Risk Assessment: Impact of Climate Change on the Healthcare System

☐ Major Risk ■ Moderate Risk ■ Minor Risk

Gradual				
Sea level rise				Minimal Impact
Increased precipitation				Minimal Impact
Higher average temperature				Minimal Impact
Extreme Events				
Storm surge				Risk to facilities will increase as sea level rises
Heavy downpour				Minimal Impact
Heat wave				Increased patient demand can likely be handled by normal operations INDIRECT: Power outages could lead to evacuation because HVAC systems are required for operation, yet many are not connected to backup power
High winds				Minimal Impact

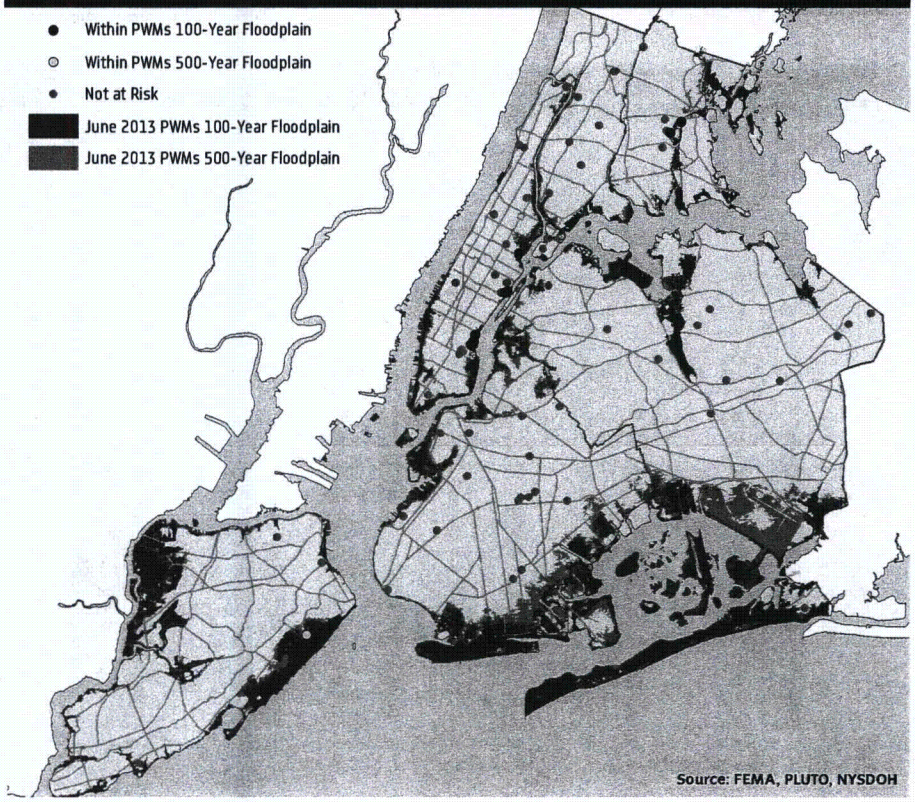
Meanwhile, 37 nursing homes and adult care facilities, representing 14 percent of citywide bed capacity, are in the 100-year floodplain, as indicated by the PWMs, with seven more likely to be in the floodplain by the 2020s. By the 2050s, 33 nursing homes and 25 adult care facilities are likely to be in the 100-year floodplain, many of these (approximately 60 percent) in Southern Brooklyn and South Queens. Among other residential care facilities, approximately 70 are in the floodplain, (7 percent of citywide bed capacity), with another 50 (an additional 5 percent of citywide bed capacity) likely to be added by the 2050s. *(See map: Nursing Homes and Adult Care Facilities at Risk in Southern Brooklyn and South Queens)*

Among community-based providers, approximately 5 percent of buildings with providers are in the 100-year floodplain, as indicated by the PWMs. There are approximately 550 buildings with community clinics, doctors' offices, pharmacies, and other outpatient and ambulatory care centers in the 100-year floodplain and nearly 400 more buildings are expected to be in the floodplain by the 2050s. *(See chart: Projected Growth in Flood Risk of Buildings Housing Community-Based Providers)*

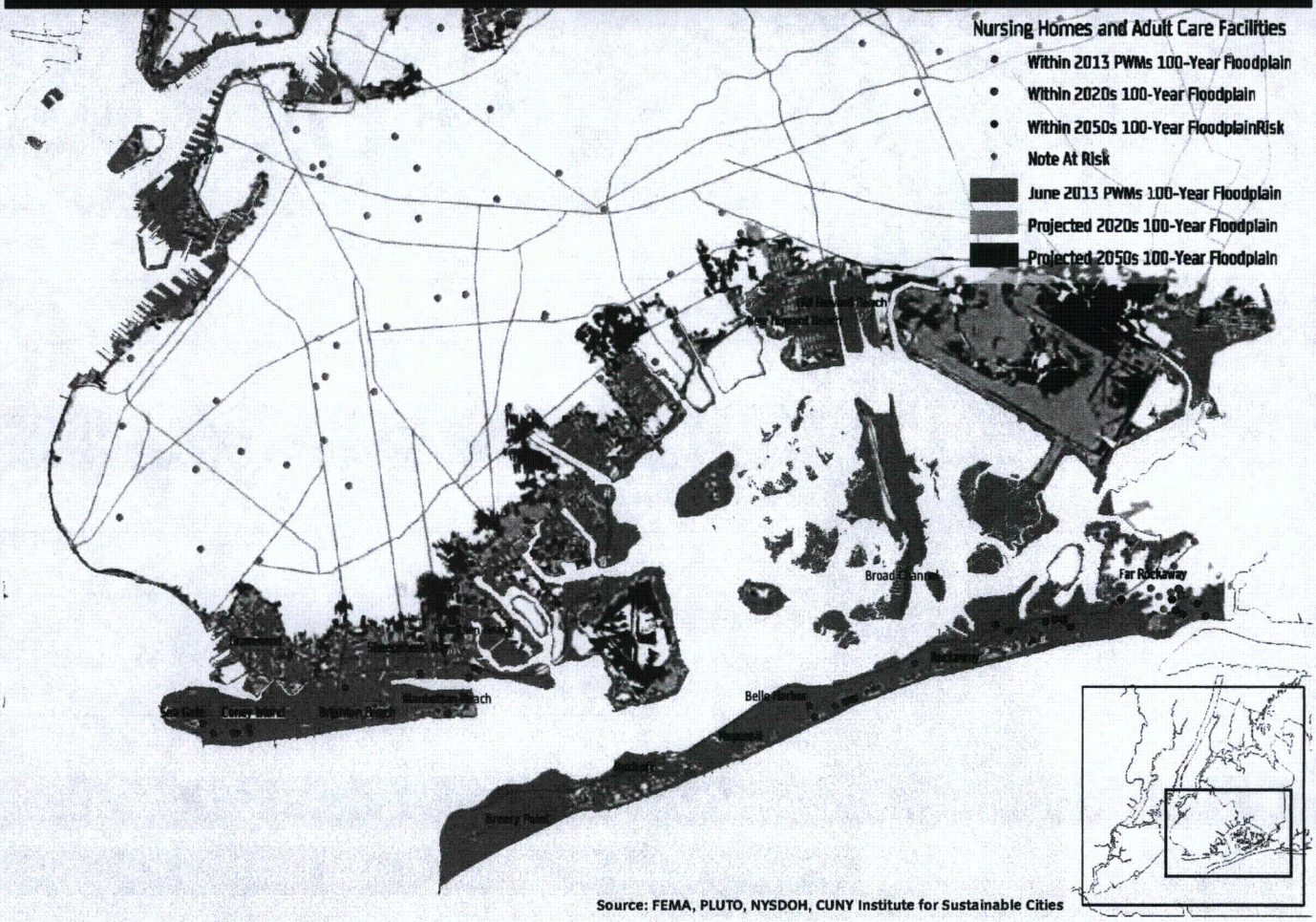
Other Risks

In addition to storm surge, heat waves pose a serious health risk to New Yorkers. They can cause

Hospitals in the Floodplain

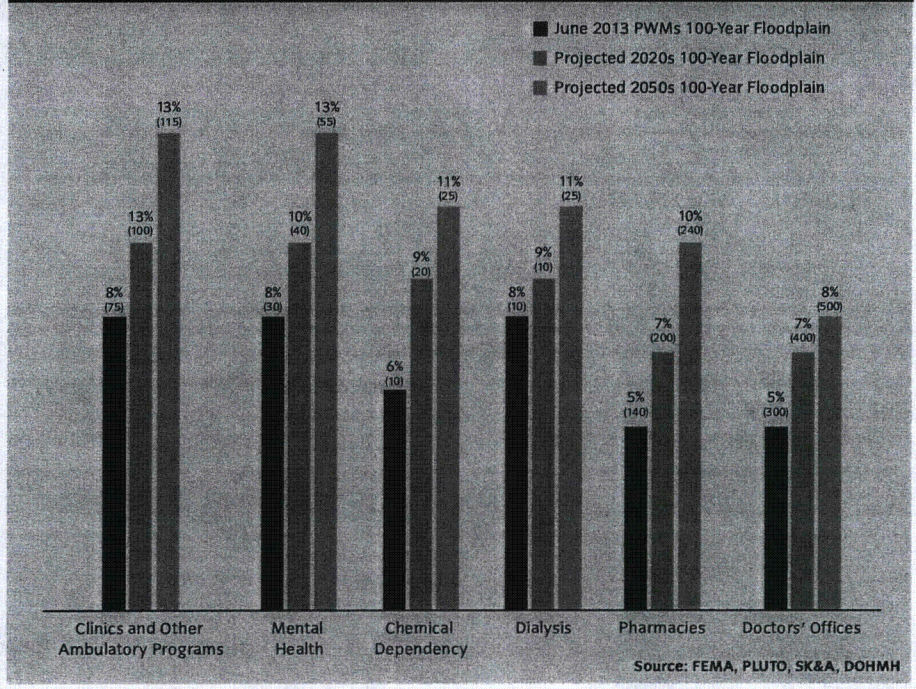


Nursing Homes and Adult Care Facilities in Southern Brooklyn and South Queens



Source: FEMA, PLUTO, NYSDOH, CUNY Institute for Sustainable Cities

Projected Growth in Flood Risk of Buildings Housing Community-Based Providers



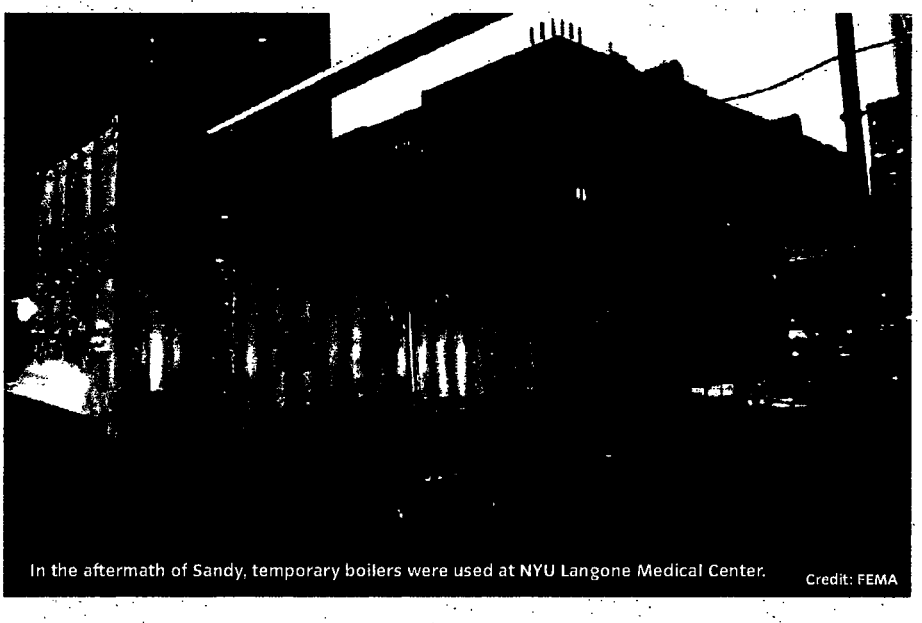
Source: FEMA, PLUTO, SK&A, DOHMH

deaths by exacerbating chronic conditions and inducing heat-related medical conditions, such as heat stroke. Heat waves are particularly life-threatening to elderly and medically fragile individuals who do not have air conditioning in their homes. Even New Yorkers who do have air conditioning will be impacted if heat waves lead to widespread power outages. In addition, power outages from heat waves cause disruptions in the healthcare system citywide. Community-based providers would likely have to shut down until power is restored. Hospitals, nursing homes, and adult care facilities would not need necessarily to evacuate immediately, provided they had backup generators to maintain adequate cooling capacity. However, today the vast majority of these facilities do not have backup power for cooling of their inpatient units.

Sudden downpours and wind are unlikely to have a significant impact on healthcare providers, particularly as facilities with the most vulnerable patients (for example, hospitals) are required to have greater structural resiliency than regular commercial buildings. However, specific facilities may be at risk depending on their site drainage capacity for heavy rains and their façade, window, and rooftop conditions.

This chapter contains a series of initiatives that are designed to mitigate the impacts of climate change on New York's healthcare 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.



In the aftermath of Sandy, temporary boilers were used at NYU Langone Medical Center. Credit: FEMA

To preserve the health and well-being of all New Yorkers, the City's healthcare system must maintain sufficient capacity to meet patients' needs during disasters and be prepared to resume normal services as quickly as possible. To this end, the City will require flood-prone hospitals, nursing homes, and adult care facilities to provide redundancies for critical systems and prevent physical damage to equipment. These facilities account for almost 90 percent of all inpatient and residential bed capacity at risk of flooding. If successfully mitigated, they can stay open and ensure that system capacity is not heavily strained during disasters. The remaining residential bed capacity at risk of flooding is spread across many smaller providers citywide. The vulnerability of these providers to climate risks is typically best addressed through emergency planning and other operational solutions, especially because physical protection of these facilities may be too difficult and not cost-effective given building and physical constraints.

Since community-based providers are located citywide, most will not be affected by flooding from extreme weather events. However, those impacted will be highly concentrated in hard-hit communities. The City will, therefore, work with clinics and pharmacies to implement targeted mitigation in areas where services may be most needed after a disaster. To further reduce barriers to the restoration of community-based care, the City will also call upon outpatient providers to consider technology-based mitigation strategies that are appropriate to their scale and allow for faster recovery. Furthermore, measures to increase the resiliency of citywide power, transportation, and water systems will ensure that community-based and home-based providers can recover the resources that they depend on most as quickly as possible. (See Chapter 6, *Utilities*; Chapter 10, *Transportation*; and Chapter 12, *Water and Wastewater*)

Strategy: Ensure critical providers' operability through redundancy and the prevention of physical damage

Hospitals, nursing homes, and adult care facilities rely on extensive equipment and utility services to diagnose, treat, and care for patients. Basic utilities (such as power and water supply); building equipment (heating, ventilation, air conditioning, and elevator systems); medical equipment (diagnostic labs, X-ray machines, and medical gas tanks); and other services (such as kitchens and laundry rooms) are all integral to normal patient care. Much of this equipment is located in the facilities' lower levels, which are at risk of flooding during extreme weather events. Fortunately, providers have operational plans and workarounds for many of these systems in case of disruptions.

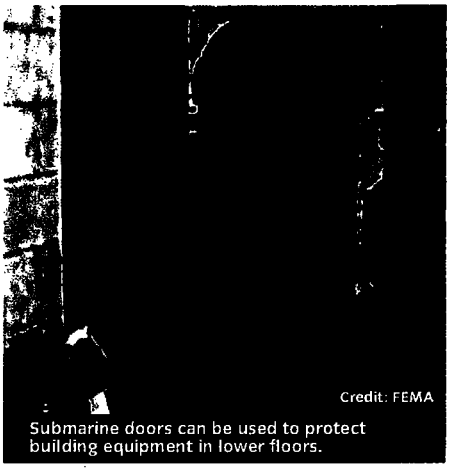
However, some systems—power, water, heating, and air conditioning—require both operational planning and physical hardening to be made more resilient. These systems are the foundation of a facility's medical infrastructure and are essential for the operation of all other services and equipment, including emergency operations. Without these critical systems, providers cannot ensure safe patient care and may be forced to evacuate. Furthermore, severe damage to these systems can result in long-term closures as repairs can often take several months.

Therefore, the City will amend its Construction Codes to require new and existing healthcare providers to take actions that ensure critical building systems are physically protected from the impacts of extreme weather, and—to address outages—are supplied with backup systems. The City also will provide financial assistance to support the mitigation projects of providers who have limited funding sources. These new resiliency measures will minimize the risk of evacuating patients and keep important healthcare facilities open for the benefit of all New Yorkers.

Initiative 1
Improve the design and construction of new hospitals

New hospitals that are constructed in the floodplain could experience critical system failures due to storm surge and may be at risk of evacuating patients. To improve the resiliency of any new hospital that is built in the 500-year floodplain, the City will, therefore, amend its Construction Codes to require a higher level of protection and critical systems redundancy.

For example, new hospital buildings will be required to meet construction code standards for flood-resistant construction to the 500-year flood elevation, which is a higher than the 100-year flood elevation to which protection is required today. Protecting utilities and mechanical equipment to this higher flood level will ensure that new hospitals—which are expected to serve the city for many decades—will be protected even as climate change increases flood risk.



Credit: FEMA

Submarine doors can be used to protect building equipment in lower floors.

In addition, the City will institute new resiliency requirements related to electronic data and communications technologies, which play an increasingly central role in patient care. New hospitals in the 500-year floodplain will be required to increase their IT and telecommunications resiliency by installing two independent points-of-entry for telecom and communication to reduce the risk of outages from a single supplier.

Backup options are crucial to ensure that critical systems can function and long-term closures can be avoided. New hospitals will, therefore, also be required to be built with pre-wired electrical connections for external emergency power generators as well as for temporary boiler and chiller connections if the primary equipment is below the 500-year flood elevation. In addition, new hospitals in the 500-year floodplain will be required to ensure that air conditioning services to their inpatient care areas are available when utility power is disrupted (for example, by placing chiller systems on emergency power). Having an air conditioning solution that is not dependent solely on primary utility power will help avert evacuations. These measures will ensure that providers do not incur high costs later for damages, repairs, or retrofits. The Office of Long-Term Planning and Sustainability (OLTPS) will include the proposed amendments to the New York City Construction Codes in its broader proposal to the New York City Council in the latter half of 2013.

Initiative 2

Require the retrofitting of existing hospitals in the 500-year floodplain

Many existing hospital buildings in the floodplain remain vulnerable to the impact of storm surge. To improve the resiliency of these buildings, the City will require existing hospital buildings in today's 500-year floodplain to meet, by 2030, a subset of the amended New York City Construction Codes standards through building retrofits.

This mandate will apply to the eleven hospitals that are, as indicated by the PWMs, in the floodplain. They will be mandated to protect their electrical equipment, emergency power systems, and domestic water pumps to the 500-year flood elevation by elevating the equipment, hardening equipment in place (for example, through the use of submarine doors), or dry flood-proofing basements and lower floors. They will also be required to ensure that emergency power systems—generators and fuel pumps—are accessible to building staff at all times, so that emergency power can be maintained continuously, even during flood conditions.

As with new hospitals, existing hospitals will also be required to install by 2030: Backup air conditioning service for inpatient care areas in case of utility outages (for example, chillers on emergency power); pre-connections for temporary boilers and chillers if primary equipment is not elevated; and pre-connections for external generators as a backup power source in case the hospital must run on emergency power for extended periods. These redundancies will provide an additional level of protection for hospitals' most critical services, and thus, will help avert evacuation in the event that primary equipment is breached or permanently damaged.

Many providers have already met several of these requirements. For example, many hospital generators are elevated today. In addition, providers generally acknowledge that power, emergency power, and water are necessary for them to remain operational, and investments in flood mitigation are needed to minimize future evacuation risk. Accordingly, many providers already have made plans to address these risks. To avoid placing an undue financial burden on providers, hospitals will not be mandated to retroactively protect other critical systems and services (such as emergency departments, elevators, lab equipment, telecommunications, IT, and medical equipment) for which other workarounds can be implemented. Never the less, protection for these systems still will be encouraged as a best practice especially since they could be essential for some facilities to remain in operation, depending on their layout and unique risks.

OLTPS will include these retrofit requirements in its broader proposal to the New York City Council in 2013. The City will enforce compliance with this mandate by 2030 (recognizing compliance to be voluntary for hospitals owned by the State or Federal government). As part of this process, by the end of 2020, hospitals will be required to submit an interim report certifying that they have complied with the requirements or to submit an affidavit describing a plan to achieve such compliance by 2030. Hospitals added to the floodplain in future versions of flood maps will have 15 years from the release of such new maps to implement retrofits.

Initiative 3

Support the Health and Hospitals Corporation's (HHC) effort to protect public hospital emergency departments from flooding

Emergency departments (EDs) are critical access points for patients in need of hospital services. Three public hospitals' EDs are at risk of flooding due to storm surge. Subject to available funding, the City will aim to ensure these EDs are protected and available to care for New Yorkers. Bellevue Hospital (Manhattan), Metropolitan Hospital (Manhattan), and Coney Island Hospital (Brooklyn) are operated by the New York City HHC, which serves all New Yorkers, regardless of their ability to pay. With EDs located below the 500-year flood elevation, direct flood damage would cause the EDs to be closed for months, as equipment, walls, and floors would need to be replaced. Extended closures would require patients to travel longer distances to receive care, and other providers to accommodate additional volume.

Bellevue Hospital has the only designated regional trauma center below 68th Street in Manhattan. The City will pursue a coastal protection pilot project, subject to available funding, which includes measures to address the flood risk to Bellevue's ED. Mitigation options under consideration include floodwalls and ramps. The City will also support HHC's on-going efforts to work with the State and Federal governments to identify mitigation solutions and funding sources that allow its other EDs to be protected from flooding. Current options being explored include elevating Coney Island Hospital's ED and other critical building systems above the 500-year flood elevation and installing temporary or permanent floodwalls around Metropolitan Hospital's ED and campus *(see* Chapter 3, *Coastal Protection).*

Initiative 4

Improve the design and construction of new nursing homes and adult care facilities

New nursing homes and adult care facilities are at risk of power service failures due to storm surge, which could result in patient evacuations. To address this risk, the City will amend its Construction Codes to require that new facilities be constructed with additional resiliency measures for their emergency power systems, which are essential to allow staff and patients to shelter in place safely during a disaster. Power in these residential facilities is needed not only for standard operational requirements—such as lighting, elevators, use of medical equipment, and communications—but also

for essential emergency operations such as pumping floodwater out of basements if flood protection fails.

New nursing homes are already required to have emergency generators, but because generators can fail when used for an extended period of time, facilities will now be required to have in place an electrical pre-connection for an external stand-by generator. The ability to switch electrical systems over quickly to a stand-by generator can reduce significantly the likelihood of emergency evacuations during or after a disaster.

Meanwhile with respect to adult care facilities, they are not currently required by the State or City to have any emergency power systems. Their residents are more ambulatory and less fragile than nursing home patients but, nevertheless, require care and living assistance that is dependent on working electricity. For this reason, the City will require new facilities to install either an emergency generator that is adequately protected or pre-connection to an external stand-by generator. OLTPS will propose these requirements for new nursing homes and adult care facilities to the City Council in the latter half of 2013.

Initiative 5

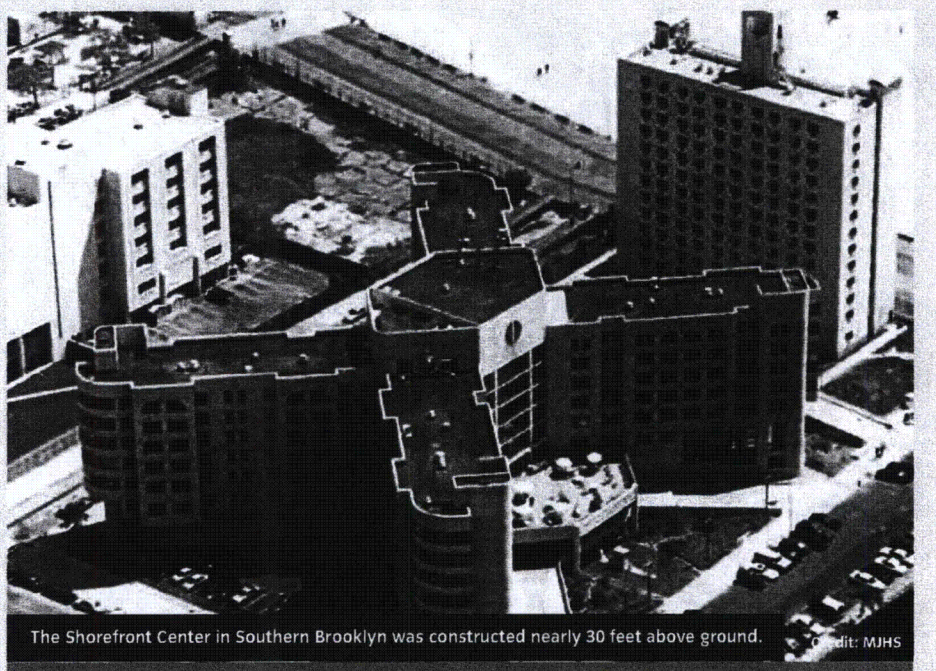
Require the retrofitting of existing nursing homes in the 100-year floodplain

Among all the critical systems that nursing homes rely on for normal operations, power and water are the most essential during emergency conditions because they are required for so many other services such as heating, air conditioning, sanitation, and elevator services.

The City will therefore require existing nursing homes in the 100-year floodplain which, as indicated by the PWMs, includes 18 facilities (11 percent of the citywide bed capacity), to meet standards by 2030 for the protection of electrical equipment, emergency power systems, and domestic water pumps (if applicable) retroactively pursuant to changes in the City's Construction Code. These systems will be protected to the 100-year flood elevation, in accordance with specifications already in the New York City Construction Codes.

OLTPS will propose these requirements to the City Council in the latter half of 2013. The City will enforce compliance with this mandate. As part of this process, by the end of 2020, nursing homes will be required to submit an interim report certifying that they have complied with the retrofit requirements or to submit an affidavit describing a plan to achieve such compliance by 2030.

Because it may be difficult for some nursing homes to secure the financial capital needed for retrofit projects, a financial assistance program will be launched by the City, subject to available funding (see Initiative 7). Nursing homes that are added to the floodplain with the release of future flood maps will be required to comply within 15 years of such new flood maps going into effect.



The Shorefront Center in Southern Brooklyn was constructed nearly 30 feet above ground. Credit: MJHS

Shorefront Center During Sandy

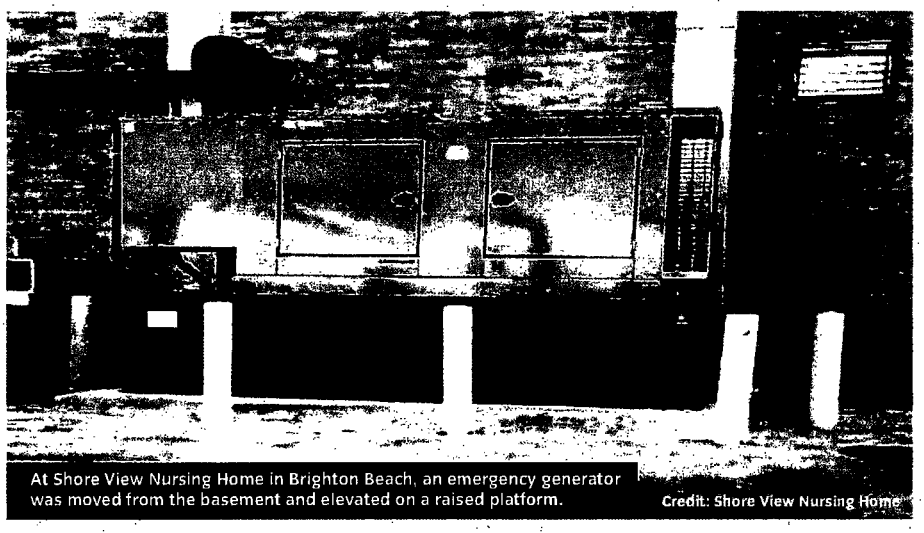
Built in 1994, the Shorefront Center for Rehabilitation and Nursing Care, in Southern Brooklyn, was designed to comply with building code requirements for flood-resistant construction due to its proximity to the ocean. Having been built to exceed the 500-year flood elevation by three feet, the entire facility is elevated nearly 30 feet above ground, with parking spaces below. All of the building's systems and equipment are also elevated and thus protected from floodwaters. The emergency power supply is furnished with enough capacity to run medical equipment, elevators, and heating, ventilation, and air conditioning (HVAC) systems to ensure the facility can continue to operate during power outages. Furthermore, the elevated first floor houses only the lobby and other support services. Community and administrative space is located on the second floor, while residents' and patients' rooms start on the third.

During Sandy, the building functioned as planned. At the peak of the storm, floodwaters filled the parking area and reached the lobby door, but did not enter the building. Emergency power generators remained safe and supplied backup power for four days while area-wide power was out. The nursing home's emergency plans for food and medical supplies allowed staff and patients to shelter in place despite limited transportation for incoming supplies. Shorefront was not only able to provide continuous care to its residents during and after Sandy, but it also assisted people from the local community who sought food and shelter.

Initiative 6

Require the retrofitting of existing adult care facilities in the 100-year floodplain

Over 25 percent of citywide adult care facility bed capacity is in the 100-year floodplain (within 19 facilities) and is at risk of power outages due to storm surge. Many of these facilities have their electrical equipment in lower levels where it is vulnerable to flooding. Furthermore, these facilties are also at risk of power outages during heatwaves. In either case, power outages would increase the risk of emergency evacuations. The City will, therefore, require existing adult care facilities located in the 100-year floodplain to elevate or protect their electrical equipment to the 100-year flood elevation, in accordance with the specifications applicable to new buildings in the New York City Construction Codes. In addition, these providers will be required to install an emergency generator that is adequately protected in their facilities. Alternatively, they may install an electrical pre-connection to an external generator,



At Shore View Nursing Home in Brighton Beach, an emergency generator was moved from the basement and elevated on a raised platform. Credit: Shore View Nursing Home

provided they have an operational plan in place that allows them to access an external generator quickly during an emergency (through, for example, regular contracts with suppliers).

OLTPS will propose these requirements to the City Council in the latter half of 2013. The City will enforce compliance with this mandate. As part of this process, by end of 2020, adult care facilities will be required to submit an interim report certifying that they have complied with the retrofit requirements or an affidavit describing a plan to achieve such compliance by 2030. As with nursing homes, adult care facilities will be eligible for financial support, subject to available funding, to comply with the mandate (see Initiative 7). Moving forward, facilities that are added to the floodplain with the release of future flood maps will be required to comply within 15 years of the new flood maps going into effect.

Initiative 7

Support nursing homes and adult care facilities with mitigation grants and loans

The primary obstacle for most nursing homes and adult care facilities in implementing mitigation measures is financing the investment.

Subject to available funding, the City, through DOHMH and the New York City Economic Development Corporation (NYCEDC), will, therefore, administer competitive grants and subsidized loans to assist providers with the upfront costs of certain mandated retrofit projects.

Most nursing homes and adult care facilities receive the majority of their revenue from publicly funded programs such as Medicaid, Supplemental Security Income, or Safety Net Assistance. Typically, reimbursement rates from these programs are not sufficient to enable nursing homes and adult care facilities to invest in costly mitigation projects that do not impact day-to-day care directly. If any capital investments are made, some nursing homes may receive Medicaid reimbursements for a portion of their mitigation costs; while other providers may not be reimbursed.

To qualify for the program, nursing homes and adult care facilities will be required to demonstrate financial need, emergency preparedness planning, and an operational commitment to remain safely open during disasters or reopen quickly thereafter. Eligible mitigation will include retrofits to meet amended building codes (see Initiatives 5 and 6) and wet flood-proofing of walls and floors below the 100-year flood elevation to limit damage from mold. The goal is for NYCEDC and DOHMH to launch the program, capped at $50 million citywide, when the proposed building code amendments for nursing homes and adult care facilities go into effect.

Initiative 8

Increase the air conditioning capacity of nursing homes and adult care facilities

Nursing homes and adult care facilities today typically do not have enough emergency power capacity to run their air conditioning systems. Thus, some providers could be forced to evacuate during power outages that occur in hot summer months. To reduce this risk, the City will seek a sales tax waiver for 100 nursing homes and adult care facilities citywide to install emergency power solutions for their air conditioning systems. This benefit, which will be capped at $3 million citywide, will only be available to those facilities eligible for such benefits under state law. Eligibility criteria for this program will be announced over the next year and will, among other things, include demonstrated financial need.

Strategy: Reduce barriers to care during and after emergencies

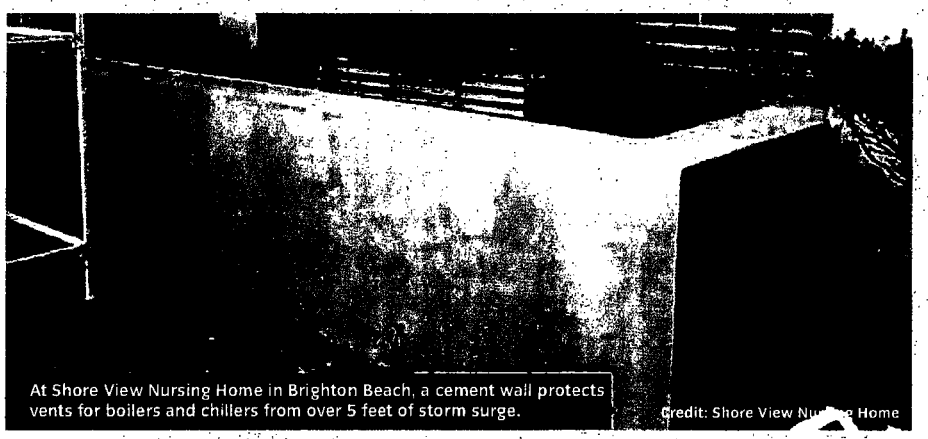
Additional initiatives, spearheaded by the City in collaboration with healthcare associations and providers, will ensure that community-based providers in the healthcare system can provide limited but critical services under emergency conditions and restore normal services as quickly as possible after a disaster. The City's goal is to improve the resiliency of the community-based provider network so that even in the hours and days immediately after a disaster, when other local businesses are still recovering, healthcare providers can offer essential services to New Yorkers with the greatest need for care.

Initiative 9

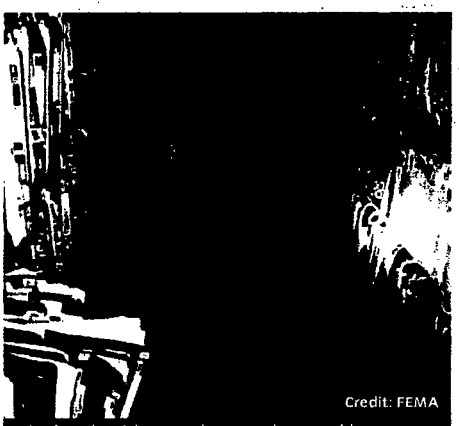
Harden primary care and mental health clinics

In communities that are at risk of extensive flooding, the accessibility of primary care and mental health services may be compromised for weeks after a disaster due to extended facility closures. Ensuring that local clinics can reopen quickly to provide primary care, mental health counseling, and other medical services in high-need communities is important for the health and safety of residents and will address the concentrated impact of storm surge.

Subject to available funding, the City, through DOHMH and a fiscal intermediary, will therefore



At Shore View Nursing Home in Brighton Beach, a cement wall protects vents for boilers and chillers from over 5 feet of storm surge. Credit: Shore View Nursing Home


Credit: FEMA

Patient health records were damaged by floodwaters.

disburse grants and interest-free loans to five to six providers that serve large outpatient populations in communities where medical services may be reduced significantly because of extreme weather events. These capital investments will enable faster recovery of services—for example, via installation of emergency power systems, protection of other critical building systems, and wet floodproofing of facilities. The goal is to launch an application process during the next year. The selection process will prioritize clinics that offer a broad scope of medical services, and demonstrate adequate emergency operations plans.

Initiative 10

Improve pharmacies' power resiliency

Pharmacies dispense life-saving drugs. However, without power, pharmacists cannot access the necessary patient records or insurance information to dispense these drugs. For retail pharmacies that do not sustain structural building damage, generators allow providers to restore the most critical building services they need to reopen. With an emergency power supply, pharmacies can access patient records, receive calls from doctors about new prescriptions or refills, and communicate with insurers and payers for billing purposes. To reopen with emergency power, pharmacies also will need to have robust emergency operations plans ensuring staff transportation and the delivery of supplies to the facility. For New Yorkers who depend on regular prescriptions, quick restoration of pharmacy services is critical.

DOHMH will, therefore, work with other agencies, including Office of Long-Term Planning and Sustainability, the Office of Emergency Management, the Department of Transportation, the Department of Buildings, the Department of Environmental Protection, and pharmacies to assist pharmacies to reopen quickly after a disaster. DOHMH will explore issues such as installing pre-connections for external generators, identifying a central emergency point of contact, permitting, and emergency operations planning. By the end of 2013, DOHMH will launch an emergency preparedness website for pharmacies.

Initiative 11

Encourage telecommunications resiliency

In the aftermath of a disaster, it is important that New Yorkers be able to speak to their doctors for guidance on needed medical care. While in-person visits are ideal for diagnosing and treating health concerns, a phone consultation can be extremely valuable in addressing many patients' needs after a disaster.

For example, a telephone conversation allows a trusted doctor who is familiar with a patient's medical history and specific health conditions to help with post-disaster anxiety, answer health-related questions, perform initial triage of medical concerns, refill prescriptions, or direct patients to alternative providers and medical resources. Telecommunications resiliency is especially important for mental health providers who may need to support patients during the extremely stressful period after a disaster.

To this end, DOHMH is developing a best practice guide and outreach plan to help community-based providers understand the importance of telecommunications resiliency as well as the options they might consider and questions to ask when evaluating solutions. Resiliency solutions could include using backup phone systems (such as a remote answering service that would not be affected by local weather hazards), Voice over Internet Protocol (VoIP) technology that allows office phone lines to be used off-site, and pre-disaster planning to inform patients of available emergency phone numbers. DOHMH will continue to develop the informational materials through the remainder of 2013.

Initiative 12

Encourage electronic health record-keeping

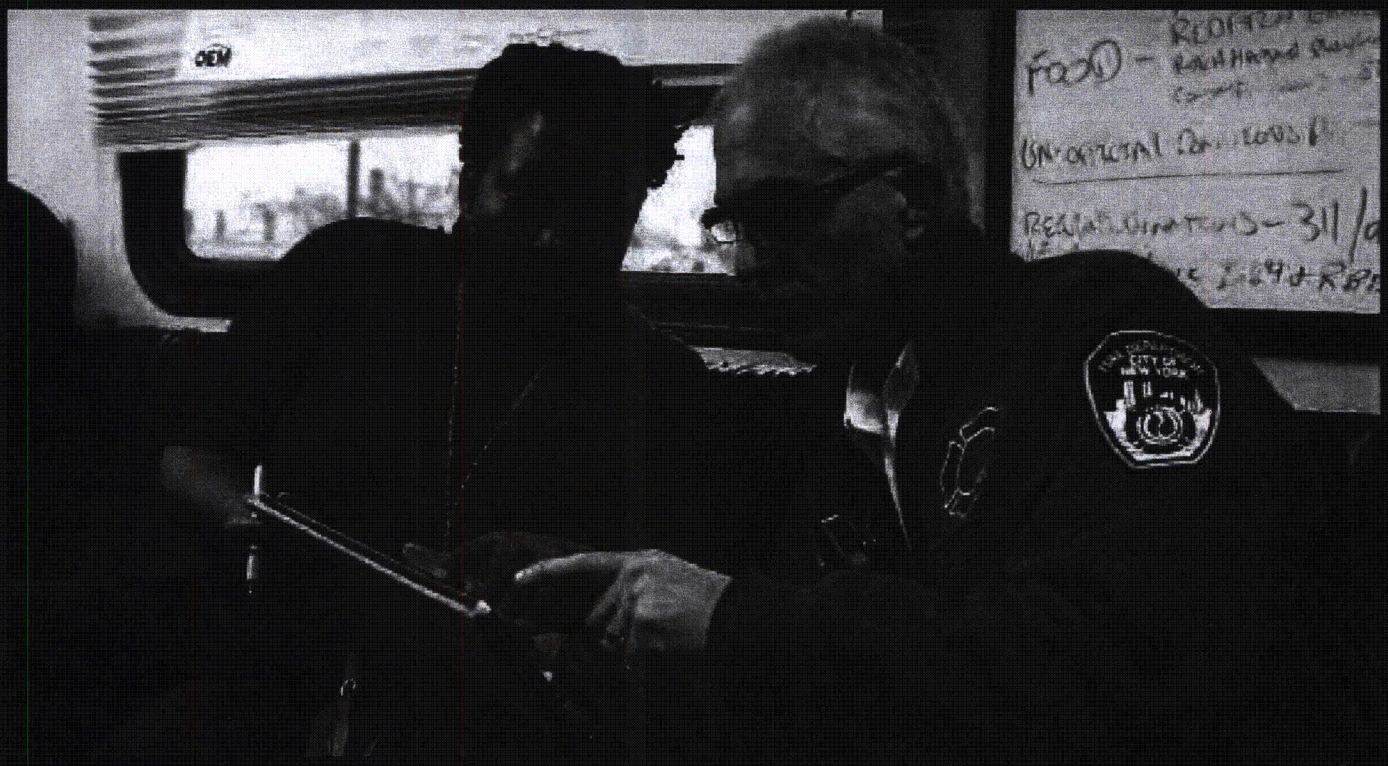
Doctors rely on patients' medical records to provide and track care, but these important records may be compromised or destroyed due to flooding. Damage to paper records results in the loss of valuable patient information, which may impact care. In addition, the specialized disposal of this sensitive material once damaged can result in high waste removal costs.

Electronic Health Records can help prevent the permanent loss of data and allow for quick restoration of services after a disaster. However, even EHR systems need to be implemented with operational resiliency in mind. For example, providers might want to ensure that they can still access patient information even if they cannot occupy their offices. In addition, providers must ensure that computers and servers are not located on floors where they may be flooded. Their vendors' servers must also be protected from flood risk.

DOHMH's Primary Care Information Project (PCIP) sponsors numerous initiatives to help primary care and mental health providers citywide with EHR technical assistance for their practices. Moving forward, PCIP programs will highlight the ways in which EHR can be used to prevent permanent loss of data and quickly restore services after a disaster. PCIP will target providers, in the floodplain, that can benefit significantly from transitioning to EHR, with specific guidance on how EHR should be implemented for maximum effectiveness in flood hazard mitigation.

Running on generator power, a temporary pharmacy in a double-wide trailer served customers in Sheepshead Bay, Southern Brooklyn. Credit: DuaneReade

Community Preparedness and Response



City employees from a variety of agencies coordinated with communities and volunteers.

Credit: Dave Seliger/OEM

Friends and family, neighbors down the block, and even strangers living in another borough—thousands of New Yorkers stepped up to help others during and after Sandy. This response was not only impressive; it has been critical to the recovery and rebuilding of hard-hit neighborhoods. The collaboration amplified the City's ability to address community needs.

Of course, community involvement should not be limited to disaster response. It also must extend to disaster preparedness, including efforts to improve communications in advance of an event that is reasonably foreseeable, such as extreme weather. During Sandy, the City launched an unprecedented campaign to warn New Yorkers of the impending storm. The City's Office of Emergency Management (OEM) sent electronic alerts to more than 165,000 residents, and NYC.gov provided information to four million unique visitors.

During Sandy, community leaders helped by reinforcing or tailoring messages to local populations, including both residents and business owners. For example, these leaders supported evacuation orders and encouraged companies to elevate valuable inventory and equipment.

But of course, community preparedness and response is most effective when it is coordinated closely with City activities, as facilitated by NYC Service and other City agencies. This requires the best possible information flows—from communities to the City, and from the City to communities.

Nowhere is information flow from communities to the City more important than with regard to vulnerable populations such as the elderly, sick, and disabled who may have a limited ability to help themselves or even to seek help from others. That is why, prior to the arrival of Sandy, representatives of the City's Human Resources Administration (HRA), the Department for the Aging (DFTA), and the Administration for Children's Services (ACS) worked around-the-clock with their partner service providers to contact clients to advise them of safety protocols.

After the storm, however, these and other agencies found it challenging to confirm that known vulnerable clients were well, due to displacement, telecommunications failures, and other reasons. Although certain agencies had access to databases with client information, in some cases, legal and technical barriers prevented the sharing of lists across agencies. Although, ultimately, City agencies and community-based organizations conducted outreach that located and served thousands of vulnerable individuals, the lack of a consoli-

Delivery of emergency relief supplies

Credit: OEM

dated and accessible information source made this task both slower and more difficult than it should have been. In recognition of these issues, the City's *Hurricane Sandy After Action Report*, released in May 2013, called for "better integration of the City's data across all platforms and agencies to increase situation awareness and allow for more targeted, efficient response and recovery operations."

Although improving the City's access to information would be an important start, the City also needs the ability to push information out in a targeted fashion to threatened or impacted communities. Today, the City's Housing Maintenance Code authorizes the Department of Housing, Preservation, and Development (HPD) to require the registration of tenant-occupied residential properties, including basic contact information such as emergency telephone numbers. However, during Sandy, several deficiencies emerged. For example, HPD does not have the legal authority to require 1- and 2-family owner-occupied homes to provide emergency contact information. Moreover, existing law prohibits HPD from sharing emergency contact information with any other entity, including other City agencies engaged in emergency preparedness and response. These and other issues hampered the City's ability to communicate information in a targeted fashion.

As the City strives to become more resilient through investments in its buildings and infrastructure, it also must continue to call upon communities to play a key role in emergency preparedness and response. The *After Action Report* outlines a series of strategies for accomplishing this goal. In addition to these robust strategies, in this report, the City also proposes two more ways of engaging communities: the development of a pilot community needs assessment and action plan for increasing local capacity, and an expansion of OEM's existing Community Emergency Response Teams (CERT). In addition, the City will pursue two measures to improve agencies' abilities to gather data from and disseminate information to communities on a real-time basis prior to, during, and after extreme weather events and other disasters.

Initiative 1

Launch a pilot program to identify and address gaps in community capacity

The local capacity to organize and support residents and businesses varies greatly from neighborhood to neighborhood. The City learned from Sandy that neighborhoods with higher community capacity tended to prove more resilient. Subject to available funding, the City will conduct a pilot community needs assessment in one to-be-identified Sandy-impacted community. Upon selection of the applicable community, OEM and the City's Center for Economic Opportunity (CEO) will work with local residents to identify community strengths and needs and develop a set of recommendations for improving local preparedness and response capacity before, during, and after an extreme weather event. Following this "gap identification process," the City and the community subsequently will develop and implement a plan—as well as seek philanthropic and other potential funding sources—to address identified needs. The goal is to launch this pilot in 2013, and subsequently to explore expanding it to other neighborhoods if additional funding becomes available.

Initiative 2

Continue and expand OEM's Community Emergency Response Teams

OEM currently oversees the CERT program, comprised of well-trained volunteers that support individuals, families, and local organizations in their communities with emergency education, preparedness, and response, including assisting first responders. Several vulnerable neighborhoods, however, are underrepresented—with small CERT teams or none at all. In the wake of Sandy, the City will expand CERT, with an initial focus on Red Hook and the New York City Housing Authority's Red Hook Houses. In addition, as referenced in the *After Action Report*, the City will expand EmergeNYC, a volunteer program run by NYC Service. This program prepares large numbers of local volunteers to support impacted communities with high-impact tasks such as food distribution following a disaster. In addition, OEM and NYC Service, working with CEO, will pursue opportunities for low-income young adults to become engaged in the City's disaster-

Relief kits awaiting distribution to families in Red Hook

Credit: RDeLetto/Flickr

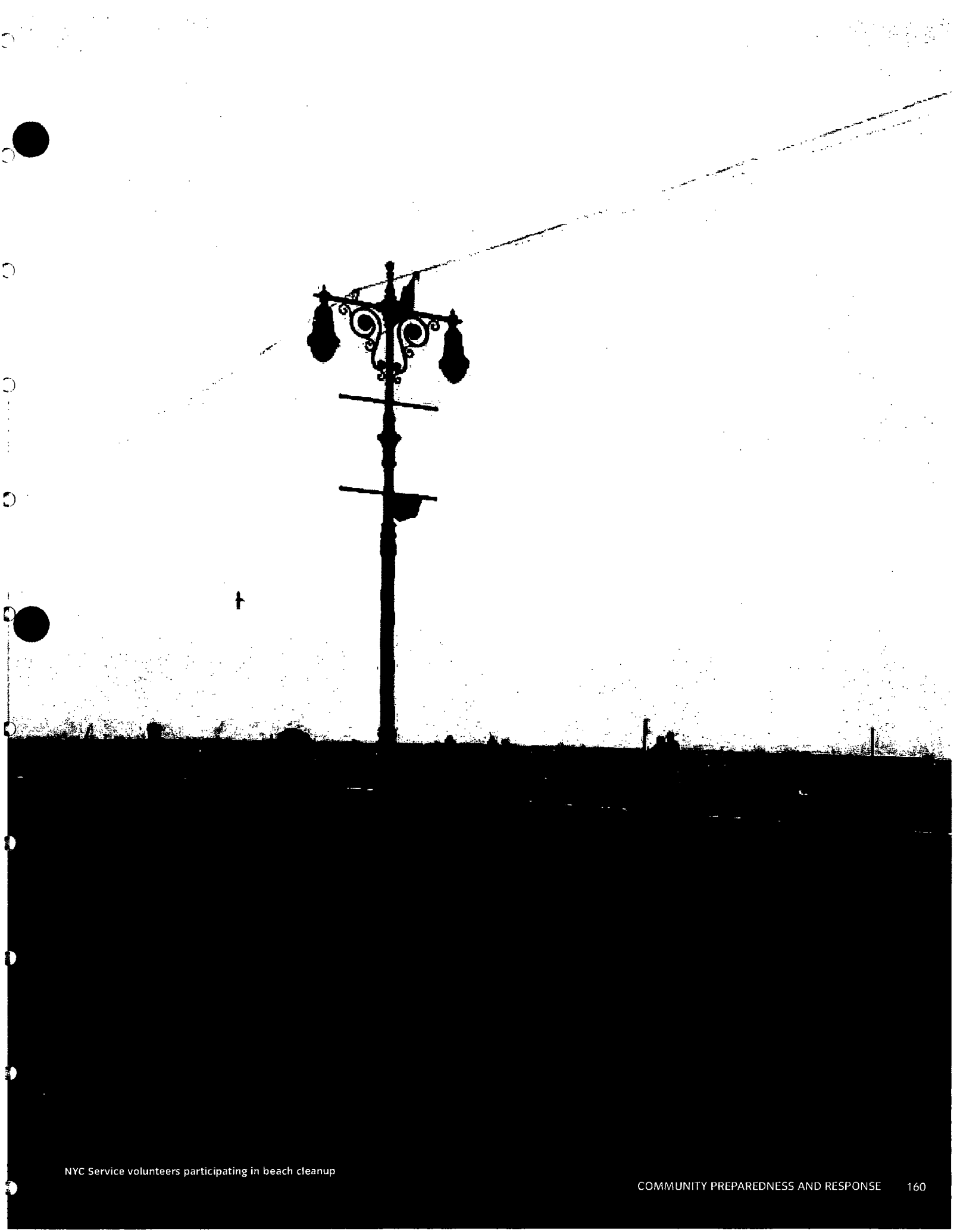
preparedness efforts. This will be done as part of a subsidized jobs program, such as NYC Recovers, and will provide participating young adults with a formal leadership role in their communities. Finally, OEM currently is piloting a simplified disaster response workshop for participants in the Neighborhood Leadership Institute, a program run by the Mayor's Office of Immigrant Affairs and the New York City Community Trust in partnership with the Citizens Committee for New York City, to provide skill-building sessions for emerging immigrant leaders. If successful, the City will seek additional funding to replicate this training.

Expand the Worker Connect information technology tool to serve as an Emergency Services Portal

Existing technical and legal barriers to information sharing limit the ability of City agencies to access limited but critical information about vulnerable populations, including the name, address, age, and medical condition of these individuals. Improving access even to this limited set of information could result in dramatic improvements to the City's ability to identify and respond to urgent needs during extreme weather events. Subject to available funding, the City, acting through the Office of the Deputy Mayor for Health and Human Services, will seek to expand the existing Worker Connect information technology tool to perform this critical function. Worker Connect currently provides access to select client information from data sources across five City agencies: HRA, ACS, the Department of Finance, the Department of Homeless Services, and the New York City Housing Authority. The City will seek to enhance Worker Connect with a new Emergency Services Portal, with access to a number of additional agency, nonprofit, and private data sources, subject to a review of legal and privacy considerations. The City also will seek to strengthen the functionality of Worker Connect's Emergency Services Portal by adding new reporting capabilities. Finally, the use of unique identifiers such as a Building Identification Number will allow this system to interrelate to other datasets or programs, as appropriate based on a legal and technical review of the desirability and feasibility of such connectivity. The goal would be to launch the effort in 2013, with full development expected to last up to four years.

Explore the creation of a new online Emergency Notification Contact System

Although HPD's existing tenant contact data collection system is a useful tool, with certain improvements it could expand into a far more robust preparedness and response communication system. Subject to available funding, the City, through HPD, will explore the creation of an online Emergency Notification Contact System (ENCS) that would be distinct from, but complementary to, the existing mandatory housing registration system. Although a local law would be required to make participation in the ENCS mandatory, in the interim, HPD will pursue the creation of a voluntary database. This database would include not only basic and emergency contact information (including for 1- and 2-family homeowners), but also supplementary details where possible—including, for example, the availability of emergency generators, the type of building heating system, information regarding vulnerable populations, and other relevant information. The ENCS also could include the ability to receive electronic updates from registrants and to push messaging to targeted subsets of registrants. The system should have the capability to integrate not only with other HPD systems but also with other City databases for emergency purposes. Upon receipt of the necessary funding, HPD would manage the system's development, implementation, and maintenance, while working with other agencies to identify the requisite data and to provide access to those other agencies where appropriate and permissible. HPD also would work with the City Council to consider mandating participation in the ENCS.



NYC Service volunteers participating in beach cleanup

Telecommunications

Someone makes a call from a cell phone in Manhattan to a house on Staten Island. That call follows a circuitous path. The call connects to a cell site atop a private building, runs through cables under the street, navigates three separate telecommunications switching facilities, and continues through miles of underground and overhead cables. When the call finally reaches the house on Staten Island, it has been controlled by at least two phone providers, it has operated under the authority of at least three government regulators, and it has relied on the seamless operation of a vast network of equipment.

Clearly, telecommunications in New York City, as elsewhere, are complex. And, of course, they cover more than phone calls, encompassing Internet and cable television services as well. All of these telecommunications services rest on a vast infrastructure of over 50 thousand miles of cabling, thousands of cell sites, and nearly 100 critical facilities. This telecommunications infrastructure not only serves New York's population of 8.3 million residents, it also serves the city's 3.9 million workers, 250,000 businesses, and 50 million annual visitors. The city's telecommunications infrastructure plays a critical global role: it is estimated that New York City accounts for approximately 3 percent of the world's web traffic—even as the city serves as home to only 0.1 percent of the world's population.

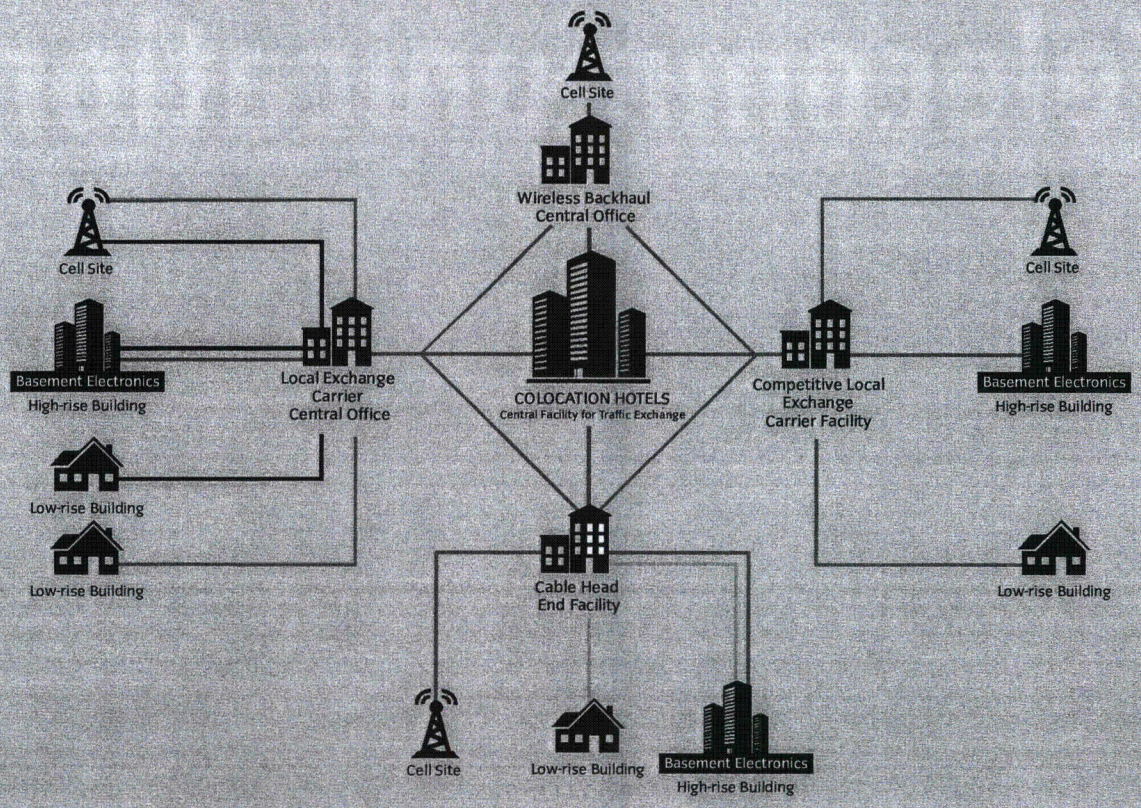
In the city's increasingly information-based economy—which depends on quickly accessing and exchanging information—telecommunications keep our city running. The finance industry depends on these services to process transactions. Small businesses rely on them to receive orders and contact customers. New Yorkers use them for everything from getting news to communicating with friends to buying food—whether ordering from favorite neighborhood takeout restaurants or paying for groceries through food assistance programs such as Electronic Benefits Transfer (EBT).

Telecommunications also are increasingly important to New Yorkers' health and public safety. Particularly for vulnerable populations during emergencies, being able to send a text to a family member or make a 911 call can be the difference between getting help and being stranded or worse. As hospitals and other healthcare providers transition to electronic medical records, connectivity is becoming even more essential to our healthcare system.

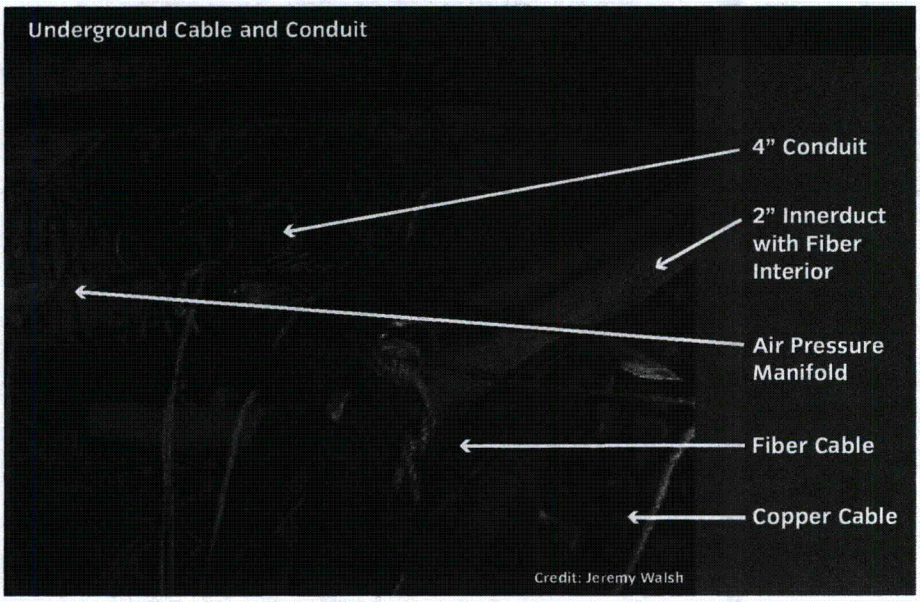
Competition across New York City's telecommunications market is robust, with multiple providers delivering overlapping services. New York City is served by four cable TV providers, the four major national wireless providers (Verizon, AT&T, T-Mobile, and Sprint), and over a dozen competitive local exchange carriers providing telephone and other services.

Nonetheless, improvements are needed. Sandy exposed weaknesses in the city's telecommunications infrastructure—including the location of critical facilities in areas that are susceptible to flooding. In Southern Manhattan and the Rockaways, the storm caused

Components of the Telecommunications System



CABLE TYPE	PERIOD IN USE	LAST INSTALLED	RESILIENCY
Copper Cables	1910s to present	Lead sheath cable until 1970s; plastic sheath still being installed	Vulnerable to flooding
Coaxial Cables	1950s to present	Still being installed	Difficult to troubleshoot; more resilient than copper
Fiber Cables	1970s to present	Still being installed	Most resilient cable; slowly replacing others



neighborhood-wide outages that lasted up to 11 days—and for those buildings that suffered inundation, restoration of service took well over three months in some places.

In keeping with the broad goals of this report—which are to minimize disruptions from climate hazards and to increase the New York's capacity to bounce back quickly if damage is sustained—the City's plan should enhance the resiliency of the telecommunications system. The City will advocate that a base level of telecommunications service is available and accessible throughout New York at all times for emergency communication, and will work toward quick restoration of full telecommunications services when disruptions do occur. The City will do this by increasing the accountability of telecommunications providers to invest in resiliency and by using new regulatory authority to enable rapid recovery after extreme weather events, to harden facilities so as to reduce weather-related impacts and to create redundancy to reduce the risk of outages. While competition may drive better service and resiliency in some areas, the City must take an active role in making the telecommunications infrastructure more resilient in all parts of New York.

How the Telecommunications System Works

Telecommunications services—telephone, wireless, Internet, and cable—are delivered from interconnected central facilities that transfer data among one another and then send that data back out over a network of cables to end users in their homes and offices or on mobile devices. All components of this infrastructure need to be functioning along the entire route for a call, text message, email, or other type of data to be sent successfully from one point to another.

Components of the Telecommunications System

The telecommunications system is comprised of four main components: critical facilities, cabling, cell sites, and equipment in individual buildings. *(See graphic: Components of the Telecommunications System)*

Critical telecommunications facilities are larger distribution and switching centers. They provide connectivity across all major services and each supports tens of thousands of customers. These critical facilities include telephone central offices; "colocation" hotels, which are secure physical sites or buildings where data are transferred from one provider to another; and cable "head ends," the facilities that distribute cable TV and Internet services to subscribers. Providing round-the-clock services, these critical facilities have back up batteries and fuel-powered generators, and they are environmentally controlled to keep electrical equipment safe from excessive humidity and overheating.

Cabling provides the connections essential to telecommunications and can be strung overhead via utility poles or can run underground. New York's oldest cabling is lead-encased copper, with sections ranging from 10 to 90 years old. The copper network is in poor condition due to its age. Many cables have leaks, compromising the pressurized air system designed to keep water away from copper wiring. Coaxial cable is a newer material that is somewhat resistant to water and is primarily used for cable TV and Internet services. Fiber cable is the newest and most resilient type of cable, being both fully water-resistant and able to carry all types of service.

Conduit, an underground pipe through which cable is threaded, is the way most cable snakes beneath New York City. While it is more expensive to construct than overhead wires, it is also more protected and less intrusive. Conduit is used in the densest areas of the city—Manhattan, the Bronx, and parts of Brooklyn, Queens, and Staten Island. Manhattan and the Bronx have a shared conduit network run by Empire City Subway, a private company that is responsible for providing conduit infrastructure for providers in all areas of those boroughs. In the other boroughs, Verizon, Time Warner Cable, and Cablevision have the most extensive conduit infrastructure, some of which is rented to other providers. *(See graphic: Underground Cable and Conduit)*

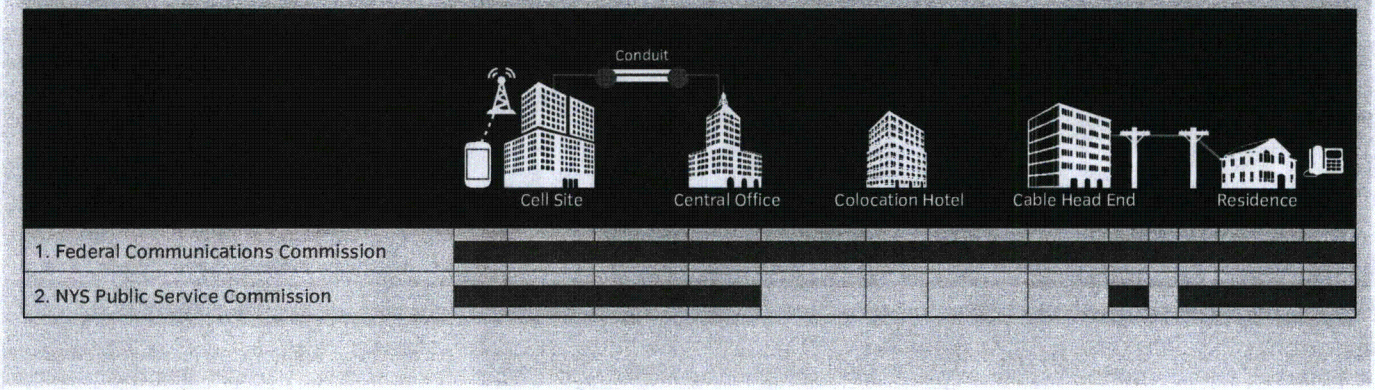
Cell sites are also key components of the telecommunications infrastructure. Unlike in rural areas, where cell sites often sit atop freestanding towers, cell sites in New York City are typically placed on the rooftops of buildings. Cell sites have three components: an antenna, electronics, and backhaul circuits—cables that connect the cell site to the larger telecommunications network. Backhaul circuits are generally copper or fiber optic cable, most frequently taking a single path back to central switching facilities. Most cell sites rely on power supplied by a utility, and have four to eight hours of battery backup.

The final piece of the telecommunications puzzle is the equipment in homes, offices, and other buildings that distributes signals transmitted via cabling from critical facilities to individual customers. This equipment ranges from electronic multiplexers in large buildings (usually found in basements) to terminals attached to the exterior of small residential buildings (positioned a few feet off the ground), to individual customers' modems.

Regulatory Framework for the Telecommunications System

Federal, State, and City agencies are involved in the regulation of the telecommunications industry. However, none currently has comprehensive responsibility for the entire system, and none is charged with ensuring that required service is available in emergencies. While the Federal Communications Commission (FCC) has a Communications Security, Reliability, and Interoperability Council that promotes best practices for resiliency, it does not require compliance with these standards.

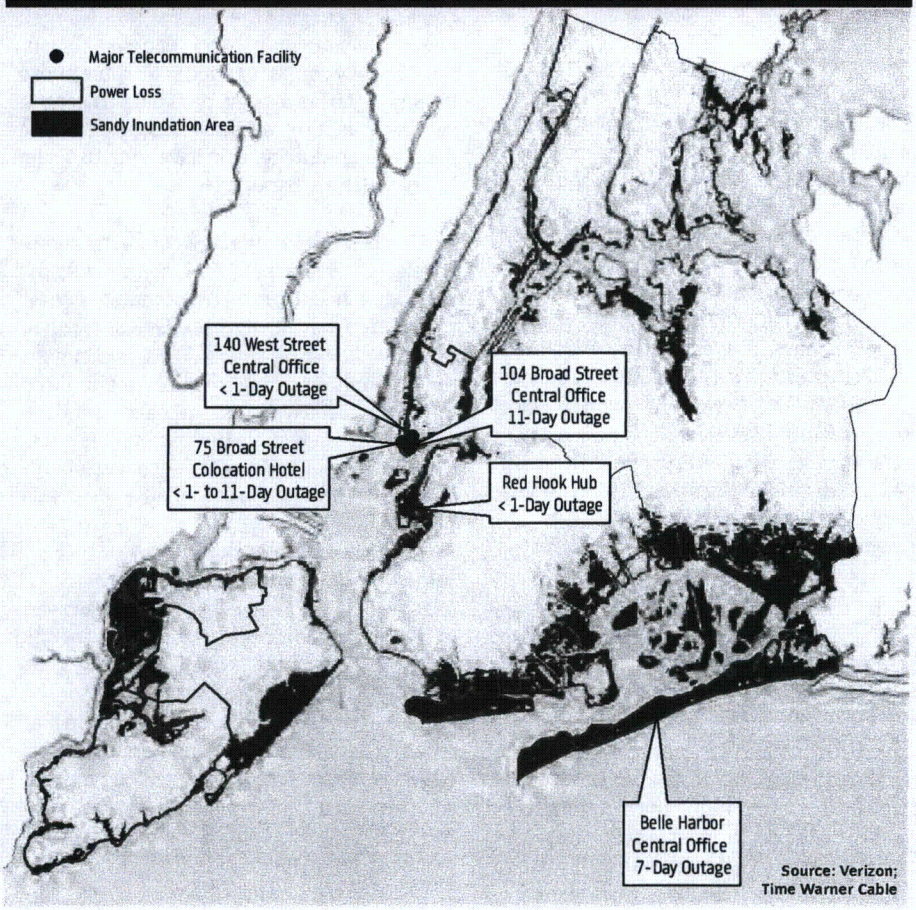
State and Federal Regulatory Authority Over a Call in New York City



The FCC has significant authority over wireless, long-distance phone, and Internet (including at least some aspects of "Voice over Internet Protocol," or VoIP) services. The New York State Public Service Commission (PSC) has significant authority regarding local traditional landline telephone service. Finally, the FCC, the PSC, and the City all share regulatory authority over cable TV service.

Three City agencies are involved in overseeing various aspects of the telecommunications infrastructure in New York City. Founded in 1994 to consolidate the City's information technology functions with its cable and telecommunications activities, the Department of Information Technology and Telecommunications (DoITT) is responsible, among other things, for purchasing and administering internal communications services for City agencies; for administering the franchises that allow communications companies to access public rights of way for their infrastructure—above and below the city's streets—and for collecting fees and other compensation for such access. The Department of Transportation (NYCDOT) also plays a role as manager of street access through its control of permitting for street construction. Finally, the Department of Buildings (DOB) is the custodian of the Building Code, which determines, among other things, the placement of electrical equipment, backup power, and fuel storage at critical telecommunications facilities. *(See graphic: State and Federal Regulatory Authority Over a Call in New York City)*

Major Telecommunications Facility Outages During Sandy



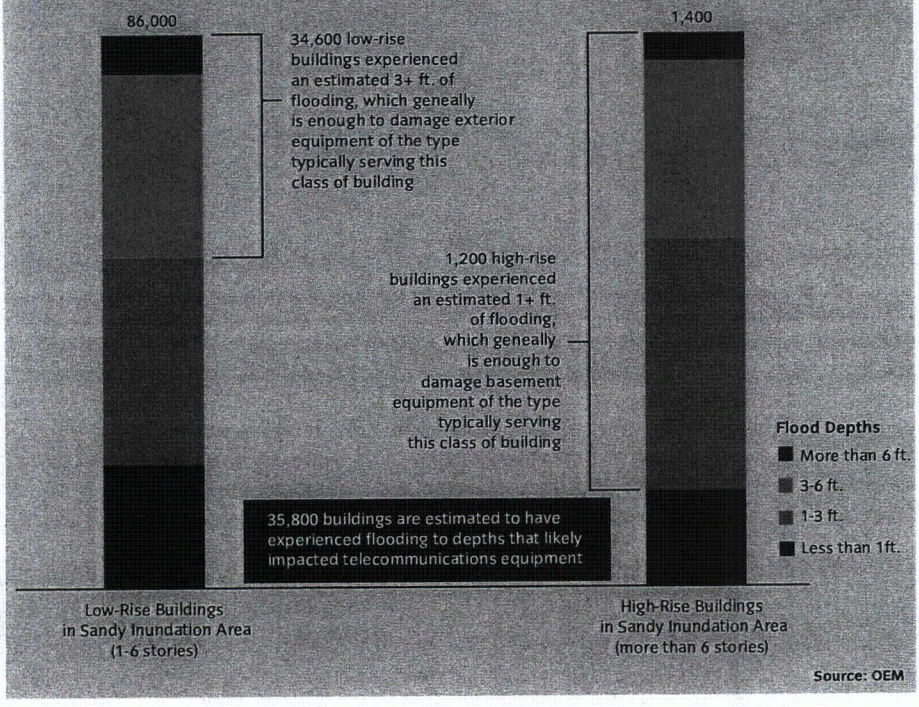
In recent decades, evolving technology has led to shifting regulatory authority, as some services move out of one regulator's domain and into that of another. The transition from traditional wire-line phone service to phone service via fiber optic cable or Internet (VoIP) is a prime example. Consumers who make the switch from a landline phone service to VoIP move from a service that is regulated by the State to a service that is at least in part regulated at the Federal level. Not surprisingly, the popular bundled services offered by many providers have a particularly complex regulatory structure. A bundled voice, Internet, and cable package, for example, is regulated on both the local (cable) and Federal (Internet and VoIP) levels.

As a result of these overlapping jurisdictions, there is currently no single entity that is prioritizing or enforcing resiliency across the entire system. To ensure that changes in technology do not compromise public access and safety, a focus on creating a more resilient telecommunications system is crucial—especially as the effects of climate change are felt in New York City.

Sample of Telecommunications Service Restoration Times of Commercial Buildings in Southern Manhattan

High-rise commercial buildings that lost telecommunications service during Sandy took weeks or months to restore service because of damage to copper cables, and difficulties in restoring power and replacing flood-damaged equipment in individual buildings.

Estimated Flood Damage to Telecommunications Equipment in Buildings



What Happened During Sandy

During Sandy, telecommunications outages followed the pattern of utility power outages and flooding. When utility power went out, it knocked out cable and Internet services in homes and businesses immediately. These power-driven telecommunications outages affected the greatest number of customers and were generally short-term. However, flood damage at critical facilities, in individual buildings, and to cable infrastructure led to longer-term outages.

The storm affected several critical facilities immediately. The loss of utility power required the use of backup power at central offices in Southern Manhattan, Staten Island, Southern Brooklyn, and the Rockaways.

At critical facilities in Southern Manhattan, Red Hook, and the Rockaways, flood damage to equipment and backup power systems caused service to go out in the areas they served. Flooding caused damage to electrical switchgear, backup generators, and fuel storage containers, particularly if they were housed in basements or sub-basements. The pumps in many of these facilities were not designed for the volume of corrosive salt water that inundated them—up to one million gallons of water at some sites. As a result, it took up to five days just to get the water out of some central offices, prompting some companies not just to repair but to redesign their facilities entirely. *(See graphic: Major Telecommunications Facility Outages During Sandy)*

Cable infrastructure experienced light outages as a result of wind damage to overhead wiring in Brooklyn, the Bronx, Queens, and Staten Island. In Southern Manhattan, the failure of the aging air pressure system caused widespread copper cable damage. The most impacted part of the city's cable infrastructure was the legacy copper network. When power failed in Verizon's central office at 104 Broad Street, the air pressure system that kept water out of its cables shut down, and the copper cables were infiltrated with salt water. Using the damage as an opportunity, Verizon swapped out its copper network for a more resilient fiber optic network. Though clearly a benefit to customers over the long term, the process required replacing equipment at all buildings served by the affected copper—even where flooding had not directly damaged a building's telecommunications equipment. This led to a loss of phone service over a wide swath of Verizon's service territory in Southern Manhattan, causing significant short-term disruption. *(See sidebar: A Tale of Two Central Offices)*

A Tale of Two Central Offices

140 West Street and 104 Broad Street

Central offices that "hardened," or protected, their equipment before the storm had shorter downtimes than central offices where equipment was left vulnerable to flooding. Two Verizon central offices in Southern Manhattan that flooded during Sandy illustrate this point. One office (at 140 West Street) had raised generators and electrical equipment after September 11 and as a result was able to restore service within one day of the storm. The other (at 104 Broad Street) had basement electrical equipment and generators that were completely flooded, knocking out service there for 11 days. Restoration of service to other buildings took significantly longer, with some buildings not restored even six months after the storm. The lesson learned: investment in resiliency works.

140 West Street Central Office

Pre-Sandy Condition
- Raised generators
- Raised electrical switchgear
- Newer copper infrastructure (plastic casing)
- Extensive fiber deployment
- Standby pumps to protect against flooding

Sandy Effects
- Raised generators and electrical switchgear were not impacted by flooding
- Newer copper infrastructure was not inundated with water for an extended period
- Fiber infrastructure was undamaged
- Fuel tanks were disabled and fuel was compromised

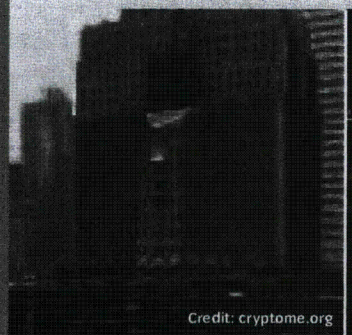
Post-Sandy Restoration
- Operational within 24 hours, after temporary fuel tanks were put in place and temporary power cables were run to the switchgear

104 Broad Street

Pre-Sandy Condition
- Generators at or below grade
- Electrical switchgear at or below grade
- Older copper infrastructure (lead casing)

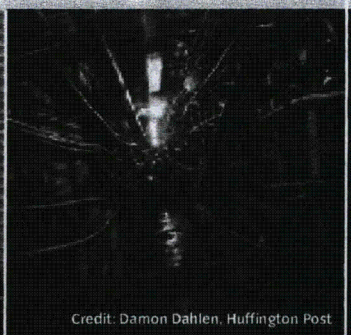
Sandy Effects
- Generators; electrical switchgear; and heating, ventilation, and air conditioning (HVAC) systems were inundated with salt water
- Water remained in the basement vault for five days
- Copper infrastructure was submerged for five days until vaults could be pumped out

Post-Sandy Restoration
- Operational after 11 days, with delays caused by need to find locations for replacement generators, electrical switchgear, and HVAC, and to connect these to the building



Credit: cryptome.org

Post-9/11, Verizon hardened 140 West Street.



Credit: Damon Dahlen, Huffington Post

140 West Street cable vault contained relatively fewer copper wires and saw less inundation post-Sandy than 104 Broad Street.

104 Broad Street contained a large number of copper wires pre-Sandy.

Cable vault of 104 Broad Street had to be stripped of copper wire post-Sandy.

140 West Street and 104 Broad Street Central Office Resiliency

Although 140 West Street fared much better during Sandy, both buildings incurred damage. Verizon currently is hardening both offices to prevent future inundation: all electrical switchgear will be raised to the second floor or higher, fuel tanks are being redesigned to withstand submersion, generators are being raised above expected flood heights, and external flood barriers are being considered by Verizon. Most of these hardening measures are expected to be in place by August 2013.

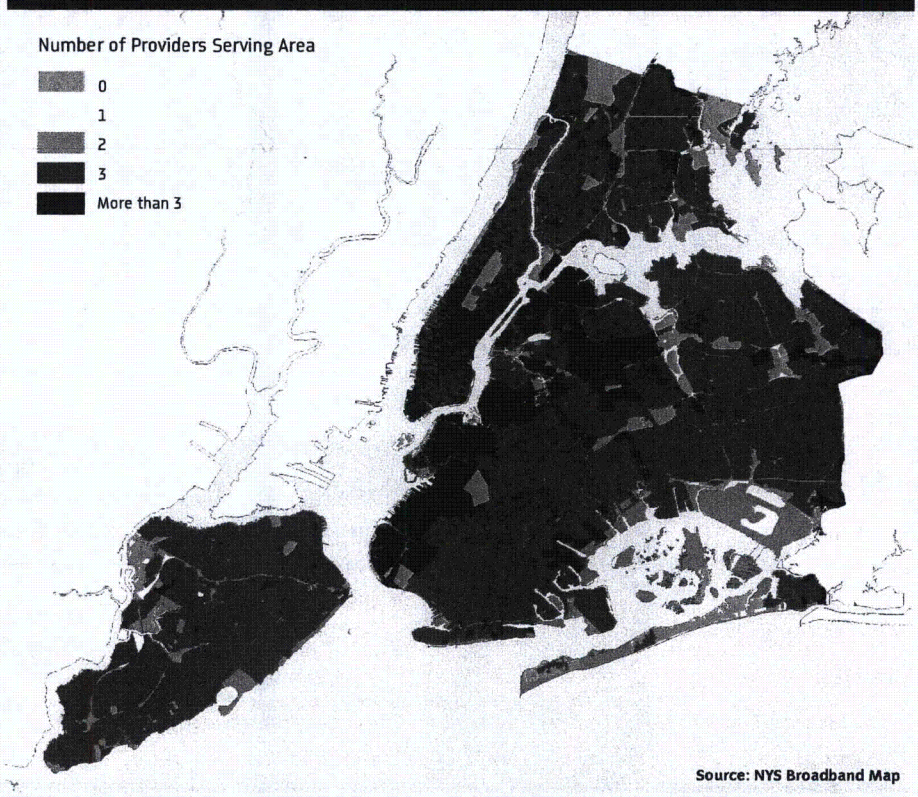
Generally, new coaxial and fiber optic cable fared better than copper cable. The coaxial and fiber cables remained in good condition throughout the storm, though wind and tree damage to overhead wires caused limited outages in areas of Staten Island, Brooklyn, and Queens. Flooding usually only interrupted service provided by coaxial and fiber cables when the electrical equipment to which they were connected lost power.

Longer-term telecommunications outages in the city were primarily caused by flood damage to commercial and residential buildings. Flooding of one to three feet or more usually resulted in damage to basement and exterior telecommunications equipment, affecting an estimated 35,800 buildings across the city. In high-rise buildings, flooding often destroyed telecommunications equipment including electronics and copper distribution frames, along with electrical switchgear that distributed power. To restore telecommunications service, buildings frequently looked for access to power and space at higher elevations for new equipment—a process that, in some cases, created delays in service restoration. *(See map: Sample of Telecommunications Service Restoration Times of Commercial Buildings in Southern Manhattan; see chart: Estimated Flood Damage to Telecommunications Equipment in Buildings)*

Cell service outages were largely caused by loss of power, loss of backhaul service, and/or physical damage to antennas, with power loss being the most significant factor. Cell providers rushed to respond to network outages by connecting generators to existing cell sites, where possible. In areas where the existing cell sites could not be quickly restored, providers used Cells On Wheels (COWs), mobile cell sites that can be deployed after a disaster. Because many cell sites in New York are affixed to private buildings, in many cases, cell sites could not be restored until power to the relevant buildings and connection to backhaul circuits were fully restored. After power was restored, providers then could work on restoring the landline connections to the cell sites. These landline reconnections caused the longest delays in restoring full cell service.

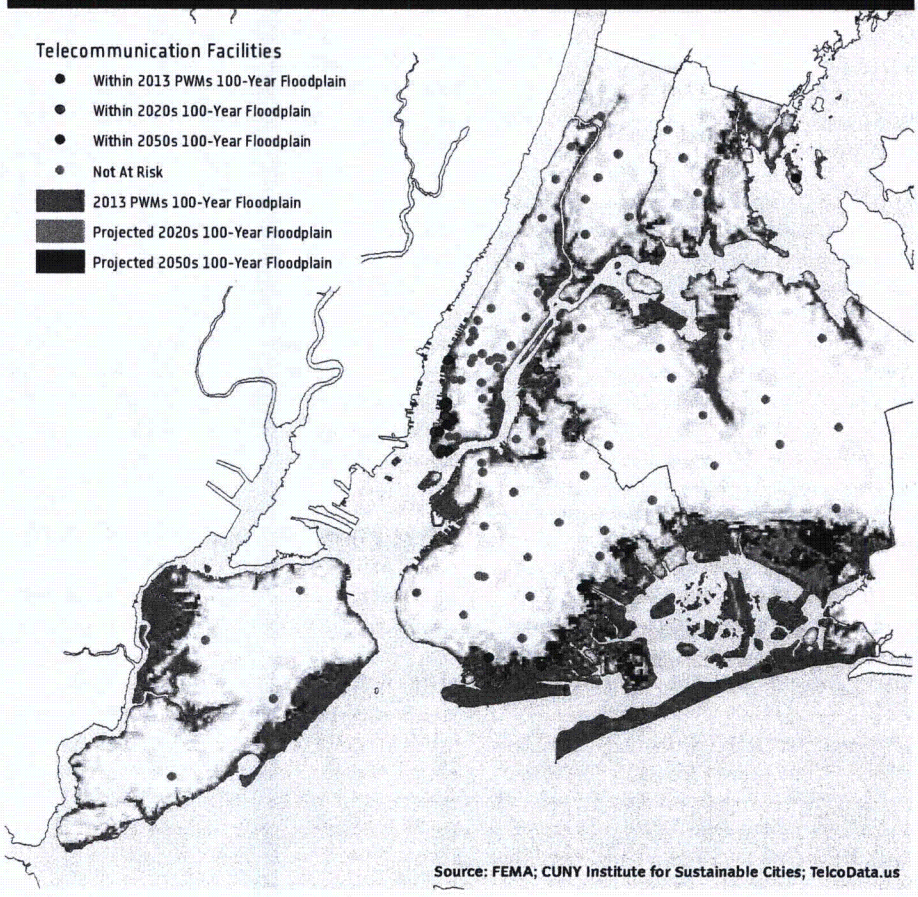
Clearly, the reasons for and duration of telecommunications outages varied, but some generalizations can be made. First, although some telecommunications equipment and facilities had been designed for power outages and flooding, many were not. Many critical facilities were not hardened to best practice standards, leaving equipment—most notably backup generators—below anticipated flood heights. In high- and low-rise buildings, telecommunications equipment in basements was flooded too easily, causing significant damage even at relatively low floodwater heights.

Wire-Line Provider Redundancy



Source: NYS Broadband Map

Critical Telecommunications Facilities in the Expanding Floodplain



Source: FEMA; CUNY Institute for Sustainable Cities; TelcoData.us

Risk Assessment: Impact of Climate Change on Telecommunications

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				Facilities face significant and increasing risk of flooding
Heavy downpour				Minimal impact
Heat wave				Extreme heat for an extended period may shorten life span of electronic gear if spaces are not properly air-conditioned INDIRECT: Power outages could lead to telecommunications outages
High winds				Minimal impact

Another problem that emerged during Sandy was that most cell sites did not have adequate backup power. Standard battery backup for cell towers of four to eight hours simply proved insufficient during the extended outages Sandy caused.

Further, single points of vulnerability in the telecommunications network posed another challenge to maintaining and restoring service post-Sandy. Though some networks were built with redundancy—for instance, cabling taking two separate routes from a cell tower back to a central switching facility—many parts of the network were not. Where these vulnerabilities exist, one cut cable or flooded facility could result in an outage for a few or a few thousand customers. The same was true for buildings, some of which had multiple telecommunications providers—in which case, residents and businesses were able to switch service to the providers that restored service fastest—but many of which, especially on the residential side, had limited or no secondary provider options. *(See map: Wire-Line Provider Redundancy)*

During and after Sandy, carriers required varying degrees of City assistance and coordination. Providers were in regular communication with City officials and elected officials at all levels about immediate recovery needs, but there were some conflicting requests. The City also had difficulty in getting accurate data from providers in consistent, usable formats on immediate outages and recovery work. In addition, some providers had trouble getting their recovery personnel access to restricted bridges because they had not been designated as critical to recovery.

Finally, the City had limited ability to gather data from or enforce standards on providers. For example, while the FCC collects information on outages, it does not do so in real-time, and does not always share it with the City. Meanwhile, the main regulators of the telecommunications network, the FCC and PSC, are exploring ways to improve communications network resiliency.

What Could Happen in the Future

Looking to the future, climate change poses several risks to the telecommunications system.

Major Risks

Storm surge poses a significant and increasing risk to the power grid upon which telecommunications infrastructure depends. Though telecommunications facilities are generally farther from the floodplain than power facilities, 13 percent of critical telecommunications facilities lie in the 100-year floodplain on Preliminery FEMAs Work Maps (PWMs), meaning that they face a risk of flooding from storm surge. By the 2020s, the number of critical facilities in the 100-year floodplain will grow to approximately 18 percent. By the 2050s, that number is expected to climb to 24 percent. With up to 31 inches of sea level rise expected by the 2050s, the risk to critical central offices, including the two largest central offices serving Southern Manhattan, is likely to increase. *(See map: Critical Telecommunications Facilities in the Expanding Floodplain)*

Other Risks

Heat waves pose a threat to the power grid, which is crucial to the operations of the telecommunications system. Extreme heat for an extended duration also may shorten the life span of electronic telecommunications equipment in buildings if the spaces housing this equipment do not have proper cooling.

High winds present a risk of damage to overhead wires in the parts of the Bronx, Brooklyn, Queens, and Staten Island where they exist. Outages due to overhead wire damage, however, do not result in system-wide failures but, rather, only affect a few buildings or blocks at a time, and they are generally able to be repaired quickly, relative to damaged underground cables.

People without power after Sandy had to use their electronic devices at a Chase Bank

This chapter contains a series of initiatives that are designed to mitigate the impact of climate change on New York's telecommunications 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.

The City will pursue a set of initiatives to ensure that all New Yorkers have access to robust telecommunications services backed by resilient networks and infrastructure. These initiatives address the telecommunications system's vulnerabilities that Sandy exposed and that climate change will exacerbate—in particular, the risk of likely service outages due to loss of power from damage caused to facilities by storm surges and heat waves. They do so by addressing a central challenge for New York—the distributed regulatory environment for telecommunications that historically has given the City little authority.

The City's initiatives can be grouped as follows: those seeking to increase accountability to promote resiliency; those seeking to enable rapid recovery after extreme weather events; those seeking to harden facilities to reduce weather-related impacts; and those seeking to create redundancy to reduce the risk of outages.

Strategy: Increase accountability to promote resiliency

The 21st century has witnessed the convergence of telecommunications service across wired voice, cable TV, and broadband, and the increasing centrality of communications networks in the daily lives, jobs, and safety of the city's people. The rapid shift in communications technology has revealed significant gaps in the regulatory framework—gaps that leave the network exposed.

To address these gaps, the City will work to strengthen its regulatory powers while also developing a stronger relationship with telecommunications providers to facilitate more consistent coordination of resiliency measures and disaster preparedness efforts.

Initiative 1

Establish an office within DoITT to focus on telecommunications regulation and resiliency planning

While the City has regulatory authority over some aspects of telecommunications service, it has no entity focused on ensuring the resiliency of public communications networks. Subject to available funding, the City, therefore, will form within DoITT a new Planning and Resiliency Office (PRO) that will have the resources needed to maintain more strategic communication with providers and provide additional monitoring of franchisee compliance with requirements.

DoITT PRO will work to better understand the way providers operate in order to promote and enforce resiliency for telecommunications providers through the franchise renewal process and through other agreements into which such providers enter with the City. Additionally, DoITT PRO will assist providers in navigating City processes, and will explore options to increase conduit infrastructure and resiliency. Furthermore, the office will standardize the formats and frequency of performance data reporting about significant outages across providers, publish service data where appropriate, and tighten service and restoration standards.

Finally, the new office will advocate for State and Federal regulatory changes, encouraging better alignment in Federal, State, and local approaches to regulation, and will push for reporting and resiliency requirements that would lead to better preparation, awareness, and response in the event of extreme weather events. DoITT will launch the new office in 2013.

Initiative 2

Establish new resiliency requirements for providers using scheduled renewals of the City's franchise agreements

Flooding caused outages during Sandy in facilities that were not following the FCC's recommended best practices for resiliency, including flood protection measures. DoITT will promulgate and enforce resiliency standards through the franchise renewal process. Franchise agreements with cable TV service providers are renewed periodically, with most up for renewal in 2020.

Within such new franchise agreements, the City may establish, for example, standards for issues such as repair timelines (called "Mean Time to Repair") in the event of individual outages, including as a result of extreme weather events. The City also will seek to standardize data reporting and publishing requirements to support quicker data analysis in the event of limited or widespread service disruption. Planning for the 2020 renewals will start in 2014 because of the long negotiation period that has been standard in previous renewals.

Strategy: Enable rapid recovery after extreme weather events

While hardening facilities and preventing damage is critical, it is not always possible to avoid every emergency. Anticipating and responding efficiently to disasters is a key feature of resilient infrastructure. The Office of Emergency Management (OEM) leads the City's efforts to prepare for emergencies and coordinates response and recovery, relying on other City agencies within each of their particular areas of expertise. For telecommunications, DoITT PRO will expand resiliency planning efforts and will liaise with franchisees to ensure restoration and resiliency.

Initiative 3

Request business continuity plans from current City franchisees as permitted under existing franchise agreements

All telecommunications providers conduct business continuity planning, but that planning has not traditionally been coordinated with the City. DoITT PRO, through the City's cable TV service franchise agreements, will encourage providers to increase disaster preparedness. Using applicable provisions in existing franchise agreements, DoITT PRO will require that providers share business continuity plans with the City and update and publish them on a regular basis. The office also will assist with preparing for providers' operational needs during emergencies such as access to the city via bridges and tunnels and deployment of equipment to critical facilities. The office also will encourage providers to take additional preparedness measures such as putting in place agreements for sharing cell networks in emergencies. Beginning in 2013, DoITT PRO will meet with providers to coordinate business continuity plans and meet regularly thereafter to update plans and address barriers to effective plan implementation with other City agencies.

Strategy: Harden facilities to reduce weather-related impacts

Short of removing equipment from the floodplain entirely—an impractical option for many buildings—the best way to protect telecommunications equipment in buildings from storm surge is to harden buildings and building systems. The City will develop new flood protection standards and encourage retrofitting of existing buildings through a combination of mandates and incentive programs. DoITT PRO also will work with cell providers to encourage hardening of cell sites. The office will request equipment hardening and upgrades in connection with the City's cable TV service franchise agreements.

Initiative 4

Develop flood protection standards for placement of telecommunications equipment in buildings

The City will develop flood protection standards for new buildings, together with programs to encourage retrofitting of existing buildings to ensure protection of utility equipment, including telecommunications equipment (see Chapter 4, *Buildings*).

Initiative 5

Use the DoITT franchise agreements to ensure hardening of all critical facilities

Damage to critical facilities caused neighborhood-wide outages during Sandy, in turn resulting in significant disruption to business and personal communications. The City will work with providers to strengthen the resiliency of these critical facilities. Specifically, through its franchise agreements with cable TV providers, DoITT has a number of tools already at its disposal that it will put to use, including requesting reports on the state of technology at provider facilities and potentially establishing requirements for facilities and equipment. DoITT already has requested from its cable TV franchisees plans to minimize the occurrence of significant outages due to future climate events. DoITT PRO will seek to expand this authority through future cable TV service franchise agreements.

Initiative 6

Work with cell providers to encourage hardening of cell sites

Wireless service went down in large sections of the city during Sandy as a result of the loss of power or connections to the larger telecommunications network at cell sites. The City will work with providers locally to encourage measures that will keep the cell networks functioning in emergencies. Although the wireless industry is regulated primarily at the Federal level, DoITT PRO will work with providers to encourage the creation of plans to pilot the hardening of some existing cell sites, including 48-hour backup power from batteries, generators, or a combination of both; raising key equipment out of the floodplain; and providing multiple wire-line paths from the sites to central facilities to provide backup network connections in the event of cable damage. DoITT PRO also will seek to meet with cell providers regularly beginning in 2013 to develop these hardening measures and clear barriers to implementation within the city.

Strategy: Create redundancy to reduce risk of outages

Beyond strengthening existing systems, ensuring system redundancy may be the best way to protect critical infrastructure from outages. Accordingly, the City will explore options for creating a redundant and resilient conduit infrastructure. The City also will implement programs to encourage redundancy among telecommunications providers in individual buildings and to disseminate information about provider redundancy and resiliency in buildings to the general public.

Initiative 7

Study options to increase conduit infrastructure redundancy and resiliency

After the significant telecommunications outages during Sandy, some areas with damaged cable did not have service for days or weeks. To avoid this in the future, the City will seek to encourage provider redundancy throughout New York through expanded spare conduit capacity and new approaches to laying cable. DoITT PRO, in consultation with NYCDOT, will explore tracking and managing providers' conduit requests to Empire City Subway in Manhattan and the Bronx, ensuring that Empire City makes spare conduit available. DoITT PRO also will work with providers to develop and test inexpensive alternatives to delivering telecommunications service, such as "micro-trenching," which provides a cheaper and faster method of conduit installation in certain areas of the city. DoITT PRO will explore further options for improving the availability and redundancy of conduit in Queens, Brooklyn, and Staten Island, including options such as a "shadow conduit policy" modeled after the current micro-trenching pilot. The office also will investigate a system to produce accurate conduit maps to manage more effectively shared infrastructure and monitor more effectively spare capacity. DoITT PRO will work to identify areas both within the Empire City Subway system and in Brooklyn, Queens, and Staten Island for potential conduit expansion initiatives. Planned ongoing engagement will include regular meetings with providers and with Empire City Subway.

Initiative 8

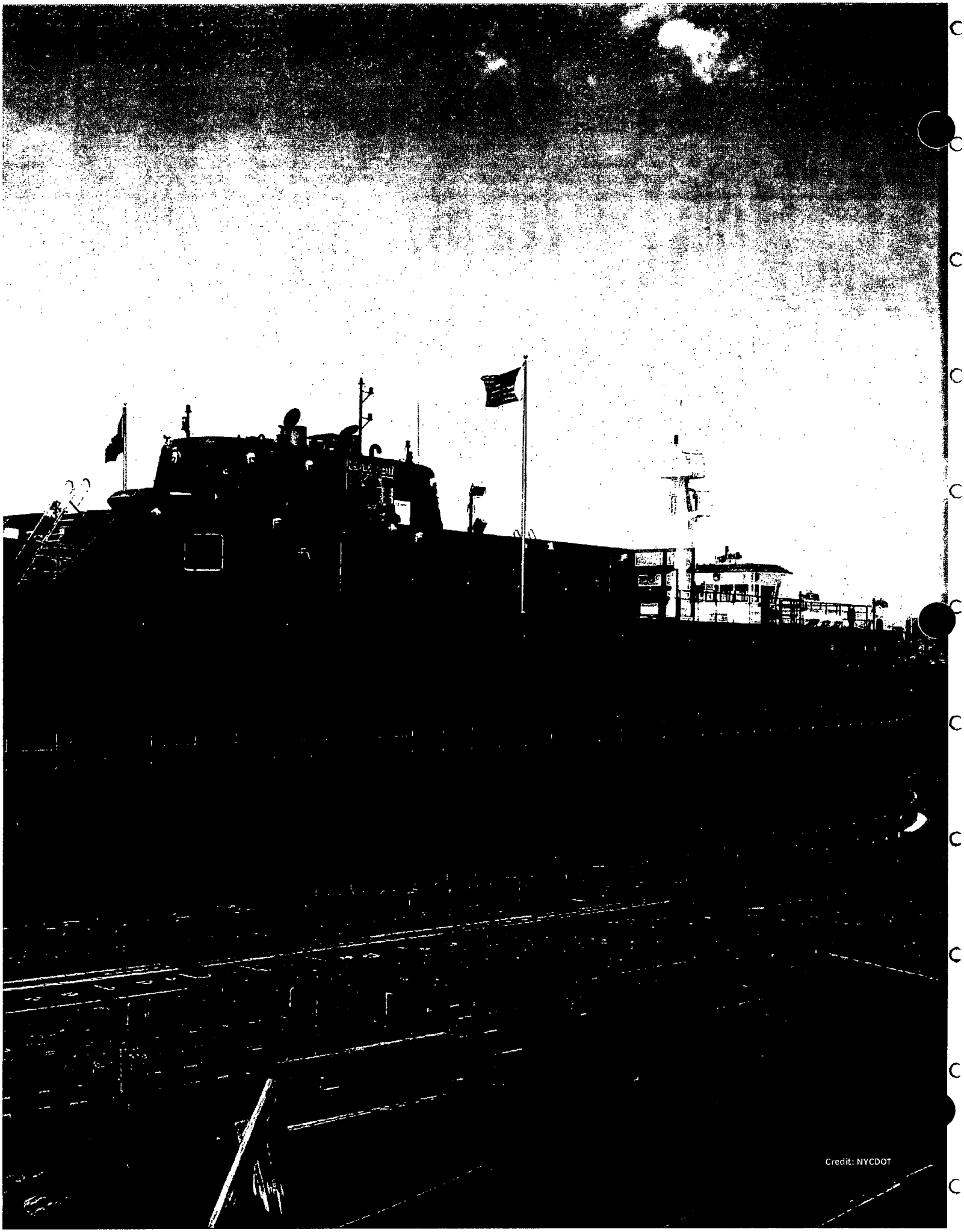
Continue implementation of ConnectNYC Fiber Access to create broadband redundancy

During Sandy, some providers restored service more quickly than others. Customers in buildings with multiple providers were able to switch to the service that was operational, while those without choice were left without options. Increasing broadband connections to buildings is another way to create redundancy. Through ConnectNYC, the City is partnering with providers to connect commercial and industrial businesses across the city with fiber. As required by their franchise agreements negotiated with DoITT, Time Warner Cable and Cablevision have allocated $12 million from their capital budgets to connect new businesses to their fiber networks. The New York City Economic Development Corporation (NYCEDC) is soliciting interest from businesses and will allocate these connections free of charge on a competitive basis. The first round of applications was received in December 2012, and the second round of applications is launching in June 2013.

Initiative 9

Add telecommunications provider quality and resiliency to the WiredNYC and NYC Broadband Map ratings

A significant challenge to broadband deployment throughout the city—and telecommunications service more broadly—is the lack of accessible data about the availability of providers, the service quality, and the resiliency of providers' systems. Without this information, companies looking for new space are unable to make informed decisions, reducing the incentive for providers to ensure that their networks are sufficiently resilient. Through the WiredNYC and NYC Broadband Connect Map programs, the City will publish information about broadband service at buildings around the city, rating the quality and resiliency, among other factors. NYCEDC will manage these programs. The WiredNYC certification system website will launch in June 2013, and the NYC Broadband Map website will launch in fall 2013.



Credit: NYCDOT

Transportation

Stillwell Avenue subway station in Coney Island

Credit: Zev Starr-Tambor

It carries one-third of all transit riders and two-thirds of all rail riders in the nation. It includes the nation's busiest rail hub and the largest bus and rail car fleets. It encompasses 6,000 miles of streets, 12,000 traffic signals, and nearly 800 bridges (including more than a couple of famous ones).

And, of course, it boasts the one and only Staten Island Ferry.

This complex behemoth is the New York region's transportation network. It encompasses the largest public transportation system in America, made up of subway networks, bus networks, commuter railroad networks, and ferry networks. And each of these networks is, in and of itself, staggeringly large.

Under normal conditions, the interconnected networks work together, adding up to an extraordinary supersystem, upon which New Yorkers—and the economy of the city, region, and nation—all depend. Day and night, millions of New Yorkers and visitors use this system to travel to and from work, school, shops, and cultural events, while goods move around the region by road, rail, and water. The city that never sleeps fittingly has a transportation system that never sleeps—until, with Sandy, nearly every element of New York's transportation system shut down.

Sandy's storm surge flooded vehicular tunnels, subway stations, roads, and airports. Transportation outages followed, impairing mobility and access to, from, and within the city and the region, and affecting 8.5 million public transit riders, 4.2 million drivers, and 1 million fliers.

Even after Sandy had departed, damage and power outages prevented restoration of the subway system for several days, with key sections shut for a week or longer. Responding quickly, City and State officials instituted a series of interim solutions to fill the transportation gap—including sending hundreds of buses to carry commuters back and forth across East River bridges and adding ferry service. However, damage to various elements of the system was severe—totaling many billions of dollars. In fact, as of the writing of this report, some elements still are not fully functional and will not be for months or even years.

The storm not only caused disruption; it demonstrated the centrality of the transportation system to the city's economy and overall ability to function. It also laid bare the vulnerabilities of various parts of the system to extreme weather and pointed to challenges that the region faces in increasing resiliency, given the size and complexity of its transportation system.

But these challenges must be tackled. In keeping with the broad goals of this report—which are to minimize disruptions caused by climate change and to enable New York City to bounce back when extreme weather events strike—the City will work to make the transportation system more resilient. It will seek to protect critical elements of the system from damage, maintain system operations during extreme events, and put in place plans for backup transportation options to increase mobility until regular services can be restored.

How the Transportation System Works

Transportation in New York City is complex due to the many different modes of travel, the ways they interact, and the grand scale of it all. And New Yorkers use this system in overwhelmingly large numbers, with 7.6 million daily subway and bus riders, close to 850,000 daily commuter rail riders, and almost 2 million people crossing the region's major bridges and tunnels every day. This network is busy for much of the day and night—not just during traditional commuting hours—with freight moving around the region by truck, hospital workers going to and from their shifts, and local residents and tourists visiting the city's many attractions.

The area of Manhattan south of 60th Street—the business center of the region and the nation—draws commuters to jobs from all over the New York area and beyond. Over 3.6 million travelers enter this district every weekday, with 1.4 million of those entering during the three-hour morning peak. Public transportation is absolutely critical to this travel, since 75 percent of those trips into the central business districts are made by public transit. Of those who do drive into this area, the majority depend on crossing a bridge or tunnel to do so, including 220,000 entering from Brooklyn, 175,000 entering from Queens, and 115,000 entering from New Jersey.

Travel within and among the outer boroughs is more varied. The use of buses is significant outside of Manhattan—with 2.1 million daily bus users in the other boroughs—as is the use of private vehicles, particularly for longer trips between the outer boroughs, where driving is generally faster and more direct. Many outer borough trips also require a major bridge crossing, and trips to and from Nassau and Suffolk Counties must pass through New York City. Close to a million trips pass between Nassau County and Queens every day, and over 500,000 trips cross the major bridges that connect between the outer boroughs every day.

While the city's transportation system is highly interconnected, it also does not exist in isolation. Instead, it is one network among the many that keep New York running. For example, the transportation network in the city depends on the power network to function; electricity is needed to run subways and trains, to switch on traffic signals, and to light tunnels, stations, and terminals. And, in turn, many of the city's other critical networks rely, wholly or in part, on the transportation network to run properly; this is especially true in times of emergency, when first responders and those bringing key

supplies (such as food and fuel) must be able to reach individuals and communities that are in desperate need.

However, due to historical development patterns and operational needs, many parts of the city's transportation infrastructure are located near the waterfront or in low-lying areas, making them particularly vulnerable to the effects of climate change. This is true for many rail yards, which require large, flat expanses of land of the type frequently found near rivers and the shoreline. Similarly, by definition, ferry terminals must be at water's edge and close to the level of the water. Other assets are on the waterfront because that is where land was available or could be created through fill—this is how, for example, New York's airports were sited.

Some transportation assets, meanwhile, are not just at sea level, but are actually built below sea level. This is the case for the large segments of the city's transportation network that were built underground (including tunnels for vehicles and trains), designed both to span water bodies and to provide higher speed and greater capacity connections through dense and congested areas.

Transportation Networks

The first formal transportation elements to develop in New York City were its roads, which, under the Dutch and later the English, evolved from a network of Native American trading paths. In fact, Broadway, the oldest north-south thoroughfare in the city, was designed to connect the street network in Lower Manhattan (initially used by people on foot and on horse) to the northern reaches of the borough—and on into the Bronx and beyond. The Commissioners' Plan of 1811 laid out what is today perhaps the most distinctive aspect of New York's City's street network: Manhattan's modern street grid.

New York's ferry system, too, has a long pedigree. New Yorkers always have used the waterways to get around. Since the city's earliest days—especially before the development of long-span bridges—ferries have provided key water crossings, connecting Brooklyn, Queens, Staten Island, and New Jersey to Manhattan, both as stand-alone services and as links from rail terminals.

Over time, as New York City grew, it became increasingly important to link the soon-to-be consolidated boroughs effectively. Accordingly, in the late 19th and early 20th centuries, the City undertook a major program of bridge-building, completing some of the city's most iconic spans, including the Brooklyn and Manhattan Bridges over the East River. With the same goal in mind, New York City also worked with the Interborough Rapid Transit (IRT) Company to create its initial underground connections, opening the first subway line in 1904. The subway system has since expanded to become the largest in the world, with 659 miles of track and 468 stations, playing a critical role in making New York the global city it is today.

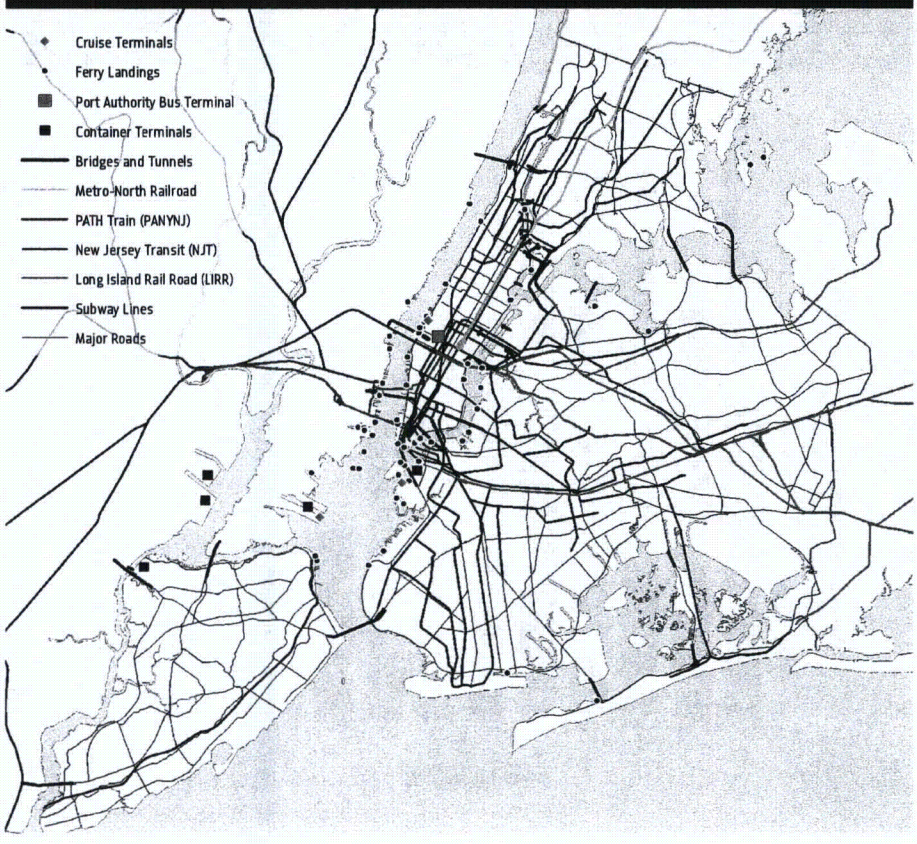
As the city continued to expand through the 20th century, New York's water-spanning tradition was picked up by the Port Authority of New York and New Jersey (the Port Authority) and the Triborough Bridge and Tunnel Authority (which subsequently became part of the Metropolitan Transportation Authority, or MTA). These two agencies built four bridges, and two tunnels connecting New Jersey to New York City, and seven bridges and two tunnels within the city. Meanwhile, in the latter half of the 20th century, the region's three major airports, including Kennedy and LaGuardia in Queens, became international gateways that, together, host more passenger traffic each year than the airports in any other metropolitan area outside of London.

In recent years, the City has expanded its transportation network by promoting a range of alternatives to driving, thus increasing the flexibility and efficiency of the system. For example, the City has expanded its pedestrian and bicycle networks. Walking has always played an important role for all manner of local trips and to gain access to the transit network, and cycling volumes in the city continue to grow. In addition, the City has maximized inter-modal connections and added several Bus Rapid Transit (BRT) routes (known in New York as Select Bus Service), or dedicated bus corridors that improve the speed, reliability, and attractiveness of bus service. Additionally, after many years during which the use of private ferries waned as new bridges and tunnels were built, the City, over the last 15 years, has helped bring about a renaissance in this transit mode, spurred by rising congestion on other networks and redevelopment of the waterfront neighborhoods of New York City and New Jersey. (*See map: Regional Transportation Network*)

Transportation Operators

All of New York's various transportation networks and services are linked in many ways, allowing a New Yorker or a visitor to the city to connect easily from one mode to another. So, for example, a marketing executive from Philadelphia might take an Amtrak train to Penn Station, then transfer to a subway, only to get off several stops later to hustle through the

Regional Transportation Network



busy streets of Lower Manhattan to her destination. In addition to shifting from one locale to another and from one transportation network to another, in making this trip, this visitor is also passing through multiple jurisdictions, from a system run by a Federal corporation, to one that is run by an authority under the control of the State, to one that is run by the City.

As illustrated in this example, many agencies manage different elements of New York's transportation system. For example, the New York City Department of Transportation (NYCDOT) has responsibility for roads and certain highways in the five boroughs, as well as over 12,000 traffic signals and 787 bridges. These bridges include the famous East River spans and 25 movable bridges that open and close to allow marine traffic to pass. NYCDOT also runs the Staten Island Ferry (SIF) and regulates all construction work on roadways and sidewalks, including work related to underground utilities. Additionally, since the launch of PlaNYC in 2007, NYCDOT has successfully expanded the city's bicycle network. It also has played a critical role, in partnership with the MTA, in creating multiple Select Bus Service (SBS) routes that make bus service faster and more reliable around the city.

Two other important transportation agencies in New York City are the MTA and Port Authority. The MTA, a State authority, operates the nation's largest transit network and is responsible for the city's subway system, most of its buses, the Long Island Rail Road and Metro-North Railroad, and the tolled bridges and tunnels within New York City. Meanwhile, the Port Authority—an entity controlled jointly by the States of New Jersey and New York—is responsible for the city's airports, the bridges and tunnels connecting New York City to New Jersey, regional bus terminals, the Port Authority Trans-Hudson (PATH) rail system, and major parts of the region's ports infrastructure.

Other agencies that play central roles in transportation in New York City include the following:

- New York City Economic Development Corporation (NYCEDC), which is responsible for the East River Ferry, certain private ferry terminals, the City's cruise ship terminals, two heliports, parts of the region's port infrastructure, and portions of the city's freight railroad lines;
- New York State Department of Transportation, (NYSDOT) which is responsible for certain highways within the city and manages major highway construction improvements;
- New Jersey Transit (NJ TRANSIT), which operates rail and bus service between the city and New Jersey;
- Amtrak, which operates intercity rail service to and from New York City, the non-subway rail tunnels under the Hudson River and the East River, as well as Pennsylvania Station, the busiest transit hub in the country; and
- the Federal government—which, through various agencies, including the Department of Transportation—provides major capital funding for many of the region's transportation systems.

Finally, a variety of private entities play roles, both large and small, in the city's transportation system. These include the operators of taxi and black-car fleets, private ferries, commuter vans, local and intercity buses, maritime freight terminals and vessels, and airlines.

What Happened During Sandy

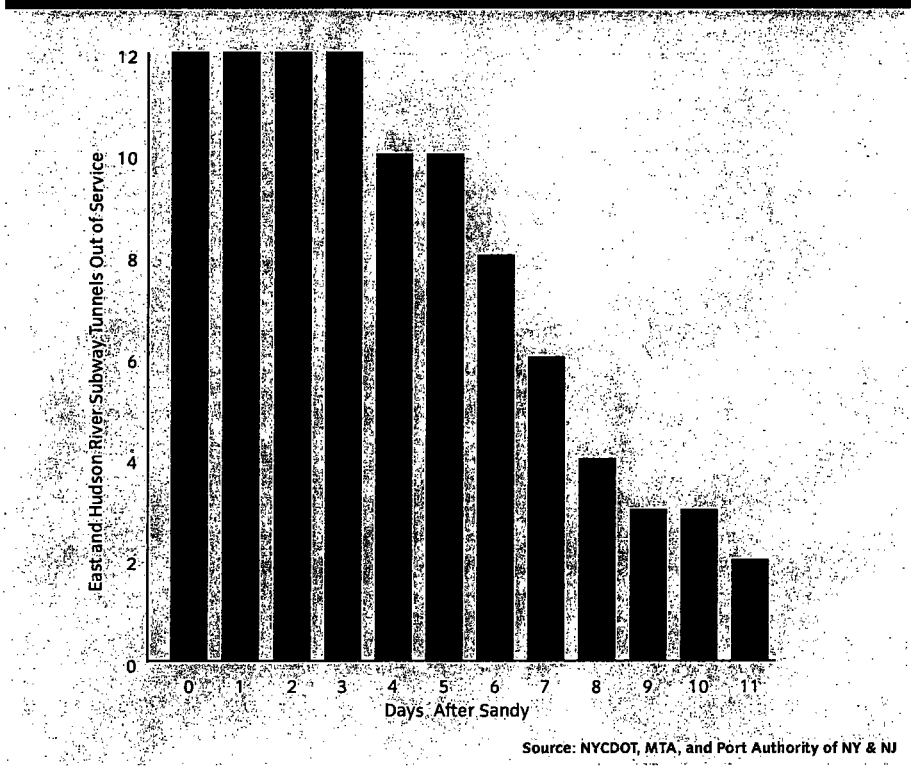
Sandy had a massive impact on the transportation system within New York City and the surrounding region, with the greatest impact felt on those elements located underground and close to the shoreline. The storm caused extensive damage and impaired the ability of the system to move people in and around the city and region.

The storm had an impact on transportation in New York City even before it arrived. Starting the day before Sandy hit, most public transportation agencies made the decision to initiate an orderly shutdown of their systems to protect transit vehicles (often referred to as rolling stock) and critical infrastructure, and to ensure public safety. So, for example, the MTA installed plywood and sandbag barriers at critical station entrances and ventilation grates, while it also moved subway cars, buses, and trains to higher ground. At ferry landings and terminals around the city, gangways were removed to allow floating elements to move with the tide and expected storm surge without damaging buildings and facilities. SIF and private ferry service was halted. All seven active SIF vessels were then docked at the St. George Ferry Terminal on Staten Island, with more than 100 dedicated employees remaining on duty to protect the fleet.

Due to concerns about high winds and flooding, the Port Authority, MTA, and NYCDOT closed the city's major bridges and tunnels crossings, with the exception of the Lincoln Tunnel, the entrances to which were deemed to be high enough above the Hudson River to be at low risk of flooding. Meanwhile, airlines flew their planes out of harm's way, sheltering them at airports out of Sandy's path.

However, once Sandy arrived, its storm surge severely impacted many elements of the transportation system, including subway, railroad, and vehicular tunnels. Stormwaters

Subway Tunnel Closures After Sandy



Source: NYCDOT, MTA, and Port Authority of NY & NJ

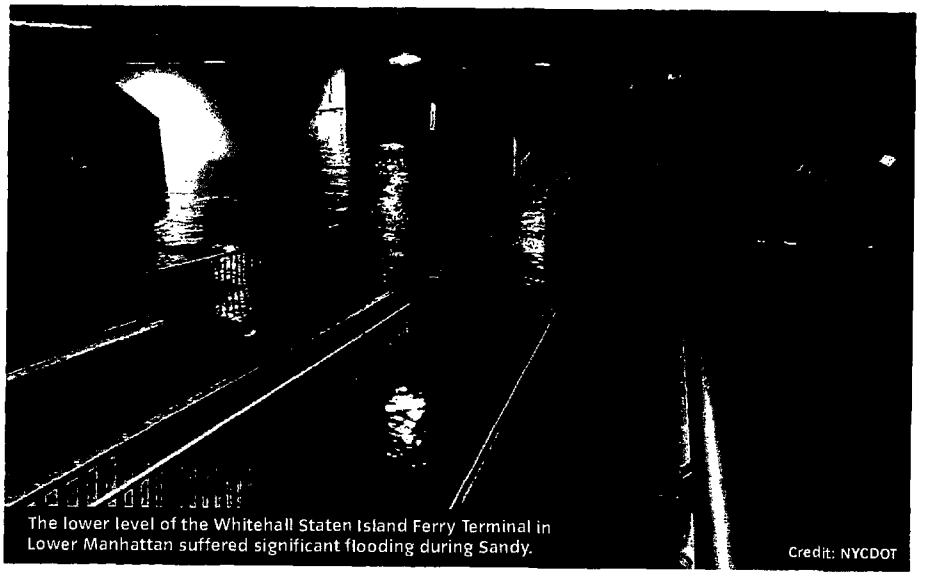
flooded tunnel entrances and ventilation structures in Southern Manhattan, Long Island City, Red Hook, Hoboken, and Jersey City. Vehicular tunnels that were knocked out of service were NYCDOT's Battery Park Underpass and West Street Underpass, the MTA's Queens Midtown and Hugh L. Carey (formerly Brooklyn-Battery) Tunnels, and the Port Authority's Holland Tunnel. Also inundated were all six of the subway tunnels connecting Brooklyn to Manhattan, the Steinway Tunnel that carries the 7 train from Queens to Manhattan, and the G train tunnel between Long Island City and Greenpoint. The PATH tunnels under the Hudson River also were flooded, with water entering via various entrances on both the New York and New Jersey sides, as were the railroad tunnels under the East River and the Hudson River. *(See chart: Subway Tunnel Closures After Sandy)*

Other elements of the subway system were impacted as well. For example, the A train viaduct connecting Howard Beach, Broad Channel, and the Rockaways was washed away in two locations, while the South Ferry subway station in Lower Manhattan was fully flooded to the mezzanine level.

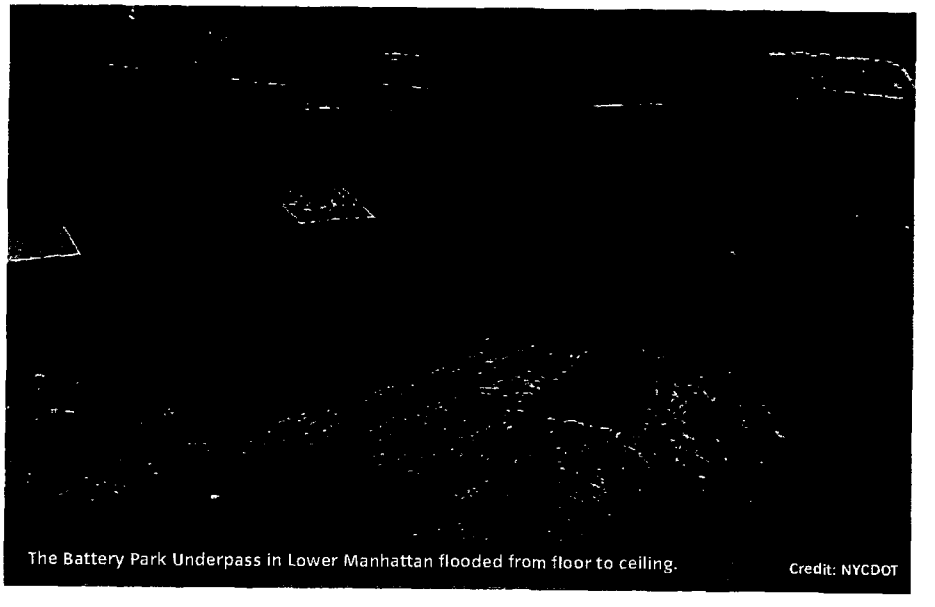
In areas inundated by Sandy, roads similarly were affected, although these floodwaters typically receded within 12 hours. While 60 lane-miles of roadways were damaged severely and 500 lane-miles of roadways sustained minor damage, most roadways in inundated areas were undamaged. However, flooding did damage traffic signals controlling nearly 700 intersections when signal control boxes and underground conduits and cables were exposed to the corrosive effects of salt water.

Sandy's surge also affected maritime transportation, damaging landings and docks and inundating facilities on land (including both cruise terminals and both SIF terminals). The storm's winds and rising waters battered the SIF vessels, breaking mooring lines and submerging the docks. To prevent the ships from crashing into the shore, the captains of six ferries remained at the helm and successfully maneuvered the propulsion systems against the force of the storm. When the unmanned Alice Austen broke free of its moorings and lurched towards the Sen. John J. Marchi, crews developed improvised fenders, protecting both ships from damage.

Surge waters inundated rail yards and airports. Several low-lying rail yards were flooded, including the MTA's Coney Island Yard complex in Brooklyn and the LIRR's John D. Caemmerer West Side Yard in Manhattan. Meanwhile, the city's airports were flooded by waters from Jamaica Bay and Long Island Sound, but these waters did not reach the terminals, where the most sensitive and highest value equipment is located.



The lower level of the Whitehall Staten Island Ferry Terminal in Lower Manhattan suffered significant flooding during Sandy. Credit: NYCDOT



The Battery Park Underpass in Lower Manhattan flooded from floor to ceiling. Credit: NYCDOT

Sandy's surge thrust debris from the shore into the region's waterways, thereby necessitating a US Coast Guard shutdown of portions of the Harbor for five days. This decision hampered the movement of people and goods, including fuel as well as other supplies critical to recovery. Beyond the immediate impact of flooding, power outages from Sandy severely affected the transportation system. Lack of power meant that key equipment could not operate (e.g., train lines and tunnel ventilation equipment dependent on electricity). It also was a major impediment to the dewatering of the major tunnel infrastructure. Eventually, as power was restored, personnel from local agencies worked with crews from the US Army Corps of Engineers, Federal Emergency Management Agency (FEMA), US Navy, US Coast Guard, and National Guard to pump several hundred million gallons of water from these tunnels.

However, the fact that many tunnels were inundated for days exacerbated the impact of flooding and led to significantly greater water and corrosion damage to delicate equipment. For example, during the months following Sandy, this lingering damage resulted in more than 100 signal failures on the subway system, as well as ongoing problems with switches, power cables, and other infrastructure in the subways. Given the age and complexity of much of this equipment, obtaining replacement equipment proved both difficult and expensive. Despite the major disruptions and damage, much of the transportation system fared relatively well. For example, Sandy had a minor impact on the MTA's vehicles, thanks to the

agency's successful relocation of this rolling stock out of harm's way. Meanwhile, the region's freight rail infrastructure also emerged from the storm with minimal damage, although some service disruptions did occur due to flooding and debris on tracks. Because wind speeds during Sandy were lower than earlier storms, the major bridges were able to reopen within 12 hours of the storm's conclusion, following safety inspections by engineers. *(See chart: Major Vehicular Bridge and Tunnel Closures After Sandy)*

However, the overall transportation system struggled to reopen, affecting millions of commuters. In the first two days following Sandy, for a variety of reasons, many people stayed at home and most businesses in impacted areas remained shuttered. However, by the third day after the storm, people started to attempt to return to their normal routines. With the subway and other major systems still partially out of service, New Yorkers were forced to improvise. In some cases, this improvisation turned mass transit users into bikers or walkers. In many other cases, however, these mass transit users turned to automobiles. The result was gridlock, especially on roads and bridges leading into Manhattan. In fact, during this period, average highway speeds dropped by as much as 71 percent, relative to speeds on normal weekdays. *(See chart: Highway Travel Speeds at Selected Locations)*

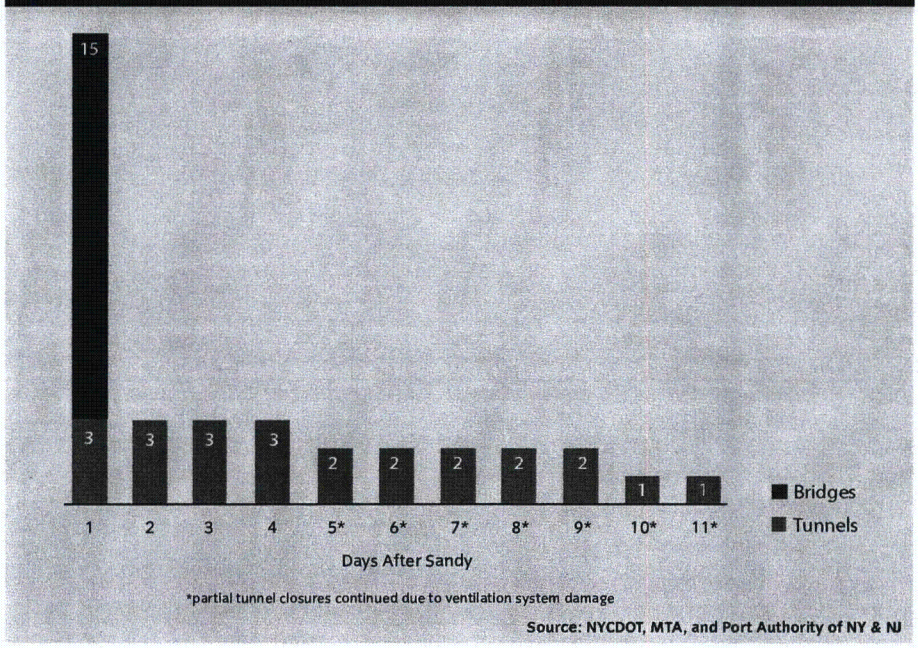
To maintain critical routes, City and State officials quickly implemented a series of temporary measures. Many of these measures were conceived on the spot immediately after Sandy hit. However, from temporary ferry routes, to bus bridges, to carpool requirements, together, they proved to be hugely successful in getting people moving again. *(See chart: East River Crossings Before and After Sandy; see sidebar: Temporary Services Help Restore Mobility After the Storm)*

As time progressed, much of the city's transportation network was brought back online. The ferry and marine transportation networks, for example, took between two days and a week to restore, while airports were back in operation within three days of the storm. The subways mostly were restored a week after Sandy, with vehicular tunnels taking closer to a week and a half to return to partial service due to damage to the ventilation equipment. By two weeks after Sandy, most of the city's transit network was functioning at or near normal capacity.

Certain elements took longer and in some cases, are still out of service as of the writing of this report, including portions of the subway system. For example, the Montague Street Tunnel used by the R train was restored eight weeks after Sandy (but will be taken out of service again for longer-term repairs), and the causeway that carries the A train connecting Howard Beach to the Rockaways was restored at the end of May 2013. Full restoration of South Ferry subway station in Lower Manhattan is expected to take several years.

In response to these longer-term transit outages post-Sandy–and generally to provide expanded mobility and access options—the following new and enhanced services were added:

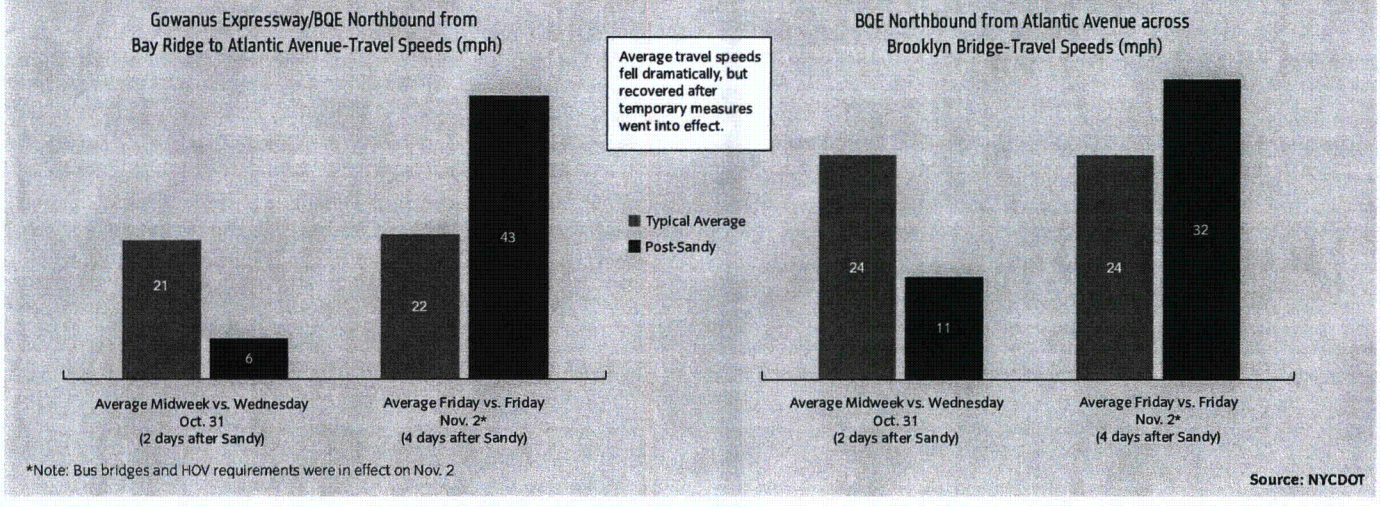
Major Vehicular Bridge and Tunnel Closures After Sandy



*partial tunnel closures continued due to ventilation system damage

Source: NYCDOT, MTA, and Port Authority of NY & NJ

Highway Travel Speeds at Selected Locations



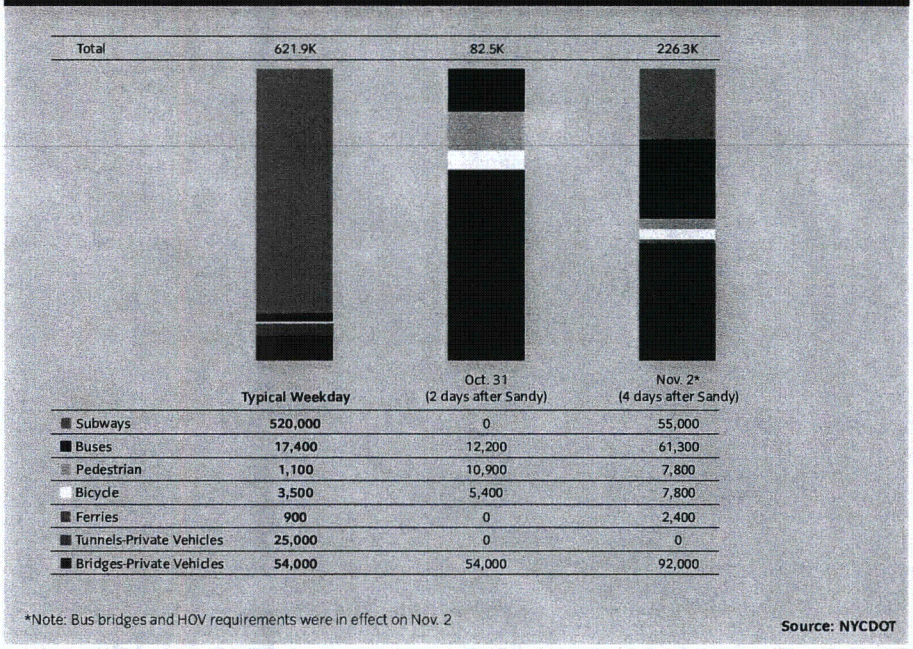
*Note: Bus bridges and HOV requirements were in effect on Nov. 2

Source: NYCDOT

- new ferry services from both the Rockaways and Staten Island to Lower Manhattan and Midtown to compensate for lost or constrained transit service;
- an H shuttle subway train, with an accompanying shuttle bus to the Howard Beach subway station through the Rockaways, to compensate for the loss of A train service across Jamaica Bay; and
- the reopening of the former South Ferry Terminal below the Whitehall Ferry Terminal, to allow 1 train service to the southern tip of Manhattan while the damaged South Ferry Terminal was being repaired.

Even as the city's transit system resumed most service, however, it was clear that Sandy's damage had been done. In total, close to 8.6 million daily public transit riders, 4.2 million drivers, and 1 million airport passengers were impacted by the shutdown of various systems. In addition, it is estimated that Sandy has resulted in a staggering $8 billion in physical damage to the region's transportation infrastructure, including $700 million in damage to NYCDOT's facilities and equipment.

East River Crossings Before and After Sandy



	Typical Weekday	Oct. 31 (2 days after Sandy)	Nov. 2* (4 days after Sandy)
Subways	520,000	0	55,000
Buses	17,400	12,200	61,300
Pedestrian	1,100	10,900	7,800
Bicycle	3,500	5,400	7,800
Ferries	900	0	2,400
Tunnels-Private Vehicles	25,000	0	0
Bridges-Private Vehicles	54,000	54,000	92,000

*Note: Bus bridges and HOV requirements were in effect on Nov. 2

Source: NYCDOT

What Could Happen in the Future

Looking to the future, the city's transportation system faces significant climate risks, including the risk of storm surge and flooding from coastal storms, heavy downpours, and sea level rise.

Major Risks

The greatest future risk to the city's transportation network is storm surge—a risk that, as Sandy illustrated, is significant even today primarily because so many critical pieces of transit infrastructure are located within the 100-year floodplain, the area that has a 1 percent or greater chance of flooding in any given year. The recently released Preliminary Work Maps (PWMs) from the Federal Emergency Management Agency (FEMA) define the 100-year floodplain as an area that already includes approximately 12 percent of the roadway network, all of the major tunnel portals other than the Lincoln Tunnel, portions of both airports, a variety of commuter rail assets, all three heliports, and a number of subway entrances and vent structures, principally in Lower Manhattan. *(See map: Transportation Network in the 2013 PWMs 100-Year Floodplain)*

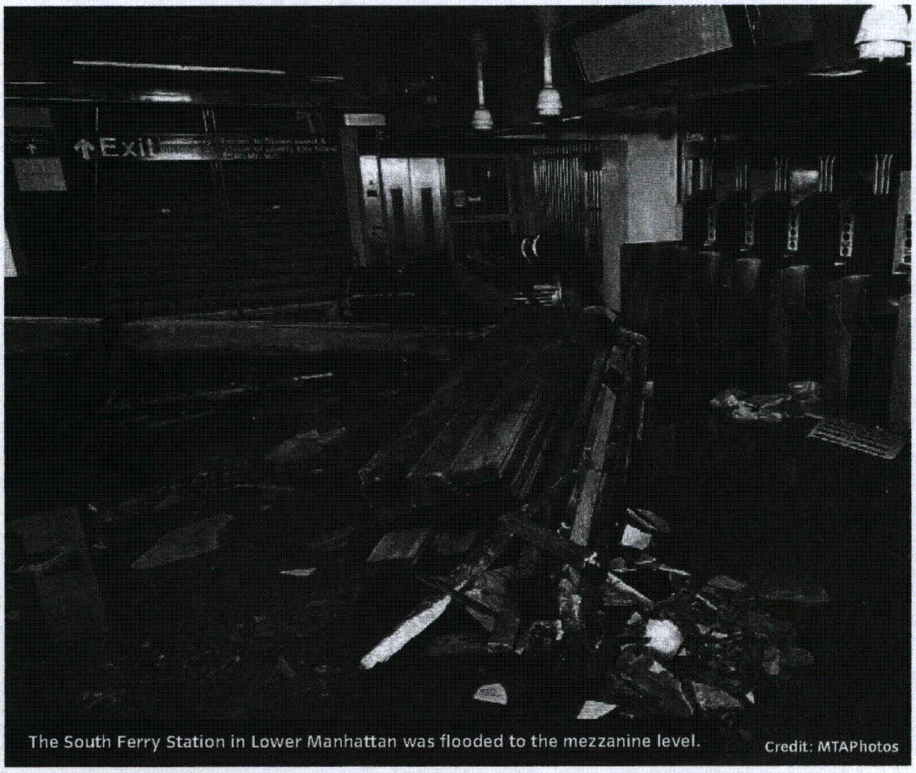
Going forward, the risks associated with storm surge will grow more severe, as rising sea levels increase the impact of those surges and turn minor surges into major events. According to projections from the New York City Panel on Climate Change (NPCC), described in Chapter 2 (*Climate Analysis*), sea levels are forecast to rise through the 2020s and 2050s. During this period, the floodplain will expand. By the 2020s, the floodplain is estimated to encompass 15 percent of the city's roadway network, and by the 2050s, it is expected to encompass 19 percent of that network. More and more of the City's airport infrastructure will be at risk as storm surges will move from

Temporary Services Help Restore Mobility After the Storm

On a normal day, the subway carries about 80 percent of the people crossing the East River into Manhattan. Following Sandy, however, with subway service across the river entirely shut down for a number of days, many people tried to commute by car. Gridlock ensued. It quickly became clear that the transportation network simply was not designed to handle the spike in drivers attempting to enter the central business district south of 60th Street.

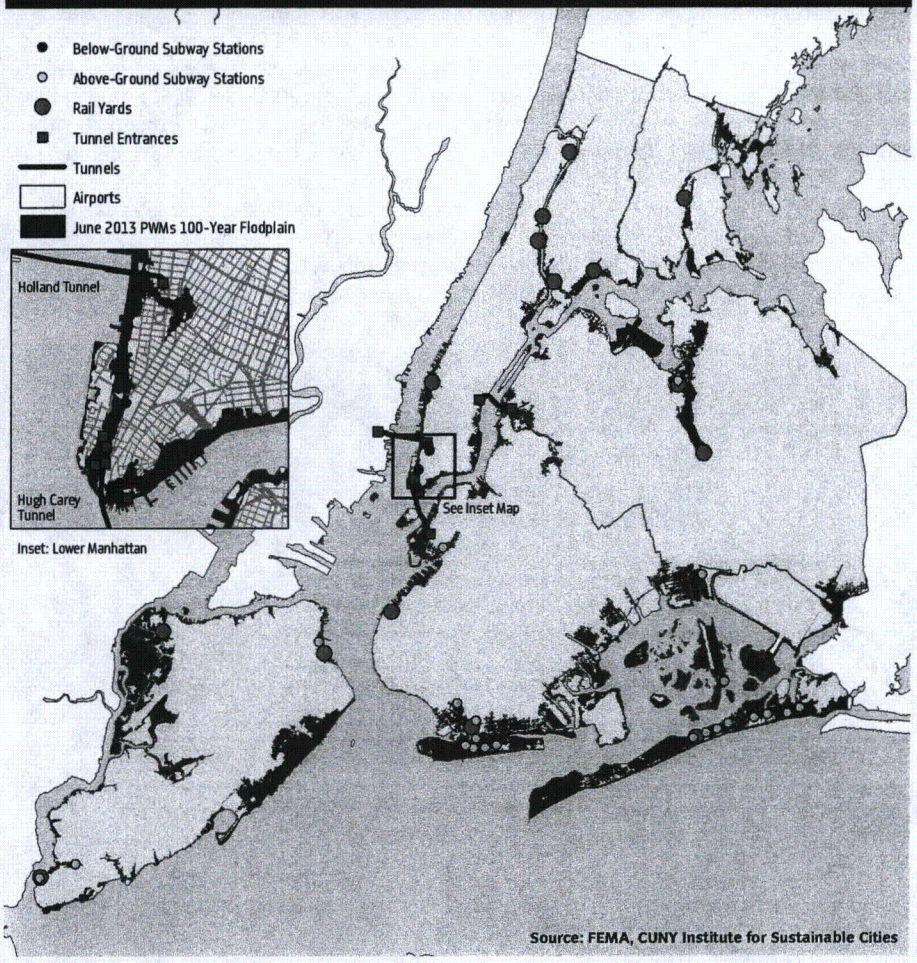
In response, the New York City Department of Transportation (NYCDOT), the New York City Police Department (NYPD), and the Metropolitan Transportation Authority (MTA) instituted a series of measures to limit the number of cars coming into Manhattan but still get people across the river. First, cars entering Manhattan's central business district were required to have three or more occupants. Second, the NYPD, NYCDOT, and the MTA implemented three new temporary, high-capacity, point-to-point bus routes (which quickly became known as "bus bridges"), connecting Downtown Brooklyn and Williamsburg with Midtown Manhattan, using 300 buses that the MTA diverted from other routes. Third, the East River Ferry service pattern was modified to increase capacity and provide faster service along routes with the highest demand, taking advantage of the infrastructure already in place and the vessels on hand.

The challenges inherent in communicating information about these temporary measures in the immediate post-Sandy environment initially led to some confusion among travelers—particularly those drivers who had to be turned away as they tried to enter Manhattan because they did not meet the occupancy requirements. However, these measures accomplished their desired goal, together enabling over 226,000 commuters to cross the East River—almost triple the number able to cross before these measures were in place.



The South Ferry Station in Lower Manhattan was flooded to the mezzanine level. Credit: MTAPhotos

Transportation Network in the 2013 PWMs 100-Year Floodplain



flooding outlying runways to threatening the terminal buildings, while additional subway stations will be at risk.

More intense downpours expected with climate change also pose a major risk to the transportation system. As with storm surge, heavy downpours pose the most significant challenge to subway and vehicular tunnels throughout the city, particularly in locations where tunnel entrances are located in low-lying areas or in areas with poor subsurface drainage. Examples of infrastructure matching this flood profile include the F train on Hillside Avenue in Queens and several subway lines in Lower Manhattan. Generally, heavy downpours are expected to pose only a moderate risk to roads and bridges, which may experience more frequent temporary flooding, but not more lasting damage.

Other Risks

High winds are likely to represent a moderate risk to the above-ground portions of the city's transportation infrastructure, such as traffic signals, signs, bridges, and street lights. They also could pose challenges to the aviation system, interfering with flight operations and, in the worst cases, creating safety hazards. Although high winds can cause power outages, which have serious impacts on the transportation network as a whole, it is not believed that these impacts will be greater than those facing the city today.

Heat waves, meanwhile, present a moderate threat to the city's ground transportation infrastructure, though it is not expected to become materially greater until the 2050s. Heat waves could create problems with opening and closing movable bridges and cause softening of asphalt roads. Heat waves also could become an issue for the subway system, increasing temperatures on platforms to levels that could turn what, today, is only a passenger comfort issue into a passenger safety issue. Moreover, heat waves could increase the potential for power outages, which affect transportation networks across the board.

Finally, sea level rise in and of itself is expected to pose a low risk to the city's transportation infrastructure for the next three decades. However, by the 2050s tidal flooding—already an issue for some low-lying areas—could become more widespread along the waterfront, including areas such as Southern Brooklyn and South Queens. Waterfront assets including the city's airports and ferry terminals could be placed at risk by this periodic flooding threat.

Risk Assessment: Impact of Climate Change on Transportation

Major Risk Moderate Risk Minor Risk

Gradual				
Sea level rise				Some protection required, but most infrastructure is above future sea level
Increased precipitation				Minimal impact
Higher average temperature				Minimal impact
Extreme Events				
Storm surge				Increased flooding of key at-grade and underground infrastructure as storms worsen
Heavy downpour				Flooding of underground infrastructure possible during heaviest downpours
Heat wave				Movable infrastructure (bridges, switches) could be impacted, as well as safety/comfort on subway platforms INDIRECT: reduced electrical supply reliability impacts many aspects of infrastructure
High winds				General damage to infrastructure possible, as well as impact on aviation

Risk Assessment: Impact of Climate Change by Category of Transportation Asset

Major Risk Moderate Risk Minor Risk

Gradual					
Sea level rise					
Extreme Events					
Storm surge					
Heavy downpour					
Heat wave					
High winds					

Note: This chart excludes increased precipitation and higher average temperature because these are expected to have minimal impact on the transportation system

This chapter contains a series of initiatives that are designed to mitigate the impacts of climate change on New York's transportation 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.

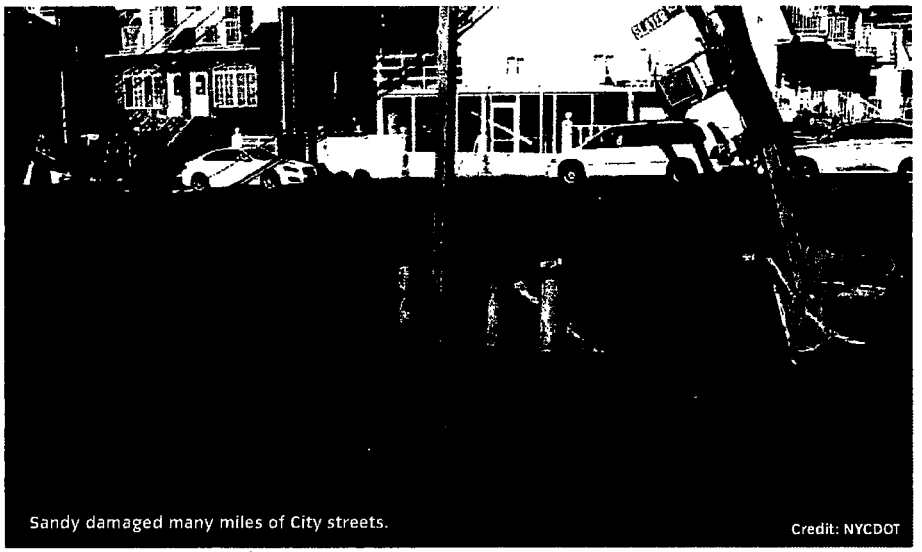
Meanwhile, in the case of certain other initiatives described in this chapter, though these initiatives may be ready to proceed, they still do not have specific sources of funding assigned to them. In Chapter 19 (*Funding*), the City describes additional funding sources which, if secured, would be sufficient 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.

As outlined above, climate change could have a significant impact on the city's transportation infrastructure, ranging from short-term outages to direct damage—or even destruction of critical assets, in some cases. These impacts may make it difficult for commuters to travel to work and school and will hinder the economic and social life of the city.

To mitigate these impacts, the City and other transportation system operators will have to protect their critical assets—particularly those most vulnerable to damage and with the greatest economic and mobility value. However, they also will have to ensure both maximum system redundancy (offering transit users as many different routes as possible to their intended destinations) and that they are well-prepared to restore transportation services quickly, if and when extreme events breach defenses.

Strategy: Protect assets to maintain system operations

Given the range of potential climate change impacts on the transportation network and the criticality of the transportation network, the City will implement initiatives to protect the infrastructure that it controls from damage and loss of service and will call on other agencies to protect other transportation infrastructure critical to the city.



Sandy damaged many miles of City streets. Credit: NYCDOT

Initiative 1
Reconstruct and resurface key streets damaged by Sandy

Sandy's waves and flooding caused significant damage to roadways. To address this damage, subject to available funding, the City, through NYCDOT, will reconstruct 60 lane-miles of streets that were severely damaged and conduct both subsurface and surface repairs. These newly-reconstructed streets also will include upgraded resiliency features to prevent future damage. In addition, NYCDOT will resurface 500 lane-miles of streets with damaged pavement but underlying structures that are in good condition. This initiative is already underway, with funding from Federal and City sources supporting rapid restoration of transportation services.

Initiative 2
Integrate climate resiliency features into future capital projects

The city's roadways are vulnerable to climate change threats in a variety of ways, including surface flooding from heavy downpours, wave action from storm surge, and asphalt damage from heat waves. These threats can have downstream impacts on other systems (including subways and utilities) and on private property. To mitigate the impact of these threats on streets and other infrastructure, subject to available funding, the City, through NYCDOT, will integrate a variety of climate resiliency features into future street reconstruction projects. This will include integrating storm water management best practices and tools. These features allow water captured on streets to soak into the ground rather than flow into the sewer system, resulting in lower drainage loads on both sewers and wastewater treatment plants. (see Chapter 12, *Water and Wastewater*)

While specific climate resiliency features will be designed for each location on a case-by-case basis, the range of tools could include raising street grades, installing bioswales (planted areas in the sidewalk designed to capture stormwater from the adjacent roadway) and/or pre-cast permeable concrete gutters, and adding or raising bulkheads. These features are already being integrated into active capital projects and this will continue in the future.

Initiative 3
Elevate traffic signals and provide backup electrical power

New York's traffic signals are vulnerable to damage from flooding, as well as to power loss from various extreme weather events. Either impact would reduce roadway network operational efficiency and could require the placement of New York City Police Department (NYPD) traffic agents to control traffic. The most vulnerable elements of the city's traffic signals are the signal controllers housing the electrical equipment that operates the traffic signal and communicate with the NYCDOT Traffic Management Center. Accordingly, subject to available funding, the City, through NYCDOT, will raise controllers at approximately 500 intersections in flood-vulnerable locations, placing the electrical hardware above the 100-year flood elevation. In tandem with this effort, the City also will install power inverters in approximately 500 NYPD vehicles, which will allow these vehicles to provide backup electrical power to critical traffic signals in the event that grid power is lost. These improvements will take place over the next three years and will increase the resiliency of this critical component of the transportation network.

Credit: The Elizabeth River Tunnel Project, Portsmouth, VA

Various technologies are available to seal tunnel entrances in the event of flooding such as the closeable flood doors on the Elizabeth River Tunnels in Portsmouth, VA.

Initiative 4

Protect NYCDOT tunnels in Lower Manhattan from flooding

The two tunnels owned by NYCDOT in Lower Manhattan—the Battery Park Underpass and the West Street Underpass—are vulnerable to flooding from both storm surge and heavy downpours, which would significantly disrupt Lower Manhattan's transportation network. NYCDOT, therefore, has evaluated a series of potential flood protection strategies, including installing floodgates and raising tunnel entrances and ventilation structures above flood elevations to provide specific protection for sensitive mechanical and electrical equipment, including ventilation, lighting, and safety systems. Subject to available funding, the City, through NYCDOT, will implement the most promising and cost effective strategies to provide this protection from water infiltration and damage. The goal is to begin work in 2014 and complete it within five years.

Initiative 5

Install watertight barriers to protect movable bridge machinery

The mechanical equipment that allows 25 of the city's bridges to move to provide a clear path for marine traffic is vulnerable to flooding. Damage to this equipment could impact marine and roadway traffic, if bridges were locked either open or closed. Subject to available funding, the City, through NYCDOT, will install watertight barriers to protect the bridges' mechanical equipment from flood damage to ensure that these critical crossings function properly.

Initiative 6

Protect Staten Island Ferry and private ferry terminals from climate change-related threats

New York City's ferry services are vulnerable to disruption and damage from flooding and wind that could lead to extended service suspensions and reduced mobility. To maintain service and allow for quicker service restoration, the City, through NYCDOT and NYCEDC, will continue to use Federal Transit Administration Emergency Relief funds to construct physical improvements to the floating infrastructure, loading bridges/gangways, pilings, and piers at both the Whitehall and Saint George SIF terminals and at additional ferry landings around the city. Within the next four years, NYCDOT and NYCEDC will protect critical aspects of these facilities by water-proofing certain equipment, relocating other equipment out of harm's way, and otherwise protecting electrical equipment from damage.

Initiative 7

Integrate resiliency into planning and project development

Climate adaptation and resiliency have not been critical considerations in prioritizing capital projects for either Federal or City funds, making it more challenging to fund projects that address critical climate change-related vulnerabilities in the city's transportation network. The City, however, already has begun working with other member agencies of the New York Metropolitan Transportation Council, which is responsible for prioritizing federal transportation funding in the New York region, to ensure that resiliency is a factor in such prioritization. Going forward, the City will advocate for similar changes in the planning and evaluation factors that are included in the next Federal legislation funding surface transportation.

At the same time, the City will call upon the various transportation agencies in the region to plan jointly for resiliency and adaptation, thus avoiding duplicative investment and unintended consequences.

Initiative 8

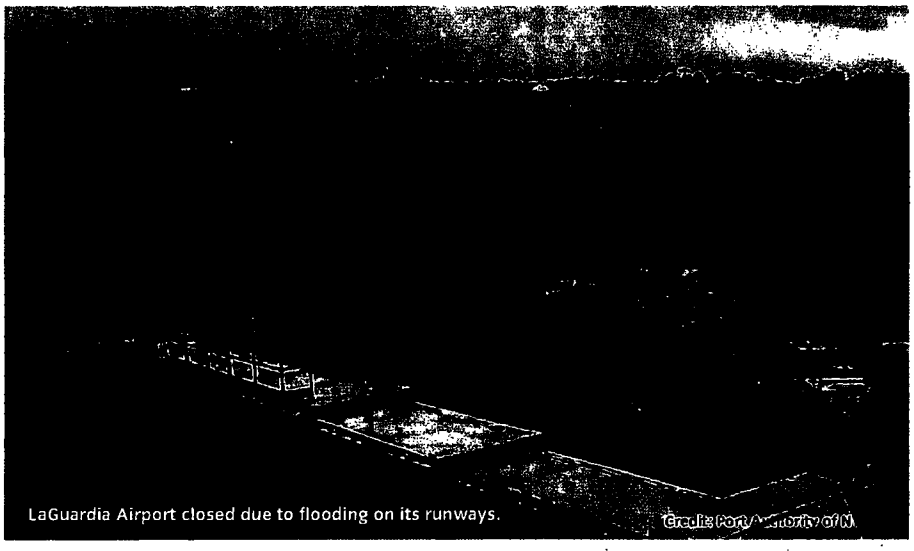
Call on non-City agencies to implement strategies to address climate change threats

Many non-City agencies that own and operate critical portions of New York City's transportation system already have called for increased investment in resiliency and protection strategies appropriate for their

Adding System Flexibility

A number of projects that improve the flexibility of the transportation system and create redundant connections along critical corridors are currently in various phases of development:

- Amtrak's Gateway Project which seeks to add intercity rail capacity into New York City;
- extension of the MTA New York City Transit's 7 subway line to New Jersey or alternatives that would significantly expand cross-Hudson commuting capacity;
- transit improvements along the North Shore of Staten Island; and
- extension of Metro-North Railroad service to Penn Station.



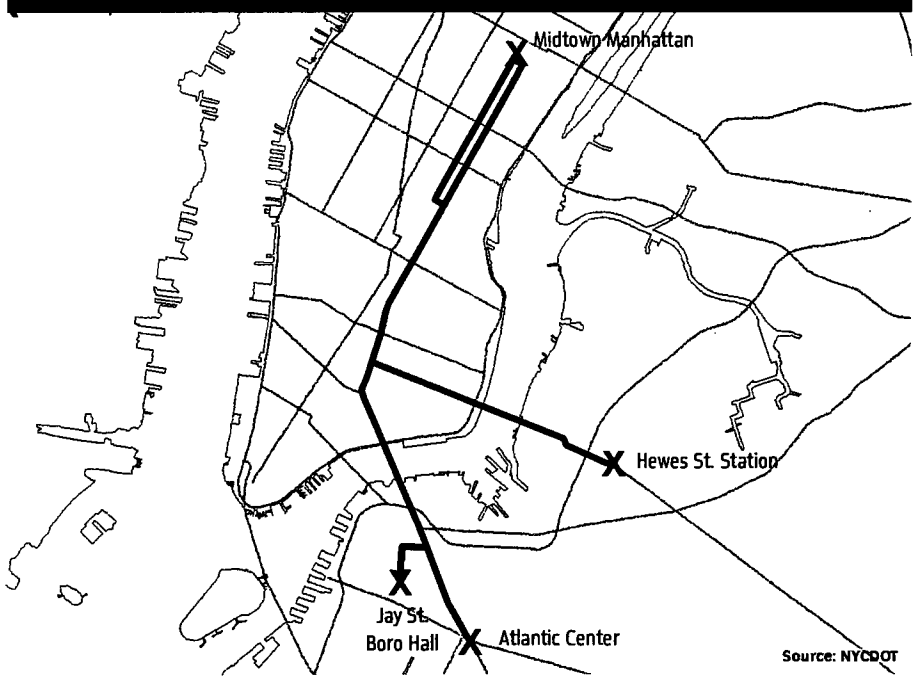
LaGuardia Airport closed due to flooding on its runways.

Credit: Port Authority of N

The LIRR's John D. Caemmerer West Side Yard during Sandy.

Credit: MTAPhotos

Temporary "Bus Bridges" (Non-Stop Bus Service) After Sandy



systems. Without comprehensive implementation of such actions across all transportation systems, critical assets could remain vulnerable to damage and disruption from future climate change-related events. Seeking to ensure that the city's entire transportation system is protected from climate change threats and is prepared for quick restoration following an extreme climate event, the City will call on these agencies to implement hardening and preparation measures, including those already outlined in plans such as the NYS2100 Commission Report. Infrastructure protection should include the following system elements:

- vehicular and rail tunnels, including the subway system;
- bus depots and terminals, and other facilities that are critical to providing bus service;
- rail and subway yards, and other facilities that are critical to providing rail service;
- airport facilities, including runways, lighting systems, navigation systems, and terminal buildings; and
- port and marine facilities, particularly those that handle critical supplies such as food, fuel, and building materials.

In addition, the City will continue to collaborate with Federal and State transportation agencies to support projects that expand the flexibility and redundancy of the transportation network. *(see sidebar: Adding System Flexibility)*

Strategy: Prepare the transportation system to restore service after extreme climate events

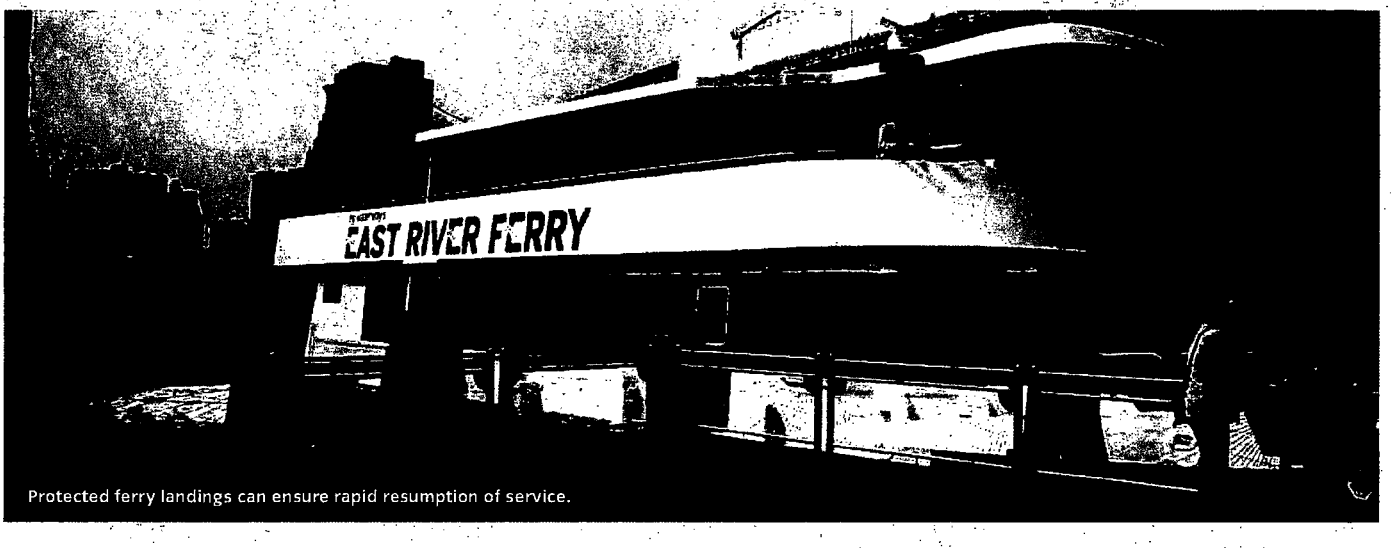
The city's transportation system is too large, too complex, and too old for it to be entirely "climate-change-proofed." In this vein, New York's experience after Sandy demonstrated the importance of maximizing modal redundancy within the system, of ensuring that—when systems are overwhelmed by extreme weather events—they are quickly brought back to regular service, and of being prepared to add temporary services to restore mobility while outages continue.

Therefore the City will implement the initiatives below.

Initiative 9

Plan for temporary transit services in the event of subway system suspensions

When major portions of the subway system are out of service, there simply is not sufficient capacity in the rest of transit network or the roadway system to carry the increased volume



Protected ferry landings can ensure rapid resumption of service.

of commuters and other travelers. To address this situation, the City, through NYCDOT, will continue to work with its transportation partners to develop and regularly update formal plans to provide temporary transportation services. These services could include temporary, high-capacity "bus bridges" of the type implemented during Sandy, temporary point-to-point ferry services, and dedicated bus lanes and necessary enforcement, among others. Identifying the range of potential threats to the transit network and the potential impacts of these threats will be critical to this effort, enabling agencies to determine the types of temporary services that may be necessary. Detailed strategies already have been developed and will continue to be refined and expanded by NYCDOT, the MTA, and other regional agencies. NYCDOT subsequently will acquire and store the traffic control, public information, and other ancillary materials necessary to implement these temporary services. *(See map: Temporary "Bus Bridges" (Non-Stop Bus Service) After Sandy)*

NYCDOT and NYCEDC will work with private ferry fleet operators, and with the MTA and private bus fleet operators, to investigate the level and type of support these companies could provide in the event of a public transit outage

Finally, NYCDOT will work with the MTA to investigate providing city residents with greater access to LIRR and Metro-North services during significant emergency events that lead to major transit disruptions, at fares comparable to those of the subway. This access would be limited to the periods of major disruption, providing an alternative mobility option similar to the type of "cross-honoring" of tickets that is often put in place on NJ TRANSIT buses, PATH, and NJ TRANSIT commuter rail following major disruptions of one of those services.

Initiative 10

Identify critical transportation network elements and improve transportation responses to major events through regular resiliency planning exercises

Many of the facilities critical to the City's ability to respond effectively to a disaster are vulnerable to disruption and damage, potentially impairing delivery of emergency services and supplies of food, fuel, and medicine, as well as impairing the restoration of critical non-transportation infrastructure and economic activity. To respond better to a variety of different possible transportation outage and restoration scenarios, the City, through NYCDOT, will begin immediately to work with a wide range of transportation agencies and other stakeholders around the region to identify the critical elements of the surface transportation network that need to be available quickly following different types of events. The key tool to identify these networks will be an ongoing series of detailed and multi-disciplinary resiliency planning exercises—and potentially even live drills—that will allow these agencies to understand where resources need to be focused before, during, and after an event. This will provide a basis for prioritizing resiliency investments, improving operational response, and disseminating guidance to transportation stakeholders about the routes that they can expect will be available following an event.

Initiative 11

Develop standard plans for implementing High-Occupancy Vehicle (HOV) requirements

During a number of different events—both natural and manmade—that have led to significant interruptions of subway service into and out of Manhattan, the volume of private vehicles trying to cross into Manhattan has overwhelmed available capacity and created gridlock in locations around the city. In response, the City has implemented requirements that vehicles entering the Manhattan central business district have three or more occupants. To improve the future implementation of these measures, the City, through NYCDOT and NYPD, is working to develop standard protocols for implementing HOV requirements, including the conditions under which these requirements will be implemented, and the tools that will be used to communicate this information to the public. NYCDOT, NYPD, and the City's Office of Emergency Management are working together to formalize any exemptions to the HOV requirements, including emergency response vehicles and potentially vehicles carrying key supplies such as food or fuel or emergency response personnel for private businesses. Detailed planning for this eventuality will be completed by the relevant agencies by the end of 2013.

Initiative 12

Plan for and install new pedestrian and bicycle facilities to improve connectivity to key transportation hubs

Subway service interruptions can cause New Yorkers to turn to walking and biking in large numbers, overwhelming the current capacity of pedestrian and bicycle paths, particularly those crossing the East River. To provide additional capacity in these situations, subject to available funding, the City, through NYCDOT and NYPD, will plan for the deployment of temporary pedestrian and bicycle capacity in the event of an emergency situation. This capacity could include special lanes on East River Bridges and their approaches, and lanes that provide access to ferry landings. These agencies will procure

and store the materials necessary to implement these facilities quickly in the event of an emergency, with such materials likely including static signs, temporary traffic control devices, and electronic message signs. Planning for this effort will begin in 2013, with the goal to fully develop these capacity enhancements by the end of 2014.

The City, through NYCDOT, also will work with CitiBike/NYC Bike Share, which provides a transportation option that does not require grid electrical power, to explore future expansion of the bike share network to areas that are vulnerable to weather-related transportation interruptions and that are also adjacent to CitiBike's initial service area, including neighborhoods such as Red Hook, Greenpoint, and Long Island City. This process will begin after the full Citibike deployment is complete.

Initiative 13

Construct new ferry landings to support private ferry services

Emergencies and other events that disrupt subway or transportation service can create serious challenges to mobility within the city, with resulting economic, community, and social impact. To increase the availability of interim transportation services—particularly between the boroughs—subject to available funding, the City, through NYCEDC, will work to expand the network of ferry landings available for both regular and emergency use. To support the establishment of emergency ferry services, NYCEDC will design and procure two new ferry landing barges that are outfitted with the required equipment for providing basic ferry service, with a goal of completing these within three years. These barges will be stored in a secure and protected location. When the need arises, they will be deployed within 24 to 48 hours as temporary landings, allowing for the rapid establishment of interim service. As part of this exercise, NYCEDC will work with the New York State Department of Environmental Conservation to identify potential locations where these barges quickly could be deployed adjacent to neighborhoods that are vulnerable to climate-related transportation interruptions, in a manner that minimizes the impact on the natural environment.

In addition, subject to available funding, the City, through NYCEDC and NYCDOT, will work together to deploy four new permanent ferry landings. These strategic locations will be selected based on the results of the ongoing Comprehensive Citywide Ferry Study in (see Initiative 18 for details on the study). The landings will be designed to be mobile so that, in an extreme situation, they can be temporarily relocated to provide alternative transit services where needed. The goal is to begin design of these landings later in 2013, with deployment based on the results of the ferry study.

Initiative 14

Deploy the Staten Island Ferry's Austen Class vessels on the East River Ferry and during transportation disruptions

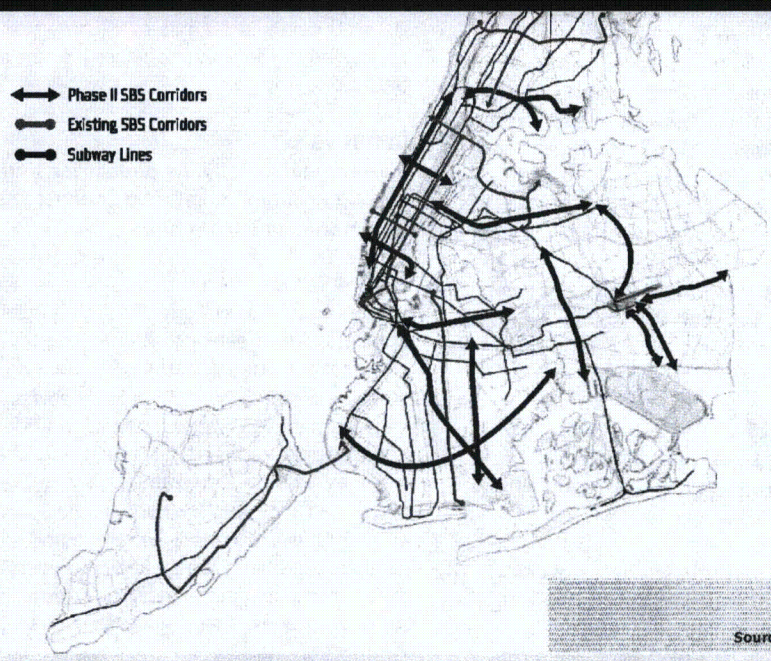
During transit service disruptions that cause large numbers of commuters to use ferry services, the increased demand can outstrip the capacity of typical private ferry vessels. To supplement East River Ferry capacity during such times, NYCDOT will be prepared to deploy the SIF's Austen Class vessels for service along these routes, developing specific operational plans for different scenarios. The Austen Class ferries, due to their size and maneuverability, have been used on a number of occasions over the years to assist in emergencies. Each of the two vessels can carry 10 times the passenger volume of a typical East River Ferry and could, therefore, during major transportation disruptions, help meet sudden increases in ridership on the East River and potentially in other locations.

Initiative 15

Improve at all levels communications about the restoration of transportation services

During and immediately following an emergency situation, communication among agencies and with the general public can suffer from a lack of reliable information and clear communication channels, leading to considerable confusion. To improve the flow of accurate and reliable information, the City will use existing interagency working groups to develop standardized communications protocols for use during transportation disruptions. The plan will include a standard "playbook" for outreach to agency stakeholders and the public regarding system status and interim measures. Truck routes will be a particular focus, in order to provide accurate information to truck companies and drivers during emergencies, minimize the impact of trucks on the City's sensitive infrastructure, and facilitate the safe, fast, and efficient delivery of relief supplies.

Existing and Proposed Select Bus Service Corridors



Source: NYCDOT

Strategy: Implement new and expanded services to increase system flexibility and redundancy

During an emergency situation when subway service is disrupted, other transportation modes often are overwhelmed, crippling the city's mobility and economy. Greater system redundancy that adds flexibility to adapt to unexpected events would add to the resiliency of the transportation network. Beyond creating additional capacity and responsiveness on a daily basis, these investments will be particularly valuable during a variety of weather events and other emergency situations.

The City, therefore, will work with its transportation partners to develop and implement the new or expanded transit services described below.

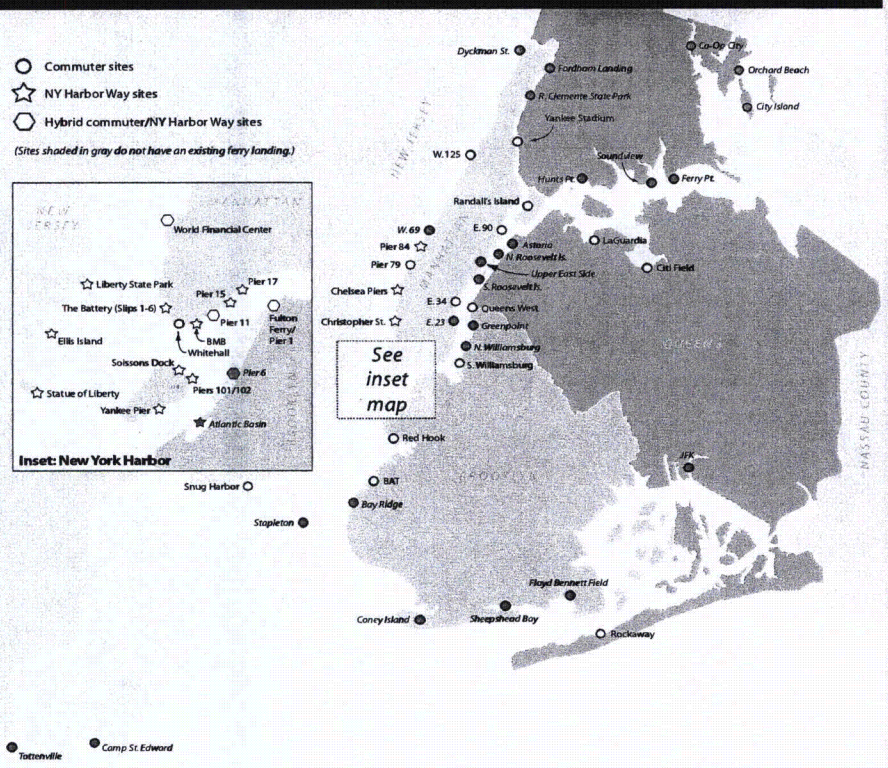
Initiative 16
Expand the city's Select Bus Service network

Subway disruptions or outages can create serious mobility challenges for many New Yorkers. As described above, since 2008 the City and the MTA have implemented four SBS Bus Rapid Transit routes to address general mobility challenges. These routes also can form the backbone of high-capacity bus service in the event of major subway outages. NYCDOT is working with the MTA to expand the city's SBS network significantly, building on a plan developed jointly in 2010 and reinforced in the New York State 2100 Report issued in January. Implementation of this plan has already begun, with three new SBS routes ready to launch shortly in Brooklyn, the Bronx, and Queens. Planning is underway for the Woodhaven Boulevard corridor in 2013, benefiting some of the Southern Queens neighborhoods impacted by Sandy. Subject to available funding, over the next five years NYCDOT will work with the MTA to implement four additional SBS routes. Also subject to available funding, the additional 12 routes included in the plan will be launched subsequently. *(See map: Existing and Proposed Select Bus Service Corridors)*

Initiative 17
Expand the network of bus priority strategies on arterial highways

During both normal and emergency situations, congestion on the region's highways can inhibit mobility and slow the city's recovery. As with the SBS routes, bus priority strategies for express, local, and intercity buses can improve this situation for both standard and emergency operations. Therefore, subject to available funding, the City, through NYCDOT, will work to expand its network of bus priority strategies. Over the next several years, the intention is to include 15 miles of bus priority corridors on major limited-access arterial highways, as these highways are improved or reconstructed in partnership with NYSDOT. This effort will focus on highways on which a variety of buses normally travel. Building on the State's Managed Use Lanes Study, these priority corridors will consist of lanes designed to help the impacted buses move through congested areas quickly and reliably. Types of treatments could include median bus lanes (similar to those on the Staten Island Expressway), contraflow bus lanes (such as contraflow lanes on the Gowanus Expressway and the Long Island Expressway), and use of shoulders for bus traffic (a technique that has been used successfully in other locations). The goal is to implement at least one new or expanded bus priority strategy within five years, with additional facilities added as opportunities arise.

Citywide Ferry Study



Initiative 18
Expand ferry services in locations citywide

The city's waterways present barriers to movement when key crossings are disrupted by a storm or other events. Ferry services provide a critical transportation option for connecting the city across these obstacles under a variety of conditions, including transit disruptions. To plan these services better, the City, through NYCEDC, is currently updating the Comprehensive Citywide Ferry Study (first published in 2011) to explore opportunities for expanding ferry service beyond the existing routes. Based on the results of this study, the City, subject to available funding, will work with its private-sector partners to provide additional service in appropriate locations throughout the city. Chapter 14 (*Brooklyn-Queens Waterfront*), Chapter 15 (*East and South Shores of Staten Island*), and Chapter 16 (*South Queens*) provide additional details on potential new or expanded ferry services in these respective neighborhoods. In addition, NYCEDC will use a Request for Expressions of Interest process to identify and validate the most promising opportunities for new ferry service. *(See map: Citywide Ferry Study).*

Staten Island Ferry Resiliency Upgrades

As was proved during Sandy, ferries are a critical lifeline during and after extreme weather events. This is, of course, true for the Staten Island Ferry, which provides a service that is directly threatened by climate change. Even as the City invests in waterfront and terminal infrastructure protections, ferry boats themselves face operational challenges and vulnerabilities during extreme weather events. Since three existing Barberi-class Staten Island Ferry boats are nearing the end of their useful lives, NYCDOT is preparing to replace these boats with new ferries with cycloidal propulsion systems. Cycloidal propulsion will improve ferry boat maneuverability and safety in high winds, rough waters, and during storm surges. NYCDOT has completed design of these boats and is seeking $300 million in federal funding to procure them. Accelerating these purchases will allow the ferries to be in operation by 2015, providing a resiliency benefit to the people of Staten Island and the city as a whole.

Manhattan's Fort Washington Park and its famous Little Red Lighthouse

Credit: NYC Parks

New York City boasts some of the most magnificent public parks in the world. From wild to manicured, from shoreline to inland, these parks run the gamut in program and design. Large or small, they offer New Yorkers and visitors alike seemingly endless opportunities for recreation. Playgrounds, waterfront esplanades, wetlands, hiking trails, dog runs, boating and kayaking areas, athletic courts and fields, beaches and swimming pools, monuments and historic buildings—all these can be found in the city's parks.

This system of parks and open spaces spans over 29,000 acres, covering 14 percent of the city and encompassing 1,942 sites across all five boroughs. Not surprisingly, because of the vast extent of the city's parks system, when Sandy hit, the impact felt across New York was also felt in parks citywide. From trees downed by Sandy's winds to large stretches of boardwalk and beaches overwhelmed by Sandy's surge, the storm not only wrought hundreds of millions of dollars in damage, but also disabled spaces that, in many cases, were the heart and soul of the neighborhoods they served. With centers for distributing food and other needed supplies, parks were the places where communities came together to begin the road to recovery.

Credit: NYC Parks

Jamaica Bay

Jamaica Bay is one of New York's largest natural features, covering over 10,000 acres of parkland in Brooklyn and Queens managed by both the City and the Federal governments. The Bay contains rare native habitats such as salt marshes, forests, and freshwater ponds. The Bay also is home to a stunning array of wildlife, including over 50 species of butterflies, and a bird sanctuary visited by 330 different species.

The accelerated loss of marshland within Jamaica Bay over the 20th century prompted many governmental initiatives to preserve and restore the Bay's ecology. With the goal of better aligning their Jamaica Bay-area holdings and to foster greater collaboration, in July 2012, then-Secretary of the Interior Ken Salazar and Mayor Bloomberg signed a landmark Cooperative Management Agreement governing Jamaica Bay-Rockaway Parks.

As part of this Agreement, the City is embarking on several initiatives with leadership support from the Rockefeller Foundation and additional support from Bloomberg Philanthropies, Moore Charitable Trust, National Grid, and the Secunda Family Foundation. First, the City aims to expand wetland restoration that it had begun around Jamaica Bay, guided by the Comprehensive Restoration Plan developed under the United States Army Corps of Engineers with support from the National Park Service, the City, and many other regional entities. These efforts are also guided by the Department of Environmental Protection's Jamaica Bay Watershed Protection Plan. Second, the City will establish interagency working groups to explore the feasibility of restoring the historic shallow basin profile of Jamaica Bay to benefit both habitat and the environment while reducing storm surge-related flood risks in areas surrounding the Bay. Third, the City, in partnership with the National Park Service, will establish the Jamaica Bay-Rockaway Parks Conservancy to promote visitation, education programs, scientific research and recreational opportunities. Finally, the Agreement also seeks to establish a Science and Resilience Center at Jamaica Bay to catalyze research and fieldwork in the Bay. Among other things, the new Center will facilitate an exchange of information among policymakers and academics on issues of coastal and urban resiliency that are relevant to cities around the world. The Center also will address local issues facing the Bay, including opportunities to improve water quality and continue to restore degraded natural areas.

As devastating as Sandy was to the parks system, the storm also taught two important lessons: First, with certain exceptions, much of the parkland emerged with only moderate damage; this showed that, where properly designed, parks and other open spaces actually can withstand the blow of a severe storm. Moreover, in many cases, they acted as the first line of defense for the neighborhoods and infrastructure that they fronted, revealing that parks serve an important protective purpose.

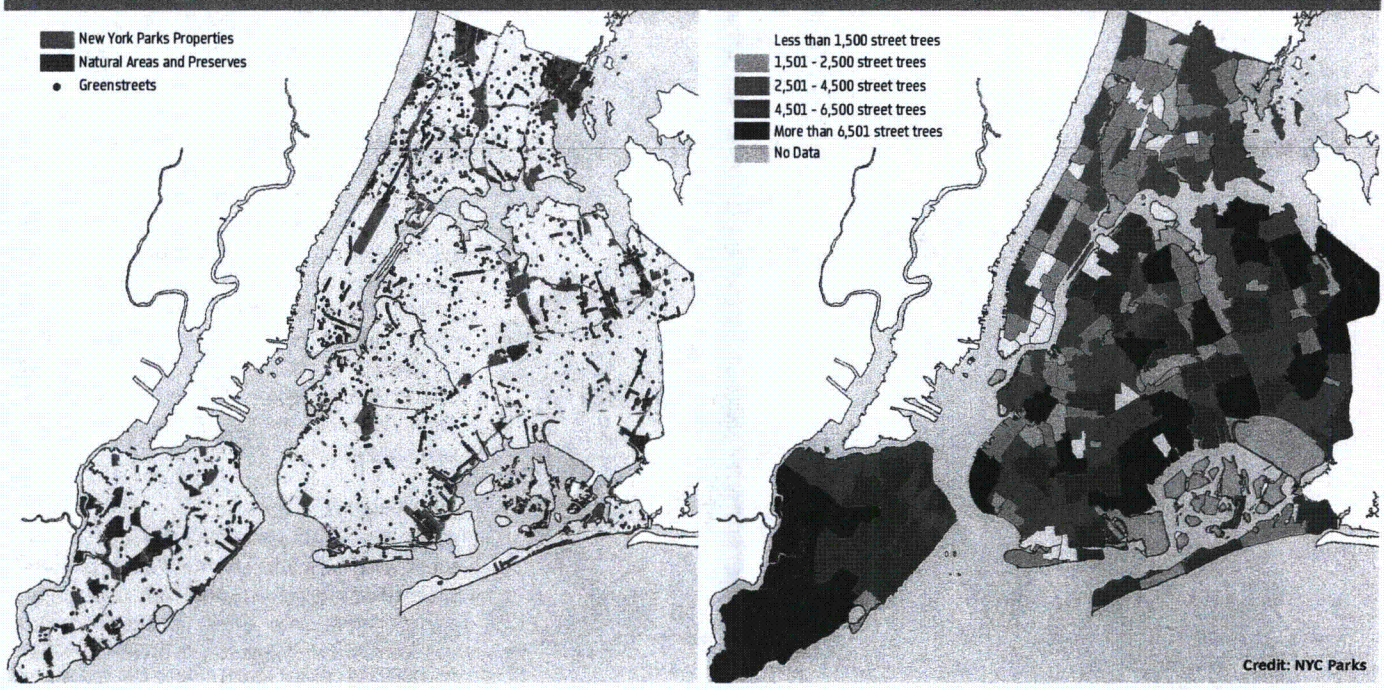
These lessons are critical because New York's parks are not only vulnerable to today's climate-related threats, but are likely to become more so as climate change continues. This is true not only with respect to acute conditions such as storm surge, but also with respect to chronic conditions such as increased temperatures and rainfall. Even modest changes can wreak havoc on the many species of plants and animals found in the city's parks—species that, in many cases, have evolved over eons to thrive in a climate that now is changing rapidly. Indeed, climate change not only threatens the natural landscape of the city's parks but actually threatens the city itself, putting at risk plants that help retain stormwater, provide shade, and make the city livable.

Given the many important roles played by the city's park system, it is critical that New York take steps today to improve the system's resiliency. In keeping with the overarching goals of this report—to minimize the impacts of climate change and enable quick recovery after extreme weather events—the City will pursue strategies that will strengthen parks themselves so they, in turn, can act as stronger buffers for adjacent communities. The City also will develop the tools to analyze and modify its park system for these many roles in an era of increasing change.

How the Parks System Works

New York is fortunate to host parks owned and operated by the City, State, and Federal governments, as well as several that are managed jointly. For example, Hudson River Park along the west side of Manhattan is managed by a trust that is jointly controlled by the City and the State. The National Park Service, meanwhile, manages a 22-acre national monument on Governors Island, while the Trust for Governors Island, a not-for-profit created by the City, manages the other 150 acres. The planned transformation of Jamaica Bay into a world-class site for recreation, ecological restoration, wildlife protection, and scientific research is an expansive example of City-Federal cooperation. (*See sidebar: Jamaica Bay*)

New York City's Parks System



The City also partners with non-governmental bodies in the management of parks. For example, Central Park, Forest Park in Queens, the Staten Island Greenbelt, and Prospect Park are supported in part by independent conservancies, which raise funds for the operation and maintenance of those parks. *(See sidebar: Public-Private Partnerships)*

For the most part, however, when New Yorkers visit parkland in the five boroughs, they are visiting recreational assets that are both owned and managed by the City through the Department of Parks & Recreation (DPR). These properties, therefore, are the primary focus of this report. *(See map: New York City's Parks System)*

The City's parks system can be categorized into four main types of properties: beaches and waterfront parks, inland parks, natural areas and preserves, and Greenstreets infrastructure.

Beaches and Waterfront Parks

Among DPR's assets, its beaches, boardwalks, and waterfront parks constitute by far its most expansive category, covering over 7,300 acres or 30 percent of its total land area. This parkland connects millions of city residents and visitors to the water. In fact, in 2012 alone, the city's beaches welcomed over 21 million people, providing them with a wide range of recreational opportunities and amenities. Especially in recent years, the city's waterfront parks also have spurred the development of residences and businesses along their peripheries. Examples of waterfront parks include Rockaway Beach in Queens, Coney Island in Brooklyn, Orchard Beach in the Bronx, Battery and Riverside Parks in Manhattan, and Midland Beach in Staten Island. Waterfront parks can be found along 150 miles—or almost 30 percent—of the city's total coastline.

Inland Parks

New York's 1,942 parks are home to more than 1,000 playgrounds, 800 athletic fields, 550 tennis courts, 60 public pools, and 30 recreation centers, as well as many other active and passive assets. Connecting these parks to one another and to the city's waterfront and beaches are over 100 miles of Greenways that provide residents and visitors alike with pedestrian- and cyclist-friendly corridors.

Natural Areas and Preserves

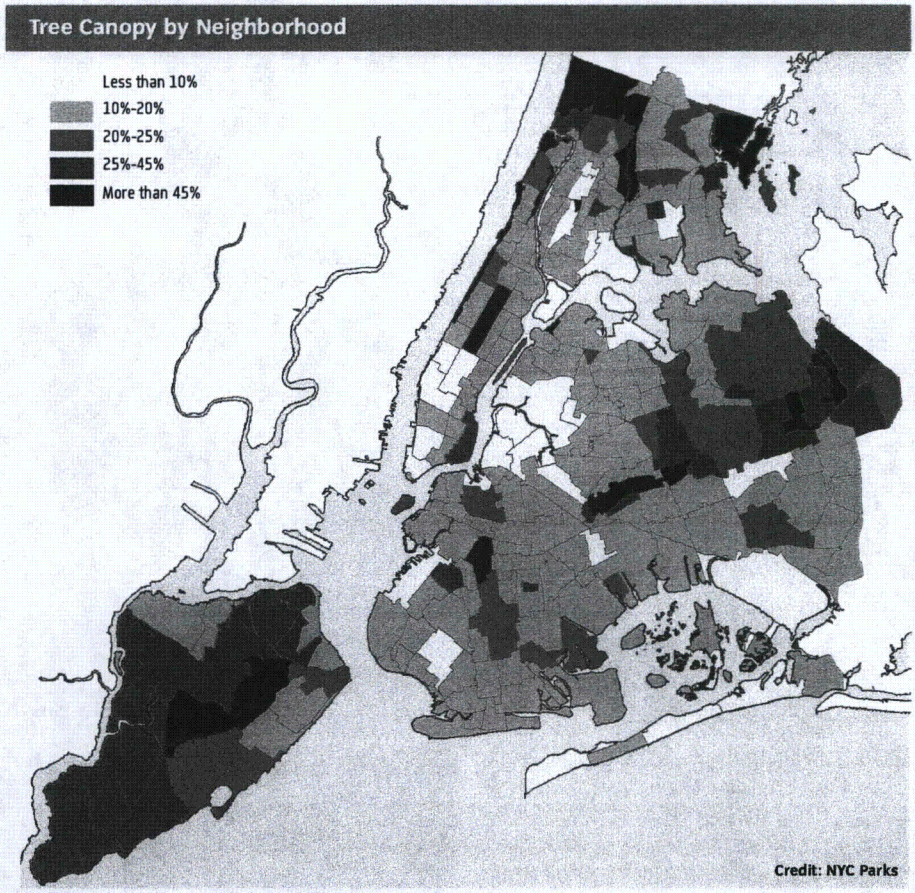
The city's 9,900 acres of natural areas include forests, grasslands, and wetlands—representing over a third of the acreage in DPR's system. Natural areas provide many benefits, including air quality improvements, carbon sequestration, enhanced wildlife habitats, stormwater retention, shoreline protection, and native plant life preservation. The city's wetlands, for example, shelter a wide variety of plants and animals. These areas protect the quality of waterways by absorbing nutrients and filtering sediment and contaminants.

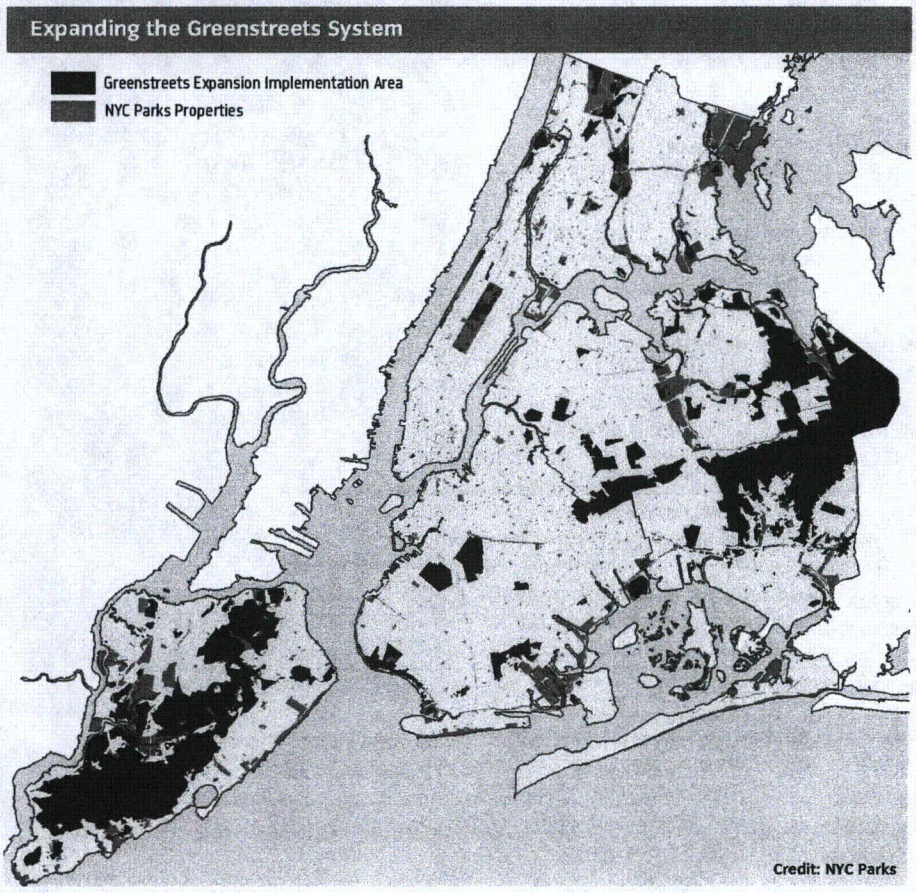
Freshwater streams play an important role in New York city's ecosystem as well as manage stormwater runoff. Today, however, there are few natural streams remaining in New York City, with many now piped underground. Some, such as Tibbetts Brook in the Bronx, also are connected to the City's combined sewer infrastructure and flow directly into the local wastewater treatment plant.

Public-Private Partnerships

New York City's parks system has experienced an incredible transformation over the past 30 years with the assistance of many partner organizations. This wide network of innovative partnerships has brought countless volunteers, much needed resources, and a shared advocacy for the city's green spaces. Hundreds of neighborhood Friends of Parks groups, many supported by Partnerships for Parks, have galvanized local interest and stewardship across the five boroughs.

Organizations like the Central Park Conservancy, the Forest Park Trust, Prospect Park Alliance, the Greenbelt Conservancy, and the Bronx River Alliance have absorbed significant maintenance responsibility in specific parks and also raise millions of dollars for capital improvements. Other partners cast a citywide focus, such as the City Parks Foundation, with its commitment to expanding opportunities for cultural and recreational programming, and the Natural Areas Conservancy, a new organization developing a innovative model to manage natural areas in parks as one ecosystem.





Also found in the city's natural areas—as well as in inland parks, along waterfront parks and beaches, and along streets—are trees, many of which are managed by DPR. These trees not only moderate temperatures; they also remove carbon dioxide and pollutants from the air, among other important functions. DPR's trees range from large canopy trees to street trees, which both enhance sidewalk environments and protect waterways by reducing stormwater runoff. DPR staff manage this urban forest by planting new trees and pruning existing trees to remove dead branches and increase light and air penetration. Since it was announced in PlaNYC in 2007, the City has planted nearly 760,000 trees as part of the MillionTreesNYC initiative. *(See map: Tree Canopy by Neighborhood)*

Greenstreets

DPR's green infrastructure includes natural areas that absorb stormwater and 2,500 Greenstreets, which transform parts of the city's asphalt areas into green landscapes. First constructed in 1996 as a joint project between DPR and the City's Department of Transportation (NYCDOT), Greenstreets have been built throughout the five boroughs in unused road areas, traffic islands, and industrial areas. Greenstreets beautify communities, improve air quality, reduce air temperatures, and enhance safety by shortening street-crossing distances and slowing traffic. *(See map: Expanding the Greenstreets System)*

In 2010, the unit that managed DPR's Greenstreets program became the Green Infrastructure Unit, solidifying its focus on active stormwater capture and using soil beds and other natural features to divert water. By using specially designed soils and plants in these areas, Greenstreets projects absorb runoff from an area 10 or more times their size. Created in partnership with the Department of Environmental Protection (DEP), new stormwater Greenstreet designs enhance cost-effective rainwater capture practices in priority areas of the city, as part of the NYC Green Infrastructure Plan. This work prevents runoff from entering the City's combined sewer system, which, in turn, lessens the frequency of combined sewer overflows (CSOs).

To manage these four categories of parks assets, DPR has a variety of administrative buildings from which staff run, build, and maintain this one-of-a-kind park system. These buildings include the agency's headquarters at the Arsenal in Central Park and other operations centers citywide. In addition to its administrative facilities, DPR also operates other facilities that support its operations and research activities. For example, the Greenbelt Native Plant Center,

a 13-acre greenhouse and seed bank, provides plant material for natural area restoration projects in the city.

Finally, across the city, DPR supports its efforts through a wide variety of recreational, cultural, scientific, and educational programming. In 2013, DPR launched a Parks Fellowship and Conservation Corps, a new public service program that will expose and attract participants to career opportunities in DPR and the environmental field. The Conservation Corps will support DPR priority projects, provide valuable work experience across DPR divisions, and foster the next generation of leaders dedicated to protecting and enhancing the City's parks and natural resources.

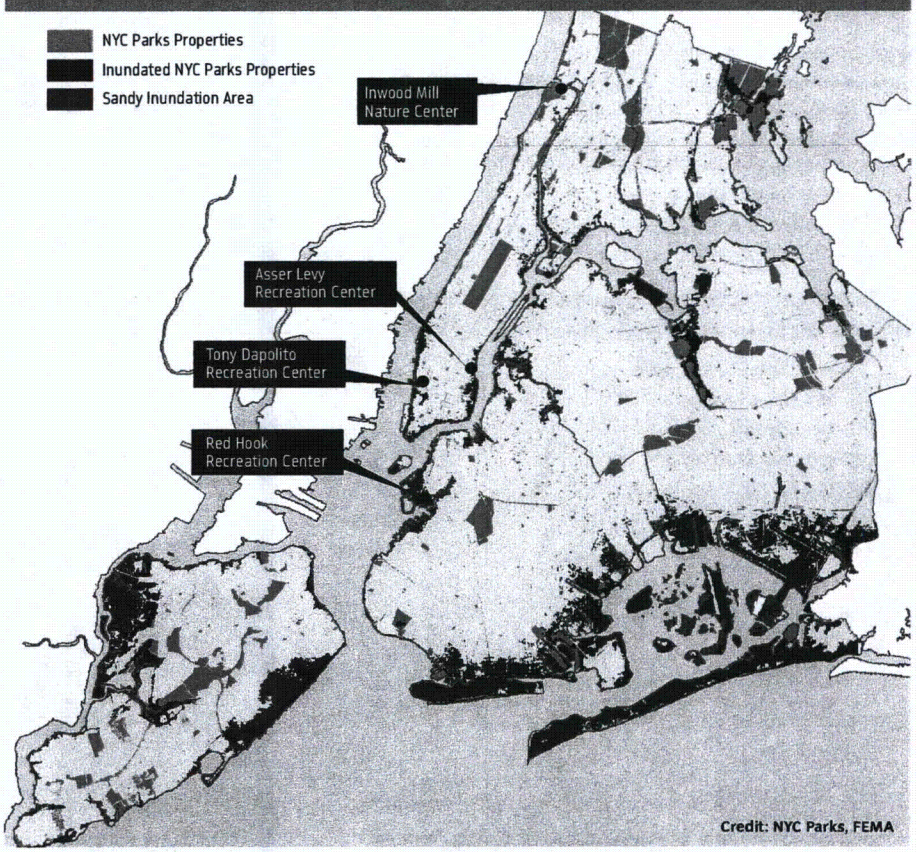
What Happened During Sandy

Sandy inundated over 5,700 acres of New York's park system and caused nearly $800 million in damage. *(See map: Parks Assets Affected by Sandy)*

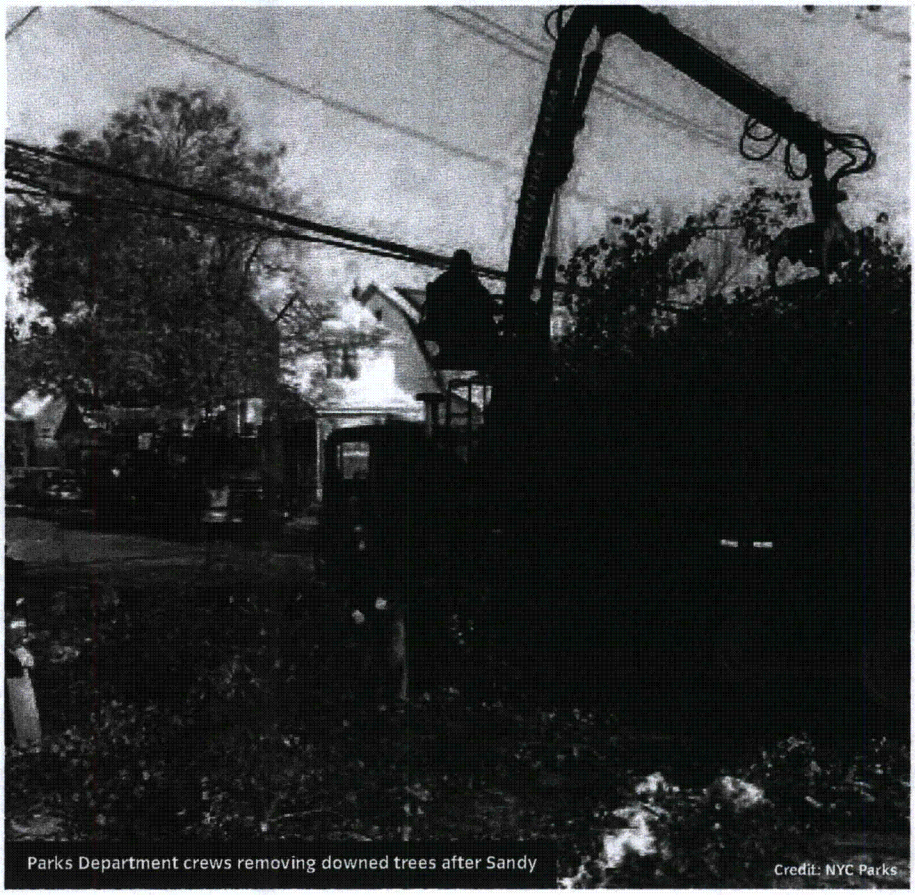
As described in Chapter 3 *(Coastal Protection)*, the city's beaches bore the brunt of the storm's wave action, with significant impacts on the Rockaway Peninsula, Coney Island and adjacent areas of Southern Brooklyn, and along the East and South Shores of Staten Island. On the Rockaway Peninsula, storm surge pounded whole sections of the boardwalk, scattering them into the neighboring communities. Meanwhile, erosion displaced up to 3 million cubic yards of sand and maybe more. In some places, beachfronts retreated by as much as 70 feet. Sandy also pushed water over bulkheads on DPR-managed waterfront sites, damaging these critical coastal defenses and allowing waters to flood parts of the Belt Parkway in Brooklyn. In addition, Sandy damaged DPR's beachfront infrastructure and facilities, including public restrooms.

However, earlier beach nourishment projects (where sand was deposited on existing beaches to both elevate and widen them) also proved successful at city beaches. As a result, for example, the portion of Rockaway Beach at Beach 56th Street, which had well-maintained planted dunes, not only was able to partially resist Sandy's force but also was instrumental in protecting neighborhoods. By contrast, at Beach 94th Street, which had limited beach nourishment and dune maintenance, storm surge destroyed the wooden boardwalk and swept significant volumes of sand into the surrounding neighborhoods. Another successful nourishment project could be found at Plumb Beach in Southern Brooklyn, where, just before Sandy hit, the United States Army Corps of Engineers (USACE) had finished adding 120,000 cubic yards of clean, dredged sand. This intervention

Parks Assets Affected by Sandy



Credit: NYC Parks, FEMA



Parks Department crews removing downed trees after Sandy

Credit: NYC Parks

kept Sandy's surge from potentially breaching a vulnerable section of the Belt Parkway.

Interestingly, not all waterfront parks in Sandy's path were impacted equally. The use of resilient materials and terraced grading helped protect Battery Park and Riverside Park. Revetments, armor stone edges that absorb and deflect waves, and salt-tolerant plantings helped Brooklyn Bridge Park escape with less damage than much of the area surrounding it. At Governors Island, meanwhile, thanks to elevation and other flood-protective strategies, the site of a future park escaped largely unharmed.

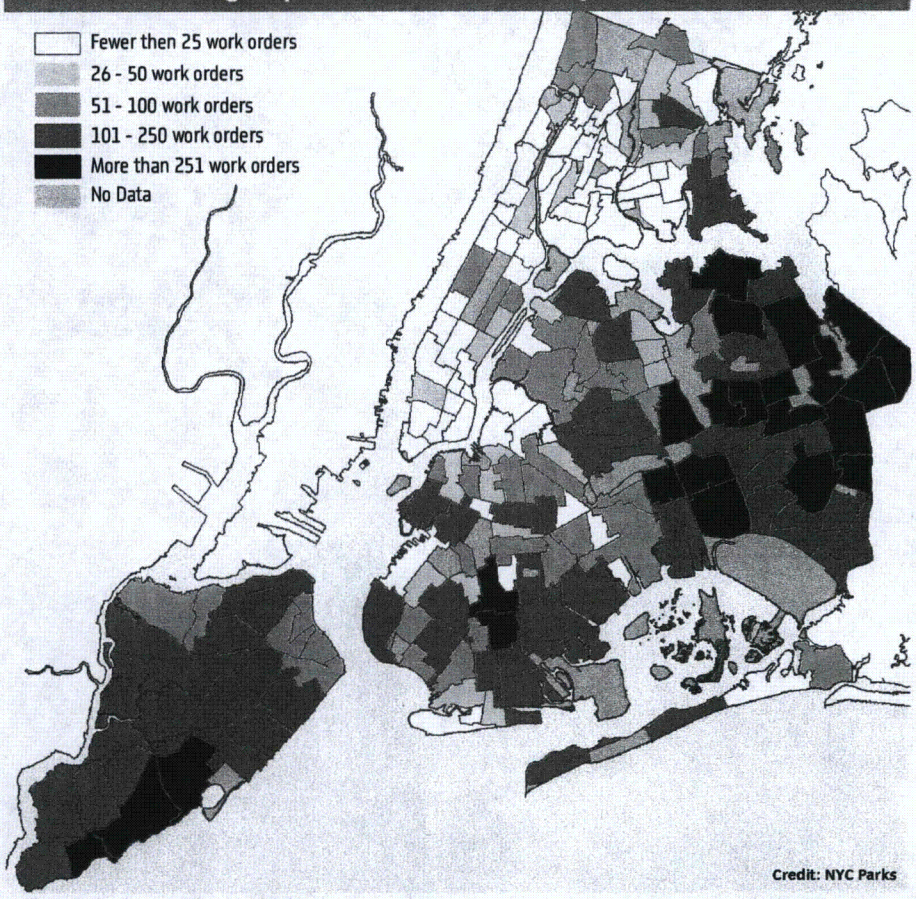
However, flooding from storm surge did affect city marinas and piers, including the 79th Street Boat Basin in Manhattan, the World's Fair Marina in Queens, the Sheepshead Bay Piers in Brooklyn, and the Lemon Creek Marina on Staten Island. Docks, pilings, and piers were damaged, and buildings supporting these marinas were inundated, causing damage to equipment and electrical and plumbing systems.

While the waterfront parks faced the most direct impacts, certain inland neighborhood recreational facilities sustained damage as well. In inundated areas, facilities such as the Asser Levy Recreation Center, the Tony Dapolito Recreation Center, the Inwood Nature Center, and the Red Hook Recreation Center suffered significant water damage to structural and mechanical systems, affecting in some cases the massive filtration plants supporting attached outdoor pools. As a result of this inundation, these centers were shut for four weeks.

Though Sandy flooded over 3,000 acres of natural areas, New York City's wetlands fared relatively well. For example, the salt marshes located in Jamaica Bay and its tributary systems remained largely clear of floating debris, with much of their vegetation surviving. By contrast, across the city, approximately 20,000 street and park trees were downed by Sandy's winds, resulting in weeks of emergency forestry work. In some areas, downed trees and limbs took down nearby utility lines, which disrupted power and telecommunications services. *(See map: Street Tree Emergency Work Orders Post-Sandy)*

With respect to Greenstreets, many performed well during Sandy. For example, the stormwater Greenstreet at Nashville Boulevard and Colfax Street in Queens absorbed water equivalent to 31 times its own area, including 1,300 gallons of rainwater falling directly on it and 39,000 gallons of runoff flowing in from surrounding streets—an amount estimated to represent 3,000 percent more water than a non-stormwater Greenstreet typically would hold. In the stormwater sites, little erosion or ponding was seen. While surge inundation killed some vegetation, generally, Greenstreets emerged from Sandy with minimal damage and plant loss.

Street Tree Emergency Work Orders Post-Sandy



Credit: NYC Parks

Parks Assets Inundated and at Risk

NYC Parks	Citywide Total	Inundated by Sandy		2013 PWMs 100-Year Floodplain		Projected 2020s 100-Year Floodplain		Projected 2050s 100-Year Floodplain	
Park Properties (acres)*	24,200	5,700	24%	5,800	24%	6,600	27%	7,400	31%
Street Trees**	592,400	41,600	7%	35,990	6%	46,400	8%	61,100	10%
Natural Areas (acres)	9,900	3,000	30%	3,117	31%	3,300	33%	3,500	35%
Greenstreets (acres)	173	26	15%	26	15%	30	17%	40	23%

* not including areas located beyond NYC shoreline
** based on 2005-2006 Street Tree Census data