members of the public to maintain and support publicly-installed source controls can lower the cost of projects initiated by the City because much of the labor is contributed free of charge by volunteers. Successful examples include the Department of Parks and Recreation's program to involve community groups in the care of Greenstreets installations. Another example is the Park Department's GreenThumb urban gardening program, the largest in the nation. Through that program, 700 neighborhood groups create and maintain community gardens, thereby increasing civic participation and encouraging neighborhood revitalization.

Volunteers are likely to acquire useful skills installing source controls that are potentially suitable for their own properties and help their local neighborhoods. Volunteers return to their neighborhoods and themselves become interpretive guides on stormwater management. In other words, volunteer programs also serve as a training ground for new leaders and encourage more connections between city government and the communities that they serve.

Partnerships to improve outreach, education, and training

As the City moves forward with this comprehensive stormwater Plan it will seek to work in partnership with organizations that have long-standing ties with communities, existing outreach, education, and training programs, and the ability to raise resources to support those programs. Through a Request for Expressions of Interest, we will challenge organizations to develop viable, funded plans for partnerships with the City on engagement.

Green Jobs and Training

The City is taking steps to encourage the development of existing and new local markets, job training, and employment opportunities to support the implementation and maintenance of source control measures. To ensure an adequate skilled workforce for the city's green initiatives, the City continues to identify and evaluate the potential disparities between the expected demand for and the supply of a "green collar" workforce. The City has been reaching out to key stakeholders, collaborating closely with State efforts, and engaging with other organizations to better understand the challenges that face specific sectors in the "green" industry, including the gaps in training programs and necessary certifications or accreditations.

Research to date has identified over 40 organizations with existing green collar jobs training programs in place in New York City. Current training programs relevant to source controls include tree pruning, urban forestry, storm water management, environmental remediation, and riverbank restoration. The City has existing training and workforce development programs, such as the MillionTrees Program, Parks Opportunity Education Horticulture Program, Individual Training Grants, and CUNY courses and certification programs. The City continues to look for additional opportunities to address the development and support of a green collar workforce of skilled labor.

Green Sector Study

To understand and improve job creation and worker training, the City, through the New York City Economic Development Corporation (EDC), is currently conducting a comprehensive study of green sector jobs to capture a global view and better understanding of the industry's current activity. Given the relative age of the green industry and the current strong public policy in favor of a greener economy, the City seeks to understand the emerging landscape of the green sector in order to support specific high priority segments that have a potential for increased economic impact.

Upon completion, the City will identify the high priority sectors in the industry; define and map the green sector; identify barriers to growth; recommend ways to overcome these barriers; and prioritize individual initiatives to stimulate job growth.

Ambient Water Quality Monitoring

The City of New York has been collecting water quality data in New York Harbor since 1909, one of the longest standing water quality programs in the world. DEP's Marine Sciences Section tests New York Harbor waters at 47 locations – 35 stations located throughout the open waters of the Harbor, and 12 stations located in smaller tributaries within the City – on a year-round basis, with weekly sampling in the summer and monthly sampling in the winter. The samples are intended to provide quality assurance and quality control for the wastewater treatment process as well as long-term information about the health of the harbor. DEP measures 27 water quality parameters, including bacteria, turbidity, temperature, and dissolved oxygen, all of which are used to monitor water quality trends. Every year, DEP compiles the sampling information and publishes the "New York Harbor Water Quality Report."

DEP also performs regular Shoreline Surveys in its patrol boats. The principal mission of these surveys is to examine all the outfalls through the bulkheads to detect any dry weather flows. DEP's Sentinel Monitoring Program samples at 80 locations in close proximity to outfalls each calendar quarter to assess local bacteria levels, which can help pinpoint illegal sanitary connections to storm sewers. When such discharges are found, DEP investigates the cause, issues fines, and requires violators to remediate the source. To date, the Shoreline Survey and Sentinel Monitoring Programs have resulted in the abatement of nearly 4 million gallons per day of unauthorized discharges. Additionally, DEP has installed telemetry systems in 105 of the regulators that control the diversion of sewage flow to WPCPs during dry weather or to open waters during major storms. The telemetry system links the regulators to DEP's operations center to allow DEP to immediately dispatch maintenance staff in instances of equipment failure or blockages that may lead to a dry-weather bypass. These 105 regulators were selected for telemetry because of their size, their proximity to beaches, and their potential impact on water quality. These regulators account for nearly 90 percent of the annual citywide CSO flow.

The Department of Health and Mental Hygiene (DOHMH) monitors the quality of waters used for recreational purposes, including at the seven public beaches operated by the Department of Parks and Recreation and the thirteen beaches run by private beach clubs. During the summer months, DOHMH collects weekly water quality samples at the beaches and assesses them for compliance with the applicable standards for levels of enterococci, a bacterium found in sewage and other waste that can cause illness. Bathing beach standards in marine waters must have mean geometric levels of enterococci below 35 per 100 ml for a series of five or more samples collected during a 30-day period; single-day enterococci results must be below 104 per 100 ml. DOHMH also shares responsibility for investigating sanitary sewage conditions that pose a threat to public health and safety, and for taking remedial enforcement actions as necessary to abate any public nuisances.

As part of this Sustainable Stormwater Management Plan, the City has assessed the adaptation of ongoing ambient water quality monitoring programs to provide for regular collection of samples in the immediate vicinity of combined sewer outfalls. DEP currently has 47 sampling site, and they add 27 more by 2017, and will add 27 These new sampling sites in the Bronx River, Westchester Creek, Hutchinson River, Alley Creek, Thurston Basin, Bergen Basin, Hendrix Creek, Fresh Creek, Paerdegat Basin, and Coney Island Creek as CSO facilities are completed. In addition, DEP is proposing to add open water stations in Jamaica Bay in order to collect more long-term water quality data and enhance ongoing ecological research. Though the full cost of this extra effort has yet to be calculated, it is estimated that there will be a 72 percent increase in the annual analytical cost component alone.

Wet weather monitoring at all 433 CSO outfalls and 349 stormwater outfalls would require additional telemetry that is not technically feasible at this time. In 2007, DEP retained ARCADIS BBL to explore the option of monitoring sewage flow at critical CSO outfall sites to detect and quantify CSOs. ARCADIS evaluated four different kinds of flow meters in order to verify their performance and accuracy over a range of flow and surcharge conditions, data logging and software capabilities, maintenance requirements, and responsiveness by the manufacturer. All four performed well during dry weather. However, all the meters experienced accuracy problems during wet weather and were determined to be unreliable. Based on the results of that pilot study, ARCADIS BBL recommended against long-term installation of any of the meters for use in quantifying CSO volumes. The flow meters are suitable only for short-term studies and sewer analyses.

Finally, DEP has assessed the presentation and timing of the sampling and monitoring information that is collected. DEP is evaluating the feasibility of managing the data in a geographic information system that will allow for more accurate maps and more detailed analyses. DEP is also working on a data distribution system that should allow a more streamlined method of displaying and accessing both historical and current data generated by the program. In the future, DEP will make this available online.

Milestones

DOB NYC DEPARTMENT OF BUILDINGS
DCP NYC DEPARTMENT OF CITY PLANNING
DDC NYC DEPARTMENT OF DESIGN AND CONSTRUCTION
DEP NYC DEPARTMENT OF ENVIRONMENTAL PROTECTION
DOF NYC DEPARTMENT OF FINANCE
DOT NYC DEPARTMENT OF TRANSPORTATION
DSNY NYC DEPARTMENT OF SANITATION
DPR NYC DEPARTMENT OF PARKS & RECREATION
EDC NYC ECONOMIC DEVELOPMENT CORPORATION
OLTPS NYC MAYOR'S OFFICE OF LONG-TERM PLANNING AND SUSTAINABILITY

PROPOSED PLAN

INITIATIVE	LEAD AGENCY	MILESTONES FOR COMPLETION BY				
		DECEMBER 31, 2008	JULY 1, 2009	DECEMBER 31, 2009	OCTOBER 1, 2010	LONG-TERM
IMPLEMENT THE MOST COST-EFFECTIVE AND FEASIBLE CONTROLS						
1 Capture the benefits of ongoing PlaNYC initiatives						
Street trees	DPR	Total of 32,972 planted by end of 2008	Additional 11,895 street trees planted	Additional 10,395 street trees planted	Street tree plantings continue	Total of 220,000 street trees planted by 2017
Greenstreets	DPR	40 new Greenstreets in Fall planting season	40 new Greenstreets in Spring planting season	40 new Greenstreets in Fall Planting season	80 new Greenstreets in 2010	PlaNYC to plant 800 new Greenstreets by 2017
Green roof tax abatement	DOF/DOB	Adopt regulations and release application	Process 2008 applications and apply abatements	Publicize tax abatement in advance of 2010 tax season		
NYC Plaza Program	DOT	DOT will select the first round of plaza projects based on their application process	Design begins on first round of Plazas	Application and design process for second round of Plazas		Goal to create 4 new Plazas per year
Bluebelts	DEP				Baisely Park Pond Project slated for construction pending funding	Springfield Park Project slated for construction in 2012 pending funding
Asphalt to Turf	DPR	1st and 2nd bundle of designs completed	Construction begins for 1st and 2nd bundles and desigs completed for 3rd-5th bundles	Construction begins for 3rd-5th bundles	Construction complete for all ballfields	
Schoolyards to Playgrounds	DPR	Construction for first 35 sites initiated		Complete community outreach and planning for remaining 129 sites		
Wetlands	OLTPS, DPR, DEP, EDC		Aerial flyovers for wetlands mapping to be completed	Wetlands mapping to be completed		
2 Continue implementation of ongoing source control efforts						
Waterfront Zoning Public Access Standards	DCP		Approval of new zoning standards			
Water Conservation Program	DEP			Launch program pending funding		
3 Establish new design guidelines for public projects						
Street Design Manual	DOT	Draft of Street Design Manual completed	Manual released			
Park Design for the 21st Century Manual	DPR	Draft of guidelines completed	High Performance Infrastructure Guidelines released			
Sustainable Sites Manual	DDC	Draft of guidelines completed	Manual released			
Water Conservation Manual	DDC	Draft of guidelines completed	Manual released			
4 Change sewer codes to adopt performance standards for new development						
Stormwater Performance Standard	DEP	Preliminary code language to be drafted	Proposed new code	New code requirements to be passed	Implementation of new code requirements	
5 Improve public notification of CSOs						
New notification signage	DEP	Design of signage to begin	Approval of signage to occur	Sign installation to begin	All new signage to be posted	
Online notification system	DEP/OLTPS	Design of web-based site to begin	Notification to be available on DEP website	Water quality alerts to be avail-able through non-emergency portion of NotifyNYC		

INITIATIVE	LEAD AGENCY	MILESTONES FOR COMPLETION BY				
		DECEMBER 31, 2008	JULY 1, 2009	DECEMBER 31, 2009	OCTOBER 1, 2010	LONG-TERM
RESOLVE THE FEASIBILITY OF PROMISING TECHNOLOGIES						
6 Complete ongoing demonstration projects						
Green Roof/Blue Roof Pilot Study	DEP	Contract awarded and design to begin December 2008	Installation to begin	Data collection continues	Data collection continues	Monitoring and reporting to be completed in 2011
Blue Roofs on Existing Buildings Pilot Study	DEP		Contract to be initiated in early 2009	Data collection continues	Data collection continues	Monitoring and reporting to be completed in 2012
Rain Barrel Give-Away Pilot Study	DEP	First phase of pilot initiated in Summer 2008	Contract for additional phases to be initiated in early 2009	Data collection continues	Data collection continues	Monitoring and reporting to be completed in 2012
Parking Lot Pilot Study	DEP	Contract awarded and design to begin December 2008	Installation to begin	Data collection continues	Data collection continues	Monitoring and reporting to be completed in 2011
NYCHA or HPD Pilot Study	DEP		Contract to be initiated in early 2009	Data collection continues	Data collection continues	Monitoring and reporting to be completed in 2012
Porous Pavement Pilot Study	DEP		Contract to be initiated in early 2009	Data collection continues	Data collection continues	Monitoring and reporting to be completed in 2012
Green Roofs on the Five Borough Buildings	DPR	Over 8,000 square feet of 8 types of green roofs installed in 2008	Research and data collection methods to be formulated	Data collection continues	Monitoring and reporting to be completed	
Domestic Sewage Treatment Plant Pilot Study	DEP		Contract to be initiated in early 2009	Data collection continues	Data collection continues	Monitoring and reporting to be completed in 2012
Flushing Bay and Gowanus BMP Grant Programs	DEP	Planning and analysis began in April 2008	Contract to be initiated			Monitoring and reporting to be completed in 2013
DEP Tree Pit Pilot Study	DEP	Contract awarded and design to begin December 2008	Installation to begin	Data collection continues	Data collection continues	Monitoring and reporting to be completed in 2011
DPR Tree Pit Pilot Study	DPR		Plantings in 40 tree pits with stormwater capture capacity and data collection to begin	More pits planted, data collection ends, and analysis begins	30 more pits planted and data to be published	
Enhanced Greenstreets Pilot Project	DPR	More stormwater pilot sites to added	Research and data collection methods to be formulated	Data collection continues	Data to be analyzed and publication of findings to be published	
Bronx Block Saturation Pilot Study	DEP	Planning and analysis began April 2008	Installation to begin	Data collection continues	Data collection continues	Monitoring and reporting to be completed in 2013
Albert Road Area Reconstruction Pilot Project	DDC/DOT	Land acquisition	75% of final design completed	Final design completed	Construction begins	Construction scheduled to be completed in 2012
East Houston Street Reconstruction Pilot Project	DDC/DOT	75% of final design completed	Final design completed	Bidding process completed	Construction begins	Construction scheduled to be completed in 2012
Astor Place/Cooper Square Reconstruction Pilot Project	DDC/DOT		Final design completed	Construction begins		Construction scheduled to be completed in 2012
Atlantic Avenue Reconstruction Pilot Project	DDC/DOT					Final design scheduled to be completed in 2012 pending funding
Constructed Wetlands Pilot Study	DEP	Contract awarded and design to begin December 2008	Installation to begin	Data collection continues	Data collection continues	Monitoring and reporting to be completed in 2011
Belt Parkway Bridges Roadside Swale	DEP	Design completed in 2008			Construction scheduled to begin	Construction scheduled for completion in 2014
Streetside Infiltration Swales Pilot Project	DEP	Contract awarded and design to begin December 2008	Installation to begin	Data collection continues	Data collection continues	Monitoring and reporting to be completed in 2011
Ballfields Source Controls Pilot Project	DPR/DEP		Contract to be initiated in early 2009	Data collection continues	Data collection continues	Monitoring and reporting to be completed in 2012
Bronx River Pilot Project	DPR	Tree pit planting completed in 100 pits utilizing stormwater capture techniques	Research and data collection methods to be formulated	Data collection continues	Research completed and results published	

INITIATIVE	LEAD AGENCY	MILESTONES FOR COMPLETION BY				
		DECEMBER 31, 2008	JULY 1, 2009	DECEMBER 31, 2009	OCTOBER 1, 2010	LONG-TERM
PROPOSED PLAN						
RESOLVE THE FEASIBILITY OF PROMISING TECHNOLOGIES, CONTINUED						
7 Continue planning for the implementation of promising source control scenarios						
Sidewalk standards	OLTPS/DOT/ DEP/DPR		Convene an interagency working group to examine technical and funding challenges	Conclude working group activity		Explore options for funding
Road reconstructions	OLTPS/DOT/ DEP/DPR		Convene an interagency working group to examine technical and funding challenges	Conclude working group activity		Explore options for funding
Performance standard on existing buildings	OLTPS/DEP/ DOB	Collect knowledge from building industry experts and manufacturers	Continue researching solutions to technical and funding challenges			Explore options for funding
Low- and medium-density residential	OLTPS/DEP	Collect knowledge from building industry experts and manufacturers	Continue researching solutions to technical and funding challenges			Explore options for funding
Green roofs on public projects	OLTPS/DPR/ DOB/DEP/ DDC		Convene an interagency working group to examine technical and funding challenges			Explore options for funding
Protocols for public projects	OLTPS		Work with agencies to consider protocols for incorporating source controls into projects			Explore options for funding
New demonstration projects	OLTPS		Develop proposals for new pilot projects Seek funding and partnerships for new pilots	Begin design on any pilot projects that are approved		Explore options for funding
Green Codes Task Force	OLTPS	Complete Phase I and II of code review process	Receive recommendations from NY Chapter of the USGBC	Consider code proposals for adoption		
8 Continue planning for the maintenance of source controsl						
Explore maintence options	OLTPS/DEP/ DOT/DPR/ DSNY		Convene an interagency working group to examine maintenance issues			Explore options for funding
EXPLORE OPTIONS FOR FUNDING SOURCE CONTROLS						
9 Broaden funding options for cost-effective source controls						
Broaden funding options	DEP/OLTPS	Support efforts to seek federal stimulus for stormwater infrastructure projects	Collect information on short-term needs and new demonstration projects			Assess progress and impacts of citywide source contol implmentation
10 Complete water and wastewater rate study and reassess pricing for stormwater services						
Rate study	DEP	Study began in July 2008	Initial study to be completed in July 2009	Reassess pricing structure for stormwater	Submit recommendations to the Water Board	Evaluate billing system and potential modifications
IMPLEMENTATION						
SUPPORT THE IMPLEMENTATION OF THE SUSTAINABLE STORMWATER MANAGEMENT PLAN						
Tracking and monitoring	DEP		Develop a system to track source controls			
Reporting	OLTPS		Sustainability indicators to be launched	Sustainability indicators results to be published in the Mayor's Management Report		
Public information tools	OLTPS/DEP		Determine appropriate web tools to support initiative	Post web tools to support initiative		
BMP Design Manual	DEP		Contract to be initiated			Manual to be completed in 2012
BMP Modeling by Watershed	DEP		Contract to be initiated			Modeling and analysis to be completed in 2012
Impervious surfaces data mapping	DEP		Contract to be initiated	Analysis to be completed		
Public education and training	DEP		Materials to be developed and distributed			
Green sector employment study	OLTPS/EDC	EDC to conduct research with external consultant	Initial data arrives and Interagency Working Group reconvenes	Final report will be released		
Ambient water quality monitoring	DEP					DEP will add a total of 27 sampling sites as CSO facilities are completed
Analysis on stormwater capture in separate sewer areas	DEP		Analysis to be completed			
Local Law 5 Updates	OLTPS				Update to be completed	Provide progress update every two years

Appendices

The Sustainable Stormwater Management Plan features 12 appendices that support and supplement the primary content of the Plan. All of the appendices are posted on the website of the New York City Mayor's Office of Long-Term Planning and Sustainability at: www.nyc.gov/planyc2030. These appendices are summarized below, and this published version reproduces in full Appendix A, Glossary of Stormwater Terms, and the Bibliography on Technical Source Controls, which is part of Appendix F.

A. Glossary of Stormwater Terms
The glossary compiles common definitions for stormwater-related terms found throughout this Plan.

B. Local Law 5 of 2008
The New York City Council passed Local Law 5 of 2008 to require the City of New York to develop and implement a sustainable stormwater management plan.

C. Summaries of Public Meetings
The City hosted five public meetings between June 12, 2007, and October 7, 2008. The topics discussed at those meetings are listed in this document.

D. Methodology for Land Use, Scenarios, and Cost-Benefit Analysis
This document describes the methodology used to develop the Plan, including cost-benefit analysis, land use quantification, cost estimates, and assumptions used to estimate the impacts of each source control scenario.

E. Demonstration Projects in New York City
This document provides descriptions for the ongoing or planned pilot projects and demonstration projects listed in Table 10 and referenced throughout the Plan.

F. Memorandum and Bibliography on Technical Source Controls
The City commissioned this literature review and bibliography by eDesign Dynamics to better understand certain stormwater source controls that have the greatest potential use in New York City.

G. Memorandum on Tracking, Monitoring, and Reporting Source Controls
This document was produced by the Low Impact Development Center, through a grant from the EPA, to help the City consider models for tracking and monitoring stormwater source control installations.

H. EPA Guidance on Green Infrastructure
These recent documents from the EPA demonstrate support for the use of green infrastructure to manage stormwater.

I. Rainfall Charts (Citywide and Waterbody-Specific)
These bar graphs show predicted CSO volumes and frequencies that are likely to occur after the construction of all plant upgrades, storage facilities, and other infrastructure required by the CSO Consent Order and anticipated in the Waterbody/Watershed Facility Plans, except for the Flushing Bay and Newtown Creek CSO tunnels.

J. Potential CSO Reduction Charts (Citywide and Waterbody-Specific)
These bar graphs show potential CSO volumes (as projected in Appendix I) compared to potential volumes of stormwater runoff capture that could be achieved through the implementation of the scenarios detailed throughout the Plan.

K. Public Comments on Draft Plan
This document includes all responses received during the public comment period from October 1, 2008, until October 31, 2008.

L. Responses to Public Comments
This document contains the City's responses to the public comments.

Glossary

This glossary provides basic definitions to terms found throughout this Plan or in other stormwater management-related documents. These definitions were collected from a variety of sources, including the EPA, the NYSDEC, and other municipalities. These definitions are provided for informational purposes only, and are not intended as official definitions for any purpose outside of this Plan.

Best Management Practices (BMPs)
Schedules of activities, prohibitions of practices, maintenance procedures, and other management practices to prevent or reduce the discharge of pollutants to waters of the United States. BMPs also include treatment requirements, operating procedures, and practice to control plant site runoff, spillage or leaks, sludge or waste disposal, or drainage from raw material storage.

Bioinfiltration
Bioinfiltration involves combining vegetation and appropriate soil compositions to both filter pollutants from stormwater and aid in retention strategies.

Bioretention
A water quality practice that utilizes landscaping and soils to treat urban stormwater runoff by collecting it in shallow depressions, before filtering through a fabricated planting soil media.

Blue Roofs
Also known as rooftop detention, a blue roof allows temporary ponding and gradual release of stormwater falling directly onto flat roof surfaces by incorporating controlled-flow roof drains into building design.

Catch Basin
Box-like underground concrete structure with openings in curbs and gutters designed to collect runoff from streets and pavement and transit it into the sewer.

Cistern
A tank for storing liquids such as rainwater.

City Environmental Quality Review (CEQR)
The City Environmental Quality Review (CEQR) process identifies and assesses the potential environmental impacts of certain actions that are proposed in New York City by public or private applicants and funded or approved by a city agency.

Clean Water Act
The federal Clean Water Act (formerly referred to as the Federal Water Pollution Control Act or Federal Water Pollution Control Act Amendments of 1972) Pub.L. 92-500, as amended Pub. L. 95-217, Pub. L. 95-576, Pub. L. (6-483 and Pub. L. 97-117, 33 U.S.C. 1251 et.seq. The CWA is the primary federal law controlling water pollution. Specific sections of the CWA seek to eliminate the release of pollutants to waterways.

Combined Sewer Overflows (CSOs)
A discharge of untreated wastewater from a combined sewer system at a point prior to the headworks of a publicly owned treatment works. CSOs generally occur during wet weather (rainfall or snowmelt). During periods of wet weather, these systems become overloaded, bypass treatment works, and discharge directly to receiving waters.

Combined Sewer System (CSS)
Pipes that convey both sanitary sewage and stormwater.

Compaction
Any process by which the soil grains are rearranged to decrease void space and bring them in closer contact with one another, thereby increasing the weight of solid material per unit of volume, increasing the shear and bearing strength and reducing permeability.

Conveyance
The transport of stormwater or wastewater from one point to another.

Design Storm
The magnitude and temporal distribution of precipitation from a storm event measured in probability of occurrence (e.g., five-year storm) and duration (e.g., 24 hours), used in the design and evaluation of stormwater management systems.

Detention
The capture and subsequent release of stormwater runoff from the site at a slower rate than it is collected, the difference being held in temporary storage.

Direct Discharges (DD)
A direct discharge is a release of stormwater into a waterbody without first passing through a municipal sewer system or receiving treatment at a WPCP.

Dissolved Oxygen
A form of oxygen found in water that is essential to the life of aquatic species.

Drywell
A structural subsurface cylinder or vault with perforated sides and/or bottom, used to infiltrate stormwater into the ground.

Effluent Limits
Limitations on amounts of pollutants that may be contained in a discharge. Can be expressed in a number of ways including as a concentration, as a concentration over a time period (e.g., 30-day average must be less than 20 mg/l), or as a total mass per time unit, or as a narrative limit (e.g. reduce to the maximum extent feasible).

Erosion and Sediment Control Plan
A plan for a project site that identifies stormwater detention and retention structures that will minimize accelerated erosion and sedimentation during the construction phase.

Exfiltration
The downward movement of runoff through the bottom of a stormwater facility and into the soil.

Fecal Coliform
Escherichia coli, *E. Coli*; of the family *Enterobacteriaceae*; bacteria naturally abundant in the lower intestine of humans and other warm-blooded animals, but rare in unpolluted waters.

Filter Fabric
A woven or non-woven water-permeable material, generally made of synthetic products such as polypropylene, used in stormwater management and erosion and sediment control applications to trap sediment or to prevent fine soil particles from clogging the aggregates.

First Flush
The first portion of runoff, usually defined as a depth in inches, considered to contain the highest pollutant concentration resulting from a rainfall event.

Green Infrastructure
An adaptable term used to describe an array of products, technologies, and practices that use natural systems – or engineered systems that mimic natural processes – to enhance overall environmental quality and provide utility services. As a general principal, Green Infrastructure techniques use soils and vegetation to infiltrate, evapotranspirate, and/or recycle stormwater runoff. When used as components of a stormwater management system, Green Infrastructure practices such as green roofs, porous pavement, rain gardens, and vegetated swales can produce a variety of environmental benefits. In addition to effectively retaining and infiltrating rainfall, these technologies can simultaneously help filter air pollutants, reduce energy demands, mitigate urban heat islands, and sequester carbon while also providing communities with aesthetic and natural resource benefits.

Green Roof
A rooftop that is covered with vegetation.

Head
The height of water above any plane or object of reference; also used to express the energy, either kinetic or potential, measured in feet, possessed by each unit weight of a liquid.

Hydrograph
A plot showing the rate of discharge, depth or velocity of flow versus time for a given point on a stream or drainage system.

Impervious Surface
A surface that prevents the infiltration of water into the ground.

Infiltration
The percolation of water into the ground. Infiltration is often expressed as a rate (inches per hour), which is determined through percolation.

Infiltration Bed
A structural facility filled with topsoil and gravel and planted with vegetation. The planter has on open bottom, allowing water to infiltrate into the ground. Stormwater runoff from impervious surfaces is directed into the planter, where it is filtered and infiltrated into the surrounding soil.

Leadership in Energy and Environmental Design (LEED)
The LEED certification process is a nationally-accepted standard for the design, construction, and operation of high performance green buildings. LEED certification criteria targets five areas important to human and environmental health: sustainable site development, water savings, energy efficiency, materials selection and indoor environmental quality.

Low-Impact Design (LID)
A comprehensive stormwater management and site-design technique. Within the LID framework, the goal of any construction project is to design a hydrologically functional site that mimics predevelopment conditions. This is achieved by using design techniques that infiltrate, filter, evaporate, and store runoff close to its source. Rather than rely on costly large-scale conveyance and treatment systems, LID addresses stormwater through a variety of small, cost-effective landscape features located on-site. LID is a versatile approach that can be applied to new development, urban retrofits, and revitalization projects. This design approach incorporates strategic planning with micro-management techniques to achieve environmental protection goals while still allowing for development or infrastructure rehabilitation to occur.

Long-Term Control Plan (LTCP)
LTCPs are the result of a 1994 EPA mandate that municipalities must develop a long-term plan for controlling CSOs. The EPA's 1994 CSO policy directive became law in December 2000 with the passage of the Wet Weather Water Quality Act of 2000. In accordance with the new law, LTCPs must include these nine minimum elements:

1. System Characterization, Monitoring and Modeling;
2. Public Participation;
3. Consideration of Sensitive Areas;
4. Evaluation of Alternatives;
5. Cost/Performance Consideration;
6. Operational Plan;
7. Maximizing Treatment at the Treatment Plant;
8. Implementation Schedule; and
9. Post Construction Compliance Monitoring Program.

Municipal Separate Sewer System (MS4)
A conveyance or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels, or storm drains):

1. Owned and operated by a state, city, town, borough, county, parish, district, association, or other public body (created by or pursuant to state law) having jurisdiction over disposal of sewage, industrial wastes, stormwater, or other wastes, including special districts under state law such as a sewer district, flood control district or drainage district, or similar entity, or an Indian tribe or an authorized Indian tribal organization, or a designated and approved management agency under section 208 of the Clean Water Act (CWA) that discharges to waters of the United States;
2. Designed or used for collecting or conveying stormwater;
3. Which is not a combined sewer; and
4. Which is not part of a publicly owned treatment works (POTW).

National Pollutant Discharge Elimination System (NPDES)
As authorized by the Clean Water Act, the National Pollutant Discharge Elimination System (NPDES) permit program controls water pollution by regulating point sources that discharge pollutants into waters of the United States. Industrial, municipal, and commercial facilities must obtain permits if their discharges go directly to surface waters.

Nonpoint Source
A diffuse source of pollution that cannot be attributed to a clearly identifiable, specific physical location or a defined discharge channel. This includes the nutrients that runoff the ground from any land use - croplands, feedlots, lawns, parking lots, streets, forests, etc. - and enter waterways. It also includes nutrients that enter through air pollution, through the groundwater, or from septic systems.

Outfall
The point where either a combined sewer discharges excess volume being conveyed to the treatment facility into a nearby waterway or where municipal separate storm sewer discharges to a waterway.

Peak Flow
Peak flow is a measure of the rate at which stormwater leaves a site.

Percolation Rate
The velocity at which water moves through saturated, granular material.

Point Source
Any discernible, confined, and discrete conveyance, including but not limited to, any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock concentrated animal feeding operation (CAFO), landfill leachate collection system, vessel or other floating craft from which pollutants are or may be discharged. This term does not include return flows from irrigated agriculture or agricultural stormwater runoff.

Porosity
The ratio of pore or open space volume to total solids volume.

Pretreatment
Treatment of waste stream before it is discharged to a collection system.

Right of Way (ROW)
Term used to describe public streets and sidewalks. This includes the infrastructure within the streets relating to utility lines, traffic signs and signaling, and a host of other features.

Rain Barrels
Rain barrels are typically small-scale, on-site storage containers for the catchment of stormwater. Rain barrels are often used in residential applications in order to manage stormwater and minimize the use of potable water for activities that do not require potable water.

Rain Garden
Also sometimes referred to as a vegetated infiltration basin, a rain garden is vegetated facility that temporarily holds and infiltrates stormwater into the ground.

Rain Harvesting
The practice of collecting and using stormwater to use in place of potable water for purposes such as irrigation and toilet flushing. Rain harvesting is both a stormwater management strategy as well as a water conservation strategy.

Retention
The permanent on-site storage or use of stormwater to prevent it from leaving the development site.

Runoff Coefficient
A unitless number between zero and one that relates the average rate of rainfall over a homogenous area to the maximum rate of runoff.

Separate Sewer System (SSS)
Separate Sewer Systems (SSS) convey stormwater directly into nearby bodies of water without treatment.

Sewershed
All the land area that is drained by a particular sewer network.

Source Controls
Source controls refer to stormwater management practices that capture and control rainfall at its source, before it can pool as runoff or combine with sewage in the combined-sewer system.

State Pollutant Discharge Elimination System (SPDES)
New York State has a program that has been approved by the United States Environmental Protection Agency for the control of wastewater and stormwater discharges in accordance with the Clean Water Act. SPDES permits can be broader in scope than those required by the Clean Water Act in that they can control point source discharges to groundwaters as well as to surface waters.

Stormwater
Stormwater is surface flow resulting from precipitation that accumulates in and flows through natural and/or man-made storage and conveyance systems during and immediately following a storm event.

Total Suspended Solids (TSS)
Matter suspended in stormwater, excluding litter, debris, and other gross solids.

Urban Land Use Review Procedure (ULURP)
The Uniform Land Use Review Procedure (ULURP) is the public review process, mandated by the City Charter, for all proposed zoning map amendments, special permits and other actions such as site selections and acquisitions for city capital projects and disposition of city property. The procedure sets forth time frames and other requirements for public participation at the community board, borough board and borough president levels, and for the public hearings and determinations of the community boards and City Planning Commission (CPC). Zoning text amendments follow a similar review process, but without a time limit for CPC review.

Vegetated Swales
A long and narrow, trapezoidal or semicircular channel, planted with a variety of trees, shrubs, and grasses. Stormwater runoff from impervious surfaces is directed through the swale, where it is slowed and in some cases infiltrated, allowing pollutants to settle out.

Water Pollution Control Plant (WPCP)
Water Pollution Control Plants process sewage from sanitary sewers and sewage and stormwater in combined sewer systems.

Water Table
Upper surface of the free groundwater in a zone of saturation.

Weir
A wall or plate placed in an open channel to regulate or measure the flow of water.

Wetland
Areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands include swamps, marshes, bogs, and similar areas.

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