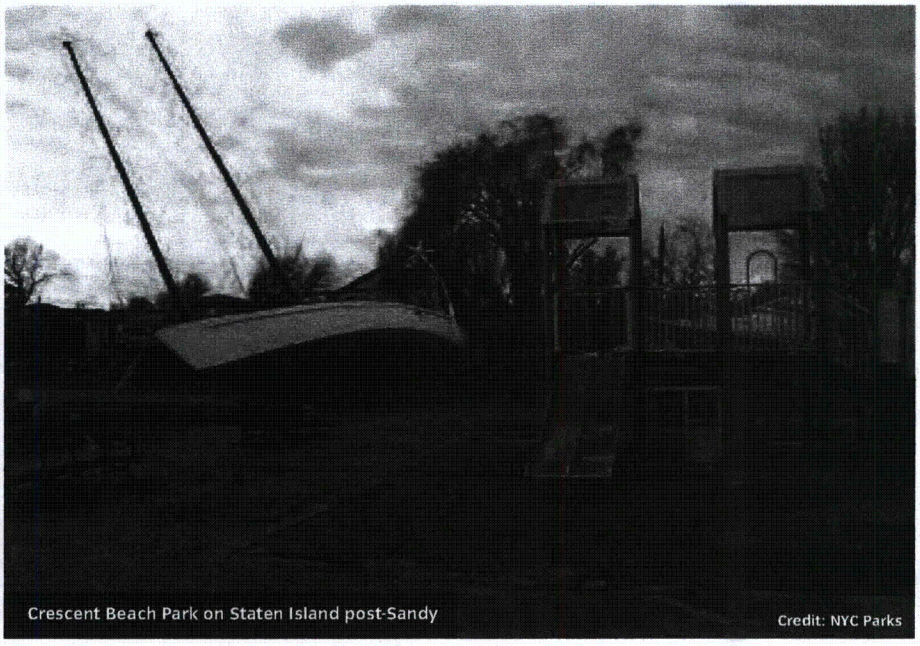
Risk Assessment: Impact of Climate Change on Parks

■ Major Risk Moderate Risk Minor Risk

Hazard	Scale of Impact: Today	2020s	2050s	Comments
Gradual				
Sea level rise				Risk in coastal areas for parks, Greenstreets, street trees, and natural areas
Increased precipitation				Could increase flooding in inland parks, natural areas and preserves, and roadways
Higher average temperature				Could increase stress on plantings, especially if coinciding with drought
Extreme Events				
Storm surge			■	Risk primarily for coastal parks (significant expansion in parks acreage in the floodplain by the 2050s), but could produce flooding in inland areas
Heavy downpour				Resulting flooding could cause street tree and forestry damage
Heat wave				Could increase stress on plantings
High winds				Street trees and forestry at risk, with indirect impacts on power lines and transportation

Key DPR operations and administrative facilities both within and beyond the inundation zone were impacted by Sandy. In Flushing Meadows Corona Park, areas of the park at lower elevations and closer to Flushing Bay were flooded, including the Olmsted Center, causing damage to office spaces, archived documents, and the computer network. On the other hand, a facility within Sara D. Roosevelt Park in Manhattan, which assists in dispatching needed Parks resources in emergency situations, was equipped with a generator and continued operation despite widespread power loss in surrounding areas. *(See table: Parks Assets Inundated and at Risk)*



Crescent Beach Park on Staten Island post-Sandy

Credit: NYC Parks

What Could Happen in the Future

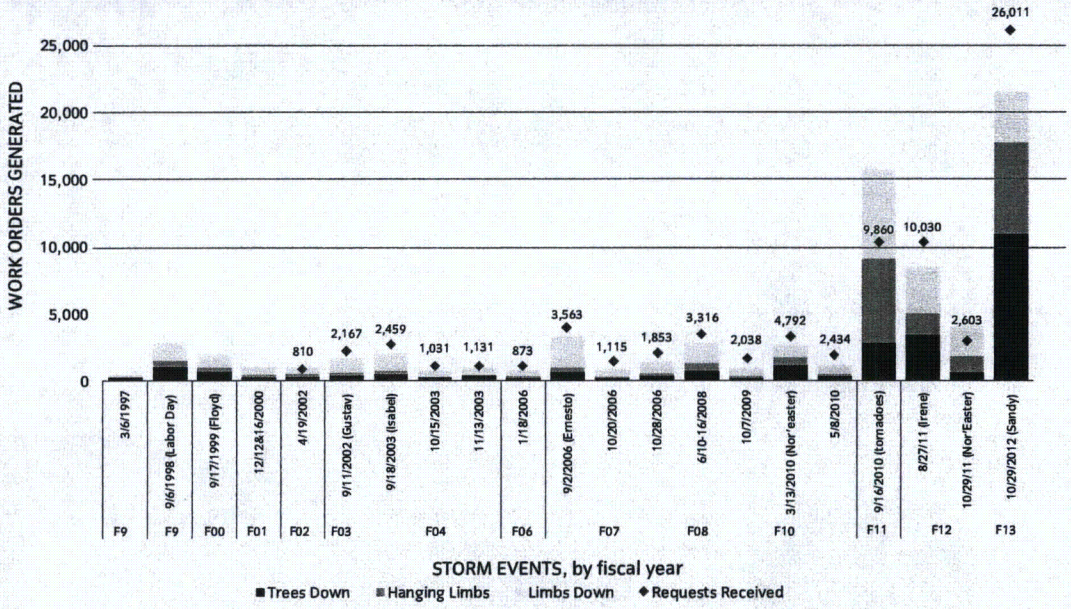
Going forward, the city's parks face a variety of risks related to climate change.

Major Risks

The most significant risk to the parks system is flooding from coastal storms, which is likely to be exacerbated by projected sea level rise. This risk is significant even today, as illustrated by recently released flood maps from the Federal Emergency Management Agency (FEMA). According to these maps, called Preliminary Work maps (PWMs), over 5,800 acres (or 24 percent) of the city's parkland are in the 100-year floodplain, an area that has a 1 percent or greater chance of flooding in any given year. Over 230 DPR buildings are within the floodplain, including several key facilities such as the Greenbelt Native Plant Center and the Lyons Recreation Center on Staten Island.

According to the New York City Panel on Climate Change (NPCC), sea levels are expected to rise around New York City. By the 2020s, under high-end sea level rise projections, 6,600 acres (27 percent) of the city's parkland could lie in the 100-year floodplain, increasing to over 7,400 acres (or 31 percent) by the 2050s. An even more disturbing pattern

Forestry Storm Events



Credit: NYC Parks

holds true for DPR buildings, with the number in the floodplain forecast to grow even faster, rising to 301 buildings (an increase of 30 percent) by the 2020s and to almost 350 buildings (a 50 percent increase) by the 2050s. This increasing vulnerability to storm surge can be seen across DPR's portfolio, from its natural areas to its street trees to its Greenstreets—putting all these assets and the surrounding communities they protect at risk. *(See map: Parks Assets in the Floodplain)*

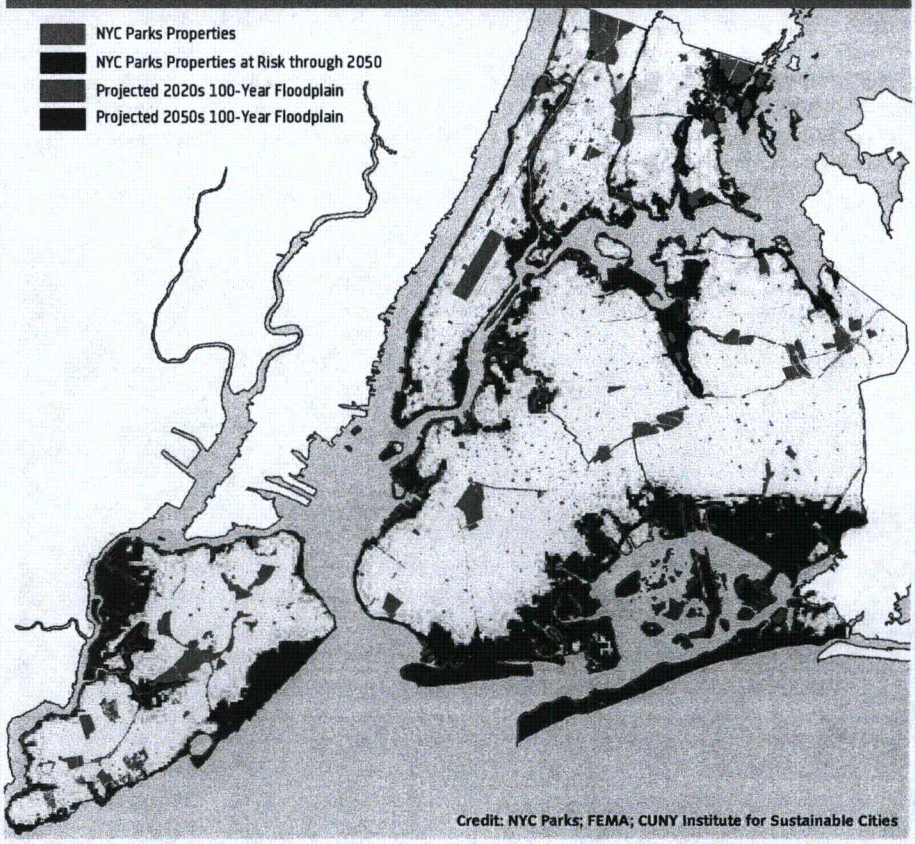
Other Risks

While surge from coastal storms poses the most significant climate-related risk to New York's parks in coming years, other extreme weather events also could impact DPR's system. With an estimated 2.5 million trees under DPR's jurisdiction, the city's urban forest is at great risk with the increasing frequency of the most intense storms with high winds, potentially impacting vital utility networks. Similarly, more frequent heavy downpours in New York could damage play surfaces and cause water quality impacts. *(See graph: Foresty Storm Events)*

Even without extreme weather events, chronic hazards also could impact New York's parks. For example, gradual sea level rise over time could lead to the loss of salt marsh habitats along the city's coastline, endangering plants and animals—a threat also posed by expected higher average temperatures and increased variability in precipitation. Additionally, sea level rise could lead to regular tidal flooding around New York City, especially in parks in South Queens, Alley Pond Park in northern Queens, and Pelham Bay Park in the Bronx.

Meanwhile, associated changes in ocean temperature may affect the distribution of oysters and other aquatic life in New York Harbor, and also could affect commercial and recreational fisheries in and around the city. Sea level rise and other chronic changes also could impact the water levels and chemistry of area freshwater ponds, harming the local ecology.

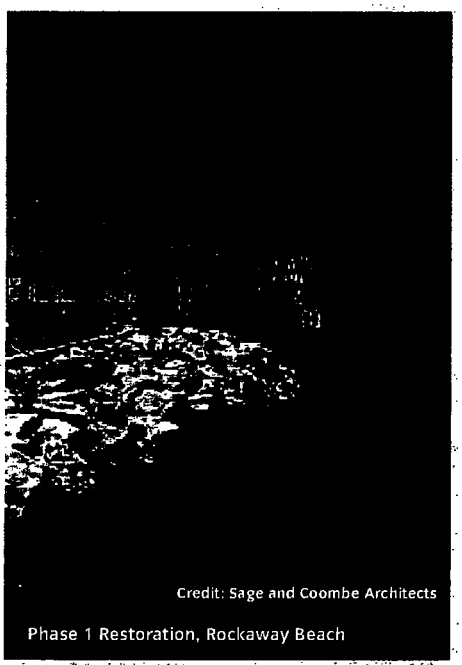
Parks Assets in the Floodplain



Credit: NYC Parks; FEMA; CUNY Institute for Sustainable Cities

This chapter contains a series of initiatives that are designed to mitigate the impacts of climate change on New York's parks system. In many cases, these initiatives are both ready to proceed and have identified funding sources assigned to cover their costs. With respect to these initiatives, the City intends to proceed with them as quickly as practicable, upon the receipt of identified funding.

Meanwhile, in the case of certain other initiatives described in this chapter, though these initiatives may be ready to proceed, they still do not have specific sources of funding assigned to them. In Chapter 19 *(Funding)*, the City describes additional funding sources, which, if secured, would be sufficient to fund the full first phase of projects and programs described in this document over a 10-year period. The City will work aggressively on securing this funding and any necessary third-party approvals required in connection therewith (i.e., from the Federal or State governments). However, until such time as these sources are secured, the City will only proceed with those initiatives for which it has adequate funding.



Credit: Sage and Coombe Architects

Phase 1 Restoration, Rockaway Beach

To protect parks and their surrounding neighborhoods, the City will work to upgrade and better prepare these parks—and related facilities—to withstand future extreme weather events as well as the chronic impacts of climate change. To this end, the City will seek to make parks more effective at absorbing and buffering the impacts of extreme events; will work to retrofit or harden parks and facilities, as well as wetlands and other natural areas; and will develop tools for comprehensive climate adaptation planning and design.

Strategy: Adapt parks and expand green infrastructure to shield adjacent communities from the impacts of extreme weather events

To protect parks themselves, together with surrounding neighborhoods, the City will seek to increase the capacity of its parks to absorb floodwaters (from storm surge and heavy precipitation) and to absorb the driving impact of surge-related wave action. The City also will seek to expand its green infrastructure citywide.

Initiative 1

Restore city beaches

Beaches play an important recreational role and also are an important component in the city's coastal defenses, but they cannot protect adjacent areas without being "nourished" (replenished with new sand to replace that lost to erosion) from time to time. Subject to available funding, the City, through DPR, will collaborate with Federal and State partners—including the USACE—to implement plans quickly to restore sand lost after extreme storm events and to conduct regular nourishment of beaches and regular monitoring to detect the early signs of erosion. The goal is launch this effort at city beaches such as Plumb Beach in Brooklyn and Orchard Beach in the Bronx by 2015 (see Chapter 3).

To restore the city's beaches following Sandy, DPR and the Department of Design and Construction, in cooperation with many other City, State, and Federal partners, conducted an expedited program of projects to provide new and elevated lifeguard stations and public bathrooms and improvements to other beachfront amenities in advance of Memorial Day 2013. DPR constructed 35 prefabricated modular buildings, to be used as comfort stations and lifeguard stations, in Rockaway, Coney Island, and Staten Island, informed by storm surge projections for the 500-year floodplain at a height ranging from 7 to 14 feet above the existing grade to reduce the risk of flood damage and give a greater level of protection to these facilities. This impressive achievement comprised the first phase of restoring the city's beaches. In the coming months and years, DPR will continue its efforts to provide emergency sand nourishment and to expedite planning, evaluation, and design work for long-term plans to restore the city's beaches, boardwalks, and other beachfront amenities.

Initiative 2

Harden or otherwise modify shoreline parks and adjacent roadways to protect adjacent communities *(See Coastal Protection Initiative 30)*

Approximately 24 percent of DPR parks and other open spaces are in the 100-year floodplain on the PWMs, which is expected to expand as sea levels rise—including in areas where parks front residential and commercial districts. Subject to available funding, the City, through DPR, will study and identify mitigation strategies, including cost-effective ways to use its parks system to protect adjacent neighborhoods and the parks themselves. Strategies could include hardening or elevating park infrastructure, construction of levees or floodwalls to minimize flooding and attenuate waves, and using flood-tolerant materials in the construction of parks. The goal is to complete this study in 2014.

Initiative 3

Reinforce or redesign bulkheads in coastal parks *(See Coastal Protection Initiative 6; see Coastal Protection Initiative 29)*

The current portfolio of bulkheads and other waterfront structures in the city includes many aging or damaged assets that are at risk of failure, particularly during a major storm event. Many of these at-risk bulkheads can be found on DPR properties. Subject to available funding, the City, will inspect—as part of a new citywide waterfront inspection program—damaged bulkheads on parkland to develop a plan that will allow, over time, for their reconstruction, elevation, or replacement with living shorelines, where appropriate, that are both more resistant to storm damage and more accommodating of marine life. The goal is to launch this program in 2013. See Chapter 3 for more information on the City's plans for inspecting bulkheads and improving the resiliency of the coastline.

Initiative 4

Expand the City's Greenstreets, including for Jamaica Bay

Increased localized flooding is likely from more frequent heavy downpours in the future.

Subject to available funding, the City, through DPR and in partnership with DEP, will expand its efforts to build more and larger Greenstreets to absorb stormwater, mitigate local flooding, decrease urban heat island effect, increase pedestrian and traffic safety, and beautify neighborhoods. This will expand the installation of green infrastructure at appropriate locations in the City's streets, with approach modeled upon the NYC Green Infrastructure Plan, which improves water quality in combined sewer areas.

The first phase of this expansion would focus on fourteen neighborhoods with the greatest potential for improvement, areas that are not slated for CSO improvements through the NYC Green Infrastructure Plan, but could be well-suited for Greenstreets based on best available data showing low bedrock and ground water. The goal is to construct and maintain 1,600 Greenstreets at a high density to amplify impacts such as cooling and ecological health. This expansion would capture approximately 32 million cubic feet of stormwater per year by 2015, with a footprint of over 50 acres of increased green space. Thereafter, DPR will consider expansion of this strategy over a 10-year period, focusing on the remaining 20 percent of the city where new Greenstreets could provide myriad benefits.

An early priority for this effort will be the area surrounding Jamaica Bay, where DPR will collaborate with DEP and NYCDOT to reduce localized flooding and stormwater runoff, directly improving the health of the Bay. The goal is to begin pilot projects in and around Coney Island, Marine Park, the Rockaways, and Canarsie Park, including Greenstreets and parkland installations by 2014.

Strategy: Retrofit or harden park facilities to withstand the impacts of climate change

Even where parks-related facilities do not serve a protective function, they nonetheless offer vitally important amenities for the communities they serve. The City, therefore, will seek to protect these facilities from the impacts of climate change where possible and to enable them to bounce back quickly when impacts do occur.

Initiative 5:
Fortify marinas and piers

Marinas and piers are valuable water-dependent facilities that are vulnerable to extreme weather events. Subject to available funding, the City, through DPR, will begin to address this vulnerability by increasing the resiliency of its fixed and floating structures at the 79th Street Boat Basin in Manhattan, the World's Fair Marina in Queens, Lemon Creek Marina in Staten Island, and the Sheepshead Bay Piers in Brooklyn in 2013. This work will include increasing piling count and height, replacing deteriorated pilings, and installing steel hurricane straps on piers. Additionally, lighter floating docks will be replaced with heavy-duty, modular articulating docks, more robust wave screens, and icebreaker systems. Contingency plans also will be developed to accommodate bow-loading passenger ferries, in the event that these sites can aid in emergency transportation measures *(see* Chapter 10, *Transportation).* The goal is to complete these improvements by 2016.

Initiative 6
Relocate or increase the resiliency of playgrounds and athletic fields

The City's park network includes over 1,000 playgrounds and 800 athletic fields—over 256 acres of which were inundated during Sandy. Subject to available funding, the City, through DPR, will continue to assess whether facilities impacted by Sandy or otherwise impacted should be relocated or otherwise protected from future inundation. Based on these findings and subject to available funding, DPR then will adopt flood-mitigation tactics at these facilities (such as carpet-style synthetic turf and tiled safety surfacing) to allow for easier post-flood repair and cleanup. DPR also will install rain gardens and water collection systems around these facilities to reduce flooding in parks and the burden on stormwater systems during these extreme events. The goal is to complete the analysis of all sites by 2015.

Initiative 7
Protect mechanical systems at major park facilities and buildings

As with buildings citywide, many park facilities in flood-prone areas have mechanical systems that are vulnerable to inundation. Damage to these systems can, in turn, result in extended facility closures and costly repairs. Subject to available funding, the City, through DPR, therefore will begin the process of flood-proofing all of its mechanical, electrical, irrigation and critical systems in parks that are located in the 100-year floodplain. These protective measures could include elevating mechanical systems, or flood-proofing their enclosures—all consistent with strategies outlined in Chapter 4 *(Buildings)*. Subject to available funding, this effort will begin with a DPR-led pilot program to test flood-proofing technologies to achieve maximum effectiveness in future capital projects. The goal is to commence this pilot program by 2015, at which time DPR will identify and implement design strategies for five different facilities, targeting boilers; heating, ventilation, and air conditioning systems; pool filtration plants; and irrigation systems.

Initiative 8
Move or protect critical operations centers

Many DPR buildings, including operations centers and administrative buildings, are located in the 100-year floodplain and are, therefore, at risk of flooding. Subject to available funding, the City, through DPR, therefore, will strive to maintain critical operations at these centers during and immediately after extreme weather events. To this end, DPR will construct waterproof walls, berms, and pump systems powered with dual fuel generators, where possible, to protect these centers from flooding. DPR also will upgrade applicable telecommunication, utility, and computer systems in these centers so they can function as temporary reporting sites. These upgrades will occur pursuant to the availability of funding. The goal is to complete this project in five years.

Strategy: Protect wetlands, other natural areas, and the urban forest

Wetlands, streams, forests and other natural areas offer substantial sustainability and resiliency benefits. The protection and restoration of these natural areas is, therefore, of critical importance.

Initiative 9
Work with the Federal government to transform Jamaica Bay

One of the most significant opportunities in New York's history for the development, management, maintenance, and programming of an integrated set of wetlands and other natural areas for natural habitat and recreational use exists in and around Jamaica Bay. Through its groundbreaking partnership with the National Park Service, the City, through DPR, will seek to promote habitat preservation and flood protection as well as a variety of programs in the 10,000 acres of Federally and City-owned parks in and around Jamaica Bay. This program will offer educational, scientific, recreational, and other opportunities to visitors. The goal for this partnership is to lead large-scale bay restoration and green infrastructure projects, which, in addition to improving the Bay itself, also will protect the many adjacent neighborhoods in Brooklyn and Queens.

Initiative 10

Increase the health and resiliency of natural areas, including Tibbetts Brook

Increased stormwater runoff mixed with sewage outflows poses a risk not just to the developed areas of the city but also to its natural areas. Subject to available funds, the City, through DPR and DEP, will restore freshwater streams and restore or construct wetlands to manage runoff and reduce the impacts of extreme weather events.

In particular, DPR will collaborate with DEP to make near-term progress toward the separation of Tibbetts Brook from the city's combined sewer system. This will reduce stormwater flow into the combined sewer system and provide wetland restoration in a cost-efficient manner. This effort will include property acquisition, conceptual design, and eventual construction. Successful separation would reduce CSO volumes into the Brook and the Harlem River by an estimated 140 million gallons per year, improving river water quality and freeing capacity at the Wards Island Wastewater Treatment Plant.

The goal is to develop conceptual designs and complete construction documents by 2015.

Initiative 11

Improve the health and resiliency of the city's urban forest

The city's forests and trees provide an array of health and environmental benefits. They are, though, vulnerable to a variety of climate change-related impacts, including storm surge, wind, and changes in average temperatures. Subject to available funding, the City, through DPR, will undertake a variety of efforts to protect trees—whether located in natural areas and parks, or along streets. Specifically, DPR will undertake three parallel efforts, all subject to available funding.

First, DPR will add to its forest management crews. Just one additional six-person crew would allow DPR, in partnership with the Natural Areas Conservancy, to expand active management of forests by 200 acres. Second, DPR will identify locations to expand tree beds, thereby giving tree roots more room to grow and reducing the high rate of tree mortality and failure during storms. Initially, DPR will target 5 percent of all planting locations for such expansion in connection with the City's existing MillionTreesNYC initiative. Finally, DPR will modify its regular tree inspection and pruning efforts to prioritize trees in areas vulnerable to extreme weather events. These pruning efforts will cover 80,000 street trees, 10,000 young trees, and 20,000 park trees annually—a rate that will enable DPR to cycle through the entire citywide tree population every seven years. To launch this program, DPR will use existing funding to hire and train 10 foresters to perform tree risk assessment inspections and supervise pruning efforts. The goal is to launch this program in 2013.

Initiative 12

Increase growth of local plant material for restoration work

Nearly every landscape restoration project undertaken by DPR around the city requires locally sourced or native plant materials. Subject to available funding, the City, through DPR, therefore will make capital improvements and add additional staff to its Greenbelt Native Plant Center. The unprecedented volume of plants needed for post-Sandy restoration projects requires the timely production of a sufficient supply of the right local genetic stock of such plants. This program was launched in 2013.

Strategy: Develop tools for comprehensive climate adaptation planning and design

As weather experts expect conditions to evolve over a long period of time, the City aims to respond appropriately with resiliency measures for its park network. To that end, the City and its partners will seek to secure appropriate tools to monitor and measure conditions in the environment and the success of investments that it is making.

Initiative 13

Establish a center for resiliency and restoration efforts in the Jamaica Bay-Rockaway Parks

The joint City-Federal effort to transform Jamaica Bay into a national model has, as one of its centerpieces, a plan to create a new Science and Resilience Center at Jamaica Bay. The City, through DPR and in close collaboration with the National Park Service, will work with leading academic institutions to make this center a reality, with initial operations to begin in the fall of 2013.

The Science and Resilience Center at Jamaica Bay will serve a variety of key functions. First, the Center will facilitate decision-making by policy makers based on the latest scientific information developed by academic institutions. Second, the Center will address Jamaica Bay issues, such as water quality and ecological restoration. Third, the Center will seek to ensure the broad dissemination of resiliency-related research and policymaking to governments and scientific institutions around the world. The goal is to launch the Center in 2013.

Initiative 14

Quantify the benefits of the city's ecosystems and green infrastructure

A lack of high-quality performance data could hamper the City's ability to make smart decisions about its green infrastructure. Subject to available funding, the City, through DPR and DEP, will commission studies on the impact of the city's green infrastructure and natural areas, seeking to quantify the program's impacts on air pollution, stormwater capture and flood control, the urban heat island effect, public health, and biodiversity. The City will adapt and employ tools developed by the US Forest Service for these studies, and will use the information to prioritize future projects. The goal is to launch this program in 2013.

Initiative 15

Create climate adaptation plans for all parks in the 100-year floodplain

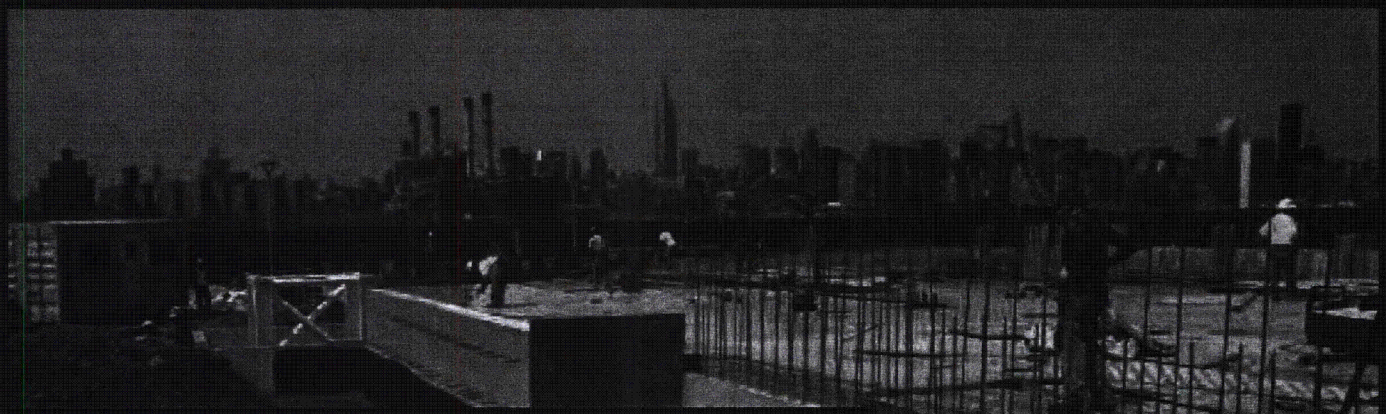
Costly infrastructure and important natural elements throughout DPR's park system face significant risk due to future climate change. Subject to available funding, the City, through DPR, will map and catalogue all of the facilities, infrastructure, and plant communities in DPR's system within the city's 100-year floodplain, with the goal of developing adaptation plans. These plans will include detailed elevation information to understand how different parks may be impacted by extreme weather events. This information will inform DPR flood mitigation measures, including updates of DPR's 2010 report *High Performance Landscape Guidelines: 21st Century Parks for NYC*. The goal is to launch this program in 2013.

Initiative 16

Map the city's overhead utilities and street trees

The city's many street trees pose a risk to utility lines and other infrastructure. Better information, however, could help to manage this risk. Subject to available funding, the City, through DPR, will collaborate with local utilities to map the city's trees against its overhead utility networks by 2015. This mapping exercise is intended to help DPR and the owners of utility infrastructure to develop an effective vegetation management plan for those street trees. The goal is to launch this program in 2013.

Environmental Protection and Remediation



Building under development at a completed cleanup site in the NYC Brownfield Cleanup Program

Credit: NYC Mayor's Office of Environmental Remediation

New York City's waterfront has long been a working waterfront, home to a diverse array of businesses large and small. From the South Bronx to Sunset Park in Brooklyn, and from the Kill Van Kull along Staten Island's North Shore to the Newtown Creek area in Queens, the working waterfront continues to thrive in many areas, home to growing companies and the strong employment opportunities they create.

Some of these businesses, however, rely upon hazardous substances to produce their goods and services. Whether on unenclosed or "open" industrial sites housing scrap metal yards or recycling centers, or at indoor or "enclosed" industrial sites housing factories and print shops, these industrial uses often depend upon chemicals and other compounds that can have harmful impacts if not used and protected properly.

Though industrial users can be found in many waterfront locations throughout the city, there are significant concentrations in several neighborhoods, including those noted above plus Red Hook and the Brooklyn Navy Yard. These working waterfront areas are not only important clusters of commercial activity, but are also vulnerable to storm surge.

Following Hurricane Sandy, the Department of Environmental Protection (DEP) undertook an effort to understand the impact of the storm on sites that store hazardous substances. This effort was in accordance with Local Law 26 of 1988, more commonly known as the NYC Right-to-Know Law. This law generally requires businesses that store specified quantities of hazardous substances to report the presence of these substances to DEP, in order to enable monitoring—including in the event of extreme weather.

In the wake of Hurricane Sandy, DEP determined that there were 367 facilities that had, in recent years, filed reports under Local Law 26 and that were located within areas impacted by the storm. According to DEP's field research, out of these 367 facilities, 263 reported no impacts whatsoever from Sandy. Meanwhile, 46 facilities, were severely affected by Sandy, but reported no spills and showed no evidence of spills. Another 40 facilities, upon inspection by DEP proved to have closed or relocated. Of the remaining 18 facilities inspected by DEP, 11 facilities reported spills but had conducted clean-ups prior to inspection, and seven were completely washed out by the storm.

With this information in-hand, DEP conducted extensive inspections of the impacted sites. These inspections did not indicate the presence of any spilled chemicals regulated by DEP at any of the applicable sites. Though the lack of evidence of contamination may indicate that the impacted businesses had secured these chemicals sufficiently prior to Sandy or adequately remediated their sites post-storm, it also may reflect the particular reality of Sandy, as the high volume of water may have diluted and washed away any spills that occurred.

For sites that continue to host industrial businesses involving hazardous substances—whether open or enclosed—continued identification and monitoring remain critical in anticipation and in the wake of extreme weather. That is why DEP continues to work closely with the City's Office of Emergency Management, ensuring, for example, that its list of vulnerable facilities takes into account the floodplain identified in the most recently produced Federal Emergency Management Agency (FEMA) maps. The City also is continuing to identify ways for these important employers to protect their business, their employees, and their neighbors.

As important as the monitoring of active industrial sites is, another significant challenge faced by the City is how to deal with the many previously industrial sites located throughout the five boroughs that have ceased to be used for such purposes, but nonetheless remain encumbered by the hazardous remnants of their industrial past. These so-called "brownfields" present risks to adjacent communities, but they also represent an opportunity—for new development and new employment. That is why the 2007 PlaNYC report set a goal of cleaning up all contaminated land in New York City.

As an outgrowth of that report—and with that goal in focus—the City created the Mayor's Office of Environmental Remediation (OER) to coordinate public and private efforts, including those targeting the many brownfields located

Mayor Bloomberg announcing new brownfield project

Credit: NYC Mayor's Office

along or near the waterfront. For example, in 2011, OER initiated the New York City Brownfield Cleanup Program (BCP) to help landowners and developers clean up contaminated property and facilitate redevelopment of these abandoned properties. The first municipal brownfield cleanup program in the nation, the BCP ensures that brownfield sites with light-to-moderate levels of contamination are properly cleaned, thus spurring neighborhood revitalization, job creation, and an increase in local amenities. In administering the BCP, OER utilizes NYS Department of Environmental Conservation (NYSDEC) standards, achieving high-quality remediation that involves removal of highly concentrated pollutants and placement of thick and often hardened layers of clean materials on the surface of remediated brownfield sites. Upon successful completion of cleanup in the BCP, program participants receive liability protection against future environmental enforcement on the property, providing lenders and occupants with assurances that these properties have been cleaned up under government oversight to a standard that is protective of human health and the environment.

Another program established by OER is the NYC Brownfield Incentive Grant (BIG) program, which provides funding for brownfield investigation and cleanup, including grants to community brownfield planners under the Brownfield Opportunity Area (BOA) program, and special grants and resources to facilitate nonprofit and local community development on brownfields. OER also has developed the Searchable Property Environmental Electronic Database (SPEED), a one-of-a-kind GIS-based web application designed to facilitate property environmental research.

Since its inception in 2011, the BCP and associated OER programs have proven to be strong drivers of remediation that have made the environment cleaner and spurred economic activity. The BCP has enrolled and approved for cleanup over 95 projects—including 70 percent in historically disadvantaged communities—representing approximately $3 billion in new investment in over 8 million square feet of new development. This new investment is expected to generate over 3,100 permanent jobs, over 8,000 construction jobs and approximately $600 million in new City tax revenues over the next 30 years—all as a result of just the first two years of operation of the BCP. *(See map: Brownfield Cleanup Program Sites; see chart: New Development Resulting from Brownfield Cleanup Program)*

In the first 48 hours after Sandy, OER undertook inspections of over 80 brownfield cleanup projects in inundated areas. These inspections indicated that the cleanup methods promoted by OER had proven very effective in preventing pollutant release from brownfield sites and associated impacts in surrounding communities. These findings, supplemented by outreach to the scientific community and inspection of almost 25 miles of waterfront in different parts of the city, strongly support the efficacy of existing cleanup approaches and suggest that the most important thing the City can do to make its brownfield sites more resilient to the effects of future climate change is to accelerate the pace of brownfield cleanup in the floodplain. These findings also support the development of several improvements in remedial procedures that can make these sites even more resilient, including development of extreme weather preparedness plans and adoption of brownfield resiliency best management practices.

To protect operating open and enclosed industrial sites with hazardous substances in an economically feasible way, and to encourage the remediation and redevelopment of brownfields in a resilient fashion, the City will pursue the following initiatives:

Initiative 1

Identify cost-effective measures to safeguard exposed substances in the 100-year floodplain

Given the large number of open industrial properties in the 100-year floodplain as

Brownfield Cleanup Program Sites

Source: NYC Mayor's Office of Environmental Remediation

Brownfield site after Sandy

Credit: NYC Mayor's Office of Environmental Remediation

delineated by FEMA, it is important to minimize the negative effects these uses have on adjacent properties, residents, and water bodies. To this end, the City will complete the Open Industrial Uses Study. The study, led by the Department of City Planning (DCP) in cooperation with DEP and the New York City Economic Development Corporation, will generate recommendations by the end of 2013 for zoning text amendments or other legislation, and assess incentives that may assist in the implementation of such controls. Recommendations for cost-effective measures will seek to improve the business climate and natural environment in industrial areas, retain important industrial businesses, and foster new businesses and jobs in areas near open industrial uses. The study, and subsequent actions to implement recommendations, will support the working waterfront and protect communities while making industrial areas stronger, safer, and more resilient to climate change.

Develop a catalogue of best practices for storing enclosed hazardous substances in the 100-year floodplain

Without the appropriate precautions, even enclosed hazardous substances in the city's 100-year floodplain could be disturbed by storm surge, resulting in undesirable impacts. As a complement to the preceding study on open industrial uses, the City, subject to available funding, will develop a catalogue of cost-effective best practices for the prevention of contamination caused by the storage of hazardous substances in the floodplain. The development of the catalogue will include outreach to community groups and businesses. Federal funding may be available to implement best practices in certain instances through the City's Business Resiliency Investment Program, funded by Community Development Block Grants. The development of these best practices will help vulnerable businesses to protect themselves through a variety of preapproved measures, including resiliency investments, which will seek to protect adjacent communities from hazardous substances that otherwise could be released. The goal is for the Mayor's Office of Long-Term Planning and Sustainability to begin the process of developing the catalogue of best practices in 2013, with participation by other City agencies.

Accelerate brownfield cleanup in the 100-year floodplain to prevent release of pollutants

Brownfields pose potential risks to surrounding areas during coastal storms, as the pollutants embedded in these sites may be released and redistributed by floodwaters. Subject to available funding, the City will expand its existing BIG cleanup program to provide bonus grants to accelerate cleanup of brownfields in the floodplain in order to mitigate the impact of extreme weather events. In the next two years, this program is expected to provide bonus grants for approximately 30 BCP sites located in the 100-year floodplain. In addition, the City will focus its use of existing State and Federal brownfield grants toward the study and cleanup of brownfields that can become parks and open spaces in the floodplain.

These grants will help to fund remedial actions that will remove concentrated pollutants and cap sites with thick or hardened clean surface layers, reducing contamination risks and providing more open space for storm surge dissipation. By focusing on shovel-ready cleanup and development projects, the program will help jump-start near-term economic recovery in waterfront neighborhoods—including investment in approximately 2.4 million square feet of development. The goal is to launch the expanded program in 2013.

Explore strengthened cleanup standards on industrial waterfront brownfields

Existing State brownfield soil cleanup standards are more lenient for sites that are to remain industrial than those for which other uses are contemplated. Where these industrial properties are located in waterfront areas that are vulnerable to erosion from future storm surges, these standards may not provide sufficient protection for surrounding communities. The City will examine the existing soil cleanup standards for industrial waterfront sites and evaluate whether such protections can be strengthened in a way that also is financially feasible for industrial development.

Launch brownfield climate change resiliency audits and improve storm preparedness

Brownfield developers can make significant progress towards improving the climate change resiliency of remediated land and the new buildings constructed on them by adopting simple best management practices during the project planning stage. However, many developers do not yet understand these practices. The City will establish a pilot program to provide free reviews of brownfield cleanup and development plans by a resiliency expert and will provide developers with a report of best management practices that could be implemented to improve the resiliency of their projects. These assessments, called Brownfield Climate Change Resiliency Audits, will be conducted by City contractors and will be provided free of charge. OER also is performing brownfield storm preparedness training for the

environmental and development industry. Going forward, OER will require an extreme storm contingency plan in every brownfield cleanup plan it approves. Developers also will have access to pro bono brownfield resiliency consultations with local industry experts through a program developed by OER and the nonprofit NYC Brownfield Partnership. OER will begin audits immediately and will publish a report of findings by the end of 2013. Subject to available funding, OER will continue and expand this program in 2014.

Initiative 6

Launch full operation of the NYC Clean Soil Bank

After remedial action is completed at brownfield sites, it is common for developers to continue excavations deep into clean native soils in order to make room for basements or underground parking garages. Developers typically are not able to use this clean soil and must pay to have it removed. At the same time, at other locations, such as City-sponsored construction sites, clean soil is needed and must be purchased at substantial cost. With approval from NYSDEC now in hand, the City will establish full operation of the NYC Clean Soil Bank, a landmark recycling program for clean native soil from deep development excavations on remediated brownfield sites, which will allow this soil to be reused, free of charge, on city construction projects or brownfield properties. This soil may be used for projects such as the elevation of grades or the creation of natural barriers to mitigate the impacts of sea level rise and storm surge. OER will launch this program in 2013.

Initiative 7

Perform update of SPEED, the City's online environmental research engine

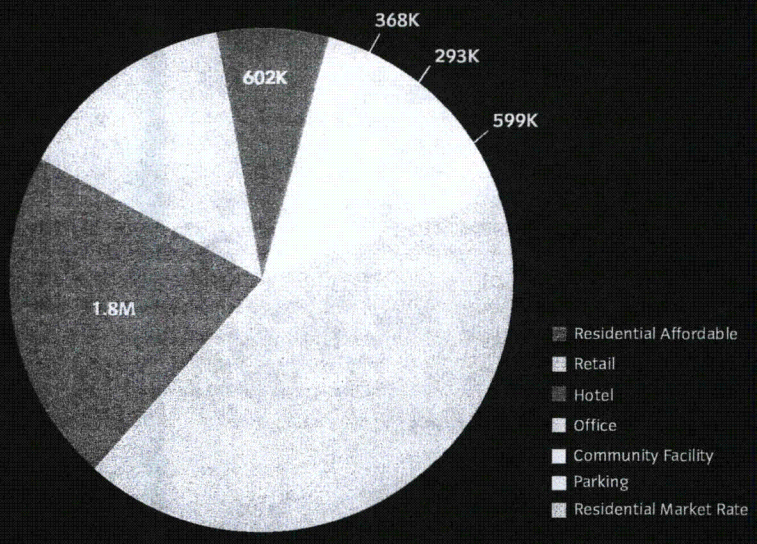
The SPEED application described previously, though useful, lacks certain information that would help inform resiliency strategies, including information from the latest FEMA flood maps. Subject to available funding, the City will expand the information available in SPEED to enable climate change resiliency analyses, and to improve the efficacy of its use before, during, and after future extreme weather. Using an existing State grant, OER also will establish an innovative application for use by community brownfield planners working to improve local brownfield cleanup, development, and resiliency efforts. The goal is to complete an update to the SPEED database by the end of 2013.

Brownfield cleanup site

Credit: NYC Mayor's Office of Environmental Remediation

New Development Resulting from Brownfield Cleanup Program

Square Feet, as of April 2013



Total = 8.3M Square Feet

Source: NYC Mayor's Office of Environmental Remediation

Paerdegat Basin, Jamaica Bay

Credit: Mylan Cannon/Th

Newtown Creek Wastewater Treatment Plant in Greenpoint, Brooklyn Credit: DEP

New York's water and wastewater system is an engineering marvel of massive scale. Every drop of water that comes out of the city's taps has traveled through a complex network of aqueducts and tunnels, some dating back more than 150 years, from sources that extend more than 125 miles from the city and across a 2,000-square-mile watershed. Water that enters the city's drains is conveyed through 7,500 miles of sewers and returned to New York City waterways.

With more than 8 million residents and many more daily commuters and visitors in New York City, merely ensuring that they all have the essentials—including uninterrupted water and wastewater services—requires a constant choreography that is as complex as it is invisible to its users. Whether turning on a tap to get a drink, running a bath, watering a lawn, flushing a toilet, or fighting a fire, New Yorkers rightly expect their water and wastewater system to work for them—all the time, no matter the conditions.

But the Department of Environmental Protection (DEP) and the water and wastewater system it manages accomplish much more than just supplying the essentials. DEP does not just provide drinking water; it provides clean, mostly unfiltered water from distant, carefully protected and managed watersheds—thereby eliminating the need for billions of dollars in filtration plant investments that would otherwise be required. DEP does not just carry and treat wastewater; it helps to protect a harbor and waterways that are cleaner than they have been in over a century.

Moreover, DEP's system is able to function even under extraordinary conditions. In the wake of storms that cause disruptions to one or several of its reservoirs, system operators are able to draw from other parts of the system, thereby maintaining an uninterrupted flow. While on average, New York's wastewater facilities treat about 1.3 billion gallons of wastewater per day, on a wet day they can treat twice as much as they do on a dry day.

Of course, even a system as effective as this one has its limits. Sandy, though it was not a significant rain event, came with a surge that affected some of DEP's assets in low-lying areas, knocking out electrical grid power and critical equipment at key wastewater facilities located along the waterfront. As a result, DEP resorted to its onsite and portable backup power systems and mobilized portable pumps.

As Sandy demonstrated, the city's water and wastewater system has vulnerabilities to extreme weather that must be addressed, particularly as climate change increases the likelihood of storm surges and heavy rains that can result in overflow of untreated sewage into the city's waterways. To prepare for the future, DEP began implementing climate change resiliency measures early, in 2008, when it issued the Climate Change Assessment and Action Plan. Prior to Sandy, DEP was already in the process of performing a detailed climate change study for representative wastewater treatment plants, pumping stations, and drainage areas to determine the potential likelihood and severity of various risks, including storm surge. After Sandy, DEP expanded that study to include all of its wastewater infrastructure across the city to systematically determine risks and resiliency measures to help prevent future disruptions.

Beyond this, DEP invests billions of dollars—from revenues generated by the water and sewer assessment charged to every New York building—to upgrade and maintain the system, thereby safeguarding efficient performance during all conditions.

However, some extreme weather events are likely to become more severe and, in some cases, more frequent. In keeping with the goals of this report, where possible and reasonable, the City will work to mitigate the impacts of climate change to the water and wastewater system. Meanwhile, for those times when impacts do occur, the City will enable rapid recovery by building resiliency into this system. To that end, the City will protect wastewater treatment facilities from storm surge, improve and expand drainage infrastructure, and invest in projects that increase the redundancy and flexibility of the water supply system.

How The Water and Wastewater System Works

DEP manages a complex system that begins with reservoirs located over 125 miles away from the city and ends at the city's 14 wastewater treatment plants with the release of treated effluent into New York Harbor. Although the system is integrated, it is best explained by separating it into two primary components: the city's water supply and distribution system, and its collections and treatment system. (*See chart: The Water and Wastewater System in New York City*)

Water Supply and Distribution

The New York City water supply system provides drinking water to almost half the population of the State of New York—8 million people in New York City and 1 million people in Westchester, Putnam, Orange, and Ulster Counties—plus the tens of millions of commuters and tourists who visit the city throughout the year. Overall, the system has a total storage capacity of 580 billion gallons, and consumption is more than 1 billion gallons each day.

The Croton watershed was the city's first Upstate water supply and is located entirely east of the Hudson River in Westchester, Putnam, and Dutchess Counties, with a small portion in the State of Connecticut. Historically, 10 percent of the city's average daily water demand has been provided by the Croton system, although in times of drought, it may supply significantly more water. As of the writing of this report, the system is offline temporarily while the City constructs a water treatment plant to filter the Croton water supply. Once completed, Croton water will be filtered and disinfected before flowing into Jerome Park Reservoir in the Bronx.

The Catskill system consists of two reservoirs—Schoharie and Ashokan—located west of the Hudson River in Ulster, Schoharie, Delaware, and Greene Counties. Water leaves Schoharie Reservoir via the 18-mile Shandaken Tunnel, which empties into the Esopus Creek and then travels 22 miles through the Esopus to Ashokan Reservoir. Water leaves Ashokan Reservoir via the 75-mile-long Catskill Aqueduct, which travels to Kensico Reservoir in Westchester County. The Catskill system provides, on average, 40 percent of the city's daily water supply.

The Delaware system consists of four reservoirs west of the Hudson River: Cannonsville, Pepacton, and Neversink in the Delaware River basin, and Rondout in the Hudson River basin. The outflow from the first three reservoirs arrives in Rondout via three separate tunnels. Water then leaves Rondout and travels to West Branch Reservoir in Putnam County via the 90-mile Rondout/West Branch Tunnel. Water from West Branch subsequently flows through the Delaware Aqueduct to Kensico Reservoir. The Delaware system provides, on average, 50 percent of the city's daily demand.

Because waters from the Catskill and Delaware watersheds mix at Kensico Reservoir, they are frequently referred to as one system: the Catskill/ Delaware system. DEP has completed construction of an Ultraviolet Disinfection Facility to improve and ensure high-quality water for the Catskill/ Delaware system. This facility provides secondary disinfection for Catskill and Delaware water before it flows to Hillview Reservoir in Yonkers.

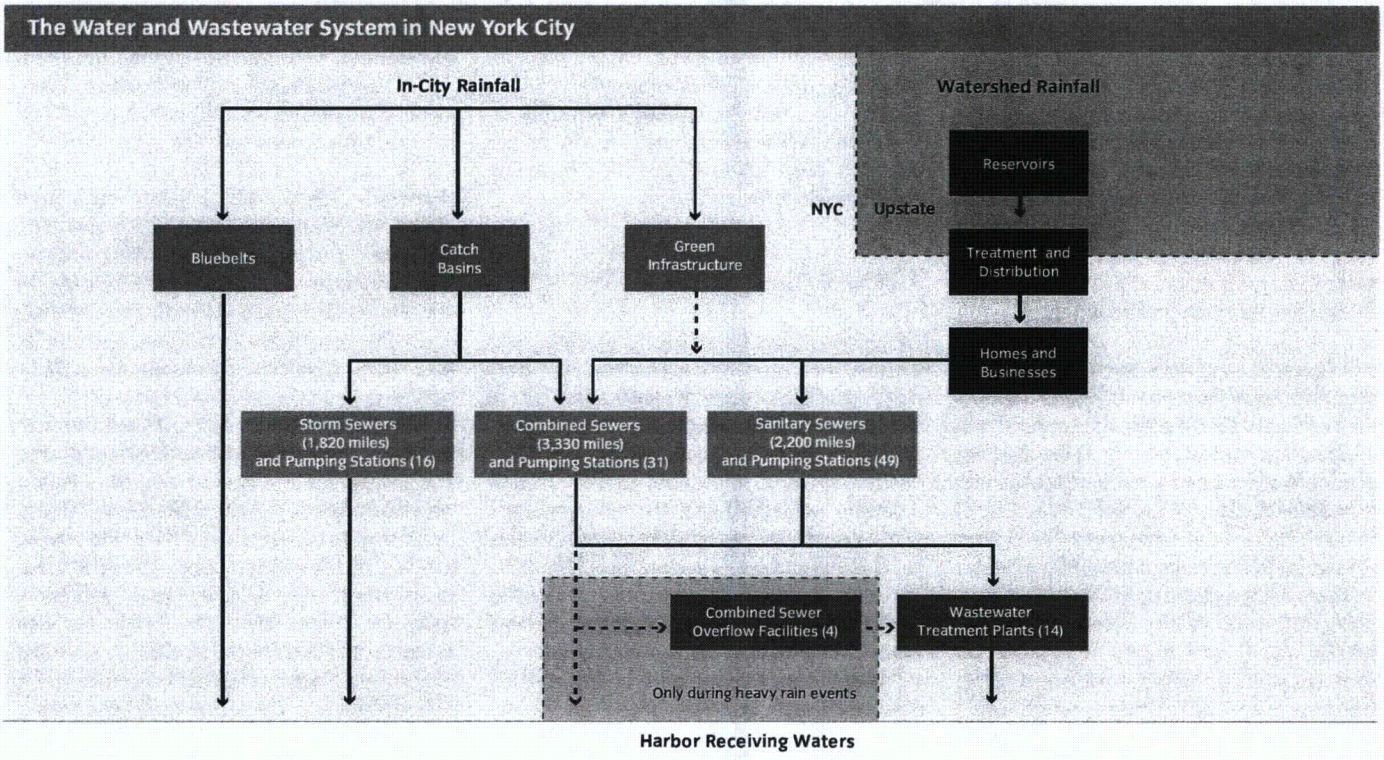
Water is distributed from Hillview Reservoir and Jerome Park Reservoir to end users throughout the city via more than 7,000 miles of water mains and pipes at pressures that, in most cases, only require privately owned electric pumps for buildings taller than six stories. The 7,000 miles of water mains and pipes that distribute water throughout the five boroughs are buried and pressurized, preventing water from infiltrating. Furthermore, there is necessary redundancy built into the system so that water supply can be diverted to different pipes within the system to ensure the constant flow of water.

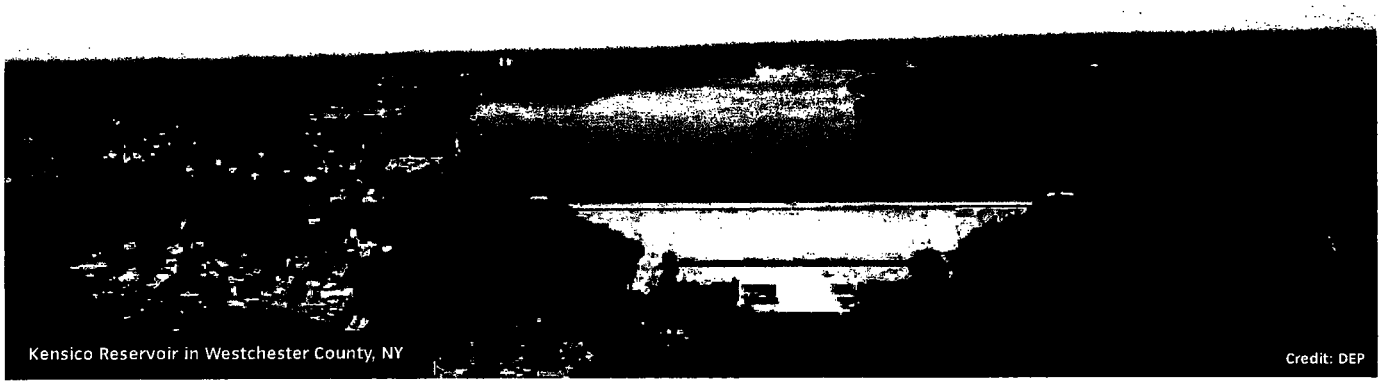
Despite this flexibility, the water supply remains vulnerable to heavy rain events. The events of the summer of 2011 illustrate this vulnerability. In late August, Hurricane Irene arrived in the Northeast, bringing with it wind and heavy rain. Although Irene weakened to a tropical storm as it moved over New York City, it nonetheless brought torrential rains, particularly Upstate, which saw more than 16 inches fall in parts of the Catskill System, and up to 10 inches in a 12-hour period in many other areas of the watershed. Twenty-three US Geological Survey stream gauges in the Catskill and Delaware watersheds recorded new maximum flow readings, and the flooding caused catastrophic damage to watershed communities, washing out many roads and bridges, damaging many homes, and causing widespread power outages. DEP responded to the resulting elevated levels of turbidity (murkiness resulting from stirred sediment) in reservoirs through various operational measures, including daily treatment and reduction of the flow of water from the Catskill system.

Just 10 days later, Tropical Storm Lee affected the same area, bringing with it more heavy rain and further affecting water quality conditions in several reservoirs. Once again, DEP responded with operational measures and maintained an adequate supply of high-quality drinking water for the city. The combination of two heavy rain events in a 10-day period led to unprecedented operational measures—including a record 260-day treatment regime for the Catskill system.

Wastewater Collection and Treatment

Every day, the City treats 1.3 billion gallons of wastewater and helps restore and maintain water quality in New York Harbor. Although the city uses a sanitary sewer system that carries only sewage, it, like other older urban centers, largely is served by a combined sewer system where stormwater and sanitary waste are carried through a single pipe. Stormwater enters the collections and treatment system from catch basins that direct flow to the city's sewer system. Sanitary waste enters the sewer system through direct connections from buildings. From there, wastewater flows by gravity through sewers, about 60 percent of which are combined sewers. In low-lying areas, the city has 96 pumping stations that lift wastewater and stormwater to a higher elevation and help continue its journey.





Kensico Reservoir in Westchester County, NY

Credit: DEP

The combined sewer and sanitary sewer systems convey wastewater to the City's 14 wastewater treatment plants. At these plants, wastewater undergoes five major processes: preliminary treatment; primary treatment; secondary treatment; disinfection; and, finally, sludge treatment. Preliminary treatment screens debris and litter to protect the main sewage pumps and other equipment. The main sewage pumps then lift the wastewater to the surface level for primary and secondary treatment. Primary and secondary treatments remove on average between 85 and 95 percent of all pollutants from wastewater (up to 40 percent removed in primary treatment and up to another 60 percent in secondary treatment). Once the treated water is disinfected, it is returned to the city's waterways. Meanwhile, the remaining sludge is treated, with the resulting material, known as biosolids, frequently shipped elsewhere for disposal in landfills, or for use as compost or fertilizer.

All of the city's 14 wastewater treatment plants are located along the waterfront at relatively low elevations. Waterfront locations significantly reduce the cost and environmental impact of treating wastewater in New York City, making it easier for flow to arrive by gravity and providing nearby waterways to discharge treated effluent. Secondarily, but also importantly, the waterfront location further allows sludge to be transported efficiently by boat to DEP facilities for additional treatment.

Under normal conditions, system capacity is adequate to perform full treatment for the combined volume of sewage. During periods of rainfall when flow exceeds two times dry weather capacity, the combined volume of sewage and stormwater quickly can exceed the capacity of the wastewater treatment plants. The system is designed to discharge a mix of stormwater and wastewater—called combined sewer overflow or CSO—into nearby waterways to drain the city quickly and prevent the biological processes at the wastewater treatment plants from becoming compromised, which could lead to extended service outages.

In response to these CSO events, the City has invested billions of dollars. Recently, however, the City restructured its approach to implement innovative strategies to absorb rain before it can enter sewers, and, in the process, create systems of greenery that shade and beautify the city. In September 2010, Mayor Bloomberg launched the NYC Green Infrastructure Plan, a comprehensive 20-year effort to meet water quality standards, and in March 2012, the plan was incorporated into a consent order with the State that will eliminate or defer $3.4 billion in traditional investments and result in approximately 1.5 billion gallons of CSO reductions annually by 2030.

The City's Bluebelt program complements its Green Infrastructure program. Bluebelts are natural areas that often enhance existing drainage corridors (such as streams, ponds, and other wetland areas) and convey, treat, and retain stormwater in place of traditional "grey" infrastructure. Bluebelts engineer these natural elements to slow the flow of water and use vegetation and other elements to absorb and filter impurities. DEP's Bluebelt program started in Staten Island (with almost 10,000 acres now in place) and is now expanding in Staten Island and into other parts of the city, including Southeast Queens.

What Happened During Sandy

While Sandy's impact on the water supply was minimal, impacts on the wastewater system were more significant—predominantly as a result of storm surge and the loss of electrical power.

Sandy passed to the south of the Catskill/Delaware watershed and, therefore, brought minimal rainfall and did not affect the city's water supply substantially. All of New York City's drinking water treatment and distribution facilities remained operational and supplied potable water throughout the storm. Kensico Reservoir in Westchester County, part of the Catskill/Delaware System, did experience a spike in turbidity. The turbidity at Kensico was the result of high winds that caused erosion on the reservoir's edge, sending natural materials into the reservoir. However, DEP was able to adjust water supply operations at Kensico so that water supply distribution and quality in the city were not affected. The city's robust water quality testing system, which takes more than 500,000 samples per year, sampled locations in the watershed and nearly 1,000 stations across the five boroughs during and after Sandy, and confirmed water quality.

Although the system fared well overall and drinking water remained safe during Sandy, there were some localized impacts on water supply. Many high-rise buildings throughout the city were unable to pump water to residents on upper floors due to the loss of power to their pumping systems. Meanwhile, in Breezy Point, a private community on the Rockaway Peninsula in Queens, fires caused significant disruption to the neighborhood's private water distribution system, which draws its supply from City-owned mains. Finally, while some City-owned water main breaks were reported, there was no significant spike citywide, and in these individual cases it took DEP an average of five hours to restore water service.

However, Sandy did impact the city's wastewater treatment plants, which are along the waterfront and at low elevations, and are thus particularly vulnerable to storm surge. To address these impacts, DEP worked tirelessly to ensure that the system would perform its core functions without significant disruption.

During Sandy, 10 of DEP's 14 wastewater treatment plants were damaged or lost power, and released untreated or partially treated wastewater into local waterways. Three of these facilities were non-operational for some time as a result of the storm: Coney Island for two hours, North River for seven hours, and Rockaway for three days. The other facilities maintained at least partial treatment, including removal of pollutants and disinfection of effluent before water from these plants was discharged into waterways. Although, collectively,

wastewater treatment plants operated at more than twice their normal flow rate at the height of the storm, approximately 560 million gallons of untreated sewage mixed with stormwater and seawater was released into local waterways, equivalent to approximately half a day's worth of normal wastewater treatment. *(See chart: Volume of Wastewater Treated During Sandy)*

Most of the damage to wastewater facilities involved electrical systems and equipment, including substations, motors, control panels, junction boxes, and instrumentation. Sandy's floodwaters inundated the lower levels of facilities, where much of this equipment is located. Even where electrical systems were not damaged during Sandy, utility power outages forced many facilities to operate on emergency generators for up to two weeks.

Where shutdowns occurred, DEP worked quickly to mitigate impacts. For example, the Rockaway Wastewater Treatment Plant (WWTP), which treats approximately 1 percent of the city's wastewater, suffered severe flooding—as did the upstream sewers and the surrounding community—and was shut down during and immediately after the storm; just three days later it was providing partial treatment, and two weeks later, it was fully back online.

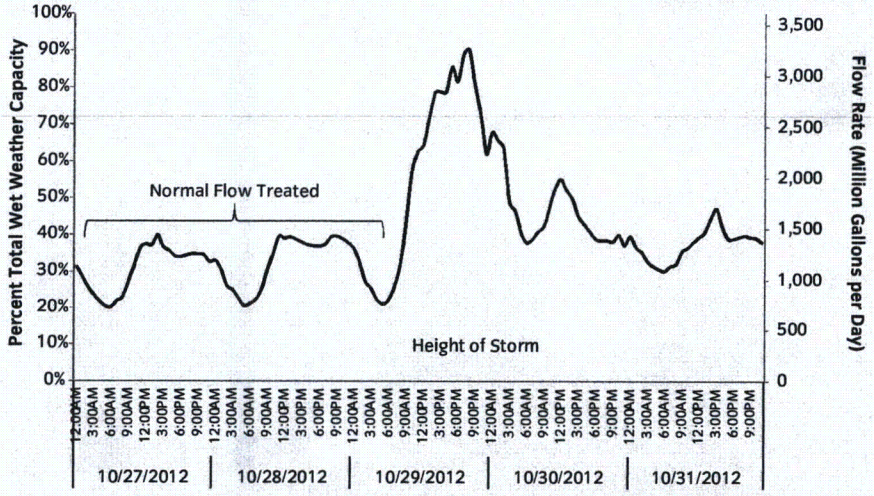
Many of DEP's wastewater treatment plants, however, performed well throughout the storm. For example, the Oakwood Beach plant in Staten Island was able to treat 80 million gallons of wastewater during the storm—twice its normal level—despite being surrounded by Sandy's surge and incurring some damage. This performance is attributable at least in part to the elevation of critical systems during a facility upgrade that took place more than three decades ago—and the dedication of the workers who stayed and continued operations even while the plant was surrounded by water.

In addition to affecting treatment facilities, Sandy also affected pumping stations. Forty-two of 96 such stations were damaged or lost power. Power outages were responsible for roughly half of the impacts, with storm surge inundation responsible for the other half—primarily in coastal communities in Staten Island, Brooklyn, and Queens. At inundated pumping stations, many of which are underground, recovery required not just pumping floodwaters out of the stations, but also repairing damage caused by the corrosive impact of seawater on electrical equipment. *(See map: Pumping Stations Affected By Sandy)*

Thanks to an immediate response by DEP employees, most affected treatment plants and pumping stations were running again shortly after Sandy's floodwaters receded. Within four days of Sandy, 13 of 14 wastewater treatment plants and most pumping stations were fully operational, treating 99 percent of New York City's wastewater.

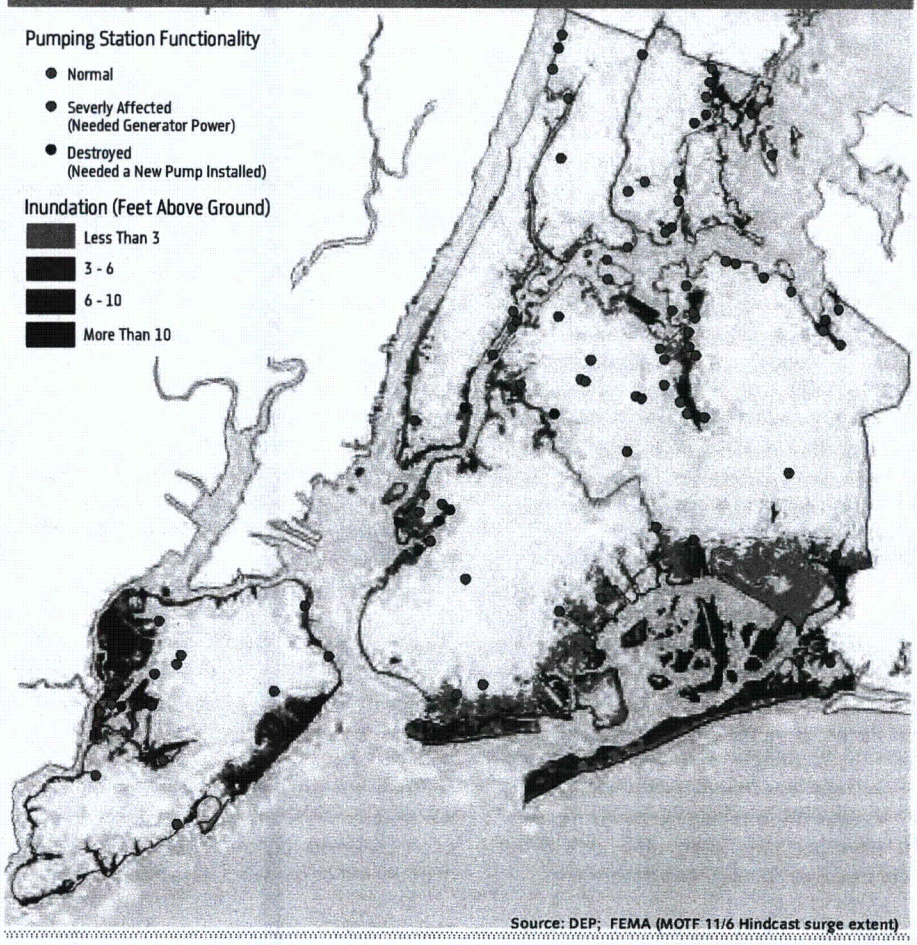
Despite the rapid response, Sandy's surge led to the release of wastewater into New York's waterways. As DEP reported, approximately 560 million gallons of untreated combined sewage, stormwater, and seawater from

Volume of Wastewater Treated During Sandy



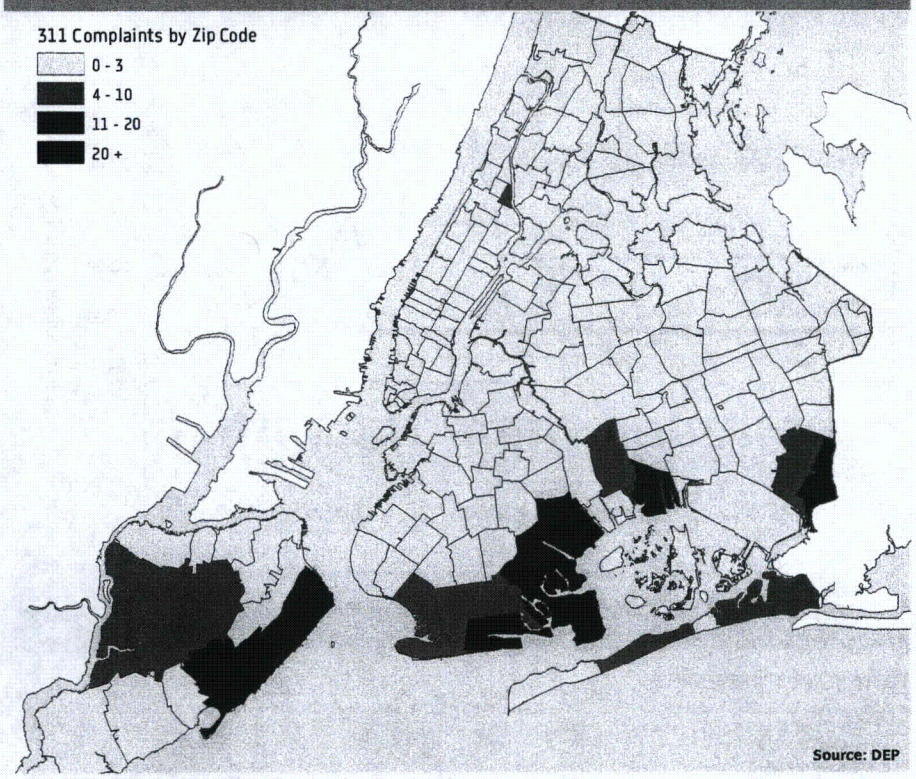
Source: DEP

Pumping Stations Affected By Sandy



Source: DEP; FEMA (MOTF 11/6 Hindcast surge extent)

Confirmed Sewer Backup and Street Flooding Complaints Oct. 30 - Nov. 1, 2012



sewers, and another approximately 800 million gallons of partially treated and disinfected wastewater, were released into waterways. After Sandy, DEP collected samples of water quality throughout the harbor. Data from these samples showed that water quality in New York Harbor was not affected significantly by the storm. Some localized and limited exceptions were attributable, at least in part, to damage at wastewater treatment facilities in other regional municipalities outside of DEP's jurisdiction. These third-party impacts were concentrated in waterways near Raritan Bay and the Narrows.

Part of the reason that Sandy's impact on water quality was so limited was likely Sandy itself. The same high volume of seawater that affected some DEP assets also helped to dilute the discharge of untreated or partially-treated sewage. Nonetheless, as a precautionary measure, two days after Sandy, the City issued a recreational water body advisory for the Hudson and East Rivers, New York Harbor, Jamaica Bay, and the Kill Van Kull. The advisory remained in place for 30 days and was lifted after DEP testing confirmed that the waterways were safe.

Another impact of Sandy was sewer backups, which occurred in some coastal areas. Sandy's surge inundated properties and the sewer system through catch basins, manholes, and storm drains in the streets. While ultimately, the city's drainage systems helped to drain floodwater after the storm surge receded, the surge also deposited sand and debris in and around drainage systems, which slowed the drainage process. Recorded complaints for sewer backups and flooding, received through the City's 311 service, were concentrated in highly developed areas near the waterfront. DEP inspected the areas of all recorded complaints and performed any necessary work. DEP crews cleaned more than 3,500 catch basins and flushed more than 190,000 linear feet of sewer lines in the three weeks following the storm, and accompanied other City agencies in additional cleanup efforts. *(See map: Confirmed Sewer Backup and Street Flooding Complaints Oct. 30 - Nov. 1, 2012)*

What Could Happen in the Future

The greatest climate change-related risk to the city's water supply is runoff from heavy downpours affecting water quality in reservoirs. By contrast, the greatest risk faced by the city's wastewater system is storm surge inundation of critical assets, potentially leading to release of untreated or partially treated wastewater.

Major Risks

Heavy downpours pose a significant risk to the city's water supply system. They produce increased runoff, which causes high pathogen and contaminant levels in reservoirs, increases turbidity due to the underlying geology of land near the reservoirs, and affects the drinking water disinfection process. These conditions are particularly challenging if extreme rainfall events happen one right after another, before the impacts of a previous event have been controlled fully. This vulnerability of the water system, particularly the Catskill system, is expected to be tested with greater frequency through the 2050s with increases in heavy downpours in the New York region.

Storm surge, on the other hand, poses a major risk for the city's wastewater treatment plants and pumping stations, as Sandy demonstrated. Floodwaters from the surge can damage equipment and disrupt the power supply at these facilities; consequently, partially treated or untreated sewage can spill into waterways around New York City.

This vulnerability only will increase as the climate changes. Given their waterfront locations, according to a recent DEP study, by the 2050s, all of the city's 14 wastewater treatment plants will have at least some of their equipment located below the Base Flood Elevation (BFE), or the height to which floodwaters are expected to rise during a "100-year flood" (a flood with a 1 percent or greater chance of occurring in any given year). As sea levels rise, expected flood heights will also increase, putting a greater percentage of treatment facility equipment at risk of flooding and increasing the likelihood that surge from a coastal storm would disrupt or even shut down DEP facilities. The percentage of critical equipment that is estimated to be below expected flood heights, based on New York City Panel on Climate Change "high end" sea level rise projections for the 2050s, varies by facility from as little as less than 1 percent at Jamaica WWTP to potentially as much as 70 percent at Hunts Point WWTP.

Meanwhile, of the city's 96 pumping stations, 37 are located in the 100-year floodplain indicated in the Federal Emergency Management Agency (FEMA) 2013 Preliminary Work Maps. That number is expected to grow over time—to 48 by the 2020s and 58 by the 2050s. *(See sidebar: Reducing Flood Risk to Key Wastewater Infrastructure)*

Other Risks

The city's wastewater system is also at risk from gradual sea level rise—without storm surge. Sea level rise itself may cause flow to back up during heavy rain and limit the ability of some wastewater treatment plants to operate at full capacity, leading to CSO events and release of partially treated sewage into area waterways.

Increased precipitation and heavy downpours alone, regardless of sea levels, also could lead to CSO events. Furthermore, heavy downpours can overwhelm the sewer system and cause

Scale of Impact

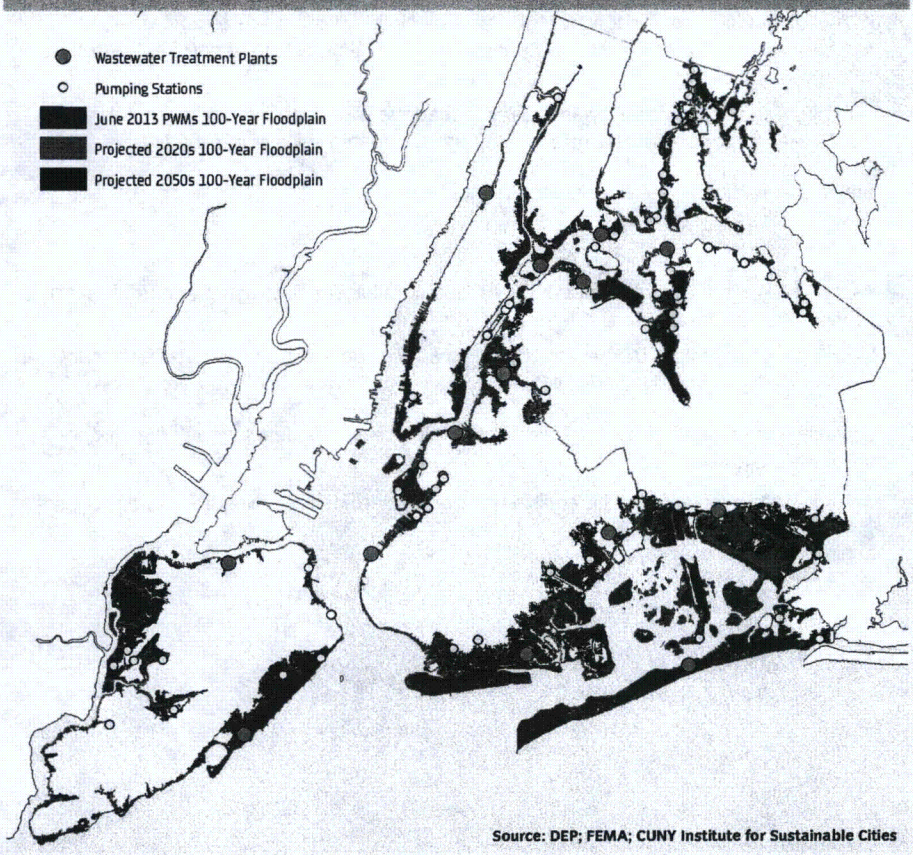
Hazard	Today	2020s	2050s	Comments
Gradual				
Sea level rise				At higher water levels, wastewater treatment plants may not be able to operate at full capacity during heavy rain events, leading to releases of untreated or partially treated sewage into waterways
Increased precipitation				Combined sewage and stormwater could exceed the capacity of wastewater treatment plants, leading to releases of untreated or partially treated sewage into waterways
Higher average temperature				Minimal impact
Extreme Events				
Storm surge				Asset damage and power disruption could lead to releases of untreated or partially treated sewage into waterways
Heavy downpour				Combined sewage and stormwater could exceed the capacity of wastewater treatment plants, leading to releases of untreated or partially treated sewage into waterways Sewer system capacity may be exceeded more frequently, leading to street flooding and sewer backups
Heat wave				INDIRECT: Utility power outages could lead to reduced treatment levels and sewage bypass
High winds				Minimal impact

Scale of Impact

Hazard	Today	2020s	2050s	Comments
Gradual				
Sea level rise				Minimal Impact
Increased precipitation				Increased turbidity, pathogen, and contaminant levels could require treatment and challenge disinfection process
Higher average temperature				Reduced snowpack, drought, and higher demand could stress water supply Increased algae growth could affect water color and taste and challenge the disinfection process
Extreme Events				
Storm surge				Minimal Impact
Heavy downpour				Increased turbidity, pathogen, and contaminant levels could require treatment and challenge disinfection process
Heat wave				Reduced snowpack, drought, and higher demand could stress water supply Increased algae growth could affect water color and taste and challenge the disinfection process
High winds				Minimal impact

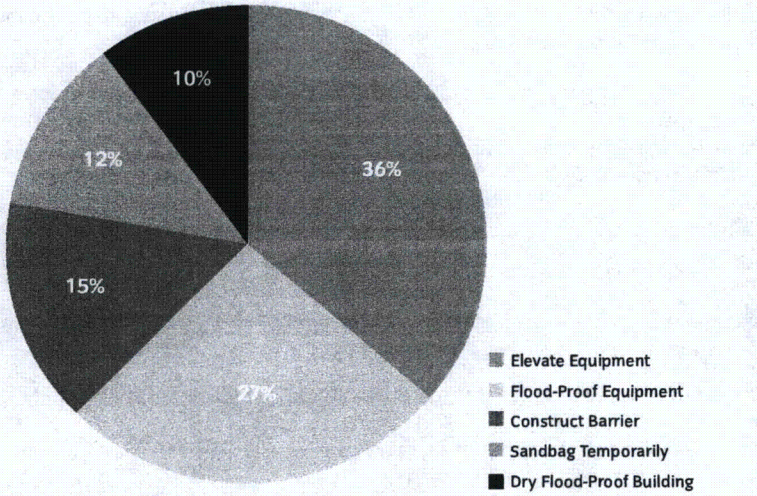
Reducing Flood Risk to Key Wastewater Infrastructure

Wastewater Facilities at Risk of Storm Surge Inundation



Source: DEP; FEMA; CUNY Institute for Sustainable Cities

Recommended Adaptation Strategy Allocations for Wastewater Facilities



Source: DEP

Many of New York City's 14 wastewater treatment plants and 96 pumping stations are susceptible to flood damage from storm surge, as seen during Sandy. With climate change, the vulnerability of these facilities likely will increase in the future. Accordingly, DEP has undertaken a detailed facility risk assessment and adaptation study to identify which wastewater infrastructure is and will be most at risk of flooding during extreme weather events, and to recommend adaptation strategies to address these risks.

To make its determination of vulnerability, DEP undertook site visits, engineering analysess and interviews with facility personnel. Common flood pathways that DEP examined included doorways, outfall pipes, bulkheads, windows, vents, conduits, and facility tunnel systems. Facility assets were determined to be at risk if they fell below expected flood heights based on "high end" sea level rise projections for the 2050s developed by the New York City Panel on Climate Change.

According to the study, all 14 wastewater treatment plants have assets that are at some level of risk. In fact, of the almost 47,700 total assets at these facilities, about 4,000 that are necessary for primary treatment and 10,600 other facility assets were shown to be vulnerable. Meanwhile, 58 of the 96 pumping stations were shown to be vulnerable.

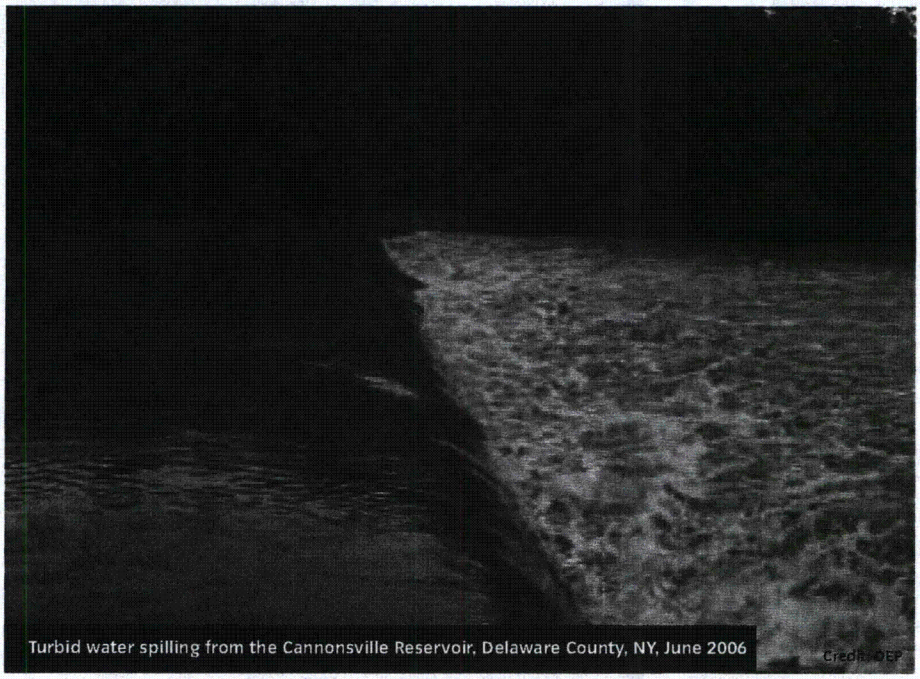
DEP also analyzed a projection of its financial exposure to the aforementioned vulnerability. Again assuming high end sea level rise projections, the City's potential exposure was estimated to be $900 million at wastewater treatment plants and $220 million at pumping stations. This exposure excluded any costs associated with loss of service or environmental impacts. Based on the potential costs alone, DEP has concluded that there is a clear need for a robust set of protective measures.

To determine which protective measures to prioritize, DEP looked at a portfolio of strategies, including dry flood-proofing buildings with watertight windows and doors, elevating equipment, making pumps submersible and protecting electrical equipment with watertight casings, constructing external flood barriers, installing temporary sandbagging, and providing backup power generation to pumping stations (wastewater treatment plants are already so equipped).

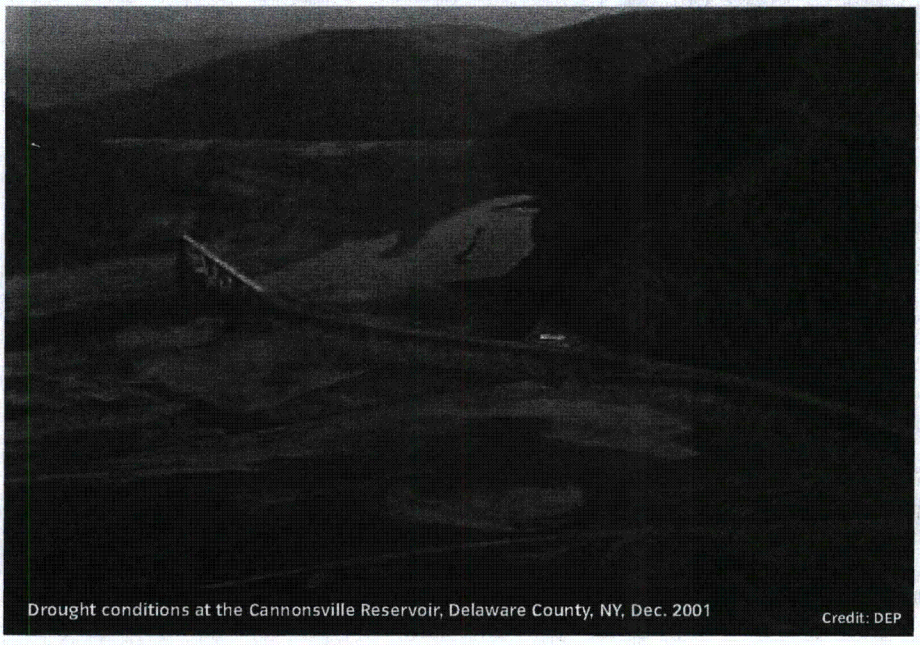
DEP also looked at operational, environmental, social, and financial metrics in deciding how to prioritize its investments. These metrics included historical flooding frequency, proximity to beaches and sensitive water bodies, population served, number of critical facilities such as hospitals affected, and scheduled improvements in DEP's 10-year capital plan.

Based on the foregoing (as well as studies of site feasibility and cost-benefit analyses) a combination of recommended strategies was selected for each facility. Generally, for assets critical to meeting a minimum required level of service, strategies that would result in the highest resiliency levels were selected, while, for other assets, DEP sought to strike a balance between resiliency and return on investment.

The bottom line of the study is that a strategic mix of protective strategies could avoid almost 90 percent of risk citywide to wastewater treatment plants and ensure continuous service at pumping stations. In this way, the study set forth a cost-effective strategy for reducing damage to infrastructure and safeguarding public health.



Turbid water spilling from the Cannonsville Reservoir, Delaware County, NY, June 2006 Credit: DEP



Drought conditions at the Cannonsville Reservoir, Delaware County, NY, Dec. 2001 Credit: DEP

flooding and backups. The city's drainage systems, however, are designed to handle heavy rainfall, with capacity for rainfall intensity of 1.5 inches per hour in most areas of the city, where sewers were built prior to 1960, and 1.75 inches per hour in locations with sewers built after 1960.

While increases in temperature can have an effect on water quality in reservoirs, such as increased algae growth which can lead to changes in water color and taste and challenge the disinfection process, it can also lead to more severe water quantity impacts, including droughts. As of the writing of this report, New York City designates the 1963–1965 drought as the "drought of record," or the city's anticipated worst-case scenario. Though precipitation in the New York City area generally is expected to increase going forward, the City does need to monitor drought patterns, and changes in winter snowpack which may limit the ability of reservoirs to refill sufficiently to meet summer demand.

Finally, potential disruptions to power supply resulting from heat waves are another challenge that the city's water and wastewater systems may face going forward as the climate changes. However, many facilities have backup generators. Wastewater treatment plants, for instance, are required to have backup generators and maintain partial treatment during a blackout or brownout, thereby limiting the net impact of this risk.

This chapter contains a series of initiatives that are designed to mitigate the impacts of climate change on New York's water and wastewater system. In many cases, these initiatives are both ready to proceed and have identified funding sources assigned to cover their costs. With respect to these initiatives, the City intends to proceed with them as quickly as practicable, upon the receipt of identified funding.

Meanwhile, in the case of certain other initiatives described in this chapter, though these initiatives may be ready to proceed, they still do not have specific sources of funding assigned to them. In Chapter 19 (*Funding*), the City describes additional funding sources, which, if secured, would be sufficient to fund the full first phase of projects and programs described in this document over a 10-year period. The City will work aggressively on securing this funding and any necessary third-party approvals required in connection therewith (i.e., from the Federal or State governments). However, until such time as these sources are secured, the City will proceed only with those initiatives for which it has adequate funding.

Uninterrupted access to high-quality drinking water and continuous treatment of wastewater are critical to the viability of New York City as the climate continues to change. Though, as Sandy demonstrated, the city's water and wastewater systems are already highly resilient due to investments over many decades, the city cannot function without either system. DEP, therefore, will accelerate its resiliency efforts across a range of initiatives, including both existing and new efforts. DEP's strategies will include protecting wastewater treatment facilities from storm surge, improving and expanding drainage infrastructure, and investing in the projects which increase the redundancy and flexibility of the water system.

Strategy: Protect wastewater treatment facilities from storm surge

The City's investments in wastewater treatment over many years have resulted in dramatic improvements in the waterfront's ecological conditions, making the area a safer place to live and enhancing opportunities for public recreation. However, a substantial number of critical wastewater treatment assets are located, by design, in low-lying areas at risk of flooding in an extreme weather event. To minimize disruptions to its wastewater systems and protect its waterfront, the City must protect its vulnerable facilities from flooding impacts that may occur from future storms. Owners of other such facilities along area waterways also must undertake similar protective measures.

Initiative 1

Adopt a wastewater facility design standard for storm surge and sea level rise

Sandy damaged wastewater treatment plants and pumping stations even though the design of City wastewater facilities has taken into account the highest historically recorded water height of nearby water bodies or the BFEs identified in FEMA maps. The City, therefore, will adopt an increased level of protection for design and construction of all wastewater facilities based on the latest FEMA maps, modified to reflect sea level rise projections for the 2050s. The design for upgrades to DEP's Gowanus Canal facility, for instance, will protect any critical equipment that is located at or lower than 2.5 feet above the best-available BFE. DEP will adopt the new design guidelines in 2013.

Initiative 2

Harden pumping stations

Many of the city's pumping stations are located in low-lying areas and are necessary to convey wastewater and stormwater out of communities; however, their location also increases their vulnerability to storm surge. Therefore, subject to available funding, the City will retrofit these pumping stations for resiliency. These protective measures include raising or flood-proofing critical equipment, constructing barriers, and installing backup power supplies. Preliminary estimates indicate that there are currently 58 at-risk pumping stations, of which several already are scheduled for capital improvements. DEP will pursue implementation of resiliency projects at these pumping stations in conjunction with repairs and planned capital work, and as appropriate based on the level of risk, historical flooding, and potential community impacts, among other criteria. The goal is to begin implementation in 2014.

Initiative 3

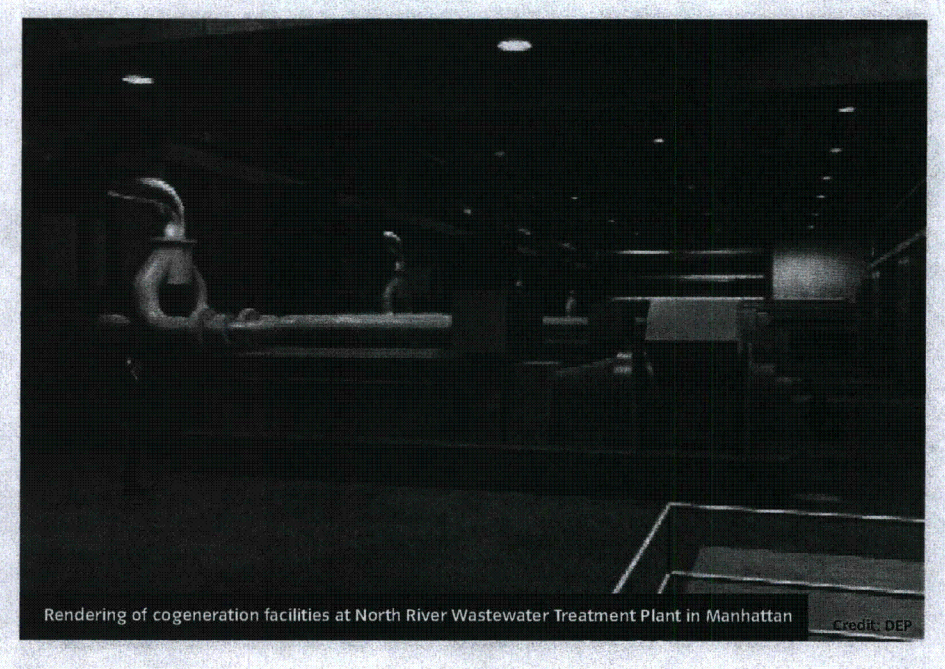
Harden wastewater treatment plants

All 14 of the city's wastewater treatment facilities are located along the waterfront and are therefore at risk in the event of a coastal storm. Subject to available funding, the City will protect these critical treatment facilities by raising or flood-proofing assets that are critical to the treatment process, constructing barriers, improving waterfront infrastructure, or implementing redundancy measures to avoid failure of these critical treatment systems. DEP will target initially facilities that have been identified as either most at risk or as having the largest implications for adjacent communities and waterways, based on the findings of DEP's in-depth study. These facilities include the Oakwood Beach, Coney Island, 26th Ward, Hunts Point, Rockaway, and Jamaica WWTPs. The goal is to begin implementation of adaptation measures for these and other facilities in 2014 as part of repairs and other planned capital projects.

Initiative 4

Explore alternatives for the Rockaway Wastewater Treatment Plant

The Rockaway WWTP was one of the most heavily damaged wastewater facilities during Sandy. However, prior to investing significant funds to



Rendering of cogeneration facilities at North River Wastewater Treatment Plant in Manhattan Credit: DEP

protect the plant from future storms, the City will consider converting it to a pumping station, which would be less expensive to protect, and potentially transferring its treatment responsibilities to a less vulnerable wastewater treatment facility elsewhere in the city. The City will conduct a feasibility study to consider all options. In addition to potentially decreasing future operations and maintenance needs, the conversion of this treatment plant would provide the opportunity to incorporate protective measures that would help avoid the failure of critical systems in future extreme weather events, and the potential impacts to water quality that could come with such failure. DEP will initiate the feasibility study in 2014 and, based on the results and subject to available funding, will consider moving forward with the conversion while incorporating additional resiliency measures.

Initiative 5

Develop cogeneration facilities at North River Wastewater Treatment Plant

The North River WWTP, in Upper Manhattan, had to cut off its electrical power supply when waters threatened the plant's internal substation. While, like other wastewater treatment plants, the facility was able to run on generators, it did have to power down for several hours. The City will continue to enhance the reliability of this critical facility by installing cogeneration equipment there while hardening electrical assets. Using methane generated by the wastewater treatment process itself, cogeneration will produce electric power to keep wastewater treatment processes at North River online during power outages or during peak summer load periods, when Con Edison may request that the facility reduce its power usage. The project will replace the existing engines at the treatment plant with new, efficient motors and a cogeneration system that will generate electricity sufficient to meet base electrical demand and recover heat for the treatment plant's entire process and building needs. DEP projects that design of the cogeneration project at North River WWTP will be completed by 2015, with construction timeline pending design specifications.

Initiative 6

Explore opportunities to expand cogeneration and other energy measures

Although all city wastewater treatment plants maintain backup power supplies, there are other measures that will improve the ability of wastewater treatment plants to operate reliably during disruptions to the electrical grid. The City will explore the feasibility of expanding cogeneration and other energy-related reliability measures to other wastewater treatment plants in the city besides North River, including the Wards Island WWTP. These measures, which could include energy efficiency, increased generation and use of renewable energy supplies such as methane gas and solar energy, and cogeneration, would improve the ability of wastewater treatment plants to operate reliably during disruptions to the electrical grid while also enabling significant reductions in DEP greenhouse gas emissions. Over the long term, DEP will continue to plan and design new and improved wastewater treatment facilities with the ultimate goal of recovering and producing all energy on site, where feasible. DEP will begin a feasibility study for cogeneration at Wards Island in 2013, with implementation and other efforts to follow based on results and subject to available funding.

Stormwater running into a green infrastructure bioswale Credit: DEP

Initiative 7

Encourage regional resiliency planning

Even if the City protects its wastewater treatment assets, the water quality at certain locations in New York Harbor may still be at risk should non-City facilities discharge sewage at a large scale—as happened during Sandy. The City, therefore, immediately will call upon nearby utilities in New York and New Jersey to take measures to protect their wastewater facilities from storm surge and sea level rise. Through regional resiliency planning, the City and neighboring municipalities alike can protect our shared Harbor.

Strategy: Improve and expand drainage infrastructure

Increased rainfall and heavy downpours may contribute to increases in street flooding, sewer backups, and combined sewer overflows. Improving the city's sewer systems will enhance the ability of the existing infrastructure to cope with environmental changes. To this end, DEP will continue to implement a number of its programs that are already under way and, where opportunities exist, will seek to expand these programs.

Initiative 8

Reduce combined sewer overflows with Green Infrastructure

As climate change brings increasing rainfall volume to the New York area, the city may also experience shifts in the frequency and volume of CSOs. The City will continue to implement its Green Infrastructure Plan and CSO Long-Term Control Plans (LTCPs) to reduce such CSOs. For this purpose, DEP, working with the Department of Parks & Recreation and Department of Transportation (NYCDOT), will continue to pursue its plan to capture the first inch of runoff in 10 percent of impervious surfaces citywide in areas within the combined sewer system by 2030. At the same time, DEP also will continue to develop LTCPs to evaluate long-term

solutions to reduce CSOs and improve water quality in New York City's waterways. DEP will issue an LTCP for Alley Creek in Queens in 2013, with nine additional water body-specific LTCPs and one citywide LTCP to follow by 2017—including plans for Coney Island Creek, the Gowanus Canal, Newtown Creek, and Jamaica Bay.

Initiative 9

Reduce combined sewer overflows with high-level storm sewers citywide

While the construction of new, green infrastructure is an effective solution to manage rainfall and reduce CSOs in some locations, in other areas, it will be more cost-effective to enhance the city's existing sewer system. The City will augment existing combined sewers with high-level storm sewers in certain areas near the water's edge around the city. These high-level storm sewers sit on top of the combined sewer and accept stormwater from the street before diverting it to a nearby waterway, with the combined sewer below it sending wastewater and a reduced amount of stormwater to a treatment plant. Such high-level storm sewers are able to capture 50 percent of rainfall before it enters combined sewers. Among the benefits of high-level storm sewers are mitigation of CSOs and the potential to reduce street flooding. To this end, DEP will continue to pursue approximately 15 high-level storm sewer projects that will be completed by 2023, and will continue to seek additional opportunities near the water's edge for additional high-level storm projects that are deemed to be most cost-effective and can be implemented in conjunction with NYCDOT street improvements and other community infrastructure projects.

Initiative 10

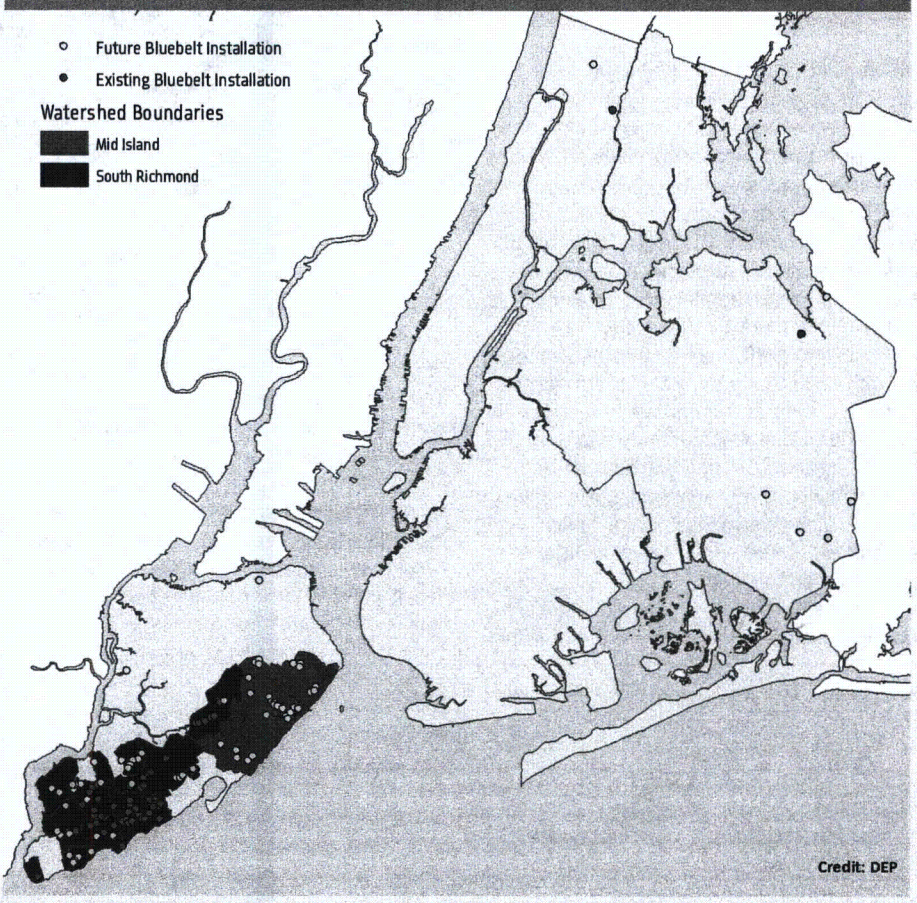
Continue to implement and accelerate investments in Bluebelts across the city

Some areas of the city lack a fully built-out storm sewer system, and street flooding can occur even during minimal rain events. The City will, in addition to implementing new sewer build-outs and upgrades, continue to implement and accelerate its innovative Bluebelt drainage program. It will do so in several of these areas where opportunities exist to preserve and enhance natural areas, including streams, ponds, and other wetlands that remove pollutants before stormwater enters waterways. Through the next decade, DEP will complete substantially the South Richmond Bluebelt in Staten Island and additional Bluebelts in Twin Ponds, Queens. DEP also will begin to construct the Mid-Island Bluebelt on the East Shore of Staten Island. DEP will also accelerate planning and design of some Bluebelt systems including in Van Cortlandt Park in the Bronx and at Last Chance Pond in Staten Island, subject to available funding and environmental review.

Bluebelt installation under normal conditions

Credit: DEP

Citywide Bluebelt Map



Credit: DEP

Initiative 11

Build out stormwater sewers in areas of Queens with limited drainage systems

Large areas of South Queens, including portions of Broad Channel, Edgemere, Bayswater, Far Rockaway, Rockaway Beach and Arverne, as well as surrounding neighborhoods in Southeast Queens, such as Rosedale and Jamaica, do not have fully built-out storm sewer systems and currently experience street flooding, which may be exacerbated if rainfall increases with climate change. DEP, therefore, will continue to build out the storm sewer systems in these locations along with sanitary sewer upgrades and

high-level storm sewers, undertaking approximately 30 projects through 2023. DEP will seek additional sewer build-out, improvement, or upgrade opportunities in conjunction with NYCDOT street improvements and other community infrastructure projects, including in areas with street flooding.

Initiative 12

Periodically review rainfall trends and implications for stormwater infrastructure

Future changes in rainfall intensity may warrant reconsideration of sewer design to decrease street flooding. DEP recently completed an assessment of historical rainfall data which revealed no changes in hourly and sub-hourly rainfall intensity. However, in order to recognize any emerging trends in precipitation intensity, DEP will work with the Mayor's Office of Long-Term Planning and Sustainability and the New York City Panel on Climate Change to create a process to reassess precipitation data periodically and incorporate any advances in climate modeling. Based on material emerging trends indicated by the foregoing, DEP will assess implications for the sizing of stormwater detention systems, sewer site connections, and green infrastructure, as appropriate. These assessments will occur approximately every eight years, with the next reassessment in 2021.

Strategy: Promote redundancy and flexibility to ensure constant supply of high-quality water

The City owns and operates an extensive water supply network that may increasingly be affected by climate change. However, redundancy and flexibility, which are already built into the system, allow the City to draw upon the largest quantity of water from the highest-quality sources in varying weather conditions. Building on this redundancy and flexibility, the City will protect critical infrastructure and watershed lands and improve upon the physical connections between different parts of the system to enable the use of the most appropriate source of water at any given moment in time.

Initiative 13

Repair the leak in the Delaware Aqueduct

Every drop of clean water counts, particularly in times of drought and other extreme weather events that affect supply. The City will implement planned repairs to the Delaware Aqueduct, which conveys, on average, 50 percent of the city's water from Upstate sources. This aqueduct has been leaking between 15 and 35 million gallons of water a day for many years. In 2013, DEP will begin construction of a three-mile bypass tunnel around the section which has the largest leak. While the bypass is connected and the aqueduct is out of service, DEP will repair other sections of the tunnel. These repairs will enhance the reliability of the city's water supply and maintain flexibility during normal operations, as well as during periods when the water system is depleted, or when water quality in other parts of the system is affected by heavy rain or heat waves. Since the Delaware Aqueduct will need to be shut down in order to connect the new bypass tunnel, this will result in a temporary decrease in water supply. Accordingly, in preparation for the shutdown, DEP will increase the capacity and use of the Catskill and Croton systems; reactivate a groundwater system in Southeast Queens; and adopt both a new Water Demand Management Plan that will conserve water citywide, and water shortage rules to impose use restrictions during droughts and infrastructure repairs. The tunnel shutdown, repairs, and reactivation are expected to be completed in 2022.

Initiative 14

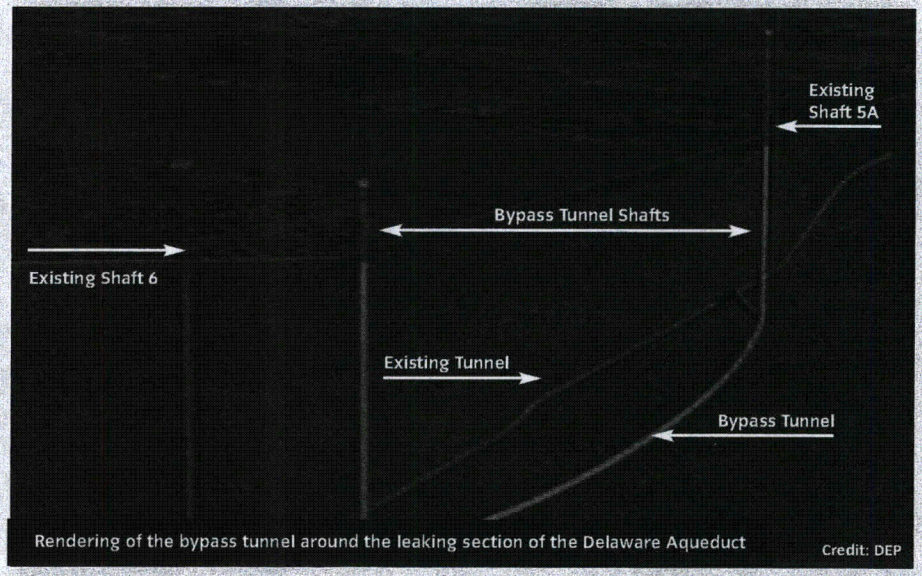
Improve interconnection between the Catskill and Delaware aqueducts and maximize capacity to deliver water from the Catskill/Delaware system

The impacts of climate change on the city's three water supply systems—the Catskill, Delaware, and Croton systems—are likely to vary. For example, while the Catskill system is prone to elevated turbidity, the Delaware system is less so. This variability is one of the strengths of the city's water supply system. However, tapping into that strength requires the right infrastructure. The City, therefore, will complete several planned infrastructure projects, including a new connection between the Catskill and Delaware water supply systems. The City also will consider a project to pressurize the Catskill Aqueduct between Kensico Reservoir and DEP's Ultraviolet Disinfection Facility, in order to give DEP the ability to maximize use of water from Kensico Reservoir and maximize flow to Hillview Reservoir. DEP will begin construction of the interconnection between the Catskill and Delaware system in 2013 and, subject to pending analysis, would commence construction of the pressurized Catskill Aqueduct after the repair of the Delaware Aqueduct is completed in 2022.

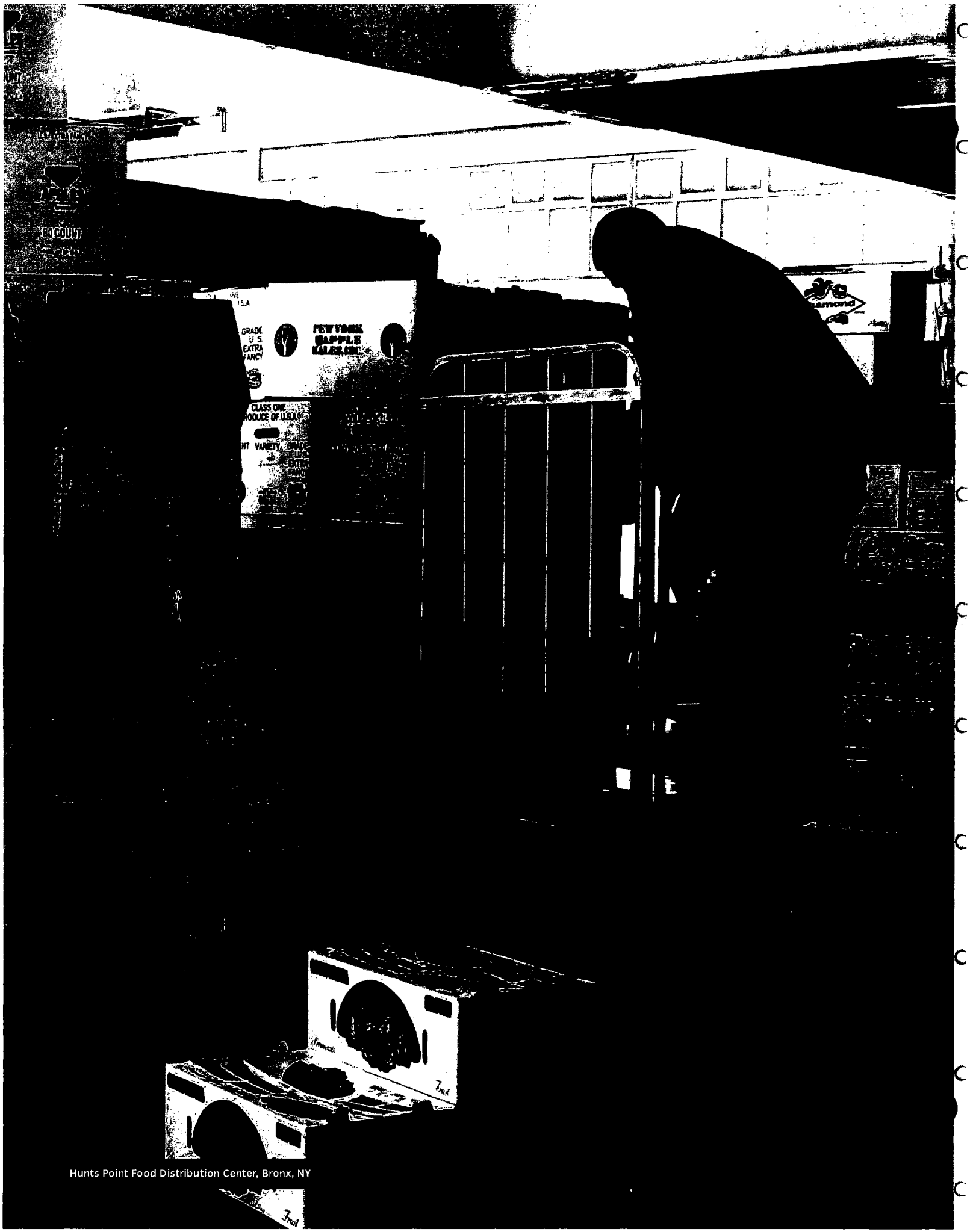
Initiative 15

Continue the Watershed Protection Program to maintain drinking water quality

The City will maintain its commitment to protect its reservoirs and the watersheds that surround them while considering the challenges of climate change. DEP will continue to implement its Long-Term Watershed Protection Program to protect water quality in the streams and other water bodies that feed its reservoirs, and in the reservoirs themselves. The City will continue to acquire land strategically in the watershed and manage that land. DEP also will continue its stream, farm, and forestry programs. These and other watershed protection efforts help maintain water quality, promote environmentally compatible economic development, and enable the City to avoid building a water filtration facility for the Catskill/Delaware systems. DEP's support of these programs in the watershed also helps to reduce the high levels of nutrients associated with stormwater, which can otherwise cause increased algae levels in reservoirs. In 2013, DEP expects that the filtration waiver applicable to the Delaware and Catskill systems will be revised and will incorporate updates to its Long-Term Watershed Protection Program, as outlined above.



Rendering of the bypass tunnel around the leaking section of the Delaware Aqueduct Credit: DEP



Hunts Point Food Distribution Center, Bronx, NY

Other Critical Networks

Food Supply

One of the least-known but most important rituals in New York takes place every night in the South Bronx at the Hunts Point Food Distribution Center (FDC). There, in striking abundance, delicacies from around the state, country, and the world are bought and sold—cabbage from New York, oranges from California, blueberries from Chile, bell peppers from the Netherlands, beef from Australia, and fish from Nova Scotia. All around the Hunts Point FDC, and in dozens and dozens of nearby buildings, everything from international food to alcoholic beverages is packaged, warehoused, and sold—sold to supermarkets, sold to bodegas, sold to street vendors, sold to restaurants. Its customer base also includes schools as well as the food banks, soup kitchens, and pantries that serve New York's most vulnerable populations.

Unfortunately, the Hunts Point neighborhood is not just critically important, it is also vulnerable. It sits on a peninsula with the East River on two sides, and the Bronx River on the third. Meanwhile, close to 28 percent of the site is at risk of flooding, meaning that approximately 93 acres of the 329-acre site lies within the 100-year floodplain (the area that has a 1 percent or greater chance of flooding in any given year) as set forth in the Preliminary Work Maps (PWMs) produced by the Federal Emergency Management Agency (FEMA).

Sandy spared Hunts Point the worst of its impacts largely because it hit New York at low tide in the Long Island Sound. However, complacency in the wake of Sandy would be a mistake, as the food supply system may not escape significant impacts in the next extreme weather event. That is why this plan seeks to protect the Hunts Point neighborhood and the various elements of the food supply system found across the city and its surrounding region from climate change-related impacts, while seeking to strengthen the ability of that system to bounce back when, from time to time, impacts do occur.

Although initiatives outlined in several other chapters of this report are important contributors to the overall resiliency of the food supply network (see Chapter 6, *Utilities*; Chapter 7, *Liquid Fuels*; and Chapter 10, *Transportation*), the City also will pursue a series of food-specific efforts, targeting the most significant concentrations of both wholesale distribution and retail access.

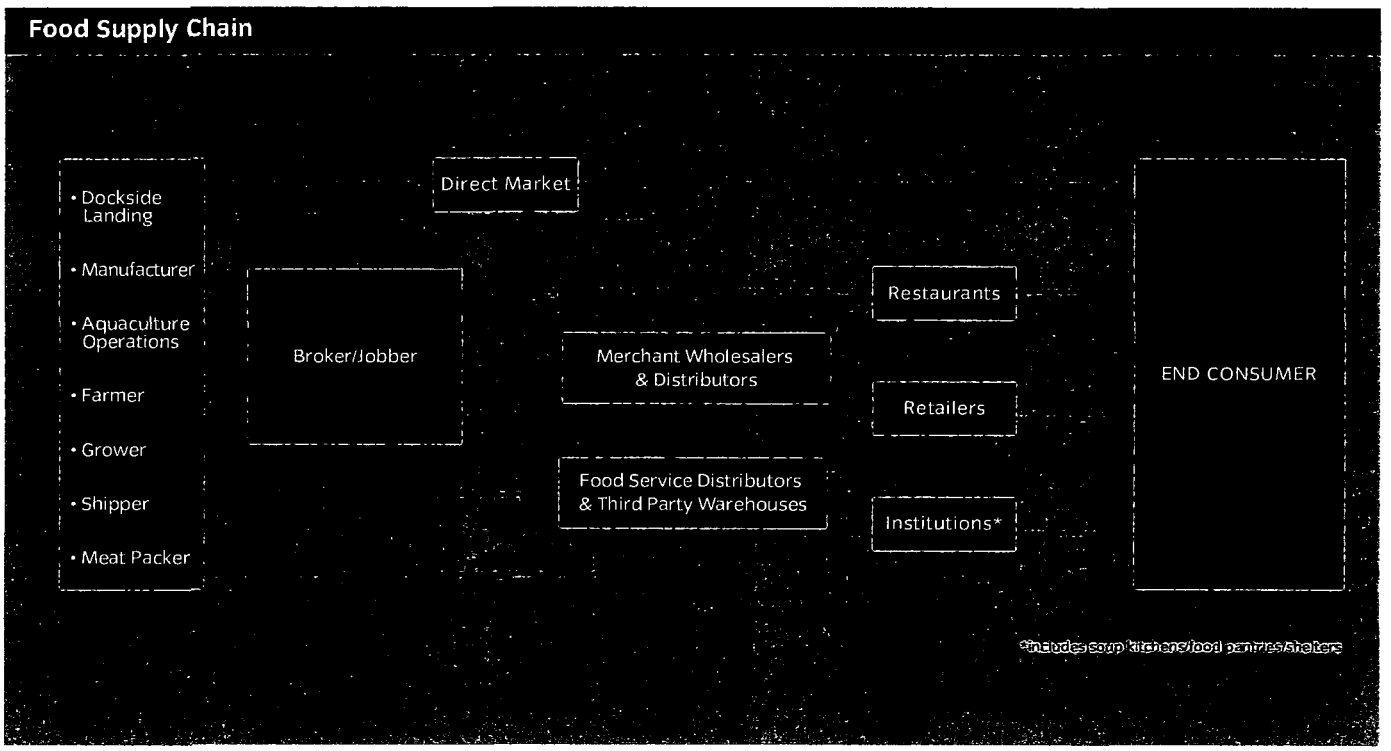
How the Food Supply System Works

Each year, more than 5.7 million tons of both domestic and international food shipments flow into New York City, snaking their way over sea, rail, and road from farms, fisheries, and factories to the city's retailers and restaurants. The system that has developed to carry this bounty to consumers is multilayered and interdependent. It begins, for the purposes of this analysis, in the city and the surrounding region, with wholesalers that take in shipments from around the world and then repackage and distribute them for retail sale.

Large, national distributors such as Sysco, General Trading, White Rose, and C&S stock a wide variety of products and distribute them via trucks primarily to large retailers, such as grocery stores, and institutions, such as hospitals and universities. Their warehouses generally are dispersed outside of the city's boundaries—including a large concentration in New Jersey and smaller concentrations in Connecticut and Upstate New York—though some facilities are located within the Bronx and other parts of the five boroughs.

Certain large retailers such as Whole Foods, meanwhile, rely upon in-house distribution facilities and trucks. Regardless of whether retailers are serviced by third-party distributors or their own distribution systems, virtually all also receive certain specialty products (such as branded snacks and soft drinks) from vendors via direct store delivery. (*See diagram: Food Supply Chain*)

When it comes to smaller stores, restaurants and other retail outlets, many rely heavily on the markets in Hunts Point—especially the public wholesale markets. In fact, about 60 percent of the city's produce and about half of the city's meat and fish passes through Hunts Point for sale and distribution to retailers and consumers. Additional major meat markets exist in Sunset Park, Brooklyn and in Manhattan's Meat Packing District, with smaller, wholesale clusters for the distribution of specialized foods found in Maspeth, Queens and the Lower East Side and Chinatown in Lower Manhattan.



Hunts Point Food Distribution Center

Karsten Moran/The New York Times

From wholesalers and distributors, much of the city's food supply makes its way to retailers such as grocery stores—including both smaller stores and "full-line" grocers, which, in New York City, generally are greater than 6,000 square feet, as defined by the City's Food Retail Expansion to Support Health (FRESH) program. About a quarter of food retail outlets are full-line grocery stores, while close to three-quarters are smaller markets and convenience stores such as bodegas. The New York State Department of Agriculture and Markets (NYSDAM) licenses these food retail outlets (those with less than 50 percent of space dedicated to selling prepared foods).

Despite the presence of approximately 10,000 stores in New York City that sell perishable food, there are many underserved neighborhoods that lack sufficient access to full-line grocers, which provide the most diverse range of products, including fresh produce and proteins (meat, fish, and dairy). These areas often are served by smaller stores that provide only basic staples and lack nutritious, affordable fresh food. In many of these neighborhoods, there are higher rates of diet-related diseases and obesity.

Since 2009, the City has used financial incentives and its zoning authority to encourage the development of full-line grocers in underserved areas, through the FRESH program. To date, 13 FRESH-supported projects will lead to the creation of 340,000 square feet of new, renovated or expanded retail space in previously retail-deficient neighborhoods.

Besides shopping at grocery stores, New Yorkers also purchase food from a variety of other retailers, including delivery services, farmers markets, and food carts—in addition, of course, to the city's dizzying array of more than 24,000 restaurants.

However, individual residents are not the only purchasers of food. Elderly and disabled populations may rely upon meal delivery services provided by nonprofits, many of which receive government funding. Furthermore, a variety of other private, nonprofit, and public institutions—including hospitals, schools, and senior centers—are huge buyers of food. The Department of Citywide Administrative Services (DCAS) purchases food on behalf several City agencies, including the Department of Corrections (DOC), the Human Resources Administration (HRA), and the Division of Youth and Family Justice (DYFJ). The Department of Education (DOE) serves about 180 million meals and snacks per year, while the Health and Hospitals Corporation (HHC), responsible for managing all City-owned health facilities, provides 10 million meals and snacks annually. Additionally, non-governmental hospitals and universities supply meals to various populations.

The food supply system is not only highly complex. It is also highly dependent on other networks such as power, transportation, liquid fuels, and—to a lesser degree—telecommunications.

Electricity is vital for the food supply system, particularly because it enables the refrigeration necessary to keep perishable food—especially produce, meat, and fish—fresh and edible for longer periods. Refrigeration is power-intensive, typically responsible for about 43 percent of electricity use at a full-line grocer. Power supports other functions as well—including lights, air conditioning, information technology (for tracking inventory), and cash registers. Consumers also rely on power to store and prepare their in-home food supplies since, for example, unrefrigerated raw chicken spoils within two hours at room temperature.

The transportation network is similarly, if not even more, important. Approximately 95 percent of the city's food travels into New York City by truck, via a limited number of access points (mainly bridges). In fact, nearly 30 percent of the truck traffic over the George-Washington Bridge on any given day is believed to be carrying food. Every day, almost 13,000 trucks travel into and out of the Hunts Point FDC alone—and, of course, those trucks are wholly reliant on the availability of liquid fuels.

Risk Assessment: Impact of Climate Change on Food Supply

■ Major Risk ■ Moderate Risk ■ Minor Risk

	Scale of Impact			
Hazard	Today	2020s	2050s	Comments
Gradual				
Sea level rise				Minimal impact
Increased precipitation				Minimal impact
Higher average temperature				Minimal impact
Extreme Events				
Storm surge				Direct damage possible to Hunts Point and retailers in the floodplain; possible interruptions to supporting systems (e.g., utilities, liquid fuels, and transportation) Power outages could lead to failures across supply chain
Heavy downpour				Minimal impact
Heat wave				Power outages could lead to failures at both distributors and retailers
High winds				Minimal impact

Telecommunications capabilities, meanwhile, enable the continued operation of payment systems at retailers—including credit card transactions as well as transactions using Electronic Benefit Transfer (EBT) cards, through which the City distributes funds for purchasing food to low-income residents, as part of the Supplemental Nutrition Assistance Program (SNAP, formerly called food stamps). The United States Department of Agriculture (USDA) oversees SNAP, while the City and its Human Resources Administration (HRA) are responsible for administering these Federal benefits to New Yorkers. Retailers also use the telecommunications network to communicate with distributors and wholesalers to help keep them adequately stocked.

Finally, in the event of a disruption in the food supply system, the City's Office of Emergency Management (OEM) has in place response procedures that include emergency feeding plans, commodity distribution plans, and coordination of emergency food programs for vulnerable populations. OEM works with nonprofits, private organizations, and other governmental agencies in developing its emergency preparations.

What Happened During Sandy

During Sandy, wholesale warehouses and distribution facilities in the city and in surrounding areas were largely unaffected, with the exception of wholesalers located in directly impacted areas such as the Gansevoort Meat Market in Southern Manhattan and the in-house distribution fleets of Fresh Direct and City Harvest in Long Island City, Queens. Facilities owned by the largest wholesalers proved to be highly resilient, thanks to redundant power systems as well as multiple locations. For example, the American Red Cross, which is responsible for certain emergency feeding operations under contract with the City, was able to rely on uninterrupted supply from US Foods, thanks to the company's diffuse sites and backup power systems.

Distribution impacts did occur, however, largely due to delays in truck-based freight. Incoming trucks to Hunts Point and elsewhere, for example, encountered restrictions or delays at major bridge crossings due to single-occupancy vehicle restrictions, since most freight trucks have just a driver and no passengers. Distributors also faced challenges sourcing fuel for their fleets due to supply shortages (see Chapter 7).

In impacted neighborhoods, retailers were hit harder than expected. The maps used to predict where floodwaters would hit, the 1983 Flood Insurance Rate Maps (FIRMs), proved to fall short of much of the Sandy Inundation Zone. Retailers suffered both direct damage from flooding and indirect losses due to power outage. Floodwaters damaged building systems and fixtures, and destroyed significant quantities of inventory—including nonperishable or shelf-stable goods that were left close to the ground. Power outages resulted in additional inventory loss due to spoilage of perishables and also prevented stores from conducting credit card or EBT transactions (even where the telecommunications network was working). Because these impacts were concentrated within inundation areas, whole neighborhoods found themselves with limited or no retail food access. Transportation breakdowns meant that the problems of residents of these neighborhoods were compounded, because they frequently had limited ability to travel to other areas to find functioning retailers. However, in many areas, unimpacted retailers were sufficiently close that physically able residents could walk to alternative locations.

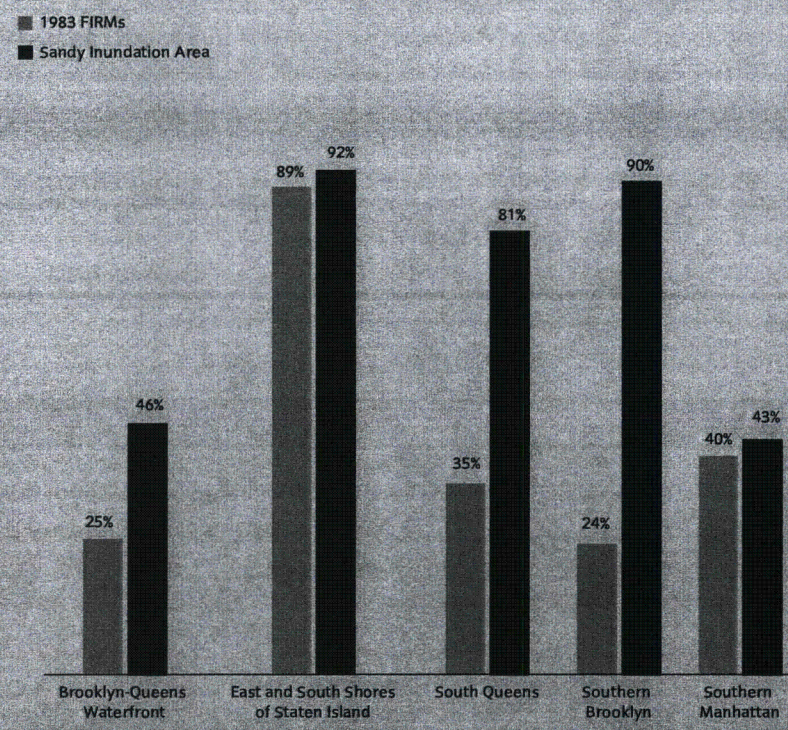
Another impact resulted from the fact that families without electricity were unable to keep perishable foods or cook (for those with electric stoves). Some emergency food providers such

as food pantries and soup kitchens—the very entities that often are called up to provide emergency food assistance—were inundated and so, in some cases, were unable to provide service in the days and weeks immediately following Sandy. While there were sustained power outages affecting entire neighborhoods, retailers big and small eventually found ways to recover. This included pumping out water or waiting for waters to recede, sourcing backup power, cleaning, rebuilding, and restocking. For example, one retailer in Coney Island used dry ice to provide temporary refrigeration for produce, while another in East Harlem hired a bus service to bring in stranded employees.

Despite these and other efforts by local retailers, some communities were forced to rely upon emergency food distribution measures In a matter of days, the City and its partners in the State and Federal governments and the nonprofit sector developed and implemented the largest emergency feeding operation in New York history. Thanks to both in-place and emergency contracts and with support from the National Guard and others, through January 31, the City and others distributed over 2.1 million shelf-stable meals, over 700,000 prepared meals, and almost 280,000 meals from food trucks. Many of these meals were served through 17 City-run "pop-up" sites across the impacted areas.

In addition, by the first week of November, HRA had worked with the State and Federal government to replace SNAP benefits equaling 50 percent of a recipient's October benefit, as well as manually processed requests for full reimbursement. These two efforts alone ensured that more than $66 million in purchasing power was available to particularly vulnerable populations affected by the storm. Combined with almost $6 million in additional benefits provided in December 2012 through the Disaster Food Stamp program, a total of more than $72 million in additional SNAP benefits reached impacted communities. The Mayor's Fund to Advance New York City provided additional support, while the DOE received Federal approval to provide additional free school meals in Sandy-impacted areas through March. Nonprofit feeding operations continued in some neighborhoods into the spring. For example, City Harvest delivered over 7 million pounds more food than during the same October-to-March period the previous year.

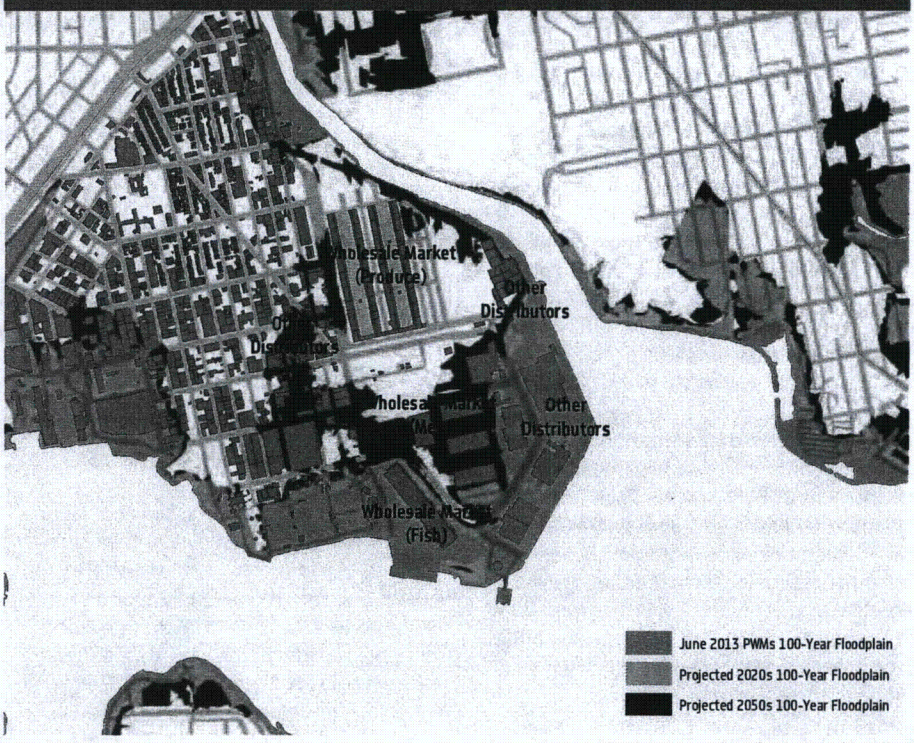
Food Retail Area in Sandy-Impacted Communities



Note: Data represents percentage of food retail square footage within impacted communities in 1983 FIRMS or Sandy Inundation areas

Source: FEMA and Hoovers

Hunts Point Peninsula and Food Distribution Center Vulnerability



Source: FEMA, CUNY Institute for Sustainable Cities

What Could Happen in the Future

As a diffuse system reliant on many different facilities, the city's food supply system is generally quite resilient. However, the Hunts Point FDC, a major link in the city's food supply chain, presents a major vulnerability to storm surge. Additionally, neighborhood-level retail impacts could be significant across the five boroughs. *(See chart: Food Retail Area in Sandy-Impacted Communities)*

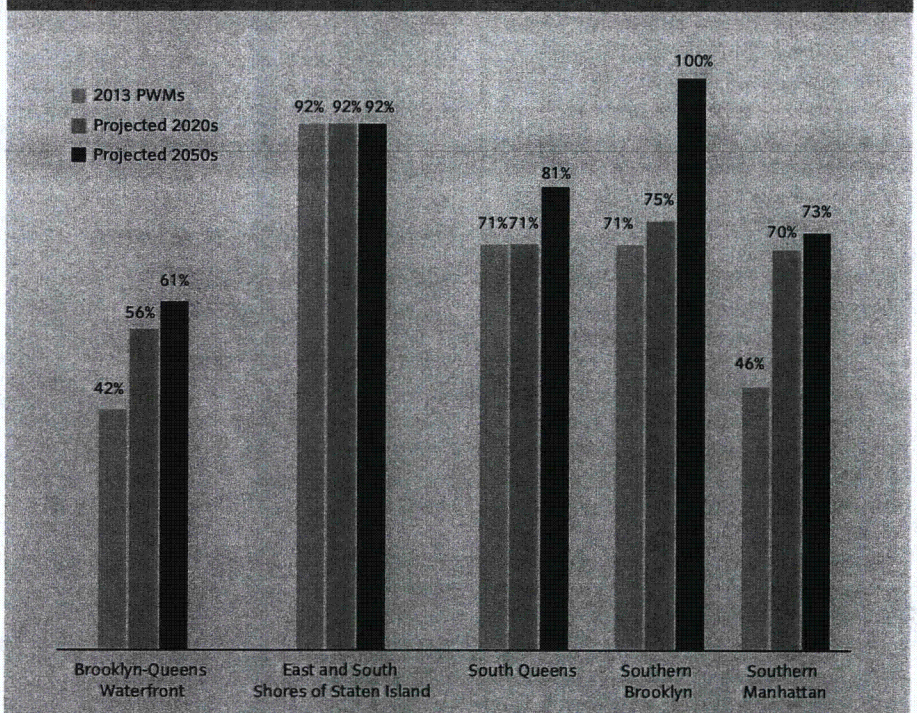
Major Risks

The most significant risk to the food supply system is the threat of storm surge, particularly as rising sea levels increase the City's 100-year floodplain. Much of this risk is attributable to the vulnerability of the Hunts Point area, which lies within the 100-year floodplain as mapped on FEMA's Preliminary Work Maps (PWMs). As mentioned earlier, the vulnerability at Hunts Point includes public markets, as well as a variety of major private distributors. As described in Chapter 2 (*Climate Analysis*), if Sandy had taken a different path or arrived at a slightly different time (i.e., high tide in Long Island Sound), the Hunts Point area might have flooded, lost power and significant inventory, and suffered from major operational interruptions. Also, because Hunts Point supplies a disproportionate share of the food wholesaling needs of low-income neighborhoods in New York, the impacts of damage in that area would be felt most dramatically in the communities with the fewest retail food alternatives. *(See map: Hunts Point Peninsula and Food Distribution Center Vulnerability)*

Storm surge is also a significant threat to neighborhood-level retail access in coastal communities, as Sandy demonstrated. There are almost 700 food retail markets in the PWM-defined 100-year floodplain, representing over 10 percent of the city's food retail space. By the 2020s, the projected 100-year floodplain will have expanded to include nearly 155 more existing food stores, the majority of which are smaller markets which almost exclusively serve low-income and vulnerable neighborhoods. By the 2050s, almost 200 additional existing stores will be found in the projected 100-year floodplain— bringing the total of at-risk retail floor area to over 15 percent of the city's total food retail space, and close to 1030 total stores. *(See chart: Food Retail Area in the 100-Year Floodplain in Sandy-Impacted Communities)*

While most of New York's food retail square footage will not be at risk of surge, the buildings that are at risk are concentrated in low-income communities. Indeed, the top four at-risk community districts—which are projected to have more than 75 percent of their food retail floor area in a floodplain by the 2050s—are all areas with high levels of low-income populations. This includes Coney Island, the Rockaways, Throgs Neck/Co-Op City, and East Harlem.

Food Retail Area in the 100-Year Floodplain in Sandy-Impacted Communities



Note: Data represents percentage of food retail square footage within impacted communities in each 100-Year floodplain scenario.

Source: FEMA, CUNY Institute for Sustainable Cities and Hoovers

Certain City government food programs also will be at risk of storm surge-related impacts. This is because some of the City's food procurement, which is managed by DCAS, is made through smaller, less-resilient distributors with fewer resources to invest in resiliency measures. In fact, it is believed that relatively less-resilient distributors currently constitute most of the contracted suppliers for DCAS procurements on behalf of agencies such as the Administration for Children's Services, HRA, DOC, and OEM.

Storm surge creates additional risks for the food supply system to the extent that it threatens the city's power, liquid fuels, and transportation networks. Power network dependency for food storage and business operations means that basic continued business operations could be at risk in the event of a significant disruption to the power grid. Many functions of the food supply system also depend on access to fuel needed for food transport or to power backup generators. Additionally, the food supply system's dependence on truck-carried freight means that transportation impacts from storm surge could have a cascading effect on food availability.

Other Risks

Heat waves that result in power losses threaten the operations of wholesale and retail facilities, where backup power is not available. The loss of refrigeration capabilities may result in the spoilage of large amounts of perishable goods, while retailers also could lose the ability to process electronic payments, including the EBT purchases that are so critical to low-income populations. Power losses also impact consumer access to food by interrupting in-home refrigeration and cooking. The initiatives outlined in Chapter 6 are meant to address these challenges. Chronic sea level rise (when no coastal storms are present) is unlikely to impact the food supply system as a whole, since it is spread broadly across a diverse geographic area. Similarly, heavy downpours and high winds should not cause impacts on the broader network or consumer access, though isolated distribution or retail sites could suffer localized impacts.

This chapter contains a series of initiatives that are designed to mitigate the impacts of climate change on New York's food supply system. In many cases, these initiatives are ready to proceed and have identified funding sources assigned to cover their costs. With respect to these initiatives, the City intends to proceed with them as quickly as practicable, upon the receipt of identified funding.

Meanwhile, in the case of certain other initiatives described in this chapter, though these initiatives may be ready to proceed, they still do not have specific sources of funding assigned to them. In Chapter 19 (*Funding*), the City describes additional funding sources, which, if secured, would be sufficient to fund the full first phase of projects and programs described in this document over a 10-year period. The City will work aggressively on securing this funding and any necessary third-party approvals required in connection therewith (i.e., from the Federal or State governments). However, until such time as these sources are secured, the City will proceed only with those initiatives for which it has adequate funding.

Careful implementation of the utility, liquid fuels, and transportation recommendations in Chapters 6, 7, and 10 of this plan will help to protect the food supply network by increasing access to the energy and freight capabilities needed to maintain operations. Additional measures will identify and address vulnerabilities at the wholesale and retail levels.

Strategy: Enable continued operations of supporting systems upon which the food system depends

Recognizing that the food system depends on power, liquid fuel, and transportation networks, the City's food supply efforts inextricably are linked to initiatives described in detail elsewhere in this report. For example, the food supply network will benefit from a variety of initiatives that seek to encourage utility-led, cost-effective resiliency measures to protect the power grid and enable it to recover quickly in the event of impacts (see Chapter 6).

Similarly, the City will work towards maintaining a sufficient fuel supply to meet the needs of the truck fleets on which the food system depends. As part of its fuel supply resiliency efforts, the City will work with government and private entities to harden liquid fuel supply infrastructure and improve the system, and to prepare it to bounce back quickly from supply chain breaks with both off-the-shelf regulatory waivers and emergency fueling capabilities. For more information on these strategies, see Chapter 7.

Finally, the City will implement measures so that the critical road networks identified in Chapter 10 include critical food supply corridors that would benefit from additional resiliency investments. As part of its transportation resiliency efforts, the City also may prioritize certain categories of food supply trucks during periods of restricted access (for example, during periods when single-occupant vehicles are not permitted to use river crossings). Building on initiatives outlined in Chapter 10 and as part of the food distribution study outlined below, the City will work with large wholesalers to identify alternative modes—such as rail or barge— of bringing in large-scale food supply in the event that truck-based routes become wholly or partially unavailable.

Strategy: Identify and harden critical food distribution assets

To help the food system to withstand direct and indirect risks, the City will study the system for prospective vulnerabilities and develop a more refined plan for long-term protections. In the short term, the City has identified critical vulnerabilities that it will seek to address. Most notably, in Chapter 3 *(Coastal Protection)*, the City proposes the construction of an integrated flood protection system to enhance protection of the Hunts Point peninsula, including the Hunts Point FDC, as part of the proposed Phase I Initiatives. Additional food supply-specific initiatives can help to implement multilayered defenses to protect the system.

Initiative 1

Study the food distribution system to identify other prospective vulnerabilities

Sandy showed New York's food supply system to be highly resilient, but a deeper analysis of the interactions between the different segments of the supply chain is necessary to refine this understanding. Subject to available funding, the City will commission a study of New York's food distribution system, to identify vulnerabilities and develop a plan to protect the system from those vulnerabilities in the long term. As an outgrowth of this study and building upon the 2011 update to PlaNYC, the Office of Long-Term Planning and Sustainability (OLTPS) will identify key distribution assets in surrounding jurisdictions (including major wholesale distributors that supply the New York market), and will work with those jurisdictions and the owners of those assets to identify and address risks. The study also would seek to improve food-related disaster preparedness at the community level in order to augment and inform efforts already underway at OEM. Through the study, the City would create a comprehensive plan to identify and integrate City resources, alternative food providers, community-based organizations, and other providers into its emergency feeding response plans. The goal is to begin this study in the next six months.

Initiative 2

Expand upon prior energy studies to explore options for cost-effective, continuous power for the Hunts Point Food Distribution Center

In order to enable continued operation, refrigerated storage capacity, and an uninterrupted supply chain to most of the city, strengthening the resiliency of the power supply at the Hunts Point FDC is critical. The City will work with

tenants at the Hunts Point FDC to put in place options to enable such a continuous power supply. The options could include expanding existing tenant-led efforts to procure and install backup generators, or raising power lines and utility infrastructure in place. New York City Economic Development Corporation (NYCEDC) will lead this cooperative effort in 2013, leveraging a prior City study that examined the feasibility of installing a combined heat and power system for the entire Hunts Point FDC.

Strategy: Improve the resiliency of consumer access

Sandy exposed the vulnerabilities consumers face in accessing food through normal channels after a major storm. Initiatives to harden retail access points and diversify City procurement of food will improve the resiliency of this segment of the supply chain. These efforts will draw on the recommended Core Flood Resiliency Measures outlined in Chapter 4 (*Buildings*), as well as a buildings incentive program that seeks to help 70 percent of New York's floor area—including retail—to become more resilient by 2030.

Initiative 3

Call on New York State to issue preparedness guidelines to retailers in anticipation of extreme weather events

Proper preparedness can enable retailers to protect more of their inventory, even during significant flooding events. The City will call on New York State Department of Agriculture and Markets, the regulatory authority that licenses food retail establishments, to develop and issue preparedness guidelines for retailers at-risk of climate impacts, such as flooding and storm surges. These guidelines would help retailers protect packaged foods, maintain ample stocks, and protect retail space, allowing for rapid reopening of retail outlets following an extreme weather event. OLTPS and OEM will work with NYSDAM to disseminate these State-issued preparedness guidelines to New York City retailers in 2013.

Initiative 4

Call on the State Legislature to pass City-sponsored legislation mandating electric generators for food retailers

Even retailers with shelf-stable inventory need electrical power to operate lights and cash registers and to process credit, debit, and EBT cards. The City will call on the State legislature to pass a law to require certain retailers to either install a transfer switch to enable quick connection to a generator, or to maintain a backup generator on site. The proposed legislation will aim to require that back-up power be capable of powering retailers' basic systems necessary for operations. The legislation, would not, however, require capacity to power refrigeration equipment, which is extremely power-intensive. The proposed legislation will aim to require stores to initiate backup power systems within 24 hours of power outages and would apply to stores of 20,000 square feet or more of floor space, or those having 60 or more employees (full- or part-time). OEM will work with the City's State Legislative Affairs Office to advance this legislation.

Initiative 5

Continue to support the FRESH program to increase the number of full-line grocers in underserved neighborhoods

Low-income neighborhoods are particularly vulnerable to retail outages as many are in vulnerable locations and, even without extreme weather conditions, lack adequate retail access options. As part of its continuing efforts to encourage the development of full-line grocery stores in underserved neighborhoods, the City, through NYCEDC and the Department of City Planning, will continue to support the FRESH program to provide multilayered benefits to encourage full-line grocery developers to locate in these underserved neighborhoods.

In parallel to the FRESH program, the New York Healthy Food & Healthy Communities Fund and New York State will work to facilitate the development of healthy food markets in underserved communities throughout New York State. This partnership will immediately provide pre-development grants and loans to new full-line grocery store projects in these communities.

Food Supply Initiative 6

Expand DCAS food procurement pilots towards contracts with larger, more resilient distributors that have active New York operations

The City currently procures food for several key agencies using a number of single-supplier, item-specific contracts that provide no alternative sources when a designated supplier is unable to deliver needed product. The City will expand current pilots to backstop DCAS food procurement to strengthen resiliency and redundancy in case of future climate hazards. DCAS will work so that its supplier contracts for DOC, DYFJ, and HRA (food pantries and soup kitchens) have backstops in place by the end of 2013.

Initiative 7

Implement preparedness measures for continued availability of SNAP benefits for vulnerable consumers following large-scale power outages

Power outages can affect the ability of consumers to store fresh food and produce, and can spoil food already in the refrigerators of households. Consumers who depend on SNAP benefits depend on the availability of these funds to replenish their food supply. The City, through HRA, will prepare waiver requests for immediate submittal to the Federal government, specifically the USDA, for the automatic mass replacement of benefits in the event of a large-scale power disruption. This is the fastest way to get food purchasing power back into the hands of low-income New Yorkers, and it will free up critical City resources and reduce administrative burden on City agencies, when these resources are needed most. HRA, as administrator of Federal SNAP benefits for New Yorkers, will initiate these preparations in 2013.

Key Food, Coney Island

Solid Waste

DSNY workers and collection truck

Credit: Emilee McGovern

Every morning before dawn, nearly a thousand Department of Sanitation (DSNY) collection trucks roll out of garages located around the city to begin their daily rounds. By the time most people wake up, DSNY employees—"New York's Strongest"—already are well on their way to collecting their daily haul of over 12,000 tons of waste and recyclables from residential buildings, schools, hospitals, and other institutions. The remainder of the city's daily intake of 50,000 tons is generated by businesses or construction sites and is collected by private haulers.

In ordinary times, garbage collection fades into the background of the city's life. The collection of solid waste, though critical to the functioning of the city, is so orderly and predictable that it becomes almost invisible to most New Yorkers.

In extraordinary times, however, DSNY's fleet of more than 2,000 collection vehicles and more than 9,000-person army of sanitation workers and support employees suddenly attract the spotlight. Never was this truer than in the aftermath of Sandy. Under the direction of the City-activated Debris Removal Task Force and with the participation of other City, State, and Federal agencies, DSNY employees worked 12-hour shifts around the clock, seven days a week, to collect more than 400,000 tons of Sandy-related debris, including downed trees.

The massive debris clean-up after Sandy demonstrated the resiliency of the City's solid waste capabilities. But the next time could be different. A storm pattern different from that of Sandy could affect more DSNY facilities more seriously. As the City's solid waste collection network shifts towards more environmentally friendly marine routes, it will rely increasingly on waterfront facilities that must be protected. And since the City's solid waste disposal network extends well beyond the five boroughs and the City's control, it will require coordination among multiple parties.

The commercial solid waste collection system served by private haulers is closely intertwined with the DSNY system, which is the focus of this chapter. Although the commercial system may suffer some unique climate impacts, it is expected that DSNY will be capable of collecting excess debris in the wake of an extreme weather event—as was demonstrated after Sandy.

In keeping with the broad goals of this report—to minimize disruptions from climate hazards and ensure New York can bounce back quickly if damage is sustained—the City will enhance the resiliency of the solid waste system. This will include hardening critical City-owned solid waste assets to protect them from storm impacts while also seeking to ensure that the broader solid waste network—both City- and third-party owned—is sufficiently resilient to enable the system to resume operations quickly should disruptions occur.

How the Solid Waste System Works

DSNY's distinctive white collection trucks are the most visible component of a vast, multimodal system that must not only collect garbage from streets but also dispose of it safely. It involves City employees, garages, and specialized vehicles, as well as a far-flung network of private haulers, transfer stations, rail lines, and disposal companies that extends well beyond the borders of the five boroughs. Significant changes are underway to make the system more efficient and environmentally friendly.

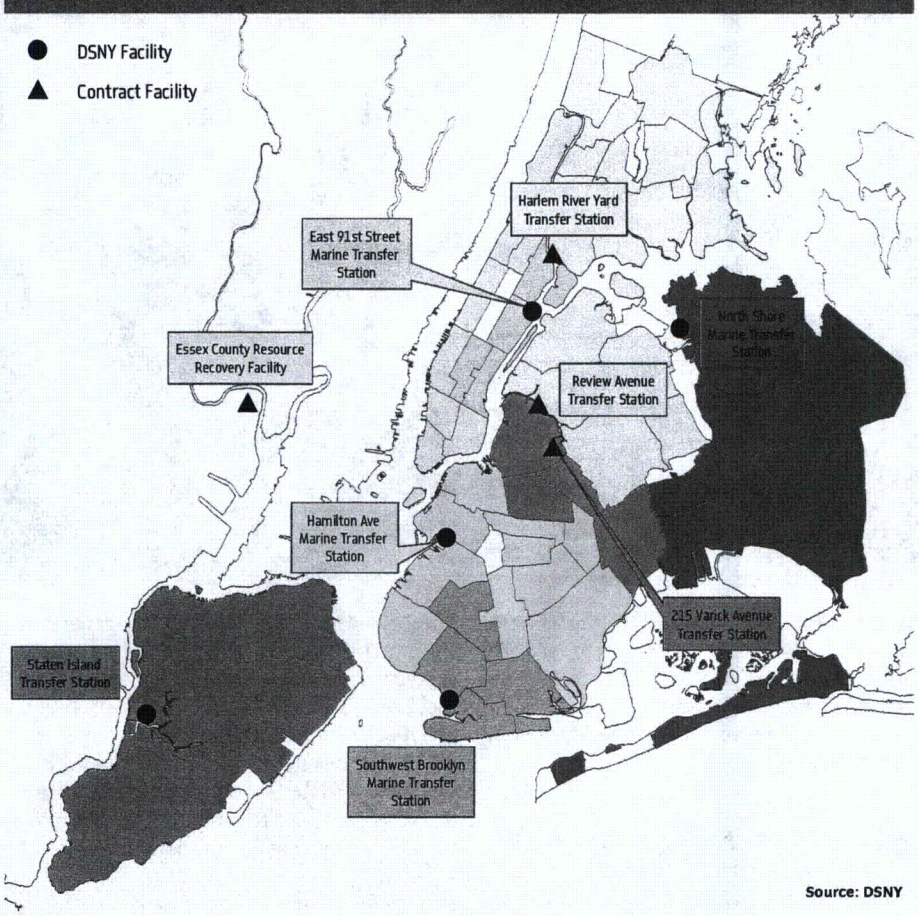
Today, collection trucks from garages in 59 separate sanitation districts carry approximately 90 percent of the city's residential and institutional waste to one of over 30 transfer stations. Then waste is moved to larger commercial tractor-trailers, also called "transfer trailers" (responsible for about 50 percent of the total), or railcars (responsible for about 40 percent of the total). Via truck or rail, the waste is then transported to disposal sites outside the city—as far afield as Pennsylvania, Ohio, and South Carolina. The approximately 10 percent remaining is carried directly by collection trucks to the Essex County Resource Recovery Facility in New Jersey, a privately operated waste-to-energy facility that combusts more than 1,000 tons per day of municipal solid waste from the city to generate electricity.

Private haulers collect commercially-generated waste, construction and demolition waste (sheetrock, wood, tiles), and fill material (dirt, rock). Most solid waste collected by DSNY and private haulers is processed at the same network of private transfer stations located in the city. Private solid waste haulers rely primarily on trucks to remove solid waste for transport to landfills and incinerators.

The closure of the Fresh Kills Landfill in Staten Island in 2001 created the need for this primarily truck-based system to begin exporting solid waste. In 2006, however, the City released the Comprehensive Solid Waste Management Plan (SWMP), a framework designed to eliminate New York's reliance on a network of land-based transfer stations and long-haul trucking to export residential waste. Once fully implemented, the SWMP will achieve a dramatic reduction in DSNY's number of truck trips and miles driven—and therefore the environmental and health impacts—in connection with the disposal of New York City's waste.

The SWMP outlined a plan to create four marine transfer stations that will be operational by 2018. Together, the four facilities—to be located on Gravesend Bay in Southwest Brooklyn; on the North Shore in Flushing Bay; along the East River in Manhattan; and along the Gowanus Canal—will enable DSNY to move approximately 50 percent of New York's non-commercial solid waste via barge and then onto rail. In so doing, the plan is expected to reduce annual DSNY collection truck travel by 2.8 million miles and reduce commercial tractor-trailer miles driven within the city by another 2.8 million vehicle miles. (*See map: DSNY Facilities and Sanitation Districts*)

DSNY Facilities and Sanitation Districts



Source: DSNY

What Happened During Sandy

Despite the scale of Sandy's impact, New York's solid waste collection and disposal system generally proved to be quite resilient, though some issues did materialize. Sandy strained the solid waste disposal network, exceeding storage capacity, disabling transportation, and requiring emergency resources such as containers and vehicles.

Amazingly, DSNY's normal collection services were affected only minimally, and neighborhoods typically missed at most just one regularly scheduled pickup, with curbside recycling resuming less than two weeks after Sandy. Although more than 60 DSNY facilities sustained some damage, including almost 50 garages, the impact was minor due in part to the fact that the facilities housed vehicles that were, in most cases, moved out of the storm surge inundation area. Nonetheless, 44 heavy-duty and 31 light- and medium-duty vehicles were damaged or destroyed by floodwaters. This damage did not prevent DSNY from carrying out its regular tasks—or from completing its massive post-Sandy cleanup efforts.

The larger waste disposal system, however, was affected by Sandy. Most significantly, one day before the storm, the Essex County Resource Recovery Facility preemptively shut down its boilers. The facility then experienced significant inundation which knocked it out of operation for a subsequent two weeks. With the loss of over 10 percent of its disposal capacity, DSNY was forced to enter into emergency disposal contracts with vendors.

The rail transport network used for waste disposal also was affected by Sandy, with operations halted in Staten Island and the Bronx for five days as vendors inspected flooded railcars and restored them to service. During that time, DSNY safely stored excess waste in containers to await restored rail service or shipped it via transfer trailer.

Although none of the four new marine transfer stations is yet operational, one of the two sites that are under construction—at Hamilton Avenue in Brooklyn—did see water levels exceed the pier elevation, though the waters remained well below the height at which solid waste will be stored once the station is completed.

Overall, DSNY found no indication that solid waste from any of its facilities was washed into the city's waterways. While the former Fresh Kills Landfill sustained light damage to its pollution control infrastructure, it appears there were minimal environmental impacts.

What Could Happen in the Future

Although the solid waste system showed itself to be relatively resilient during Sandy, it nonetheless faces risks associated with climate change.

Major Risks

Given the dispersed nature of the city's solid waste network, its reliance on largely movable equipment, and the resiliency measures built into the new marine transfer stations, it is not expected that climate changes will present major risks to that network in the foreseeable future.

Other Risks

With a number of facilities such as garages located along the waterfront as well as four new marine transfer stations scheduled to begin operations in the next four years, the solid waste system is most vulnerable to storm surge (particularly as sea levels rise), although only moderately so. Many of DSNY's facilities and that of its third-party providers are critical to the degree they house vehicles, but those

Debris at Jacob Riis Park, Queens

Robert Stolarik/The New York Times

Risk Assessment: Impact of Climate Change on Solid Waste

■ Major Risk ■ Moderate Risk ■ Minor Risk

	Scale of Impact			
Hazard	Today	2020s	2050s	Comments
Gradual				
Sea level rise				Minimal impact
Increased precipitation				Minimal impact
Higher average temperature				Minimal impact
Extreme Events				
Storm surge				Disruptions to garbage collection could result from flooding of transportation networks Marine transfer stations could experience limited damage Excess debris could be generated due to property damage
Heavy downpour				Minimal impact
Heat wave				Minimal impact
High winds				Minimal impact

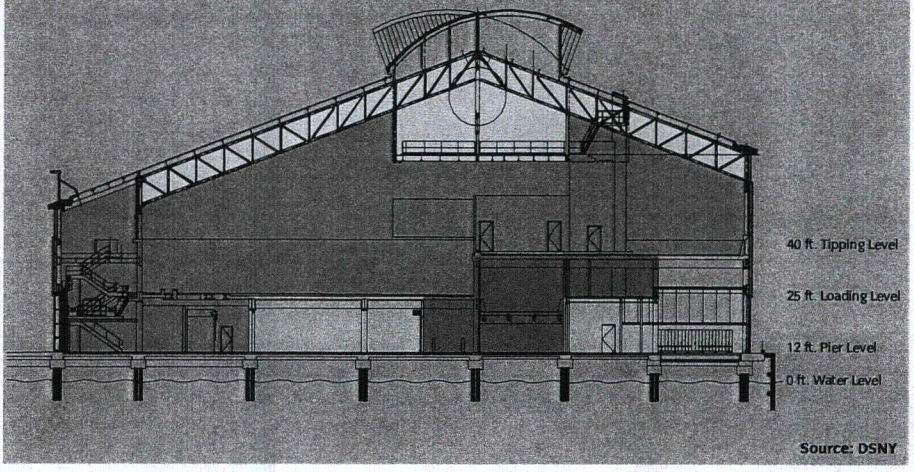
vehicles can easily be moved out of the floodplain to other facilities and locations, as needed.

The four planned marine transfer stations are designed not only to be environmentally friendly, but also highly resilient and, therefore, are not expected to be at significant risk. Marine transfer stations will have three levels. The uppermost level will be a so-called "tipping floor," from which collection vehicles will discharge solid waste onto the middle level or loading floor. On the loading floor, front-end loaders will manage the waste and push it through slots in the floor into waterproof sealable containers. These containers then will be placed onto barges for waterborne export. The loading floors, where loose waste will be found, generally will be located approximately 16 feet above the Base Flood Elevation, or the height to which floodwaters are expected to rise during a 100-year flood (i.e., a flood with a 1 percent or greater chance of occurring in any given year). This means that the risk of loose waste being washed away by inundation—even in an extreme weather event—will be extremely limited. (*See image: Marine Transfer Station Cross-Section*)

Meanwhile, disruptions to vendor operations, including rail networks, might affect the capacity to remove bulk waste from the city both today and in the future. However, as Sandy showed, DSNY has a number of alternatives for redirecting waste, including a network of vendors and backup equipment such as storage containers.

None of the other identified extreme risks (such as heavy downpour, heat wave, and high winds) or chronic impacts (such as sea level rise, increased precipitation, or higher average temperatures) is expected to create any direct risk to the city's solid waste network. However, the solid waste system is exposed to indirect impacts of climate change to the extent that, for example, the city's liquid fuel supply is threatened. This risk and proposed strategies are addressed in Chapter 7 (*Liquid Fuels*).

Marine Transfer Station Cross-Section



Source: DSNY

This chapter contains a series of initiatives that are designed to mitigate the impacts of climate change on the solid waste disposal system. In many cases, these initiatives are both ready to proceed and have identified funding sources assigned to cover their costs. With respect to these initiatives, the City intends to proceed with them as quickly as practicable, upon the receipt of identified funding.

Meanwhile, in the case of certain other initiatives described in this chapter, though these initiatives may be ready to proceed, they still do not have specific sources of funding assigned to them. In Chapter 19 (*Funding*), the City describes additional funding sources, which, if secured, would be sufficient to fund the full first phase of projects and programs described in this document over a 10-year period. The City will work aggressively on securing this funding and any necessary third-party approvals required in connection therewith (i.e., from the Federal or State governments). However, until such time as these sources are secured, the City will only proceed with those initiatives for which it has adequate funding.

New York City's solid waste disposal system—inside and outside of the city, public and private—is designed to collect waste and recyclables and dispose of both safely through continuous operation when possible or through fast restoration.

Strategy: Protect solid waste facilities and disposal networks

Fixed solid waste collection and disposal assets, including critical facilities, roads, and railways, typically were not built with flood protection or other climate change risks in mind. To address the potential risks to the solid waste network, the City will harden its waste collection and disposal facilities and work within its extended third-party-owned solid waste network to ensure that practical resiliency measures are in place for future extreme weather events.

Initiative 1

Harden critical City-owned facilities

Although storm surge is not a major risk to the solid waste system, selected key assets could suffer limited impacts in the event of a significant storm. Subject to available funding, the City will harden equipment at four marine transfer stations, garages, and other vulnerable facilities to prepare for the impacts of future storm surge and to minimize future service disruptions. These efforts will include resiliency projects such as raising and flood-proofing equipment at nearly 70 facilities that will be prioritized based on their flood risk. In addition to physical measures such as raising elevation levels of switches and pumps to keep them out of harm's way and installing bulkhead doors to keep water out, DSNY will develop operational protocols to prepare its facilities and equipment for extreme weather more effectively.

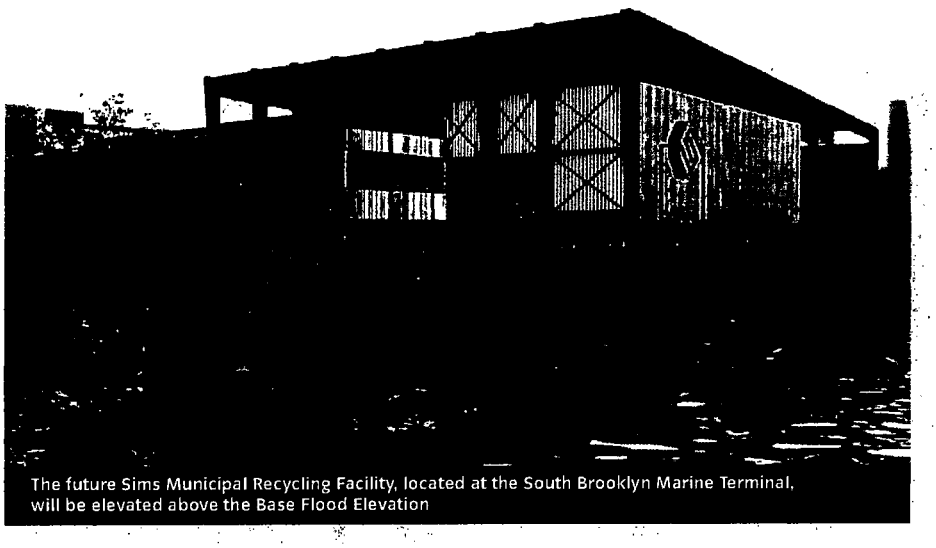
In so doing, the City not only will ensure continued waste collection and disposal during future events, but also will minimize impacts that might otherwise result from flooding of facilities that store loose waste. Additionally, by ensuring the continued operation of marine transfer stations, the City also will ensure that additional trucks are not needed on New York's roads during storm recovery, thereby easing congestion and minimizing impacts to transportation and fuel networks. DSNY will complete a detailed assessment of protection measures for at-risk facilities by the end of 2013. The goal is to implement these measures as part of Sandy reconstruction and other planned construction and capital projects through 2018.

Initiative 2

Work with third-party owners to protect critical assets and networks

Many of the disruptions to the solid waste disposal process that occurred during Sandy—and that could occur in the future—were due to affected assets owned by third parties. These assets are essential to DSNY waste disposal efforts and to the removal of commercial waste by private haulers. The City will work with its network of vendors and rail operators to identify priority resiliency measures and to encourage them to provide redundant and alternative capacity. For instance, DSNY will request or require, as appropriate, that its vendors maintain additional railcars and storage containers in safe, accessible locations in advance of storm events. DSNY also will direct its vendors to secure agreements for additional tractor-trailer capacity in the event that a rail disruption exceeds storage capacity and to provide dumping capacity at alternate company-owned transfer stations.

DSNY further will work to ensure that critical solid waste facilities that are not under its jurisdiction are incorporating storm surge risk and sea level rise projections into their design. This includes developing an inventory of critical system vulnerabilities and working with vendors, rail operators, and private transfer stations to catalogue known risks and develop contingency plans. These measures will limit the potential for disruptions to solid waste collection and disposal. DSNY's coordination and planning efforts are anticipated to occur within the next year, with implementation expected to commence immediately thereafter.



The future Sims Municipal Recycling Facility, located at the South Brooklyn Marine Terminal, will be elevated above the Base Flood Elevation

Credit: Kirsten Luce/The New York Times

The Sims Municipal Recycling Facility under construction in November 2012


MARKS-A-LOT
NYC

Community Rebuilding and Resiliency Plans

New York is a city of neighborhoods—hundreds of them, all different but all treasured both by those who know them intimately and by the city as a whole. These neighborhoods are where New Yorkers live and raise families and where they work and run businesses. Whether these communities have peaceful parks or lively beaches, historic buildings or hip shops, these are the places New Yorkers return to again and again—and visitors search out for a taste of the city's famed diversity.

The city cherishes its neighborhoods, and the strategies and initiatives detailed in previous chapters are designed to benefit all of them. For example, strengthening the electric grid will help minimize power outages in all neighborhoods. Protecting the transportation network will help keep roads open and mass transit running. Making the healthcare system more resilient will help hospitals to remain operational for residents throughout the city.

Yet even as the city plans for the future and seeks to make neighborhoods in all five boroughs more resilient in the face of climate change, it also recognizes that Sandy affected people in certain neighborhoods more than those in the rest of the city. As of the writing of this report, many of these people still are struggling to get back on their feet. They still are trying to repair homes, replace lost inventory, and generally put lives back together in places that have not yet returned to "normal."

Though these people can be found in many corners of the city, the neighborhoods that ultimately suffered the greatest lingering physical damage—the neighborhoods where "normal" continues to feel farthest away—are clustered in five areas of the city. These five areas, which together are home to 683,000 people and nearly 42,000 businesses, are the Brooklyn-Queens Waterfront, the East and South Shores of Staten Island, South Queens, Southern Brooklyn, and Southern Manhattan.

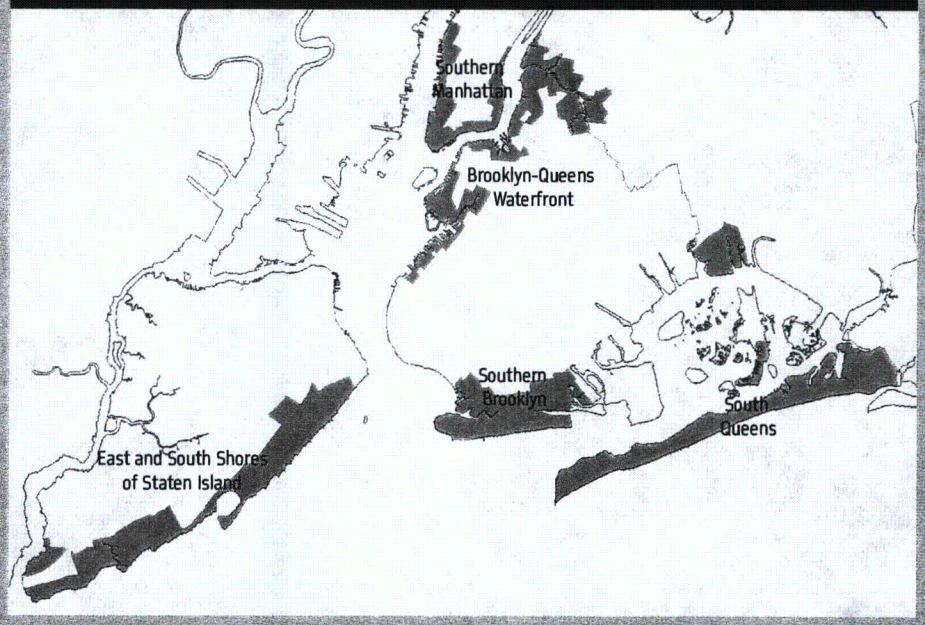
While these areas of the city generally share a number of traits since Sandy—including widespread damage, significant business interruption, and lost infrastructure—they also have in common yet another attribute. Namely, in each there is a fierce attachment to home and community—an unwavering determination to recover. The Community Rebuilding and Resiliency Plans for these five communities are offered in recognition—and celebration—of that resilient spirit.

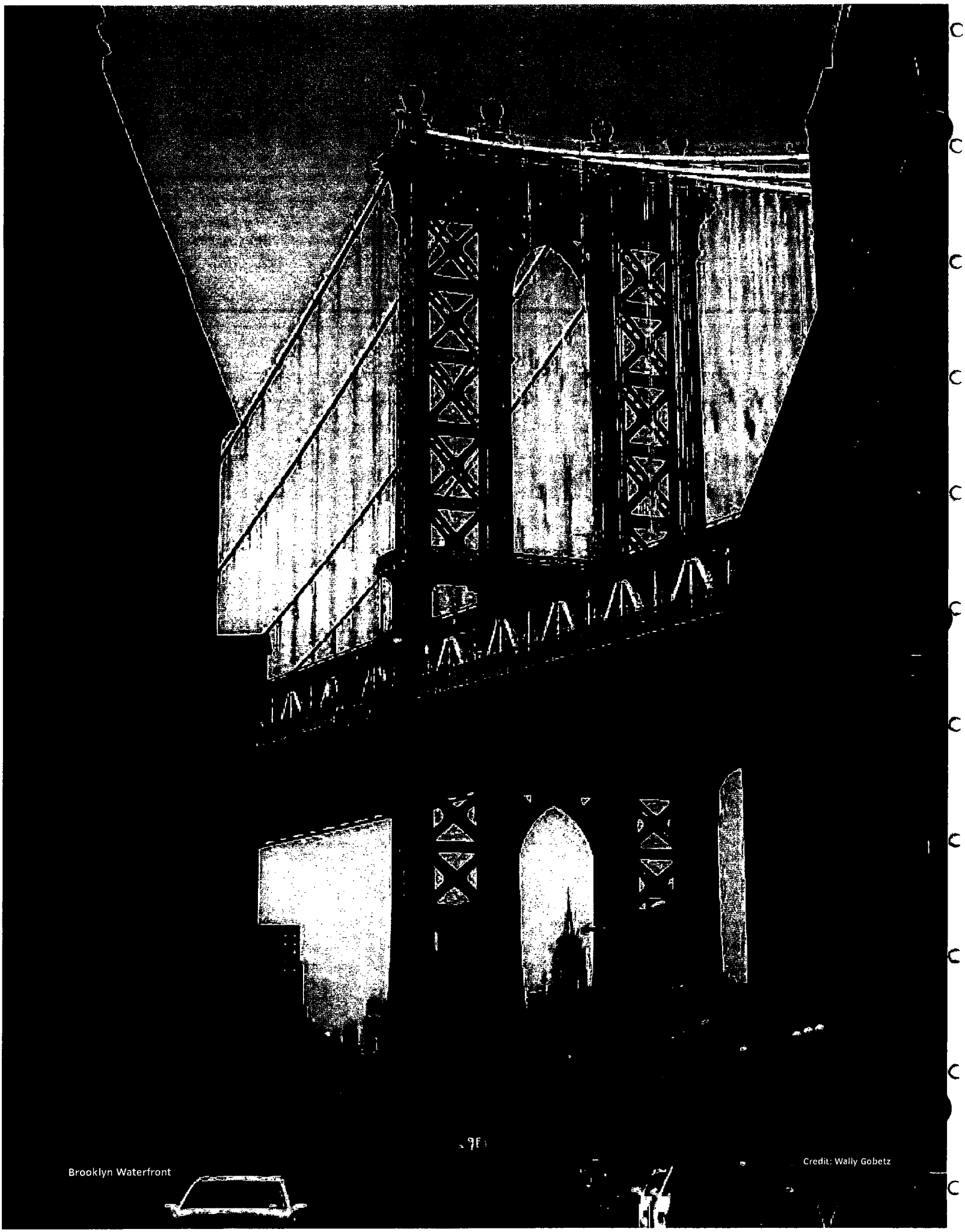
The chapters on the following pages tell these communities' stories. They describe the vulnerabilities these areas possessed before Sandy, they explain what happened during the storm, they suggest what a future of increased climate risks may bring, and they describe dozens of citywide and community-specific initiatives that will help these communities stand strong again.

Some have said that following Sandy the only answer is to "retreat" from the shore. But in New York City, as a general matter, that is simply not possible. The city's waterfront areas are dense, urban places containing hundreds of thousands of people and hundreds of millions of square feet of built space that simply cannot be picked up and relocated elsewhere. Furthermore, New York's experience during Sandy shows that with the right mix of defenses, built up in layers—defenses at the coastal level, at the building level, and at the infrastructure level—it is possible to live on the waterfront in a more resilient fashion. While it is not possible to "climate change proof" these communities, it is possible to continue to enjoy their many virtues while addressing many of the threats that exist today and that are likely to increase with changes in the climate.

So New York City will not retreat, and it will not abandon. New York City, instead, will stand with its waterfront neighborhoods. The City will fight for these neighborhoods and for all neighborhoods across the five boroughs.

Areas of Focus for Community Rebuilding and Resiliency Plans





Brooklyn Waterfront

Credit: Wally Gobetz