



# 2014 NEW YORK CITY HAZARD MITIGATION PLAN



THE CITY OF NEW YORK  
**HAZARD MITIGATION PLAN**

2014



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Cover Photo: Power outage in Lower  
Manhattan during Hurricane Sandy

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# CHAPTER 1: INTRODUCTION



## Overview

Hazard mitigation, the effort to reduce or eliminate the risks from hazards to people and property, is the first of the four phases of emergency management. It is followed by preparedness, response, and recovery (see Figure 1.1: Phases of Emergency Management). Although the mitigation stage of emergency management often gets the least attention, it is one of the most important steps in creating a disaster-resistant community.

Hazard mitigation is most effective when based on an inclusive, comprehensive, long-term plan that is developed *before* a disaster actually occurs. Although it is impossible to predict exactly when and where disasters will occur or the extent to which they will affect localities, careful planning and collaboration among public agencies, stakeholders, and citizens can minimize losses.

The 2014 New York City Hazard Mitigation Plan (HMP) is the result of this kind of extensive, collaborative effort. The plan—which assesses hazard vulnerabilities, identifies mitigation opportunities, and secures funding for the benefit of New York City—was developed by the New York City Office of Emergency Management (OEM) and the New York City Department of City Planning (DCP) working with the Mayor's Office of Long-Term Planning and Sustainability (OLTPS).

The development of the plan coincided with the arrival of Hurricane Sandy in October 2012, which provided both constraints and opportunities. In early 2013, the City of New York developed a long-term, comprehensive climate resiliency plan, *A Stronger, More Resilient New York*, to assess the impacts of Hurricane Sandy and provide recommendations for rebuilding communities and increasing the resilience of infrastructure and buildings citywide. The research and recommendations in this report heavily influenced the development of the HMP. The HMP is also the culmination of a cooperative partnership among dozens of city, state, and federal agencies, authorities, and organizations, with input from the private sector, academic institutions, community organizations, and citizens.

The 2014 update differs from New York City's original HMP, published in 2009, in two important ways:

Figure 1.1: Phases of Emergency Management



First, it includes *non-natural* hazards along with natural hazards. Second, it addresses the impacts of climate change on identified natural hazards. The plan is a living document and will be refined and updated every five years.

This plan meets all requirements for hazard mitigation plans under the Robert T. Stafford Disaster Relief and Emergency Assistance Act (Stafford Act). The Stafford Act was signed into law in 1988 and provides the authority for federal disaster assistance activities, including preparedness and mitigation along with assistance for response and recovery.

The Disaster Mitigation Act of 2000 (DMA 2000) amended the Stafford Act to reinforce the importance of mitigation planning and emphasize planning for disasters before they occur. DMA 2000 established provisions and requirements for state, local, and Indian Tribal entities to closely coordinate mitigation planning and implementation efforts. States and communities must have an approved Hazard Mitigation Plan to be eligible to apply for and receive FEMA hazard mitigation funds. The plans must demonstrate that the proposed mitigation actions are based on a sound planning process that accounts for the risk to and the capabilities of the community. To facilitate plan development, the Federal Emergency Management Agency (FEMA) has issued guidelines under DMA 2000 regulations.

The New York State Division of Homeland Security and

Emergency Services (DHSES) supports the development of HMPs for jurisdictions within the state, including New York City, through various planning initiatives. NYS DHSES also administers select hazard mitigation grants as well.

### Benefits of Mitigation Planning for New York City

Hazard mitigation planning helps New York City reduce risk from hazards by identifying vulnerabilities and developing strategies to lessen and sometimes even eliminate the effects of the hazard. Some of the benefits of mitigation planning to New York City agencies and other stakeholders are as follows:

- **Leads to selection of risk-reduction actions.** Hazard mitigation planning is a systematic process of learning about the hazards that can affect the city; setting clear goals; and identifying and implementing policies, programs, and actions that reduce losses from disasters.
- **Builds partnerships.** Hazard mitigation planning enhances collaboration among a broad range of stakeholders to achieve a common vision for New York City. Increased collaboration also reduces duplication of efforts among organizations with similar or overlapping goals.
- **Creates a more sustainable and disaster-resistant city.** There is an intrinsic link between the concept of sustainability and natural hazard risk

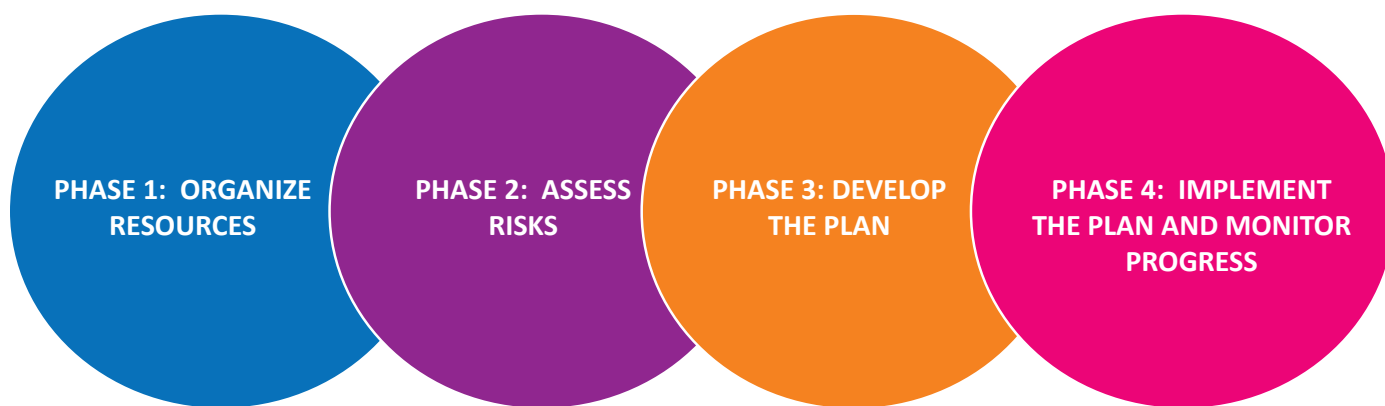
reduction. An essential characteristic of a sustainable city is its resilience to disasters.

- **Establishes funding priorities.** Mitigation planning coordinates existing and potential mitigation actions into a unified mitigation strategy. A mitigation plan allows New York City to better identify and articulate its needs to state and federal officials when funding becomes available, particularly after a disaster. With its HMP in place, New York City can propose projects as part of an overall, agreed-upon strategy. Importantly, this plan ensures New York City's eligibility to receive FEMA's Unified Hazard Mitigation Assistance funds for mitigation projects, especially Hazard Mitigation Grant Program (HMGP) funding.
- **Increases public awareness of hazards.** Mitigation planning serves to help residents better understand the threat to public health, safety, and welfare; economic vitality; and the operational capability of critical infrastructure.

### Planning Phases for the New York City Hazard Mitigation Plan

New York City engaged in a four-phase planning process, as recommended by FEMA guidelines and as illustrated in Figure 1.2: Four-Phase Planning Process.

Figure 1.2: Four-Phase Planning Process



**Phase 1: Organize Resources.** The first phase of the process involved coordinating with agencies and organizations, integrating hazard mitigation with other planning efforts, and involving community groups and other stakeholders in the planning process.

**Phase 2: Assess Risks.** The second phase included identifying and profiling hazards, assessing vulnerability, and estimating potential losses. This phase helped establish the scientific and technical foundation for mitigation actions.

**Phase 3: Develop the Plan.** The third phase included developing hazard mitigation goals and objectives, conducting a capability assessment, working with planning participants to identify and analyze mitigation actions, and documenting the planning process.

**Phase 4: Implement the Plan and Monitor Progress.** New York City is currently in this fourth phase of mitigation planning. This phase involves adopting, implementing, monitoring, and reviewing the HMP to ensure the plan's goals and objectives are met.

### Organization of the New York City Hazard Mitigation Plan

New York City's HMP is organized into the following sections:

#### Chapter 1: Introduction

The Introduction—the section you are now reading—provides a brief overview of the HMP's background and purpose.

#### Chapter 2: Planning Process

This chapter outlines the manner in which New York City created the HMP. It identifies which agencies and organizations were involved in the process, how they were involved, and the methods of public participation that were employed. It also provides a detailed description of the decision-making and prioritization processes.

#### Chapter 3: Risk Assessment

This analysis of the hazards and risks facing New York City contains detailed hazard profiles and loss esti-

mates—the scientific and technical basis for mitigation actions.

#### Chapter 4: Mitigation Strategy

This chapter shows how New York City intends to reduce losses identified in the Risk Assessment chapter. It includes goals and objectives to guide the selection of actions to mitigate and reduce potential losses. It contains a prioritized list of cost-effective, environmentally sound, and technically feasible mitigation actions. It identifies current and potential sources of funding and other resources needed to implement the mitigation actions. Finally, it includes a discussion of New York City's policies and programs that will serve to help administer many of the identified actions.

#### Chapter 5: Plan Adoption

As the Plan Adoption chapter indicates, New York City will formally adopt the HMP by executive order. This ensures comprehensive mitigation planning citywide, strong program management, and a citywide commitment to mitigation planning.

#### Chapter 6: Plan Maintenance

New York City will monitor, evaluate, and update its plan according to the process outlined in the Plan Maintenance chapter. The section establishes a review process and method for measuring progress during the five-year period until the next HMP update.

#### Plan Status and Contact Information

This report incorporates comments submitted by the Planning Team, the Mitigation Planning Council Steering Committee, Mitigation Planning Council members, members of the public, and other stakeholders during the 30-day public comment period as well as comments from NYS OEM and FEMA during the formal HMP review process. The City formally adopted the final plan by Executive Order on April 15, 2014.



If you have any questions or comments on the New York City HMP or require additional information, please contact:

Hazard Mitigation Unit

New York City Office of Emergency Management

165 Cadman Plaza East

Brooklyn, NY 11201

Email: [mitigation@oem.nyc.gov](mailto:mitigation@oem.nyc.gov)

Website: [nyc.gov/hazardmitigation](http://nyc.gov/hazardmitigation)

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# CHAPTER 2: PLANNING PROCESS



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## 1. Introduction

Effective planning efforts result in useful, high-quality plans, but written plans are only one element in the process. The planning process is as important as the plan itself.

A successful planning process forges partnerships and brings together a cross-section of government agencies, the public, and other stakeholders to reach consensus on how to achieve a desired outcome or resolve a community issue. An inclusive and transparent process adds validity to the plan. Those involved gain a better understanding of the problem or issue and how solutions and actions were devised. The result is a common set of community values and widespread support for directing financial, technical, and human resources to an agreed-upon action.

New York City followed an inclusive, transparent planning process to complete the update to the New York City Hazard Mitigation Plan (HMP). This chapter of the HMP serves as a permanent record of New York City's mitigation planning process.

The process, which evolved over the past year, was consistent with the steps presented in the Federal Emergency Management Agency (FEMA) [Local Mitigation Plan Review Guide](#) (2011) (see end of chapter 2 for website link). The following FEMA requirements were addressed in this process:

- **FEMA 44 CFR Requirement §201.6(b):** An open public involvement process is essential to the development of an effective plan. In order to develop a more comprehensive approach to reducing the effects of natural disasters, the planning process *shall* include:
  - (1) An opportunity for the public to comment on the plan during the drafting stage and prior to plan approval;
  - (2) An opportunity for neighboring communities, local and regional agencies involved in hazard mitigation activities, and agencies that have the authority to regulate development, as

well as businesses, academia and other private and non-profit interests to be involved in the planning process; and

(3) Review and incorporation, if appropriate, of existing plans, studies, reports, and technical information.

- **FEMA 44 CFR Requirement §201.6(c)(1):** [The plan *shall* document] the planning process used to develop the plan, including how it was prepared, who was involved in the process, and how the public was involved.

The following New York State Division of Homeland Security and Emergency Services (DHSES) [Hazard Mitigation Planning Standards](#) (2012) (see end of chapter 2 for website link) are also addressed in this chapter:

- **NYS Requirement §F1:** Plans developed with State OEM-administered funds must document that the stakeholders were invited to participate at each phase, and whether they did or not.
- **NYS Requirement §F7:** Plans developed with State OEM-administered funds must be posted (draft plan during the public comment period, and final adopted versions after adoption) and must include specific contact information.

**2. Planning Participants and Organizational Structure**

The process for developing the 2014 Hazard Mitigation Plan was facilitated by the organizational structure described here (see Figure 2.1).

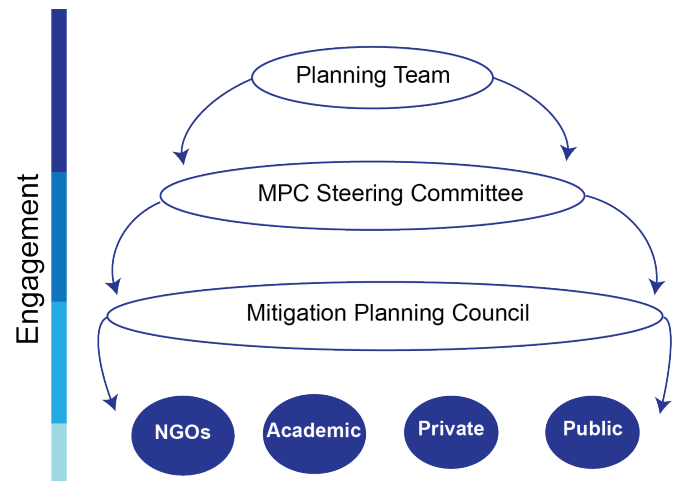
**i. Planning Team**

The Planning Team was the overall lead for developing the HMP. It was comprised of representatives of the New York City Office of Emergency Management (OEM) and the New York City Department of City Planning (DCP), working in close collaboration with the Office of Long-Term Planning and Sustainability (OLTPS). Specifically, the Planning Team consisted of four planners from the OEM Planning and Preparedness Division, one specialist from OEM's Geographic Information Systems (GIS) Unit, and five planners from DCP. OEM planners facilitated the overall plan development to ensure the HMP met the requirements of DMA 2000, and OEM's GIS specialist worked to customize and execute hazard models and create maps and data tables for the plan. DCP, which has expertise in demographic and land-use analyses in addition to several agency-driven climate change initiatives, designated its planners to work on two specific sections of the HMP: New York City's Hazard Environment and the Flooding hazard profile in the Risk Assessment chapter. DCP also provided guidance on the public outreach strategy. OLTPS assisted both OEM and DCP with the future environment sections of the report. The Planning Team participants and information about their agencies are included in Figure 2.2.

As the HMP coordinator, the Planning Team had the following responsibilities:




- Organize and guide all meetings with the Mitigation Planning Council (MPC) Steering Committee and members
- Develop and implement the community involvement process
- Guide the plan development to adhere to DMA 2000 requirements
- Manage identification, collection, and analysis of mitigation actions submitted by the MPC

**Figure 2.1: HMP Organization Structure**



- Facilitate responsibilities and provide support for all participants in the hazard mitigation planning process
- Coordinate with MPC members to identify relevant material for the HMP

Figure 2.2: HMP Planning Team

|   |   |   |
|---|---|---|
|    | <p>The New York City Office of Emergency Management (OEM) plans and prepares for emergencies, coordinates emergency response and recovery, and collects and disseminates emergency information. To accomplish this mission, OEM maintains a disciplined unit of emergency management personnel, including planners, watch commanders, and administrative and support staff, to identify and respond to various hazards.</p> | <p>Heather Roiter Damiano , Hazard Mitigation Program Manager</p> <p>Amy Post, Director Transportation and Infrastructure</p> <p>Melissa Umberger, Hazard Mitigation Specialist</p> <p>Gary Monitz, Hazard Mitigation Specialist</p> <p>Joshua Friedman, GIS Specialist</p> |
|    | <p>New York City Department of City Planning (DCP) is responsible for the city’s physical and socioeconomic planning, including land-use and environmental review; preparation of plans and policies; providing technical assistance and planning information to government agencies, public officials, and community boards. The commissioner of the agency serves as the chair of the City Planning Commission.</p>       | <p>Sarah Goldwyn, Planner</p> <p>Ralph Blessing, Planner</p> <p>Maryam Hariri, Planner</p> <p>Reza Tehranifar, GIS Specialist</p> <p>Thaddeus Pawlowski, Planner</p> <p>Jesse Levin, Project Manager</p>  |
|  | <p>New York City’s Office of Long-Term Planning and Sustainability (OLTPS) was created as part of the Mayor’s Office by local law in 2006. The office coordinates with all other City agencies to develop, implement, and track the progress of PlanNYC and other issues of infrastructure and the environment which cut across multiple City departments.</p>  | <p>Carrie Grassi, Senior Policy Advisor</p> <p>Erika Lindsey, GIS Specialist</p>  |



**ii. Mitigation Planning Council Steering Committee**

The Mitigation Planning Council Steering Committee (MPCSC), which helped develop, manage, and implement the HMP, is a core group of 13 local agencies and regional organizations that own or manage some of the city's largest infrastructure networks and/or engage in planning for or regulating these systems (see Figure 2.3). The MPCSC includes New York City agencies and entities that were involved in the 2009 HMP and remained involved through the 2014 HMP update: OEM, DCP, and OLTPS in addition to the Department of Buildings (DOB), Department of Environmental Protection (DEP), Department of Parks & Recreation (DPR), New York City Department of Transportation (DOT), Metropolitan Transportation Authority (MTA), and the Regional Plan Association (RPA). For the 2014 update to the HMP, the Planning Team expanded the membership of the MPCSC to include the Department of Health and Mental Hygiene (DOHMH), the Mayor's Office for Housing Recovery (HRO), the New York City Police Department (NYPD), and the New York City Fire Department (FDNY). The MPCSC provided subject-matter expertise in the following areas: emergency management, land use planning, building codes, housing recovery, public health, public safety, transportation, infrastructure protection, climate change, regional planning, and natural resource protection.

On July 26, 2013, the Planning Team led the first MPCSC meeting. During this meeting MPCSC members discussed selecting hazards for the HMP, developing goals and objectives, and identifying agency-specific capabilities for implementing mitigation actions. Following the first meeting, MPCSC members attended two additional meetings during the planning process to facilitate the development of the HMP. During these meetings, the MPCSC provided information for and reviewed the Risk Assessment section of the plan and evaluated mitigation actions. OEM also conducted individual meetings with MPCSC members and maintained regular phone and email contact to develop specific ideas and identify additional resources related to the development of the plan.

The MPCSC's responsibilities were as follows:

- Support plan development
- Attend meetings through December 2013
- Develop HMP mission statement, goals, and objectives
- Provide subject-matter expertise
- Assist in evaluating and prioritizing mitigation actions
- Review and comment on draft HMP sections provided by the Planning Team
- Assist with maintaining the HMP

Figure 2.3: MPCSC Members



**New York City Department of Environmental Protection (DEP)** protects public health and the environment by supplying clean drinking water, collecting and treating wastewater, and reducing air, noise, and hazardous materials pollution. DEP distributes more than one billion gallons of clean drinking water each day to nine million New Yorkers and treats the 1.3 billion gallons of wastewater that New Yorkers produce each day in a way that protects the quality of the New York Harbor.

William Morris  
Alan Cohn  
Gregory Anderson



City of New York  
Parks & Recreation

**New York City Department of Parks & Recreation (DPR)** is responsible for maintaining the City's parks system, preserving and maintaining the ecological diversity of the City's natural areas, and furnishing recreational opportunities for City residents. The department maintains more than 17,000 parks, playgrounds, and recreation facilities across five boroughs. It is responsible for more than 1,000 playgrounds, 800 athletic fields, 550 tennis courts, 48 recreational facilities, 66 public pools, 14 miles of beaches, 13 golf courses, and 17 nature centers. Parks also cares for park flora and fauna, community gardens, historic houses, statues and monuments, and more than 2.6 million trees.

Jon Ells  
Mike Dockett  
Jessenia Aponte



**New York City Department of Buildings (DOB)** ensures the safe and lawful use of more than 950,000 buildings and properties through enforcing the City's Building Code, Electrical Code, Zoning Resolution, New York State Labor Law, and New York State Multiple Dwelling Law. DOB's main activities include performing plan examinations, issuing construction permits, inspecting properties, and the maintenance of construction codes and licensing trades.

Keith Wen  
Charles Shelmar  
Daniel Cornwell  
Juan Arias



**Department of Health and Mental Hygiene (DOHMH)** protects and promotes the health of all New Yorkers. DOHMH is responsible for issuing birth and death certificates, providing food safety training, restaurant inspections, immunization information, and public health publications. In addition, DOHMH works to prevent, protect against, respond to, and increase NYC's ability to recover from public health threats. The agency works to build NYC Community resilience against public health emergencies through collaboration with NYC healthcare facilities and community organizations.

Kizzy Guzman  
Mitchell H. Stripling  
Lachelle Francis



**New York City Department of Transportation (DOT)** is responsible for providing safe, efficient, and environmentally responsible movement of people and goods throughout New York City. The agency's responsibilities include day-to-day maintenance of the City's 5,800 miles of streets, highways, and sidewalks. The agency's responsibilities also include the management 6,300 miles of streets and highways, over 12,000 miles of sidewalk, 781 bridge structures and six tunnels. The agency also operates the Staten Island Ferry and other ferry operations on City owned piers. DOT staff installs and maintains more than 1.3 million street signs, traffic signals at more than 12,000 signalized intersections, and over 300,000 street lights.

Alan Olmsted  
Tom Maguire  
Magdeline DeCamps  
Sharita Hunter

# PLANNING PARTICIPANTS AND ORGANIZATIONAL STRUCTURE

## CHAPTER 2: PLANNING PROCESS



**Fire Department of New York City (FDNY)** responds to fires, public safety and medical emergencies, disasters and terrorist acts, FDNY protects the lives and property of New York City residents and visitors. The Department advances public safety through its fire prevention, investigation and education programs. The timely delivery of these services enables the to make significant contributions to the safety of New York City and homeland security efforts.

Jeff Roth  
Caroline Kretz  
Anthony Migliore



**The Mayor's Office of Housing Recovery (HRO)** is responsible for providing information on the City's efforts to help New Yorkers recover from Hurricane Sandy; NYC Build it Back is a central tenant of HRO. This program assists homeowners, landlords, and tenants in the five boroughs whose homes and properties were damaged by Hurricane Sandy. NYC Build it Back provides several pathways to help affected residents return to permanent, sustainable housing by addressing unmet housing recovery needs in several categories.

Thaddeus Pawlowski



**Metropolitan Transportation Authority (MTA)** serves a population of 15.1 million people in a 5,000 sq mile area spanning from New York City through Long Island, southeastern New York State and Connecticut. MTA subways, buses, and railroads provide 2.62 billion trips each year to New Yorkers. In addition, MTA bridges and tunnels carry more than 280 million vehicles per year.

Judy Walker  
Keyla Hamman



**New York City Police Department (NYPD)** enhances the quality of life by working in partnership with the community and in accordance with constitutional rights to enforce the laws, preserve the peace, reduce fear and provide a safe environment. NYPD protects the lives and property of citizens and impartially enforces the law and fights crime both by preventing it and by aggressively pursuing violators of the law.

Robert Harnischfeger  
James Wahlig  
Victor Ferrante  
Chris Matousek



**Regional Plan Association (RPA)** is an independent, not-for-profit regional planning organization that focuses on recommendations to improve the quality of life and the economic competitiveness of the 31-county New York-New Jersey-Connecticut region through research, planning, and advocacy. RPA's mission is to help shape transportation systems, protect open spaces, and promote better community design for the region's continued growth. RPA addresses future challenges to the region and works to mobilize the region's civic, business, and government sectors to take action.

Rob Pirani  
Laura Tolkoff

**iii. Mitigation Planning Council**

The MPC's 41 members played an integral role in identifying existing and potential mitigation actions that will make New York City more resilient to natural and non-natural disasters. The members include the 39 agencies, public authorities, non-profit organizations, and private utility providers that were involved in the 2009 HMP: the New York City Department for the Aging (DFTA), DOB, DCP, Department of Citywide Administrative Services (DCAS), Department of Design and Construction (DDC), Department of Correction (DOC), Department of Education (DOE), DEP, DOHMH, Department of Homeless Services (DHS), Department of Information Technology and Telecommunications (DoITT), DPR, Department of Sanitation (DSNY), DOT, the Economic Development Corporation (EDC), FDNY, Health and Hospitals Corporation (HHC), Housing Preservation and Development (HPD), Human Resources Administration (HRA), Landmarks Preservation Commission (LPC), New York City Housing Authority (NYCHA), NYPD, OEM, OLTPS, the Port Authority of New York and New Jersey (PANYNJ), RPA, Small Business Services (SBS), the United States Army Corps of Engineers (USACE), Consolidated Edison (Con Ed), Public Service Electric and Gas Company (PSEG) (formerly known as the Long Island Power Authority), Verizon, and the MTA (see Figure 2.4). For the 2014 HMP, the Planning Team expanded the MPC to include the following agencies: City University of New York (CUNY), HRO, the Mayor's Office of Environmental Remediation (OER), the Office of Management and Budget (OMB), and the Office of the Chief Medical Examiner (OCME). In addition, New York's Director of Resiliency (OLTPS), Dan Zarrilli was engaged in the planning process of the HMP. Furthermore, James Colgate, the New York City Floodplain Administrator, supports the implementation of the mitigation strategy identified in the HMP.

On June 18, 2013, MPC members participated in a large-group kickoff meeting (discussed further below). The Planning Team used this meeting to introduce participants to hazard mitigation, discuss hazard mitigation funding and eligible projects, and request a list of mitigation actions from each participant. In addition, the Planning Team met with each member agency or

organization separately to provide additional hazard and risk information and discuss specific mitigation actions.

MPC members' responsibilities were as follows:

- Attend MPC meetings
- Identify, develop, and submit alternative mitigation actions for inclusion in the Mitigation Strategy section
- Review and comment on the draft HMP
- Provide ongoing monitoring of hazard mitigation efforts after plan adoption

Figure 2.4: Mitigation Planning Council (MPC) Members



Renato Derech  
Dennis Connelly



Frank Eilam  
Patricia Lyons  
Sharvon Stewart  
Jeff Pico  
Hardee Saini



Howard Apsan  
Bernard Jones



Alan Olmsted  
Tom Maguire  
Magdeline DeCamps  
Sharita Hunter



Kevin DePodwin  
Brad Zoref



Lisa Templeton  
Joseph Gallagher



Sarah Goldwyn  
Maryam Hariri  
Jessie Levin  
Reza Tehranifar



John Chingas  
Gerald Carannante



Eric Macfarlane  
Sofia Zuberbuhler-Yafer  
Alek Pitel



Rich Cote  
Rory Melvin



William Morris  
Alan Cohn  
Gregory Anderson



Jeff Roth  
Caroline R. Kretz  
Anthony P. Migliore



Linda Whitaker  
Lenny James



Tamiru Mammo  
Susan Meehan



Fernando Miranda  
Thomas Vanacore  
Glen Panazzolo



Vito Mustaciuolo  
Ann Marie Santiago



City of New York  
Parks & Recreation

Jon Ells  
Mike Dockett  
Jessenia Aponte



Kathryn Dyjakk  
Lisa Montllor Macedo



Keith Wen  
Charles Shelhamer  
Daniel Cornwell  
Juan Arias



Thaddeus Pawlowski

**PLANNING PARTICIPANTS AND ORGANIZATIONAL STRUCTURE**

CHAPTER 2: PLANNING PROCESS



Cory Herrala  
Edith Bellinghausen



Carrie Grassi  
Erika Lindsey  
Dan Zarrilli



Keyla Hammam  
Judy Walker



Nick Lizanich  
Salvatore Iraci  
Ken Kane



Douglas McNevin  
Matthew Nolty



Jeff Garafalo  
Noreen Chambers  
Kerry Fristoe



Robert Harnischfeger  
James Wahlig  
Victor Ferrante  
Chris Matousek



Bruce Swiren



Donnell Harvin  
Frank DePaolo



Rob Pirani  
Laura Tolhoff



Amy Post  
Heather Roiter  
Melissa Umberger  
Gary Monitz  
Joshua Friedman  
Cynthia Barton



Al Miller  
Zarines Negron



Daniel C. Walsch  
Hannah Moore



John Beldin-Quinones

\*MTA members include New York City Transit (NYCT), MTA Bus Company, Long Island Rail Road (LIRR), Metro-North Railroad (MNR), and Bridges and Tunnels

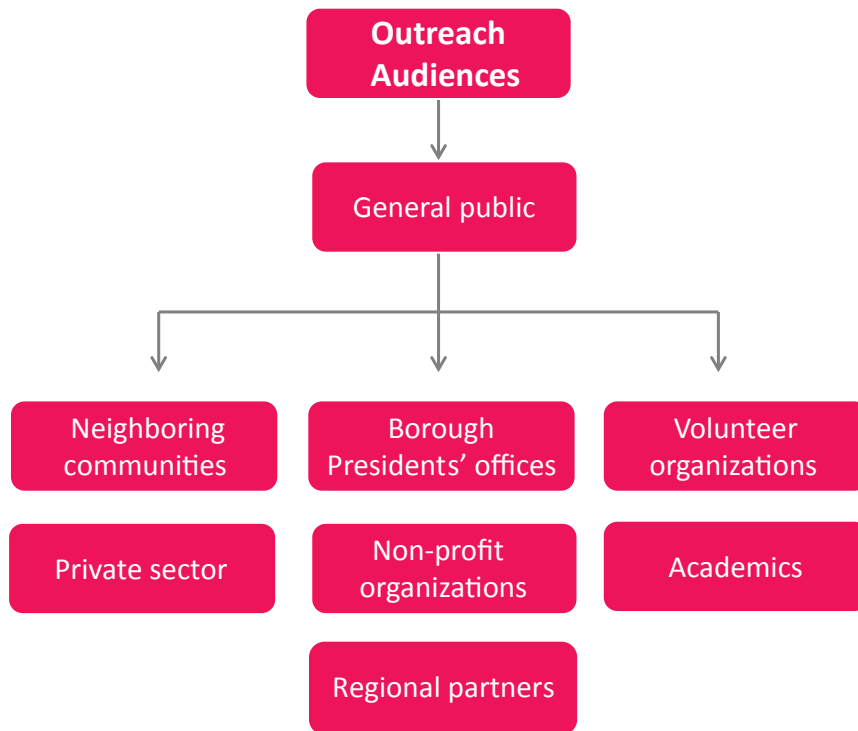
**iv. Community Involvement**

To engage the community in the hazard mitigation planning process, the Planning Team developed a comprehensive community involvement strategy. The Planning Team first compiled a list of outreach contacts based on the following intended audiences: neighboring communities, community board offices, borough presidents' offices, the private sector, professional organizations, neighboring jurisdictions (Nassau, Suffolk, and Westchester counties and New Jersey), regional partners, non-profit organizations, and academics. The strategy employed to engage the public in the planning process is detailed in Figure 2.5.

igation postcard to be distributed at public outreach meetings and Ready New York events (see Figure 2.7). This postcard was also attached to the newsletters that were emailed to the general public.

In addition, the Planning Team created an online survey. The purpose of this survey was to gain a better understanding of the types of hazards that members of the general public feel pose a risk to the city as well as communicate actions that local communities can take to mitigate the impact of hazards and strategies that local, state, and federal government can implement to lessen disaster losses. The survey can be found in the Appendix C. The survey was posted to OEM's website

**Figure 2.5: Hazard Mitigation Public Outreach Audiences**



The HMP's community involvement process also builds on and incorporates the City of New York's *A Stronger More Resilient New York*, developed in early 2013, which included significant community engagement and feedback (see Figure 2.6).

The Planning Team emailed newsletters notifying the general public about the update to the HMP and guiding them to the OEM website for more information on the plan. The Planning Team also created a hazard mit-

igation postcard to be distributed at public outreach meetings and Ready New York events (see Figure 2.7). This postcard was also attached to the newsletters that were emailed to the general public. In addition, the Planning Team created an online survey. The purpose of this survey was to gain a better understanding of the types of hazards that members of the general public feel pose a risk to the city as well as communicate actions that local communities can take to mitigate the impact of hazards and strategies that local, state, and federal government can implement to lessen disaster losses. The survey can be found in the Appendix C. The survey was posted to OEM's website

Figure 2.6: A Stronger More Resilient New York Public Outreach Statistics

| Outreach Mechanism | Metric                                   | Status  |        |
|--------------------|--|---|--------|
| Elected Officials  | SIRR presentation and Q&A                | # of collective/individual briefings  | 30+    |
|                    |  | # of elected offices briefed  | 65+    |
|                    |  | # of community boards briefed   | ~20    |
| Organizations      | SIRR presentation and Q&A                | # of community-based, business, environmental, faith, labor, policy organizations briefed | 320+   |
| Public Workshops   | SIRR overview and facilitated discussion | # of public workshops   | 11     |
|                    |  | # of attendees  | 1,000+ |

Figure 2.7: Hazard Mitigation Postcard



ings in addition to the full list of general public contacts can be found in the Appendix C.

To engage academic, private sector, and community-based stakeholders, the Planning Team held four meetings designed to inform participants about hazard mitigation, generate discussion, and elicit feedback on the HMP. The meetings targeted New York City academic institutions, professional organizations and the private sector, community-based organizations, re-

gional organizations, and non-profit organizations.

1) Academic Institutions Meeting

On November 18, 2013, the Planning Team held a Hazard Mitigation Plan information session for academic institutions engaged in the fields of hazard mitigation, climate change, urban planning, architecture, and engineering. The Planning Team first presented an overview of the HMP, which covered the planning process,



the plan components, and the public review process.

The Planning Team then asked participants for feedback as well as suggestions for additional research and potential mitigation actions. Throughout the meeting, participants had the opportunity to ask questions and participate in the discussion. One topic of concern was the need to incorporate community organizations in the public outreach process and to include the mitigation strategies and projects these organizations are currently involved in. The Planning Team addressed this topic, explaining that the mitigation actions of non-profits will be included in the narrative description in the Mitigation Strategy section of the plan and noting that the Planning Team would be coordinating a webinar for community groups in early December 2013. The Planning Team also explained that the public outreach process will continue in 2014 for an abridged version of the plan due in fall 2014. One meeting participant recommended that the city address an additional hazard: meteor crashes. To solicit additional comments and suggestions, all meeting invitees were notified when the draft HMP was available for review online.

Members from the following academic institutions attended this meeting: Columbia University (Center for Climate Systems Research/Graduate School of Architecture, Planning and Preservation/Mailman School of Public Health), CUNY Hunter College (Urban Planning), East Carolina University, Harvard University (Urban Planning), Manhattan College, New York University (NYU) (Center for Catastrophe Preparedness and Response/Polytechnic Institute/Wagner Graduate School of Public Service), Pratt Institute (City and Regional Planning), and Stevens Institute of Technology. The full invitee list is included in the Appendix.

### *2) Private Sector and Professional Organizations Meeting*

On November 13, 2013, the Planning Team held a community involvement meeting with representatives from New York City's private sector, professional organizations, and volunteer groups. This meeting was organized by OEM's Public Private Initiatives Unit, which regularly holds webinars for their Partners in Prepared-

ness program. The Partners in Preparedness program helps organizations better prepare their employees, services, and facilities for disasters, and its members include private companies, institutions, and non-profit groups (see Appendix A). At this meeting, the Planning Team provided an overview of the Hazard Mitigation Plan, covering the planning process, plan components, select hazard profile summaries, mitigation action types, and a timeline of major milestones. The presentation was followed by a question-and-answer period. Participants were asked for feedback on the work presented as well as suggestions on how the Planning Team can help participants educate their members about hazard mitigation. The webinar was recorded and is available via OEM's [website](#) (weblink provided at the end of the chapter). The Planning Team will work with interested parties to help promote hazard mitigation through future working groups or mitigation discussions.

The following organizations RSVP'd to the webinar: Allied Rockaway Foundation for Animal Recreation and Fitness (ARF-ARF), American Red Cross (ARC), BNP Paribas, BNY Mellon, Brooklyn Bureau of Community Services, Building Owners & Managers Association of Greater NY, CIBC World Markets, CME Group, Cravath, Swaine & Moore LLP, CUNY Hunter College, Disney/ABC Television Group, Fordham University, Hippodrome, Institute for Business & Safety, Macy's, Marubeni America Corporation, Mass Mutual, Medical Reserve Corps, Neighborhood Housing Services of New York City, New York Law School, New York Life Insurance Company, NYC Amateur Radio Emergency Communication Service, NYC Clothing Bank, NYC Department Cultural Affairs (DCA), DOE, HHC, New York Liquidation Bureau (NYLB), NYS DEC Region 2, Orrick, Herrington & Sutcliffe, Remlu, Inc, RXR Realty, Shearman & Sterling LLP, St. Johns University, New York Botanical Garden, The Walt Disney Company, Time Warner Cable, and Trinity Real Estate.

The full invitee list is included in Appendix A. All meeting invitees were notified when the draft HMP was available for review online.

### *3) Non-Profit Organizations and Regional*

*Partners Meetings*

On September 17, 2013 the Planning Team held a community involvement meeting with the New York City Citizen Corps Council. The Citizen Corps Council is part of a national initiative to bring together local leaders from community organizations, government agencies, the private sector, and volunteer programs to promote community preparedness and volunteerism. At the meeting, the Planning Team presented a brief overview of the HMP, which included a discussion of the hazards to be included in the plan and some of the mitigation actions identified by the MPC. The participants were asked for feedback as well as suggestions for improving the plan.

Several of the participants inquired about how local communities or neighborhoods can become more involved in developing mitigation practices. The Planning Team addressed this question by explaining the New York State Community Reconstruction Zone (CRZ) Program, which allows communities to identify safe, resilient, and innovative reconstruction projects based on community-driven plans that consider current damage, future threats, and the community's economic opportunities. On December 11, 2013, the Planning Team held a webinar with representatives of a variety of New York City community-based non-profit organizations and regional organizations. These organizations are a valuable resource for educating the public about hazard mitigation and actions the community can engage in to make New York City more disaster-resilient. After the presentation, participants were given the opportunity to ask questions.

The following organizations were invited to the webinar event: Association for the Advancement of Blind and Retarded (AABR), Arch Care (health ministry of the Archdiocese of New York), Birch Family Services, Inc., Broad Channel Volunteer Fire Department and Ambulance Corps, Brookdale Hospital Medical Care, CARES, Inc., Central Family Life Center, Inc., Cerebral Palsy Association of NYS, Continuum Health Partners, Guild for Exceptional Children, Hamaspik of Kings County, Hebrew Academy for Special Children, Intrepid Museum, Jamaica Hospital Medical Center, Jewish Community Council of Greater Coney Island, Inc, Jewish Institute

of Queens, Lutheran Medical Center, Mercy Home for Children, National Society Hebrew Day Schools, New York Hospital Queens, New York Presbyterian Hospital, NY eHealth Collaborative, NY Sandy Hook Pilots, Ohel Children's Home and Family Services, Providence Rest, Queens Borough Public Library, Regional Catastrophic Planning Grant Team, Rogosin Institute, Services for the Underserved, St John's University, Unique People Services, Womens League, Wyckoff Heights Medical Center, and YAI Network. For more information on these organizations please see Appendix A. All meeting invitees were notified when the draft HMP was available for review online.

**v. Public Review**

To engage the public in the planning and development of the HMP, the Planning Team posted the draft of the plan on the OEM website for a 31-day comment period beginning December 16, 2013 and concluding January 16, 2014. The website provided an online comment form for people to provide feedback.

Hard copies of the draft HMP were also available for on-site viewing at the five DCP Borough Offices. The addresses are listed below:

**Table 2.1: Draft HMP Hard Copy Locations**

| Borough Office | Address   |
|----------------|---|
| Bronx          | One Fordham Plaza, 5 <sup>th</sup> Fl. Bronx, NY 10458-5891       |
| Brooklyn       | 16 Court Street, 7 <sup>th</sup> Fl. Brooklyn, NY 11241-01203     |
| Manhattan      | 22 Reade Street 6 <sup>th</sup> Fl. West New York, NY 10007-1216  |
| Queens         | 120-55 Queens Blvd., Kew Gardens, NY 11424                        |
| Staten Island  | 130 Stuyvesant Place, 6 <sup>th</sup> Fl. Staten Island, NY 10301 |

To publicize the plan and elicit feedback, OEM sent email notifications to New York City's CERT teams, Citizen Corps Council, Partners in Preparedness members, OEM Special Needs Advanced Warning System contacts, FEMA Long-term Recovery groups, MPC members, vol-

unteer organizations, neighboring jurisdictions (Nassau, Suffolk, and Westchester counties and New Jersey), regional partners, elected officials, borough presidents' offices, community board offices, professional organizations, academics, and non-profit organizations.

The Planning Team also coordinated with the New York City Citizens Corps Council, the OEM Public Private Initiatives unit, and the OEM Sandy Special Needs Recovery Task Force to help publicize the plan and solicit feedback. The Citizen Corps and Partners in Preparedness newsletters made note of the HMP to solicit comments. Planning Team members also made announcements of the HMP public review period to the Sandy Special Needs Recovery Task Force during a weekly conference call and the Special Needs Advisory Group (SNAG) at a quarterly meeting (see Appendix A).

Although there were several on-site visitors and readers, DCP borough offices did not receive any comments. However, there were 25 total comments received via email or the on-line comment form. These comments focused on adding additional mitigation actions and refining the hazard profiles. The Planning Team documented and reviewed comments received during the official comment period for inclusion in the 2014 HMP. Comments received after the 31-day period will be reviewed and considered for inclusion to the upcoming abridged version of the HMP.

### 3. Development of the HMP

The HMP has two major sections, Risk Assessment and Mitigation Strategy. These sections were developed through the process described here.

#### A. Review and Incorporation of Existing Plans and Studies

The Planning Team members reviewed various plans, studies, and guides to begin developing the HMP. These plans included New York City's 2009 HMP along with comparable plans from surrounding jurisdictions and other cities; FEMA guidance documents; emergency-services documents; contingency plans; climate change studies; community plans; and federal, local, and state regulations and ordinances (see Table 2.2).

#### B. Development of the Risk Assessment Chapter of the HMP

To develop the Risk Assessment chapter of the plan, the Planning Team followed these steps:

##### i. Identifying Hazards

To determine which natural hazards to profile in the HMP update, the Planning Team reviewed the hazards profiled in the draft *2014 New York State Standard Multi-Hazard Mitigation Plan* (NYS HMP). In addition, the Planning Team researched numerous natural hazard resources to determine the hazards that have the potential to occur in New York City.

To gain a better understanding of the non-natural hazards that may pose a threat to the city, the Planning Team reviewed existing plans from other regional jurisdictions. In addition, the Planning Team consulted the New York City Urban Area Working Group's *Threat and Hazard Identification and Risk Assessment* (THIRA) report and reviewed historic activations of the OEM Emergency Operations Center (EOC).

The Planning Team then distributed a hazard selection worksheet to MPCSC members to determine which hazards may affect their facilities or operations. The Planning Team eliminated some hazards addressed in the draft 2014 NYS HMP because they were either outside the scope of the plan or do not impact New

York City. The final list of natural and non-natural hazards chosen to be included in the New York City HMP is: coastal erosion; coastal storms; disease outbreaks; drought; earthquakes; extreme temperatures; flooding; severe weather; wildfires; winter storms; chemical, biological, radiological, and nuclear releases (CBRN); cyber threats; and infrastructure failures.

##### ii. Profiling Hazards

In the report, the hazard profiles are divided into two main components: hazard description and vulnerability assessment. The hazard description provides a general description of the hazard as well as an analysis of severity, probability of occurrence, location, and historic occurrences. The vulnerability assessment examines how the hazard impacts the social, built, natural, and future environments. For most of the hazards, climate change will play a significant role in determining future vulnerability.

To ensure the Risk Assessment section contains the most accurate information, the Planning Team reviewed local and state hazard mitigation plans and natural and non-natural hazard-related publications, and consulted with hazard-specific experts.

##### iii. Estimating Potential Losses

The Risk Assessment section includes potential loss estimates for New York City for each hazard. HAZUS-MH, a nationally applicable standardized methodology and software program, generated potential loss estimates for earthquakes, coastal storms, and floods. OEM GIS specialists and the Planning Team employed a variety of methods to generate loss estimates for the remaining hazards, such as estimating exposure, identifying vulnerable populations, determining frequency of past occurrences, and mapping infrastructure. The Risk Assessment section details the methodology and potential loss estimates for the hazards.

#### C. Development of the Mitigation Strategy Section of the HMP

Developing the Mitigation Strategy section of the HMP involved the following steps:

**Table 2.2: Plans and Studies Consulted in the Development of the HMP**

| Plans/Studies/Guides   | Author  |
|--|---|
| <i>VISION 2020: New York City Comprehensive Waterfront Plan</i>  | DCP   |
| <i>Urban Waterfront Adaptive Strategies</i>  | DCP   |
| <i>Designing for Flood Risk</i>  | DCP   |
| <i>New York City Zoning Resolution</i>   | DCP   |
| <i>Planning Population: Projecting the Future</i>  | DCP   |
| <i>History of New York City's Water Supply System</i>  | DEP   |
| <i>NYC Green Infrastructure Plan</i>   | DEP   |
| <i>Drought Management Contingency Plan 2012</i>  | DEP   |
| <i>Downstream Flooding Reduction Program</i>   | DEP   |
| <i>Reservoir Release Notification Plan</i>   | DEP   |
| <i>New York City Construction Code</i>   | DOB   |
| <i>Pandemic Influenza: Preparedness and Response Plan</i>  | DOHMH   |
| <i>Vital Signs: Deaths Associated with Heat Waves in 2006</i>  | DOHMH   |
| <i>FEMA's How-to-Guide(Series 386-1, 2, 3, 4 and 5)</i>  | FEMA  |
| <i>Hazard Mitigation Planning</i>  | FEMA  |
| <i>Integrating Manmade Hazards Into Mitigation Planning 2003</i>   | FEMA  |
| <i>Local Mitigation Handbook</i>   | FEMA  |
| <i>National Flood Insurance Program</i>  | FEMA  |
| <i>NFIP Community Rating System</i>  | FEMA  |
| <i>Local Mitigation Planning Handbook</i>  | FEMA  |
| <i>Post-Sandy Housing Reconstruction Analysis</i>  | FEMA/HRO  |
| <i>NYC Build it Back</i>   | HRO   |
| <i>Nassau County Hazard Mitigation Plan</i>  | Nassau County OEM   |
| <i>State of New Jersey 2011 Hazard Mitigation Plan</i>   | New Jersey OEM  |
| <i>Waterfront Action Agenda (WAVES)</i>  | NYC EDC   |
| <i>Flood Mitigation Taskforce Stormwater Mitigation Study Area Report</i>  | New York City Mayor's Office  |
| <i>Hurricane Sandy After Action: Report and Recommendations to Mayor Michael R. Bloomberg</i>  | New York City Mayor's Office  |
| <i>2014 New York State Multi-Hazard Mitigation Plan (Draft)</i>  | NYS OEM   |
| <i>New York City Urban Area: Materials and Background Information for the Threat and Hazard Identification and Risk Assessment (THIRA)</i> | NYC Urban Area Working Group: NYC, Westchester, Nassau, Suffolk, Port Authority, MTA, Yonkers |
| <i>New York State Coastal Erosion Act</i>  | NYSDEC  |

| Plans/Studies/Guides  | Author   |
|---|--|
| <i>New York State Coastal Erosion Map</i>   | NYSDEC   |
| <i>Citywide Interagency Management System (CIMS) Protocol</i>                                   | OEM  |
| <i>Coastal Storm Plan</i>   | OEM  |
| <i>Flash Flood Plan</i>   | OEM  |
| <i>Heat Emergency Plan</i>  | OEM  |
| <i>H1N1 Playbook</i>  | OEM  |
| <i>Power Disruption</i>   | OEM  |
| <i>Radiological Response and Recovery Plan (RRRP)</i>   | OEM  |
| <i>Winter Weather Emergency Plan (WWEP)</i>   | OEM  |
| <i>Cyber Incident Response Protocol</i>   | OEM  |
| <i>PlaNYC: A Greener, Greater New York</i>  | OLTPS  |
| <i>A Stronger, More Resilient New York</i>  | Special Initiative for Rebuilding and Resiliency |
| <i>Parks Department Parkland Plan</i>   | DPR  |
| <i>Local Waterfront Revitalization Plans - Consistency Review</i>                               | DPR  |
| <i>Commonwealth of Pennsylvania 2010 Standard All-Hazard Mitigation Plan</i>                    | Pennsylvania                                     |
| <i>Sandy Regional Assembly Recovery Agenda</i>  | Sandy Regional Assembly                          |
| <i>Suffolk County Multi-Jurisdictional Multi-Hazard Mitigation Plan October 2008</i>            | Suffolk County, NY                               |
| <i>Flooding and Land Use Planning: A Guidance Document for Municipal Officials and Planners</i> | Westchester County Department of Planning        |
| <i>Westchester County Comprehensive Emergency Management Plan</i>                               | Westchester County, NY                           |
| <i>Threat and Hazard Identification and Risk Assessment Guide 2012</i>                          | US DHS   |

### i. Establishing Goals and Objectives

Using information gleaned from the draft 2014 NYS HMP, hazard profiles, and community meetings, the Planning Team drafted a set of goals (see Figure 2.8) and objectives that represent New York City's long-term vision for reducing the impact of natural and non-natural hazards on the built environment and the city's population. The Planning Team distributed the draft goals and objectives to the MPCSC for review and comments. Mitigation goals were also presented at community involvement meetings. Based on feedback, the Planning Team produced a final set of five goals and 28 objectives (see Mitigation Strategy chapter).

**Figure 2.8: Hazard Mitigation Goals**



### ii. Identifying Preliminary Mitigation Actions

The MPC was the designated entity for identifying preliminary mitigation actions. At its kickoff meeting, Commissioner Joseph Bruno (OEM) and Commissioner Amanda Burden (DCP) made opening remarks concerning the importance of mitigation planning and OEM and DCP's collaboration in the report. Marc Ricks, Senior Advisor to the Mayor, described the findings and recommendations from *A Stronger, More Resilient New York*, which provide underpinnings for the HMP. Heather Roiter Damiano (OEM) presented on the components of the HMP and the expectations for MPC members, and Thaddeus Pawlowski (DCP) presented on the upcoming *Flood Resiliency Design Manual* and DCP's role in the HMP update. At the conclusion of the meeting, MPC members were given mitigation action worksheets to take back to their agencies to identify current and potential projects that aim to reduce the

impact of natural and non-natural hazards.

### Mitigation Action Worksheets

MPC members were asked to use the following criteria to identify mitigation actions for the mitigation action worksheets: mitigates against one or more of the 13 natural or non-natural hazards profiled in the HMP and falls under one of the six FEMA mitigation categories (prevention, property protection, public education and awareness, coastal/natural resource protection, emergency services, and infrastructure projects), and achieves one or more of the five hazard mitigation goals and 28 objectives. For each mitigation action, agencies identified: the lead agency; "existing"

or "potential" projects (existing projects are those with funding in place and ongoing strategies, whereas potential actions are projects agencies would like to implement and for which they are seeking funding); relevant hazard(s); project type; and project description. Agencies were also asked to use the mitigation action worksheets to report on the status of actions that were the result of the 2009 HMP.

### Agency One-on-One Meetings

After receiving the completed mitigation actions worksheets from the MPC agencies, the Planning Team cross-referenced the actions with ongoing city resiliency initiatives. These initiatives included *A Stronger, More Resilient New York* recommendations and Hazard Mitigation Grant Program (HMGP) applications. The Planning Team then scheduled meetings with each agency to review actions and recommend including any additional actions identified in the city's ongoing

resiliency initiatives.

These meetings were a valuable opportunity for each agency to ask specific questions and gain a better understanding of how their operations relate to hazard mitigation. The Planning Team also gained a better understanding of the mitigation actions proposed by the agencies. During each meeting, the participants determined what, if any, modifications were necessary to the text and/or content of the worksheet and if there were additional mitigation actions the agency could undertake in the future. Agencies were then tasked with re-submitting mitigation actions to include support agencies, timeline, project costs, funding, and action status (for actions from the 2009 HMP). In total, the Planning Team conducted 32 agency one-on-one meetings.

Following the meetings, agencies reviewed their submissions, made appropriate corrections and additions, and resubmitted a revised list of mitigation actions for incorporation into the HMP.

### **iii. Finalizing Mitigation Actions**

Upon receiving the revised mitigation action worksheets from the MPC agencies, the Planning Team compiled a list of 330 existing mitigation actions and 332 potential actions based on consistency with mitigation funding guidelines and relevancy to natural and non-natural hazard mitigation.

### **iv. Evaluating Mitigation Actions**

The Planning Team and MPCSC performed a qualitative analysis of the potential 332 mitigation actions. The Planning Team and MPCSC used FEMA's Social, Technical, Administrative, Political, Legal, Economic, and Environmental (STAPLEE) analysis to understand the opportunities and constraints for implementing the potential mitigation actions (see the Chapter 4: Mitigation Strategy for the full results of the STAPLEE analysis).

### **v. Prioritizing Mitigation Actions**

In accordance with FEMA requirements, the Planning Team prioritized mitigation actions to maximize benefits with consideration for potential costs. The Plan-

ning Team devised a prioritization methodology using the seven STAPLEE criteria as well as the number of objectives each action addressed, project cost, and project timeframe. Based on these criteria, the potential mitigation actions received a numerical ranking that translated to a high, medium, or low priority (see the Mitigation Strategy chapter for a detailed explanation of the prioritization process). These rankings are dynamic and can change because of funding availability, revisions to the mitigation actions, or changing city conditions. OEM's Hazard Mitigation Unit (HMU) will work closely with New York State Division of Homeland Security and Emergency Services (NYS DHSES) and FEMA to secure funding for mitigation actions that are in accordance with the goals and objectives of this plan.



**4. Plan Development Meetings**

Hurricane Sandy's arrival on October 29, 2012 created both constraints and benefits for the development of the HMP. Due to the storm's impact on the city, the planning process for updating the HMP was delayed for several months. However, the storm also initiated a dialogue among agencies, utility providers, and non-profit organizations about strategies to mitigate the impact of hazards on the city's built environment.

The Planning Team initiated the development of the 2014 New York City HMP in January 2013 and concluded the process in December 2013. During this period, the Planning Team coordinated and participated in 86 plan development meetings with agencies, the academic community, non-profit organizations, the private sector, volunteer organizations, and regional partners (see Appendix A). The Planning Team held bi-weekly meetings and met numerous times throughout the planning process on specific issues. In addition, the Planning Team and MPC members worked on many Sandy-related resiliency and recovery initiatives throughout this plan development process.

Website Links:

FEMA Local Mitigation Plan Review Guide:

[http://www.fema.gov/media-library-data/20130726-1809-25045-7498/plan\\_review\\_guide\\_final\\_9\\_30\\_11.pdf](http://www.fema.gov/media-library-data/20130726-1809-25045-7498/plan_review_guide_final_9_30_11.pdf)

NYS DHSES Hazard Mitigation Standards:

<http://www.dhSES.ny.gov/oem/mitigation/documents/hazard-mit-plan-standards2012.pdf>

Private Sector and Professional Organizations Meeting Webinar:

[https://oemnyc.adobeconnect.com/\\_a1089546215/p3buqqokaa5/?launcher=false&fcsContent=true&pbMode=normal](https://oemnyc.adobeconnect.com/_a1089546215/p3buqqokaa5/?launcher=false&fcsContent=true&pbMode=normal)

# CHAPTER 3: RISK ASSESSMENT



Coastal Erosion



Drought



Flooding



Winter Storms



Coastal Storms



Earthquakes



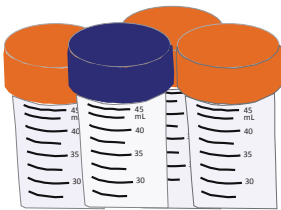
Severe Weather



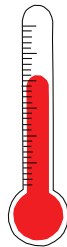
Chemical, biological,  
radiological, and nuclear



Infrastructure Failures



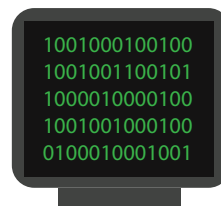
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Wild Fires



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#### B. FEMA and NYS OEM Requirements Addressed in this Chapter

New York City's Mitigation Strategy was developed consistent with the process and steps presented in the FEMA [Local Mitigation Plan Review Guide](#) (2011) (website link provided at the end of chapter 2). This chapter's presentation of the Risk Assessment satisfies the following FEMA requirements:

- **FEMA Requirement 44 CFR §201.6(c)(2)(i):** [The risk assessment *shall* include a] description of the type, location and extent of all natural hazards that can affect the jurisdiction. The plan shall include information on previous occurrences of hazard events and on the probability of future hazard events.
- **FEMA Requirement 44 CFR §201.6(c)(2)(ii):** [The risk assessment *shall* include a] description of the jurisdiction's vulnerability to the hazards described in paragraph (c)(2)(i) of this section. This description shall include an overall summary of each hazard and its impact on the community. All plans approved after October 1, 2008 must also address NFIP insured structures that have been repetitively damaged by floods. The plan should describe vulnerability in terms of:
  - **FEMA Requirement 44 CFR §201.6(c)(2)(ii)(A):** The types and numbers of existing and future buildings, infrastructure, and critical facilities located in the identified hazard areas.
  - **FEMA Requirement 44 CFR §201.6(c)(2)(ii)(B):** An estimate of the potential dollar losses to vulnerable structures identified in ... this section and a description of the methodology used to prepare the estimate.
  - **FEMA Requirement 44 CFR §201.6(c)(2)(ii)(C):** Providing a general description of land uses and development trends within the community so that mitigation options can be considered in future land use decisions.

The following DHSES [Hazard Mitigation Planning Standards](#) (2012) (website link provided at the end of chapter 2) are also addressed in this chapter:

- **NYS Requirement §F2:** Plans developed with State OEM-administered funds *must* document that proposed (or already implemented) projects will protect facilities to a 500-year flood event or the actual worst-damage scenario, whichever is greater.
- **NYS Requirement §F6:** Plans developed with State OEM-administered funds *must* include climate change information within their discussion of these hazards and *must* contain strategies and projects to address them.



2. Hazard Identification

The first step in the risk assessment process is to identify hazards to include in the plan. To initiate this determination, the Planning Team, with input from the Mitigation Planning Council Steering Committee (MPCSC), identified an initial list of hazards that could potentially impact the city and then selected the hazards of greatest concern for further research and analysis.

A. Potential Hazards

Since New York is such a large and dynamic city, it faces a broad spectrum of hazards, many of which are also caused or exacerbated by human activities. During the hazard identification process for the 2014 Natural Hazard Mitigation Plan (HMP), the Planning Team considered the full range of natural hazards identified

in the 2011 New York State Multi-Hazard Mitigation Plan and made a few minor alterations, which included wording and organization, to produce a comprehensive natural hazard list. For this 2014 plan update, the Planning Team decided to expand upon this list, adding "non-natural" hazards to the required natural hazards.

To identify a preliminary list of non-natural hazards, as well as develop and refine its working list of natural hazards, the Planning Team reviewed existing plans from other local, regional, and national jurisdictions. The Planning Team also reviewed historic activations of the OEM Emergency Operations Center (EOC). Table 3.2.1 lists the full range of natural hazards that the Planning Team considered for inclusion in the HMP, and Table 3.2.2 lists the full range of non-natural hazards.

Table 3.2.1: Natural Hazards Considered for Inclusion in the 2014 HMP

| Hazard               | Description  |
|----------------------|--|
| Coastal erosion      | Loss or displacement of land along the coastline due to the action of wind, waves, currents, tides, runoff of surface waters, or groundwater seepage   |
| Coastal storms       | Includes tropical cyclones (tropical storms and hurricanes) and nor'easters  |
| Dam failure          | An uncontrolled release of impounded water resulting in downstream flooding  |
| Disease outbreaks    | When disease cases exceed what would normally be expected in a defined community, geographic area, or season   |
| Drought              | A prolonged period with below-average precipitation  |
| Earthquake           | A sudden, rapid shaking of the earth caused by the breaking and shifting of rock beneath the earth's surface   |
| Extreme temperatures | <i>Extreme Heat:</i> Summertime temperatures that are well above average, usually combined with high levels of humidity. A heat wave is defined as three or more days with temperatures at or above 90°F.<br><br><i>Extreme Cold:</i> Wintertime temperatures that drop well below normal in an area |
| Floods               | A general and temporary condition of partial or complete inundation on normally dry land   |
| Hailstorms           | Shower-like precipitation in the form of irregularly shaped ice pellets falling from a thunderstorm  |
| Landslides           | The downward and outward movement of slope-forming materials reacting to the force of gravity  |
| Land subsidence      | Depressions, cracks, and sinkholes in the earth's surface, which can threaten people and property  |

## 2. HAZARD IDENTIFICATION

### CHAPTER 3: RISK ASSESSMENT

| Hazard               | Description  |
|----------------------|--|
| Tornadoes/windstorms | <p><i>Tornadoes:</i> Local atmospheric storms, generally of short duration, formed by winds rotating at very high speeds, usually in a counterclockwise direction, with vortices visible to the observer as whirlpool-like columns of winds rotating about a hollow cavity or funnel.</p> <p><i>Windstorms:</i> Non-rotating, straight-line winds that can knock down trees and power lines and cause damage to structures</p> |
| Wildfires            | Uncontrolled burning in grasslands, brush, or woodlands that can eventually spread to the built environment  |
| Winter storms        | Ice storms, heavy snow, and blizzards, often accompanied by extreme cold. Heavy snow generally means snowfall accumulating to 6 inches or more in 12 hours or less, or snowfall accumulating to 8 inches or more in 24 hours or less. A blizzard has winds of 35 miles per hour or more with snow and blowing snow, reducing visibility to less than 1/4 mile for at least three hours   |

**Table 3.2.2: Non-natural Hazards Considered for Inclusion in the 2014 HMP**

| Hazard   | Description   |
|--|---|
| Air contamination  | Poor air quality resulting from a high concentration of primarily industrial pollutants (including particulate matter and ozone) near the ground          |
| Aviation incidents   | Accidents involving aircraft departing from or arriving at Kennedy or LaGuardia Airports that cause or have the potential to cause injury or loss of life |
| Building collapses/fires/explosions  | Damage to or destruction of a building resulting from collapse, fire, or explosion  |
| Civil unrest   | A public crisis that occurs without warning and may adversely impact a significant portion of the population  |
| Cyber threats  | An adverse event in an information system or network in which the digital infrastructure of a person or organization is compromised                       |
| Release of chemical, biological, radiological, or nuclear materials (CBRN) | A situation in which hazardous materials are released into the environment, causing a threat to human health and safety                                   |
| Infrastructure failure   | Failure of infrastructure systems—including transportation, water, and wastewater—to perform their intended functions.                                    |
| Utility disruptions  | Disruptions to essential utilities, including energy (electric, gas and steam) and communications.  |

## 2. HAZARD IDENTIFICATION

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#### B. Hazard Selection Process

##### i. Existing Plans and Procedures

When considering which hazards to include in the HMP, the Planning Team identified the City's existing emergency plans and procedures that address both natural and non-natural hazards. OEM and other City agencies have plans and procedures in place for many natural hazards, including coastal storms, drought, extreme temperatures, floods, tornadoes/windstorms, and winter storms. The Planning Team also drew from [A Stronger, More Resilient New York](#) (website link provided at the end of section 4), New York City's comprehensive plan with actionable recommendations for rebuilding the communities impacted by Sandy and increasing the resiliency of buildings and infrastructure citywide.

New York City also has plans in place for non-natural hazards, including various types of hazardous materi-

als releases (chemical, biological, and radiological) and power disruptions. In addition, OEM is currently drafting an emergency plan for cyber threats. It was evident that all of these hazards can significantly affect New York City and should be included in the HMP.

##### ii. Hazard Selection Worksheet

The MPCSC supported the hazard identification process by completing a hazard selection worksheet. The hazard selection worksheet asked MPCSC members to indicate which hazards would affect their agencies' operations, policies, and/or physical infrastructure. Agencies were asked to indicate "Yes" if they felt strongly that the hazard posed a significant threat and "No" if they felt strongly that the hazard did not pose a significant threat. If they did not feel strongly one way or the other, they left the field blank. Since the Planning Team was involved in the initial hazard selection, OEM, DCP, and OLTPS did not fill out hazard selection worksheets.

**Table 3.2.3: New York City Hazard Selection Worksheet Results**

| Hazard                   | DEP | DOT | FDNY | MTA | DOHMH | DPR | RPA | DOB | NYPD | Total Yes | Total No |
|--------------------------|-----|-----|------|-----|-------|-----|-----|-----|------|-----------|----------|
| Coastal erosion          | Yes | Yes | Yes  | Yes |       | Yes | Yes | Yes | Yes  | 8         | 0        |
| Coastal storms           | Yes | Yes | Yes  | Yes | Yes   | Yes | Yes | Yes | Yes  | 9         | 0        |
| Dam failure              | No  | No  |      |     |       |     |     | No  | No   | 0         | 4        |
| Drought                  | Yes | No  | Yes  | Yes |       | Yes | Yes | Yes | Yes  | 7         | 1        |
| Earthquakes              | Yes | Yes | Yes  | Yes |       | Yes | Yes | Yes | Yes  | 8         | 0        |
| Extreme temperatures     | Yes | Yes | Yes  | Yes | Yes   | Yes | Yes | Yes | Yes  | 9         | 0        |
| Floods                   | Yes | Yes | Yes  | Yes | Yes   | Yes | Yes | Yes | Yes  | 9         | 0        |
| Hailstorms               | No  | No  | Yes  |     |       |     | Yes | No  | No   | 2         | 4        |
| Landslides               | No  | Yes | No   |     |       |     |     | Yes | Yes  | 3         | 2        |
| Tornadoes and windstorms | Yes | Yes | Yes  | Yes | Yes   | Yes |     | Yes | Yes  | 8         | 0        |
| Land subsidence          | Yes | Yes | No   |     |       |     |     | Yes | No   | 3         | 2        |
| Wildfires                | Yes | No  | Yes  |     |       | Yes |     | No  | Yes  | 4         | 2        |
| Winter storms            | Yes | Yes | Yes  | Yes | Yes   | Yes | Yes | Yes | Yes  | 9         | 0        |
| Air contamination        | Yes | No  | Yes  |     | Yes   |     | Yes |     |      | 4         | 1        |

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| Hazard                                  | DEP | DOT | FDNY | MTA | DOHMH | DPR | RPA | DOB | NYPD | Total Yes | Total No |
|---|-----|-----|------|-----|-------|-----|-----|-----|------|-----------|----------|
| Aviation incident                       | No  | Yes | Yes  |     |       |     |     | No  | Yes  | 3         | 2        |
| Building collapses/<br>fires/explosions | Yes | Yes | Yes  | Yes |       |     | Yes | Yes | Yes  | 7         | 0        |
| Civil unrest                            | No  | Yes | Yes  |     |       |     |     | Yes | Yes  | 4         | 1        |
| Cyber threats                           | No  | No  | Yes  | Yes |       |     | Yes |     |      | 3         | 2        |
| Disease outbreaks                       | Yes | Yes | Yes  | Yes | Yes   | Yes | Yes |     | Yes  | 8         | 0        |
| Hazardous materials<br>release (CBRN)   | Yes | No  | Yes  | Yes |       |     | Yes | Yes |      | 5         | 1        |
| Utility disruption                      | Yes | Yes | Yes  |     | Yes   | Yes | Yes | Yes | Yes  | 8         | 0        |
| Infrastructure failure*                 | -   | -   | -    | -   | -     | -   | -   | -   | -    | -         | -        |

Notes: \*This hazard was added after the worksheet was distributed to the MPCSC

Table 3.2.3 summarizes the tally from the worksheets. A majority of Steering Committee members checked "Yes" for the following hazards: coastal erosion, coastal storms, drought, earthquakes, extreme temperatures, floods, tornadoes/windstorms, winter storms, disease outbreaks, building collapses/fires/explosions, CBRN, and utility disruptions. Other hazards listed required additional research to determine whether they should be included in the HMP. The Planning Team collected and analyzed additional data on dam failure, hailstorms, landslides, subsidence, wildfires, air contamination, aviation incidents, civil unrest, and cyber threats from newspapers, City records, the National Oceanic and Atmospheric Administration (NOAA), the National Weather Service (NWS), and FEMA databases.

After further consideration, the Planning Team decided to include wildfires and cyber threats in the final list. In addition, several new categories were created to consolidate multiple hazards from the original list; severe weather (incorporates hail and tornadoes/windstorms) and infrastructure failures (incorporates utility disruptions and damage to other types of infrastructure). Air contamination was incorporated into the extreme temperatures and CBRN hazards.

### C. Eliminated Hazards

For this plan, the Planning Team chose to address only the most prevalent hazards affecting New York City and hazards for which sufficient data was available to develop a full profile. After conducting additional research, the Planning Team completely eliminated from the HMP process dam failure, landslides, land subsidence, aviation incidents, and civil unrest. Although building collapses/fires/explosions received a majority vote, these types of events are generally caused by other types of hazards (both natural and non-natural) that serve as a trigger event. After drafting a profile for this hazard, the Planning Team decided to incorporate this information into other hazard profiles.

### D. Final List of New York City Hazards

Based on recommendations from the MPCSC and additional research conducted by the Planning Team, the Planning Team decided to retain 10 natural hazards and three non-natural hazards for analysis in the HMP. They are as follows:

Natural hazards:

- (1) *Coastal erosion*
- (2) *Coastal storms*
- (3) *Disease outbreaks*

## 2. HAZARD IDENTIFICATION

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- (4) *Drought*
- (5) *Earthquakes*
- (6) *Extreme temperatures*
- (7) *Flooding*
- (8) *Severe weather*
- (9) *Wildfires*
- (10) *Winter storms*

Non-natural hazards:

- (1) *CBRN*
- (2) *Cyber threats*
- (3) *Infrastructure failures*

Since this plan was written shortly following Hurricane Sandy, the worst natural disaster in New York City's history, the Planning Team decided to include a retrospective analysis of this particular storm and what the City learned from it. The Sandy section is separate from the coastal storms profile.

3. Hazard Risk Assessment Organization

The risk assessments for each hazard are divided into two primary components (see Figure 3.3.2). The first component, the Hazard Profile, is a description of the hazard and the city's physical risk. The second section, the Vulnerability Assessment, is an analysis of how susceptible the city's social environment (population), built environment, natural environment, and future environment are to each hazard. The one exception to this organizational structure is the section on Hurricane Sandy because it is a description of a historic event rather than an assessment of risk from a potential hazard.

A. Hazard Profile

The Hazard Profile is divided into five subsections, as follows:

- 1) **Hazard Description:** a general description of the natural or non-natural hazard that can affect New York City
- 2) **Severity:** the strength or magnitude of the hazard, how it is measured, and the range of impacts it can have
- 3) **Probability:** the likelihood of the hazard occurring in New York City
- 4) **Location:** the geographic areas within New York City that may be most significantly affected by the hazard
- 5) **Historic Occurrences:** previous events of this type in New York City

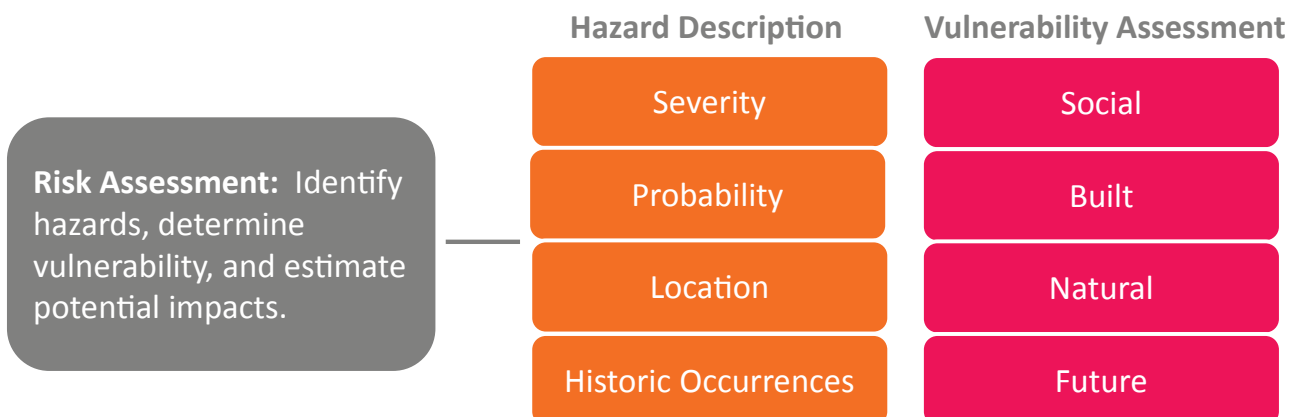
This organization structure is in accordance with the requirements from FEMA, and most hazards included in this report fit these categories at least fairly well. However, complete information was not always available for every category of every hazard profile (for example, probability is generally not quantifiable for coastal erosion and most non-natural hazards).

B. Vulnerability Assessment

This Vulnerability Assessment section is divided into four subsections, as follows:

- 1) **Social Environment:** the hazard's effect on the general public, including public health impacts and potential fatalities, with an emphasis on vulnerable and special needs populations
- 2) **Built Environment:** structural vulnerabilities of the city's building stock and infrastructure. For flooding, coastal storms, and earthquakes, this section also includes a quantitative calculation of loss estimates (see i. Vulnerability Assessment Methodology, below)
- 3) **Natural Environment:** the hazard's impact on the natural resources, ecosystems, and recreational areas
- 4) **Future Environment:** how trends such as climate change, population growth, aging infrastructure, and new technology may change the risk and/or impacts of hazards in the future

Figure 3.3.2: Risk Assessment Diagram



### 3. HAZARD RISK ASSESSMENT ORGANIZATION

#### CHAPTER 3: RISK ASSESSMENT

##### *i. Vulnerability Assessment Methodology*

To conduct the vulnerability assessment, address the requirements of the Disaster Mitigation Act of 2000, and better understand the potential vulnerability and losses associated with hazards of concern, New York City used standardized tools including the HAZUS-MH modeling software, combined with local, state, and federal data.

##### *HAZUS-MH Methodology*

Hazards U.S. Multi-Hazard (HAZUS-MH) is a nationally applicable standardized methodology and software program, developed by FEMA and under contract with the National Institute of Building Sciences. The program estimates potential losses from earthquakes, hurricane winds, and floods. In HAZUS-MH, current scientific and engineering knowledge is coupled with Geographic Information Systems (GIS) technology to produce estimates of hazard-related damage before or after a disaster occurs.

Potential loss estimates analyzed in HAZUS-MH include:

- **Physical damage** to residential and commercial buildings, schools, critical facilities, and infrastructure
- **Economic loss**, including lost jobs, business interruptions, and repair and reconstruction costs

HAZUS-MH is designed to generate estimates of hazard-related damage to a city or a region from a hypothetical "hazard event" (that is, an earthquake, hurricane, or flood) of a fixed severity and location, also known as a "deterministic" event. This type of analysis can also be used to estimate damages from a historic event. Another type of analysis models the damage caused by an event that is likely to occur over a given period of time (return period), also known as a "probabilistic" event." For example, HAZUS-MH can estimate the damage caused by an earthquake that is likely to occur once every 500 years (which has a 1 in 500 or 0.2% chance of occurring in any given year, see Table 3.3.4). For all HAZUS-MH models, the focus is on damage to buildings, quantified as a measure of build-

ing damage counts, damage states, and dollar losses. Buildings are assumed to have a lifespan of 50 years.

**Table 3.3.4: Return Periods with Annual Chance of Occurrence**

| Return period (years) | Chance of occurrence in any given year (%) |
|-----------------------|--|
| 10                    | 10   |
| 20                    | 5  |
| 30                    | 3.33                                       |
| 50                    | 2  |
| 100                   | 1  |
| 200                   | 0.5  |
| 250                   | 0.4  |
| 500                   | 0.2  |
| 1,000                 | 0.1  |
| 2,500                 | 0.04                                       |

In addition, HAZUS-MH provides an estimate of annualized economic building losses. These values are averages based on the total estimated losses over the entire simulation period divided by the total number of years in the simulation. For example, if a particular location is expected to suffer \$20 billion in damage from hurricanes over a 20-year period, the annualized economic losses would be \$1 billion. The formula for calculating annualized economic losses must take into account a wide range of possible scenarios and probabilities.

HAZUS-MH uses demographic and general building stock (GBS) data to estimate hazard-related damage. The GBS data input into HAZUS-MH is a summary of building counts, values, construction types, and uses by census block or tract. New York City supplemented this default data with a refined set of GBS data because an initial review found that for the city as a whole, the default GBS data provided with HAZUS-MH did not adequately reflect actual conditions. To refine the default GBS dataset, OEM provided an updated set of building data to Applied Research Associates, Inc. (ARA), a private consulting firm which is one of the developers of the HAZUS-MH software. This dataset consisted of Property Land Use Tax lot Output (MapPLUTO) from the Department of City Planning (DCP) and mass appraisal data from the Department of Finance (DOF). ARA converted this dataset to a format that was usable by HAZUS-MH, classifying all structures according to the building type and occupancy classes required

### 3. HAZARD RISK ASSESSMENT ORGANIZATION

#### CHAPTER 3: RISK ASSESSMENT

by the software. Additionally, for this update of the HMP, FEMA personnel assisted OEM by reformatting the revised GBS data for use with the latest version of HAZUS-MH (version 2.1). The resulting census block-based dataset provided a much more accurate starting point for subsequent analyses. Due to different methodologies and variations in data sets, total citywide building counts will differ from the numbers listed in Section 4: New York City's Hazard Environment, Table 3.4.18.

It is important to note that while the HAZUS-MH analyses provide a good starting point for loss and damage estimation, they are approximate predictions. There is uncertainty inherent in any predictive model, and HAZUS-MH is no exception. This software is not meant for site-specific damage analysis. Furthermore, since HAZUS is an asset damage model, it generally does not capture impacts to networks, such as utilities, telecommunications, transportation, and liquid fuel systems. The City has created models to better understand the interdependencies of these systems and has discovered that it is more effective and cost efficient to target investments toward key critical facilities. These upgrades will reduce the impact of extreme events and increase the recovery time.

Despite its limitations, the results of the HAZUS-MH analyses help shed light on the expected distribution and level of losses for different areas. Although building damage counts may not always reflect exact conditions on the ground, especially when analyzing small areas, percentages of buildings damaged and losses over the entire study area should provide a relatively accurate picture of the level of damage that might be expected to occur on a citywide scale.

#### *Methodology for Assessing Hazards Not Covered by HAZUS-MH*

Hazards included in this report that cannot be analyzed using HAZUS-MH are coastal erosion, drought, extreme temperatures, severe weather, wildfires, winter storms, CBRN, cyber threats, and infrastructure failures. Potential impacts on vulnerable populations and infrastructure were evaluated using the best available data to assess risks for these hazards and to help identify appropriate mitigation efforts.

While this risk assessment relies on the best available data and methodologies, uncertainties are inherent in any loss-estimation methodology. These uncertainties arise in part from incomplete scientific knowledge concerning hazards and their effects on the social, built, natural, or future environment. They can also result from the unique nature, geographic extent, and severity of each hazard. Therefore, potential exposure and loss estimates should be considered approximate.



## 4. NEW YORK CITY'S HAZARD ENVIRONMENT

### CHAPTER 3: RISK ASSESSMENT

#### 4. New York City's Hazard Environment

With more than 8.2 million residents, New York City is the most populous city in the United States. It is also one of the most densely populated places in the country with an area of just 305 square miles.

Ranking among the largest urban centers in the world, New York City has for more than a century been a global center for commerce, finance, politics, foreign affairs, media, and the arts. Many of the city's neighborhoods and landmarks are famous around the world. To support its population and maintain international prominence, New York City has developed interconnected networks of infrastructure and services.

However, these defining characteristics—density, international stature, and complex infrastructure—also increase the potential significance of hazards.

#### A. The Natural Environment

##### i. Geography

New York City is located in the southeastern part of New York State, at the confluence of the Hudson River and the Atlantic Ocean. Much of the city is built on three islands: Manhattan, Staten Island, and Long Island (part of the city occupies the western tip of Long Island). New York City not only abuts the Hudson River and the Atlantic Ocean, it also contains or borders numerous bays, rivers, and tidal straights including New York Harbor, Long Island Sound, the East River, Jamaica Bay, and the Harlem River. The city is comprised of five boroughs: the Bronx, Brooklyn, Manhattan, Queens, and Staten Island (see Figure 3.4.3), each of which is a county. If the boroughs were independent cities, four of them (the Bronx, Brooklyn, Manhattan, and Queens) would be among the 10 most populous cities in the United States.

Figure 3.4.3: The Five Boroughs of New York City



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#### ii. Current Climate

New York City has a humid, continental climate with cold winters and hot, moist summers. The temperature has ranged from  $-15^{\circ}\text{F}$  (on February 9, 1934) to  $106^{\circ}\text{F}$  (July 9, 1936), with an average annual temperature of  $55^{\circ}\text{F}$ , an average January temperature of  $33^{\circ}\text{F}$ , and an average July temperature of  $77^{\circ}\text{F}$ . The city's average annual precipitation, which is spread throughout the year, is 55 inches. Its average annual snowfall is 26.7 inches.

Much of New York City's weather moves in from the west off the interior continent due to the prevailing winds. This results in hotter summers and colder winters than coastal locations at similar latitudes where prevailing winds are off the water. In addition, the concentration of buildings and pavement in New York City

raises temperatures relative to surrounding areas due to a phenomenon known as the "urban heat island effect."

However, the ocean still has some influence over the city's climate. Wind coming off the ocean often moderates afternoon heat, though less so farther away from the immediate shoreline. In winter, the warmth of the ocean relative to the land keeps the central city slightly warmer than inland suburbs and delays winter snows; in spring, the ocean water, which drops in temperature over the winter, keeps air temperatures cooler longer into the season.

#### iii. Topography

Elevation generally ranges from less than 50 feet (for most of Manhattan, Brooklyn, and Queens) to nearly

Figure 3.4.4: New York City Topography, including the Highest Points for Each Borough



## 4. NEW YORK CITY'S HAZARD ENVIRONMENT

### CHAPTER 3: RISK ASSESSMENT

300 feet (in northern Manhattan and the Bronx). Figure 3.4.4, including the Highest Points for Each Borough shows New York City's topography and the highest point for each borough. The highest point in New York City is Todt Hill on Staten Island at 412 feet above sea level.

Human intervention and land reclamation along the waterfronts has altered the city's topography. Reclamation is most notable in Lower Manhattan, with developments such as Battery Park City built entirely on fill.

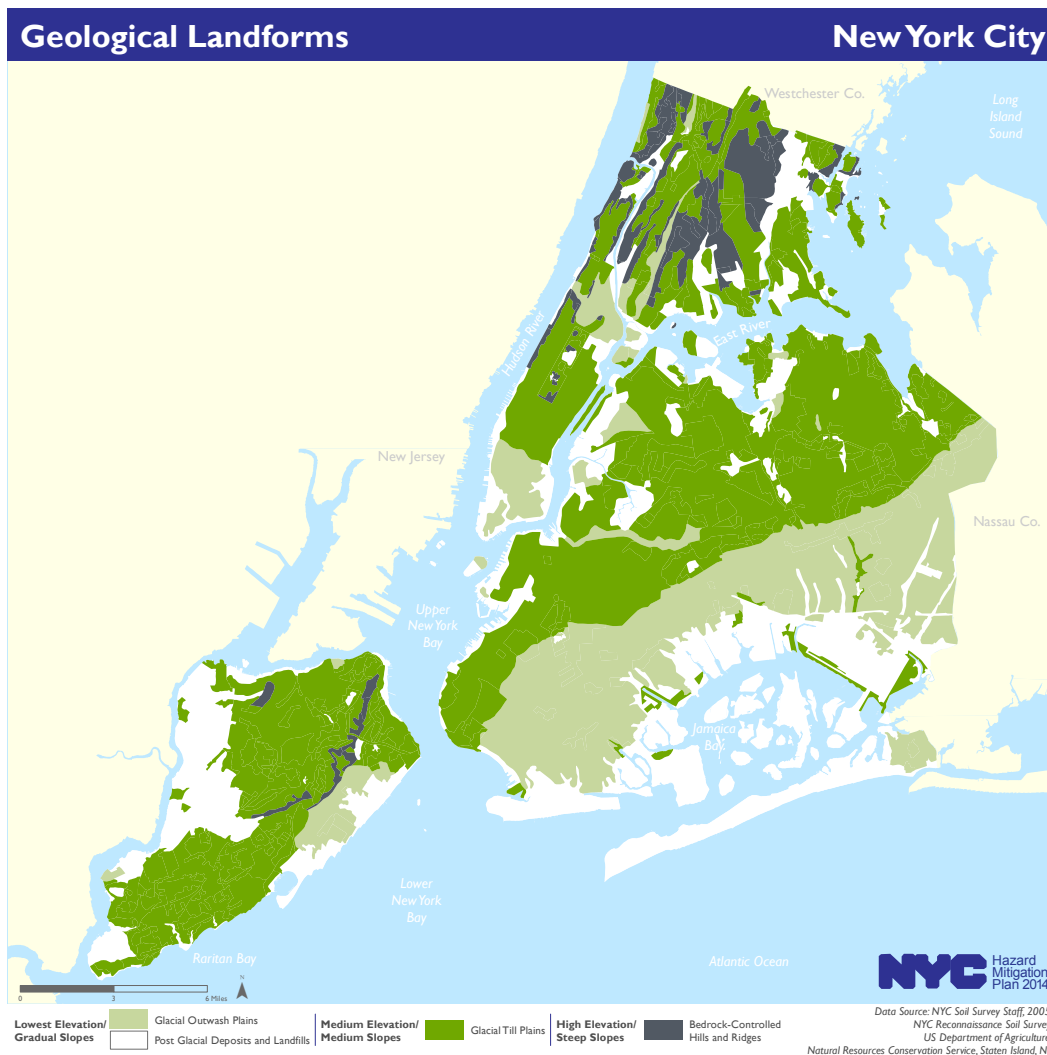
#### *iv. Geomorphology*

Geomorphology, the study of geographic features and landforms and the processes that shape them over time, is relevant to understanding New York City's

coastal hazard vulnerability. The land the city occupies was shaped to a large extent by the Wisconsin Ice Sheet, a giant glacier that stretched from Canada to what is now New York City. This glacier reached the New York City area about 20,500 years ago, grinding up rock as it traveled south and carrying chunks of gravel, pebbles, and sand with it. The glacier began its retreat about 18,000 years ago.

When the glacier began to melt, this rock debris was deposited at its southernmost end, forming the "terminal moraine," the hilly area of the city that stretches through Staten Island and central Brooklyn/Queens. Streams from the melting glacier carried deposits of sand, silt, and clay, which formed today's "outwash plains," the low-lying areas on Staten Island's East Shore and along southern Brooklyn and Queens (see

Figure 3.4.5 : Geological Landforms of New York City



## 4. NEW YORK CITY'S HAZARD ENVIRONMENT

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Figure 3.4.5). While other areas of the city are generally higher in elevation, due to the presence of bedrock closer to the earth's surface, these low-lying areas are generally more vulnerable to storm surge and gradual sea level rise.

#### *v. Barrier Islands*

A barrier island is a long offshore deposit of sand parallel to the coastline. Generally barrier islands are made up of beach, dunes, barrier flat, and salt marsh, separated from the mainland by a shallow sound, bay, or lagoon. Barrier islands act as a buffer against storms by absorbing the most severe impacts of waves and storm surges. Tidal inlets often separate a series of barriers and connect the bays with the ocean.

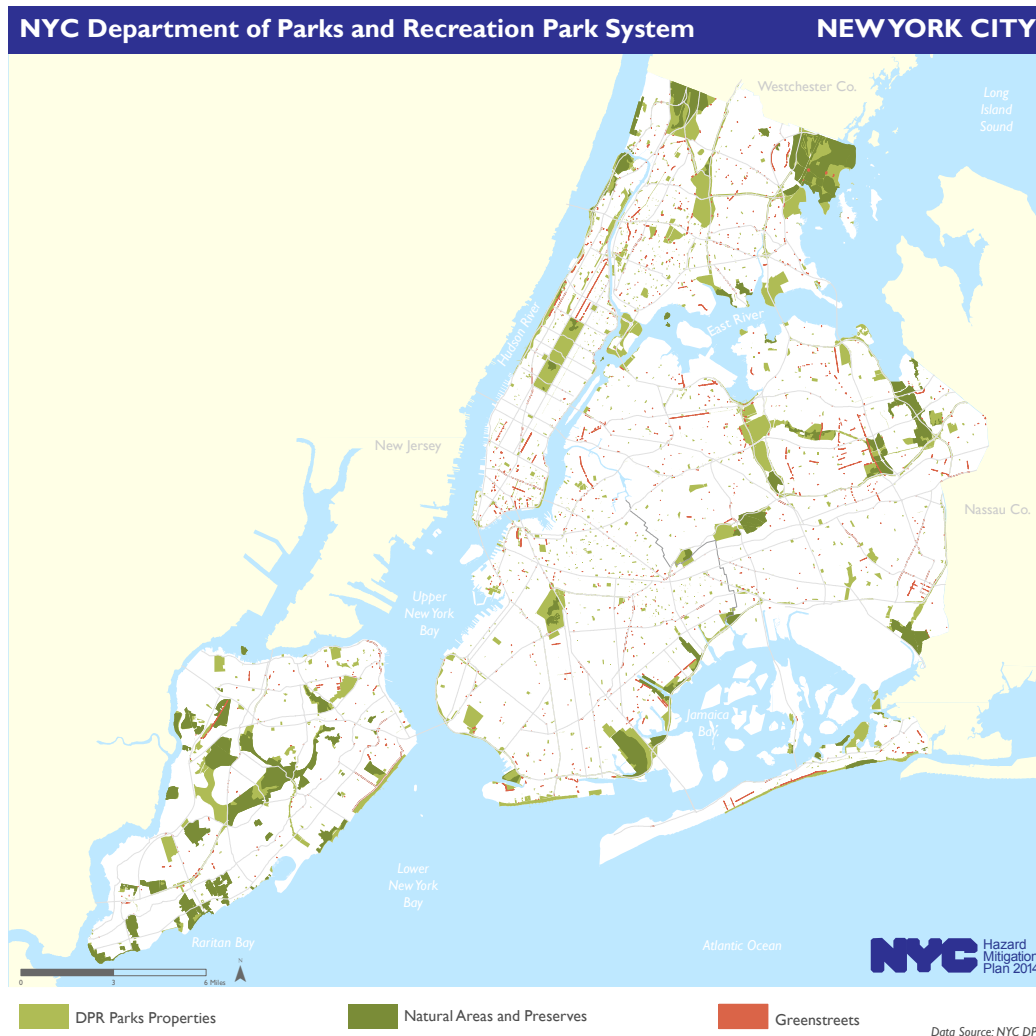
Long Island, which stretches over 100 miles and includes Brooklyn and Queens on its western shore, is

buffered by five barrier islands; including Coney Island in Brooklyn, and two spits including the Rockaway Peninsula in Queens. All of the inlets are artificially stabilized with structures and are dredged to allow for navigation by commercial and recreational boats.

#### *vi. Parks, Open Space, and Natural Areas*

New York City boasts some of the most magnificent public parks in the nation. From wild to manicured, shoreline to inland, large to small, these parks run the gamut. The city's parks include playgrounds, waterfront esplanades, wetlands, hiking trails, dog runs, boating and kayaking areas, athletic courts and fields, beaches and swimming pools, monuments and historic buildings. The system of parks and open spaces managed by the New York City Department of Parks & Recreation (DPR) spans over 29,000 acres, covering 14% of the city and encompassing 1,942 sites across all

**Figure 3.4.6: New York City Department of Parks & Recreation Park System**



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five boroughs (see Figure 3.4.6). Additionally, the city's wetlands, streams, forests, and other natural areas offer substantial sustainability and resiliency benefits, playing a critical role in managing runoff and reducing the impacts of extreme weather events.

The properties in the City's park system can be categorized according to four main types: beaches and waterfront parks, inland parks, natural areas and preserves, and tree infrastructure.

#### *a) 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% of its total land area and found along 150 miles—or almost 30%—of the city's total coastline. 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 a wide range of recreational amenities and opportunities. Especially in recent years, the city's waterfront parks have also spurred the development of residences and businesses along their peripheries. 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.

#### *b) Inland Parks*

New York City's 1,942 inland 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.

#### *c) Natural Areas and Preserves*

The city's 9,900 acres of natural areas—representing over a third of the acreage in DPR's system—include forests, grasslands, and wetlands. Natural areas offer public enjoyment and education along with passive recreation opportunities. They also provide many ecological benefits, including air quality improvements,

carbon sequestration, enhanced wildlife habitats, stormwater retention, shoreline protection, and native plant life preservation.

The city's wetlands (see Table 3.4.5), in particular, play an important role in protecting the quality of waterways by absorbing nutrients and filtering sediment and contaminants, helping to manage stormwater runoff, and buffering coastal areas from the impacts of flooding through wave attenuation.

There are two major wetland types in New York City: freshwater wetlands and tidal wetlands.

Freshwater wetlands play an important role in New York City's ecosystem by connecting the freshwater streams to tidal marshes for aquatic and other organisms. Freshwater wetlands and their floodplains also convey, detain, and store stormwater runoff. Today, however, there are few natural freshwater wetlands and streams remaining in New York City, with most now piped underground. For example, Tibbetts Brook in the Bronx is connected to the City's combined sewer infrastructure and flows directly into the local wastewater treatment plant. Tidal wetlands are the areas where the land meets the sea. These areas are periodically flooded by seawater during high or spring tides or, are affected by the cyclic changes in water levels caused by the tidal cycle. Salt marshes and mud flats are some typical types of tidal wetlands found along New York's marine shoreline. Tidal wetlands are classified by the amount of water covering the area at high and low tides and the type of vegetation.

Today wetlands are the focus of preservation, restoration, and enhancement projects. In particular, the city is investing in more monitoring and evaluation of wetlands to better manage climate change risks such as submergence from sea level rise.

New York City's largest remaining wetland complexes can be found in Jamaica Bay, on northwest Staten Island, and along the upper East River and western Long Island Sound.

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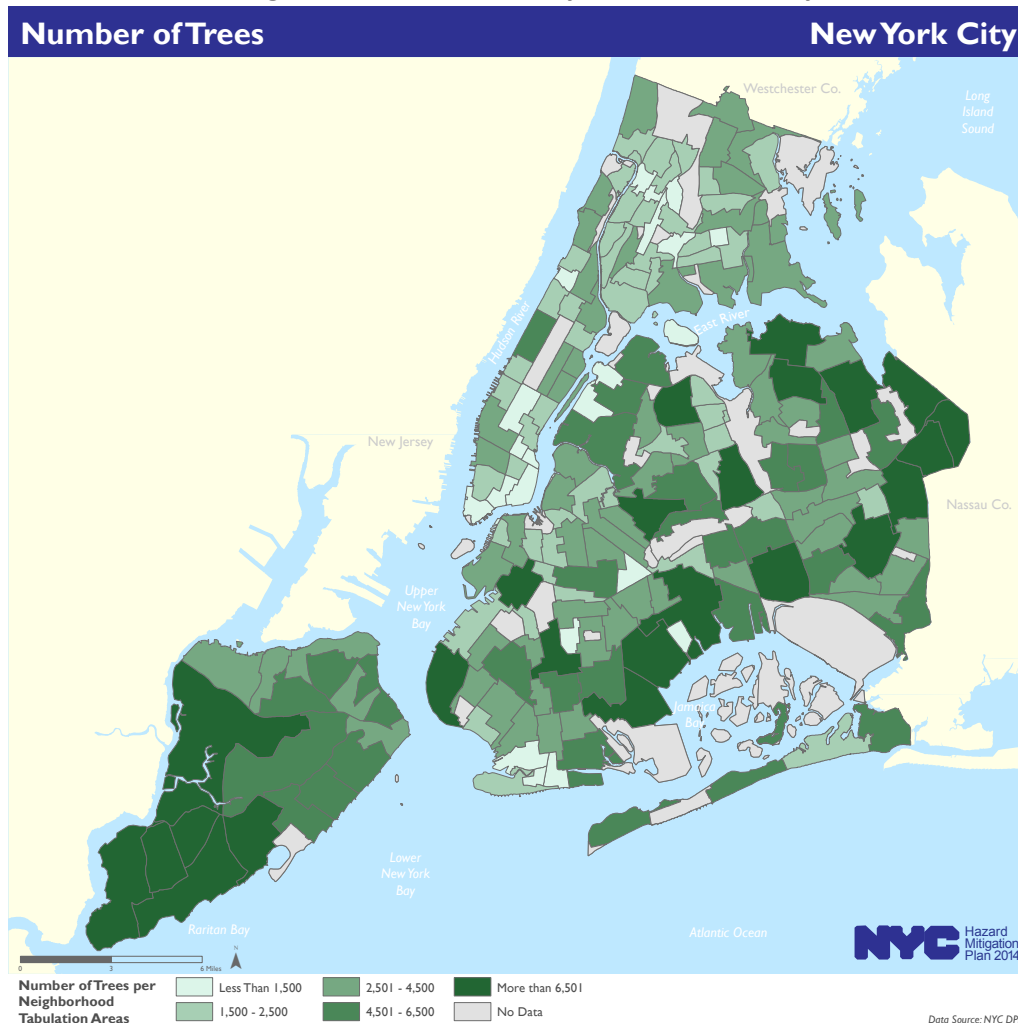
#### a) Trees

**Table 3.4.5: Selected Wetlands in the New York City Region**

| Wetlands                 | Borough             |
|--------------------------|---------------------|
| Pelham Bay Park Wetlands | Bronx               |
| Jamaica Bay              | Brooklyn and Queens |
| Alley Pond Park          | Queens              |
| Udall's Cove             | Queens              |
| Lemon Creek              | Staten Island       |
| Fresh Kills              | Staten Island       |
| Sawmill Creek Marshes    | Staten Island       |
| Arlington Marsh          | Staten Island       |

Also found in the city—in inland parks, along waterfront parks and beaches, and dotting streets—are trees, many of which are managed by DPR (see Figure 3.4.7: New York City Street Tree Density). These trees moderate temperatures, remove carbon dioxide and pollutants from the air, enhance sidewalk environments and other settings, protect waterways by reducing stormwater runoff, and help reduce the urban heat island effect (see section 10. **Extreme Temperatures**). DPR's trees range from large canopy trees to street trees, and its staff manages 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 Million-TreesNYC initiative.

**Figure 3.4.7: New York City Street Tree Density**



**B. The Social Environment**

New York City's social environment—its distinct history and culture, diverse communities and neighborhoods, and dynamic economy and resources—plays a critical role in how New Yorkers are impacted by, plan for, and respond to disasters. Data on population growth and density, neighborhoods, and the economy can provide a powerful context for understanding New York City's social environment.

*i. Demographics*

*Density*

More people live in, work in, and visit New York City today than at any other time in the city's history. According to the 2011 American Community Survey (ACS), conducted by the U.S. Census Bureau, more than 8.2 million people reside in the 305 square miles that make up New York City. With an approximate density of 42 people per acre, New York City is by far the most populous, densest city in the nation. In fact, it has more than double the population of the second largest city in the country, Los Angeles.

Within New York City, Manhattan remains the densest borough, with more than 109 people per acre, while Staten Island continues to be the least densely popu-

lated borough, with approximately 12 people per acre (see Table 3.4.6 and Figure 3.4.8).

*Age*

New York City's population has historically been characterized by its high concentration of young adults. Today, as Table 3.4.7 shows, New York City's population is comprised of a growing number of both older adults and children.

*Seniors*

The last 30 years have seen a large increase in the number of older New Yorkers. According to the 2011 U.S. Census, over 12% of New York City's population—roughly one million residents—is over the age of 65. This trend is largely due to the fact that the first cohort of people born during the baby boomer era is now reaching senior status. This population has been growing much more rapidly (12.4% since 2000) than the city's overall population (2.1% since 2000). According to the New York City Department for the Aging (DFTA), the highest percentage of elderly people reside in Brooklyn and Queens, each accounting for about 29% of the city's population aged 65 and over, followed by Manhattan (21%), the Bronx (15%), and Staten Island (6%) (see Table 3.4.7 and Figure 3.4.9). Given growth

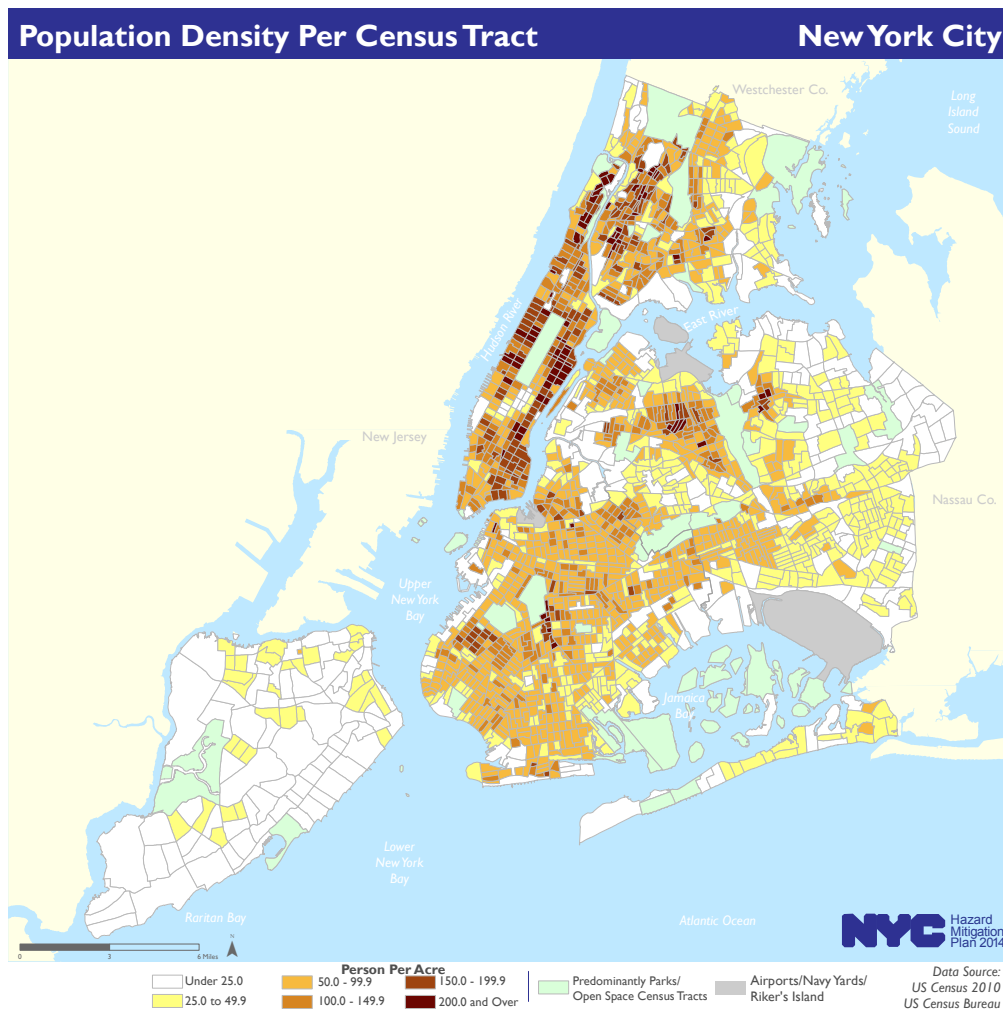
**Table 3.4.6: New York City Population Density by Borough (Source: U.S. Census, American Community Survey 2011)**

| New York City |             | Bronx     |             | Brooklyn  |             | Manhattan |             | Queens    |             | Staten Island |             |
|---------------|-------------|-----------|-------------|-----------|-------------|-----------|-------------|-----------|-------------|---------------|-------------|
| Count         | Person/Acre | Count     | Person/Acre | Count     | Person/Acre | Count     | Person/Acre | Count     | Person/Acre | Count         | Person/Acre |
| 8,244,910     | 42.47       | 1,392,002 | 51.09       | 2,532,645 | 56.30       | 1,601,948 | 109.64      | 2,247,848 | 32.11       | 470,467       | 12.62       |

**Table 3.4.7: New York City Population by Age and Borough (Source: U.S. Census, American Community Survey 2011)**

|          | New York City |      | Bronx    |      | Brooklyn |      | Manhattan |      | Queens   |      | Staten Island |      |
|----------|---------------|------|----------|------|----------|------|-----------|------|----------|------|---------------|------|
|          | Estimate      | %    | Estimate | %    | Estimate | %    | Estimate  | %    | Estimate | %    | Estimate      | %    |
| Under 5  | 534,400       | 6.5  | 106,190  | 7.6  | 183,027  | 7.2  | 80,126    | 5    | 136,797  | 6.1  | 28,260        | 6    |
| Under 18 | 1,775,171     | 21.5 | 368,276  | 26.5 | 598,160  | 23.6 | 237,292   | 14.8 | 463,568  | 20.6 | 107,875       | 22.9 |
| Over 65  | 1,011,996     | 12.3 | 149,110  | 10.7 | 291,892  | 11.5 | 218,875   | 13.7 | 290,927  | 12.9 | 61,192        | 13   |

Figure 3.4.8: New York City Population Density by Census Tract



trends over the last decade, it is expected that the city's older adult population will continue to increase in the coming decade.

Growth is not uniform across all seniors, however. Women over 65 continue to outlive men in the same age bracket, though the gender gap among the city's older adult population is slowly narrowing. Immigrant seniors are one of the fastest-growing demographic groups in the city. From 2000 to 2010, the number of immigrants in the city aged 65 and up increased by about 30%. Data from the 2010 U.S. Census indicate that almost 50% of New York City's older residents are foreign-born. According to the Center for an Urban Future, immigrant seniors often earn lower wages than native-born seniors, and they also have less in retirement savings and receive fewer benefits from traditional entitlement programs like Social Security and

Medicare.

In addition to being one of the fastest-growing demographic groups in New York City, seniors are also among the more vulnerable populations during emergencies. Older adults who have chronic health conditions or disabilities, live alone, experience isolation, or have limited access to emergency assistance services face higher risks from a hazard. According to the 2010 U.S. Census, approximately 300,000 seniors—or roughly 10% of all New York City households—live alone. Isolation can be more acute among immigrant seniors, nearly two-thirds of whom have limited English proficiency and therefore might not be informed of warnings and evacuation orders or know about critical city services and resources during an emergency.



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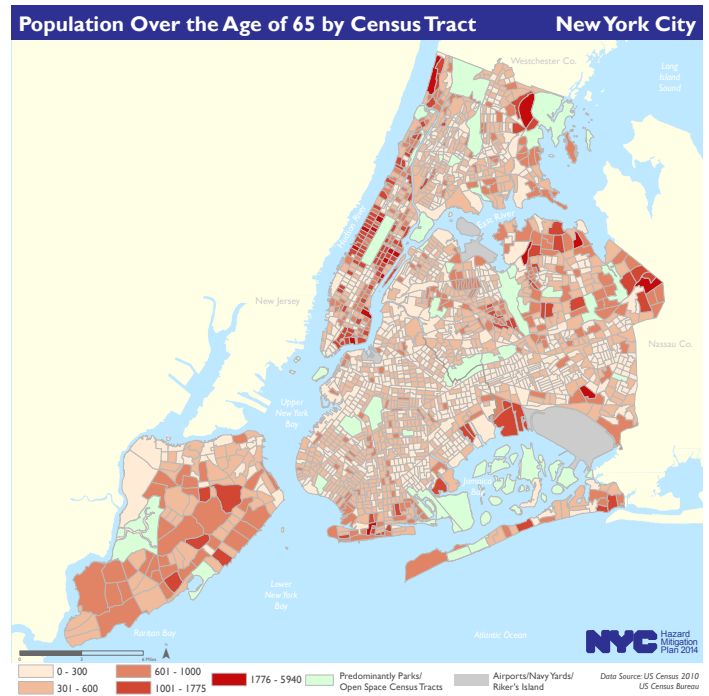
#### Children

Just as the city's older population has grown, so, too, has its group of younger inhabitants. New York City has seen a steady increase in its youth population over the last decade, with the latest U.S. Census data showing that 21.5% of the city's population is under the age of 18, and 6.5%, or over half a million, is under the age of 5. In fact, over 30% of all households in New York City have children under the age of 18. In addition, according to ACS data from 2011, more than 10% of the city's school-aged population is enrolled in nursery school, preschool, or kindergarten. Though Manhattan has seen some of the highest growth rates in its population of children since the 1960s, Brooklyn remains the borough with the greatest number of children under the age of 5, at approximately 180,000 (see Figure 3.4.10).

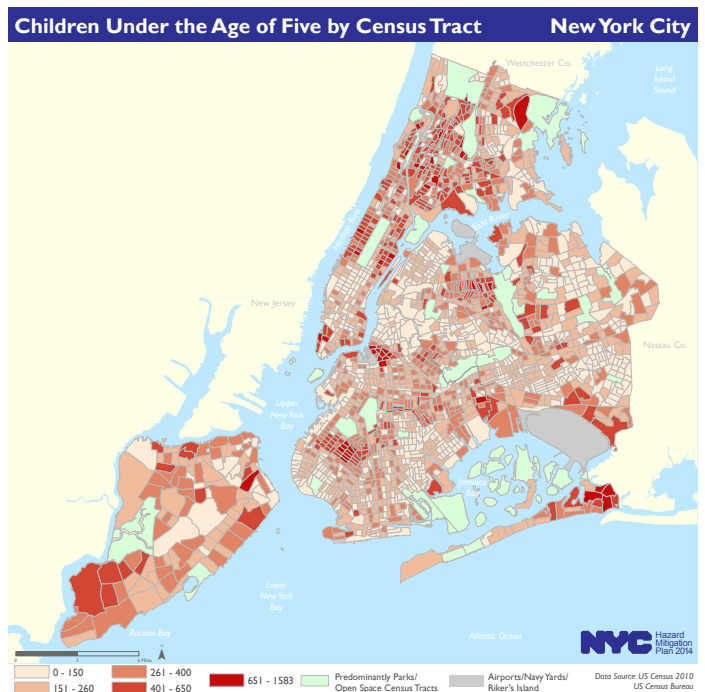
According to the Federal Emergency Management Agency (FEMA), children are particularly vulnerable to natural disasters. This is because they are disproportionately dependent on others, such as parents or adult caretakers, for shelter, transportation, and general guidance. The stress that follows a natural disaster may linger longer in children than in adults, according to FEMA's mental health experts.

Socioeconomic and pre-existing health considerations place some children at even greater risk from hazards. In New York City, approximately 30% of those 18 years of age and under (over 500,000) live below the federal poverty level (see Income and Poverty section, below), and over 100,000 of these children are under the age of 5. Additionally, the 2011 ACS showed that more than 54,000 children under the age of 18—roughly 3% of the city's population—have some form of disability, which may make them more vulnerable during a hazard event.

**Figure 3.4.9: New York City Population over the Age of 65 by Census Tract**



**Figure 3.4.10: New York City Population under the Age of 5 by Census Tract**



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#### Income and Poverty

Federal poverty status is determined by annual income and therefore influenced by larger economic trends. In 2011, the U.S. Census set the poverty threshold at \$11,484 for a one-person household and \$23,021 for a four-person household. The official poverty measure's definition of family resources is pre-tax cash. This includes income from all sources such as earnings, interest, and government transfer payments that take the form of cash, with Social Security benefits included in this measure but in-kind benefits, such as Food Stamps or tax credits, such as Earned Income Tax Credit, excluded.

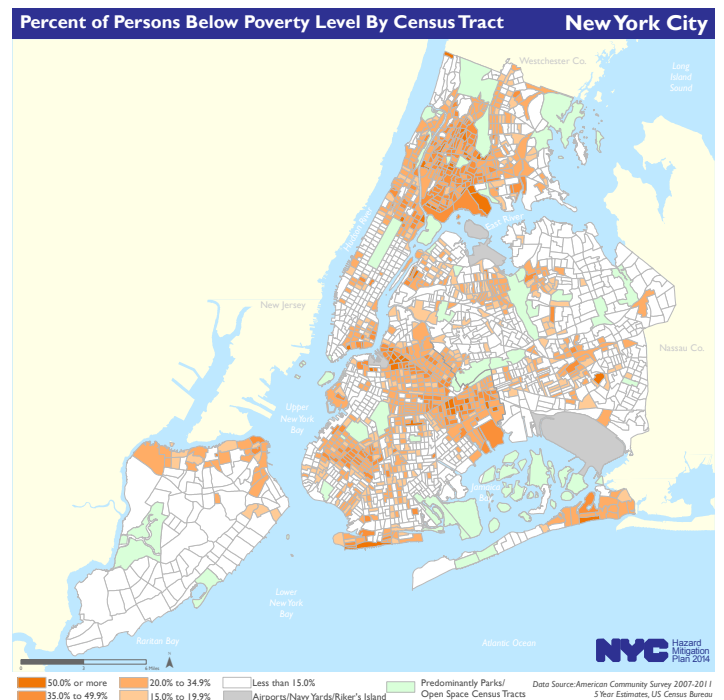
The recent recession and subsequent period of sluggish employment growth have had lingering effects on income and quality of life for many New Yorkers. According to the 2011 ACS, the percentage of the city's working-age population, defined as 18 to 64 years of age, that was unemployed increased between 2008 and 2010 (as compared to the previous two-year period), resulting in an all-time-high unemployment rate of 10% in 2010. However, starting in 2011, the upturn in the national and local economy resulted in a drop in New York City's unemployment rate. The latest ACS data (July 2013) show an unemployment rate of approximately 8% in New York City.

Despite employment growth, some New Yorkers continue to struggle economically. According to the 2011 ACS, almost 21% of the city's population, or approximately 1,700,000, live below the federal poverty line. Of those people living below poverty, almost 30% are children under the age of 18, and just under 20% are adults over the age of 65 (see Table 3.4.8). The greatest concentration of low-income populations can be found in the south Bronx, upper Manhattan, and scattered throughout Brooklyn. See Figure 3.4.11 for a spatial distribution of people living below the poverty line.

**Table 3.4.8: New York City Population below Federal Poverty Level by Age (Source: U.S. Census, American Community Survey 2011)**

|          | New York City |       | Bronx    |       | Brooklyn |       | Manhattan |       | Queens   |       | Staten Island |       |
|----------|---------------|-------|----------|-------|----------|-------|-----------|-------|----------|-------|---------------|-------|
|          | Estimate      | %     | Estimate | %     | Estimate | %     | Estimate  | %     | Estimate | %     | Estimate      | %     |
| All      | 1,695,088     | 20.9% | 412,139  | 30.4% | 592,789  | 23.6% | 284,572   | 18.3% | 351,223  | 15.8% | 54,365        | 11.7% |
| Under 18 | 520,799       | 29.8% | 147,402  | 40.9% | 198,874  | 33.6% | 59,796    | 25.6% | 95,880   | 21.1% | 18,847        | 17.5% |
| Over 65  | 186,006       | 19.0% | 34,239   | 24.7% | 66,439   | 23.2% | 37,892    | 17.8% | 42,273   | 15.1% | 5,163         | 8.7%  |

**Figure 3.4.11: Percentage of New York City Population below the Federal Poverty Level by Census Tract**



Many low-income New Yorkers depend on some form of public assistance. More than 600,000 lower-income New Yorkers are served by New York Housing Authority (NYCHA) public housing and Section 8 programs. Based on the 2010 U.S. Census, NYCHA public housing represents 8.2% of the city's rental apartments and is home to 4.9% of the city's population. Almost half (47.5%) of the families enrolled in NYCHA are working families, with an average family income of \$22,994, whereas the median household income in New York City is close to \$50,000, according to the 2011 ACS.

Low-income households in New York City tend to be renters, a fact that is relevant in a post-disaster context. Investment in post-disaster repairs is typically made by property owners, leaving most renters with little control over the quality and duration of the repairs. With the high-cost of housing in New York City, finding alter-

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native housing, even temporarily during an evacuation or immediately following a disaster, can pose a serious challenge. As a consequence, many low-income individuals and families choose to continue to occupy their damaged homes to avoid a greater allocation of income towards rent, or even homelessness.

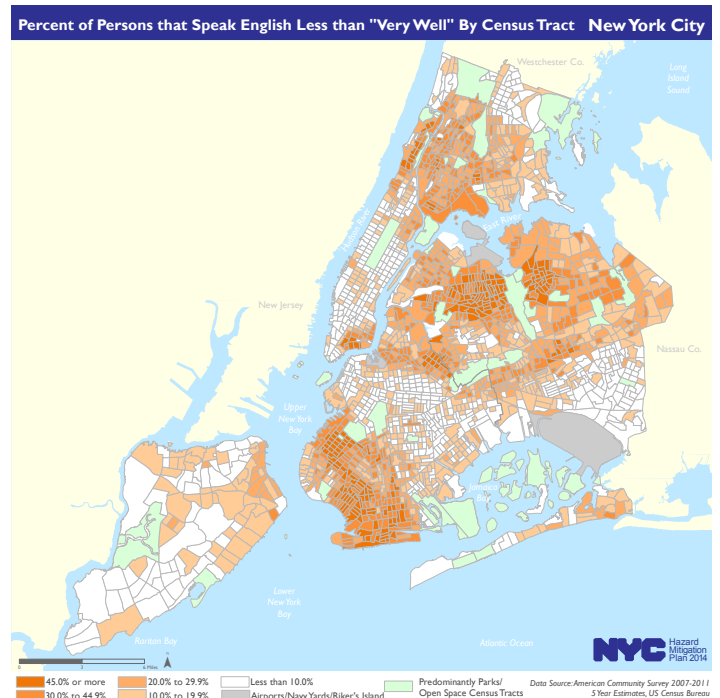
However, occupying damaged residences can increase their vulnerability in other ways—exposing them to hazardous materials, for instance. Health problems, in turn, can result in lost wages or even loss of employment, further increasing economic vulnerability. As a group, low-income individuals have fewer resources to prepare for and recover from disasters and therefore face higher health and safety risks along with economic hardships post-disaster.

#### *Linguistic Isolation*

New York City is exceptionally diverse and has been a major point of entry for immigrants throughout its history. The city's 2011 foreign-born population of 3.07 million was an all-time high and represented 37% of the city's overall population. Given that New Yorkers hail from all over the world, it is no surprise that over 200 different languages and dialects are spoken in New York City.

For some of the city's foreign born population, English proficiency continues to be a challenge. People who do not speak English very well, or are "linguistically

**Figure 3.4.12: Concentrations of Linguistically Isolated New Yorkers by Census Tract**



isolated" are of special concern during an emergency as they might not become aware of warnings and evacuation orders or know about critical city services and resources. According to the 2011 ACS, an estimated 23% of the city's population speaks English less than "very well" and is therefore considered "linguistically isolated" (see Table 3.4.9 and Figure 3.4.12).

**Table 3.4.9: New Yorkers Who Speak English Less than "Very Well" by Borough (Source: U.S. Census, American Community Survey 2011)**

|  | New York City |       | Bronx    |       | Brooklyn |       | Manhattan |       | Queens   |       | Staten Island |       |
|--|---------------|-------|----------|-------|----------|-------|-----------|-------|----------|-------|---------------|-------|
|  | Estimate      | %     | Estimate | %     | Estimate | %     | Estimate  | %     | Estimate | %     | Estimate      | %     |
| Speak English less than "very well"                        | 1,795,678     | 23.3% | 336,583  | 26.2% | 559,161  | 23.8% | 251,218   | 16.5% | 602,667  | 28.5% | 46,049        | 10.4% |
| Spanish/Speak English less than "very well"                | 899,769       | 11.7% | 275,381  | 21.4% | 186,476  | 7.9%  | 161,418   | 10.6% | 262,078  | 12.4% | 14,416        | 3.3%  |
| Other Indo-European/Speak English less than "very well"    | 433,675       | 5.6%  | 30,141   | 2.3%  | 213,666  | 9.1%  | 23,834    | 1.6%  | 147,087  | 7.0%  | 18,947        | 4.3%  |
| Asian/Pacific Islander/Speak English less than "very well" | 394,990       | 5.1%  | 11,539   | 0.9%  | 132,247  | 5.6%  | 60,915    | 4.0%  | 180,856  | 8.6%  | 9,433         | 2.1%  |
| Other/Speak English less than "very well"                  | 67,244        | 0.9%  | 19,522   | 1.5%  | 26,772   | 1.1%  | 5,051     | 0.3%  | 12,646   | 0.6%  | 3,253         | 0.7%  |

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#### Disability

According to the U.S. Census, there are four major categories of disabilities. "Sensory" disabilities include blindness, deafness, or a severe vision or hearing impairment. "Physical" disabilities are long-lasting conditions that substantially limit one or more basic physical activities, such as walking, climbing stairs, reaching, lifting, or carrying. "Self-care" disabilities are conditions lasting six or more months that make dressing, bathing, or getting around inside the home challenging. "Go-outside-the-home" disabilities are conditions lasting six or more months that make it difficult to shop or visit a doctor's office on one's own. See Table 3.4.10 for numbers and percentages of New Yorkers with disabilities by age and borough.

The geographic boundaries and names of neighborhoods are dynamic and change as populations move and development occurs. Figure 3.4.13 through Figure 3.4.17 show the diverse neighborhoods throughout New York City.

#### The Bronx

There are twelve community districts in the Bronx. The northernmost borough of New York City, the Bronx is the only borough that is not an island or part of one. It is home to Yankee Stadium, the Bronx Zoo, and the New York Botanical Garden. Almost 30% of the land use in the Bronx is dedicated to parks and open space uses, the most in New York City. This includes Van Cortlandt Park, Bronx Park, and Pelham Park, the largest

**Table 3.4.10: New Yorkers with Disabilities by Age and Borough (Source: U.S. Census, American Community Survey)**

|          | New York City |       | Bronx    |       | Brooklyn |       | Manhattan |       | Queens   |       | Staten Island |       |
|----------|---------------|-------|----------|-------|----------|-------|-----------|-------|----------|-------|---------------|-------|
|          | Estimate      | %     | Estimate | %     | Estimate | %     | Estimate  | %     | Estimate | %     | Estimate      | %     |
| All      | 842,477       | 10.3% | 189,467  | 13.8% | 235,372  | 9.3%  | 157,324   | 9.9%  | 214,530  | 9.6%  | 45,784        | 9.8%  |
| Under 18 | 54,189        | 3.1%  | 18,773   | 5.1%  | 12,185   | 2.0%  | 6,849     | 2.9%  | 13,678   | 3.0%  | 2,704         | 2.5%  |
| Over 65  | 362,507       | 37.1% | 60,000   | 43.3% | 112,983  | 39.5% | 69,633    | 32.7% | 100,333  | 35.7% | 19,558        | 33.0% |

*Please Note: A map is not provided for disability because this dataset does not exist at the census tract level. This indicator is no longer part of the Decennial Census and is instead part of the ACS. The ACS now provides these estimates with a margin of error. If the margin of error for an indicator is too large, the ACS does not publish its estimates. Currently there is no updated information for persons with disabilities at the census tract or the PUMA (Public Use Microdata Areas) level (approximately equivalent to a community district level). The only available data is at the borough level, which doesn't make a compelling thematic map. A table is sufficient for the purposes of this report.*

#### ii. Neighborhoods

New York City has a wide variety of neighborhoods. It encompasses five boroughs, 59 community districts (CDs), and hundreds of neighborhoods. Each neighborhood has unique physical and social characteristics.

park in New York City.

Its housing stock ranges from dense urban neighborhoods located throughout the borough to small bungalows in Edgewater Park. The southern portion of Community Districts 1 and 2 are mainly occupied with manufacturing and industrial uses. This includes Hunts Point Cooperative Market, New York City's largest food distribution center. There are other pockets of significant manufacturing and industrial uses such as in Eastchester, Bathgate, and along Westchester Creek. Commercial activity, much like the rest of New York City, is scattered throughout the Bronx serving local neighborhoods. However, the Hub, which is the district anchored by the intersection of 3<sup>rd</sup> Ave and East 149<sup>th</sup> Street, and the corridor along West and East Fordham Road are the borough's most well-known and visited regional commercial destinations.

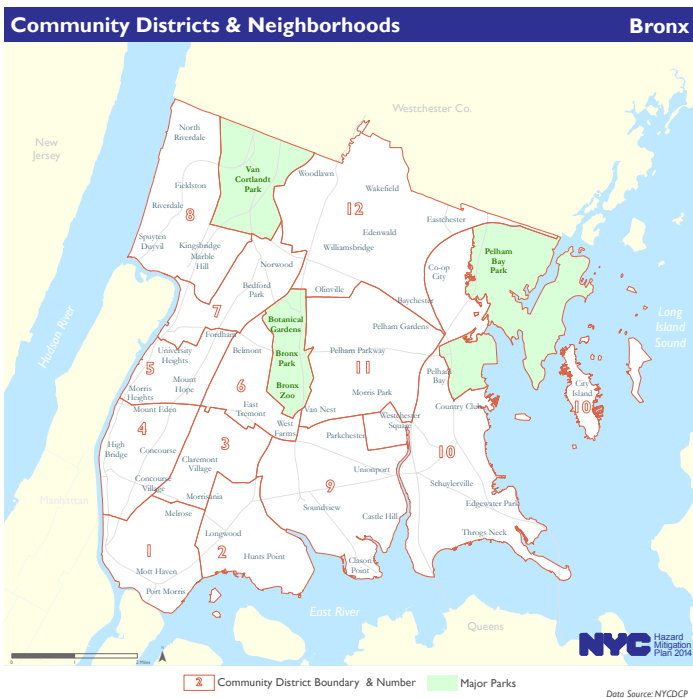
As of 2011, the Bronx had a population of approxi-

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mately 1.4 million and its household median income was \$32,058, which was the lowest of the five boroughs. Nearly 78% of the borough's total private employment is concentrated within the Services and Trade sectors. The Health Care and Social Assistance sector alone makes up 39.0% of total private sector employment in the Bronx.

**Figure 3.4.13: Bronx Community Districts and Neighborhoods**



### Brooklyn

Brooklyn consists of 18 community districts, the most in any borough. It is known, among many characteristics, for its stretches of neighborhood streets lined with buildings of brownstone architecture. Brooklyn can be accessed through some of the nation's most well-known crossings including the Brooklyn Bridge and Verrazano-Narrows Bridge. Coney Island and its 2.5-mile boardwalk and sandy beach have been an amusement destination for over a century. It is home to the historic Cyclone rollercoaster, New York Aquarium, and the Luna Park amusement area; amongst other local and regional attractions. Prospect Park, located in the center of the borough, is a 526-acre park that contains the Prospect Park Zoo and Brooklyn Botanical Gardens. The Barclays Center, completed in 2012 and

home to the Brooklyn Nets, is located along Atlantic Avenue near Downtown Brooklyn.

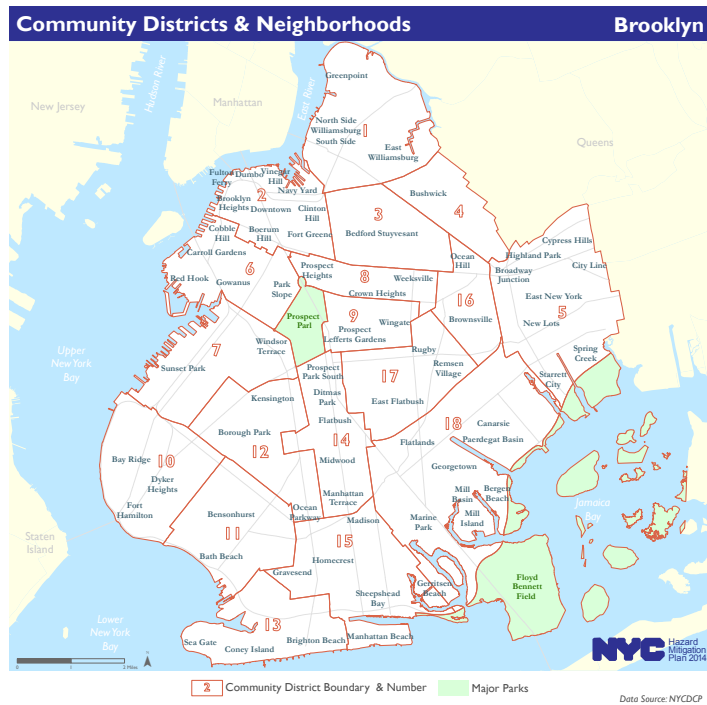
Aside from brownstone residences, Brooklyn has a wide variety in building type and density. Generally neighborhoods closer to Manhattan are denser and were developed earlier than more auto-dependent neighborhoods at the outer reaches of the borough. Former industrial sections of Brooklyn along the East River such as Williamsburg, Greenpoint, and DUMBO have slowly been transforming into mixed-use districts. However, a significant amount of manufacturing and industrial uses remain in Brooklyn. They range from less intensive manufacturing uses that take place in the warehouses of Red Hook, Gowanus, and Sunset Park to heavier and more intensive uses found along Newtown Creek in the northern parts of the borough. Downtown Brooklyn serves as the borough's major central business and commercial district though commercial corridors that serve local residents are scattered throughout along borough arterials.

Brooklyn had a population of over 2.5 million according to the 2011 ACS, making it the most populous borough in the City. Its households had a median income of nearly \$43,000. Like the Bronx, private sector employment in Brooklyn is predominantly made up of the Services and Trade sectors as they constitute 74% of total employment. The Health Care and Social Assistance sector make up one-third of overall private employment in Brooklyn.

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**Figure 3.4.14: Brooklyn Community Districts and Neighborhoods**



#### Manhattan

Manhattan, the smallest borough in terms of geographic area, is comprised of twelve community districts. Several culturally, politically, and economically significant institutions are located in New York City's central borough. The Metropolitan Museum of Art, the American Museum of Natural History, Lincoln Center for the Performing Arts, Ellis Island Immigration Museum, Times Square and the Theatre District are just a few examples of cultural institutions that can be found in Manhattan. The United Nations with its satellite embassies and consulates; and the New York Stock Exchange, NASDAQ, and other major global financial institutions of Wall Street are just a few of the politically and economically significant institutions centered in Manhattan.

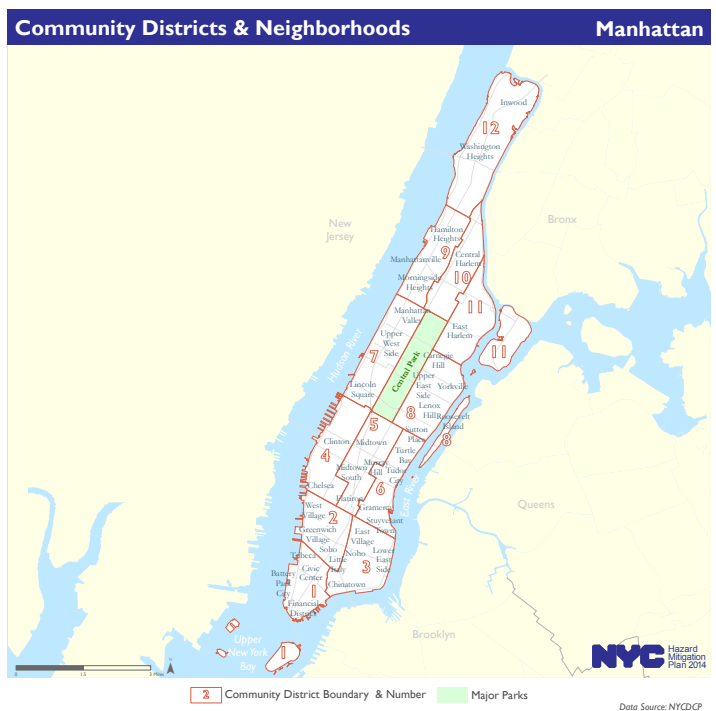
In the middle of the island is Central Park, an 843-acre parkland that takes up six percent of Manhattan's total landmass. It is considered the first public park built in America and is visited by 25 million people annually.

Manhattan is the most densely populated county in the nation. Its iconic skyline is made up of buildings that

house or provide a place of work for millions of Americans. However, not all parts of Manhattan have skyscrapers. Greenwich Village, Lower East Side, Harlem, and many of the residential streets of the borough have retained their medium density characteristics, while SoHo and Chelsea serve as examples of former manufacturing districts whose warehouse structures have been converted to residential and mixed-use. Lower Manhattan and Midtown Manhattan are the primary central business districts of New York City and serve as global centers for finance and economic activity.

Approximately 1.6 million residents call Manhattan home and the median household income for the borough is \$66,299. Approximately 15% of private employment sector jobs in Manhattan are within the Finance, Insurance, and Real Estate (FIRE) sector. This is a much higher concentration in comparison to the other four boroughs where it makes up about five percent of the entire private employment sector. The Services Sector makes up 45.1% of such jobs, which is significantly less than elsewhere in New York City.

**Figure 3.4.15: Manhattan Community Districts and Neighborhoods**



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#### Queens

Queens is the largest borough in terms of geographic area and is made up of 14 community districts. It is known for its diversity as nearly half its residents are foreign born. Queens holds the largest amount of park and open space out of the five boroughs. The larger parks include Gateway National Recreational Area in Jamaica Bay, Forest Park, and Flushing Meadows/Corona Park. The latter is home to the annual US Open Tennis Championship and had been the site for both the 1939 and 1964 World Fair. Citifield, home of the New York Mets major league baseball team, is nearby. The sandy beaches along the southern edges of the Rockaway Peninsula are a popular recreational destination for New York residents.

The built environment of Queens takes on several characteristics; from newly constructed residential towers along the East River in Long Island City and Hunter's Point to suburban-style, auto-dependent neighborhoods with one-family homes that are found throughout the eastern section of the borough. Downtown Flushing and Jamaica are emerging regional commercial districts and provide office space and retail establishments serving local residents. There is significant manufacturing and industrial use activity in Queens. This is primarily found in Long Island City, Maspeth along Newtown Creek, and College Point. Both major New York City airports, LaGuardia Airport and John F. Kennedy International Airport, are located in Queens.

The population of Queens exceeded 2.2 million in 2011, second to only Brooklyn. The median household income was \$53,572. Approximately 40% of all private sector employment is concentrated in the Services sector with Health Care and Social Assistance jobs making up about one-fifth of overall employment. The Retail sector is a significant factor in the overall economy of Queens due to the presence of Queens Center Mall and other shopping areas in the vicinity of Corona and Elmhurst. The borough is also home to approximately 37% of Construction sector jobs in New York City.

Figure 3.4.16: Queens Community Districts and Neighborhoods



#### Staten Island

Staten Island, the southernmost borough of New York City, has three community districts. Staten Island can be accessed from the rest of New York City via the Verrazano-Narrows Bridge from Brooklyn and the Staten Island Ferry which travels between the southern tip of Lower Manhattan and St. George on the North Shore of Staten Island. The borough can also be accessed from New Jersey from the Bayonne Bridge, Goethals Bridge, and Outerbridge Crossings. In recent years, Staten Island has become an environmental and recreational destination with the introduction of a new parks system that transformed the Fresh Kills landfill into a 2,200 acre park with various active and passive recreational opportunities.

Historically, Staten Island developed as town villages which were connected by railway. With the opening of the Verrazano-Narrows Bridge in 1964, Staten Island began to transform into a more suburban, auto-oriented community. The majority of Staten Island neighborhoods are low density in character consisting of one- and two-family homes. Key commercial corridors include Hylan Boulevard in the vicinity of New Dorp

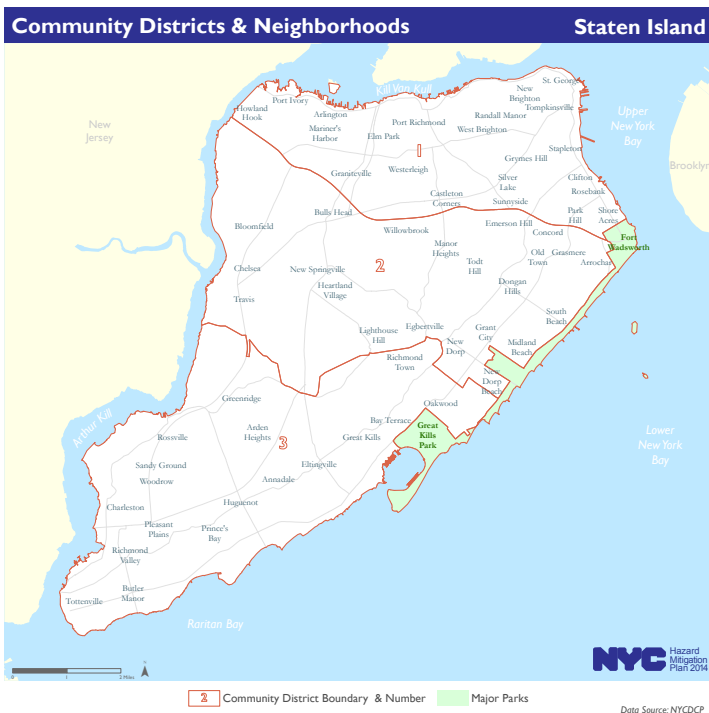
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and Grant City, Forest Avenue and Victory Boulevard on the north shore, and Richmond Avenue in Heartland Village and New Springville. Portions of the north and west shore of Staten Island are dedicated to manufacturing and industrial uses with several water-dependant industries occupying these areas.

Staten Island is the least populated with 470,467 residents according to the ACS, yet it has been the fastest growing borough over the past three decades. Its median household income is \$70,578, which is the highest of the five boroughs of New York City. Much like the Bronx, Brooklyn, and Queens, the Services sector plays an important role in the Staten Island economy as it accounts for 57.2% of private sector jobs in the borough.

**Figure 3.4.17: Staten Island Community Districts and Neighborhoods**



The Health Care and Social Assistance Services alone account for nearly 30% of such jobs. Retail and Wholesale-related jobs, which are part of the Trade Sector, collectively account for 20% and are the next largest source for private sector jobs in Staten Island.

### iii. Economy

New York City is one of the world's financial capitals and serves as the hotspot for both national and regional economic activity. It is home to a broad spectrum of industries—from finance and real estate, high-tech to tourism and manufacturing to service sector—and millions of regional jobs (see Table 3.4.11).

**Table 3.4.11: New York City Employment by Industry August 2013 (Source: New York City Economic Development Corporation)**

| Industry   | Number of Employees |
|--|---------------------|
| Finance, Insurance, Real Estate                  | 436,585             |
| Finance and insurance                            | 318,395             |
| Securities                                       | 163,421             |
| Banking  | 91,516              |
| Other  | 63,458              |
| Real estate                                      | 118,190             |
| <b>SERVICES</b>                                  | <b>2,196,258</b>    |
| Information                                      | 174,920             |
| Professional and business                        | 639,055             |
| Professional, scientific, and technical services | 361,275             |
| Management of companies and enterprises          | 63,157              |
| Administrative services                          | 214,623             |
| Educational                                      | 201,153             |
| Health and social assistance                     | 621,254             |
| Arts and entertainment                           | 81,469              |
| Accommodation and food                           | 300,844             |
| Other  | 177,563             |
| <b>TRADE</b>                                     | <b>482,209</b>      |
| Retail   | 337,930             |
| Wholesale  | 144,279             |
| <b>MANUFACTURING</b>                             | <b>75,133</b>       |
| <b>TRANSPORTATION AND UTILITIES</b>              | <b>126,121</b>      |
| <b>CONSTRUCTION</b>                              | <b>119,403</b>      |
| <b>TOTAL PRIVATE</b>                             | <b>3,435,709</b>    |
| <b>GOVERNMENT</b>                                | <b>543,751</b>      |
| <b>TOTAL (private and government)</b>            | <b>3,979,460</b>    |



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New York City leads the country in the number of *Fortune* 500 and 1,000 companies headquartered in a metropolis, including the country's top securities and law firms as well as banks representing every major country. These firms create jobs that attract highly skilled professionals from across the country and the world. According to the New York City Economic Development Corporation (EDC), private-sector employment has risen by 84,700 jobs, or 2.5%, since August 2012.

New York City is also a global center for the arts, fashion, tech/information, and both old and new media. Most major publishing houses and many TV and radio stations are located in the city. TV and film production are long-standing and growing industries, with established studios in Manhattan and new ones sprouting in other parts of the city.

Drawn by world-class museums, architecture, arts, and fashion, tourists flock to New York City, making tourism a major industry and contributing greatly to the local economy. In 2012, tourism generated a record \$55.3 billion in revenue, welcoming an all-time high of 52 million visitors and employing more than 363,000 New Yorkers across all five boroughs. In fact, tourism jobs have been growing at a faster rate than any other major industry in the city with an increase of 27% since 2006. Direct visitor spending was \$36.9 billion, with \$4.2 billion spent on arts, recreation, and entertainment. Over the past six years, the city has added 167 new hotels, increasing room inventory by 26% to a record 90,387 rooms.

In recent years, tech/information and new media (which includes tech start-ups and established tech companies, along with major information companies such as Bloomberg L.P. and the New York Times Company) have become billion-dollar industries in New York. The City supported growth in this arena—particularly in what is referred to as "Silicon Alley" in Manhattan, now expanding into other boroughs—by investing in fiber-optic cable and other infrastructure systems that enable and enhance high-speed business communication. There are established world-class academic and research facilities such as NYU-Poly Tech and Columbia University, and plans for the Cornell-Tech campus on Roosevelt Island. Alongside cutting-edge research,

professional services firms related to financial consultation or legal issues of intellectual property have also rapidly developed.

Given the leading role New York City plays in the national and international economy, natural and non-natural hazards in New York City can have impacts that ripple out into areas well beyond the city's borders. For example, a severe storm or flood event can cause direct damage to local inventory, equipment, and interior spaces, not to mention structural damage to New York City's buildings, transportation and communication networks – all of which can result in bottlenecks in business in places like New Jersey, San Francisco and even London and Tokyo.

**C. The Built Environment**

No other American city can match New York City in the diversity of its built environment. From beachfront bungalows to Manhattan skyscrapers, street networks to ferry terminals, power plants to fuel pipelines, airports to marinas—New York is one of the most varied and complex cities in the world. It has more than 6,000 miles of streets and highways, over 800 miles of subway track, more than 2,000 bridges, and four major tunnels—all working together to move millions of people in and through the city. Additionally, the city has nearly a million structures of almost every imaginable type and use, including more than 2,647 schools, over 60 hospitals, scores of museums, four major stadiums, and two major airports. Below the streets and buildings lies a vast network of critical underground infrastructure—including pipes and fiber-optic cables—that enable millions of people to live in and visit the city daily.

Though New York City's physical assets have become safer and more structurally sound as building codes and land use laws have been modernized, they remain vulnerable to a variety of natural and non-natural hazards. For example, buildings located within the floodplain or storm surge zone are susceptible to flooding and/or coastal storms. Buildings along the coastline are also vulnerable to the impacts of long-term coastal erosion. Unreinforced masonry buildings are at a higher risk to earthquake damage than buildings made

from sturdier materials, or buildings that are reinforced. Extreme temperatures can cause pavement to buckle and damage overhead electric and telephone lines. Windstorms can cause trees and power lines to fall and debris to fly in the air. High-wind events, such as coastal storms or tornadoes, can cause less robustly built structures to suffer roof failures and building collapses. Winter weather can cause surface degradation to buildings and roadways, and disrupt movement on the roadway.

While millions of physical assets exist throughout New York City, certain assets are vital to the city's security, public health and safety, economy, and way of life. In the event of a major disaster, the city will need these critical assets to continue operating and sustain daily activities for its residents.

*i. Land Use*

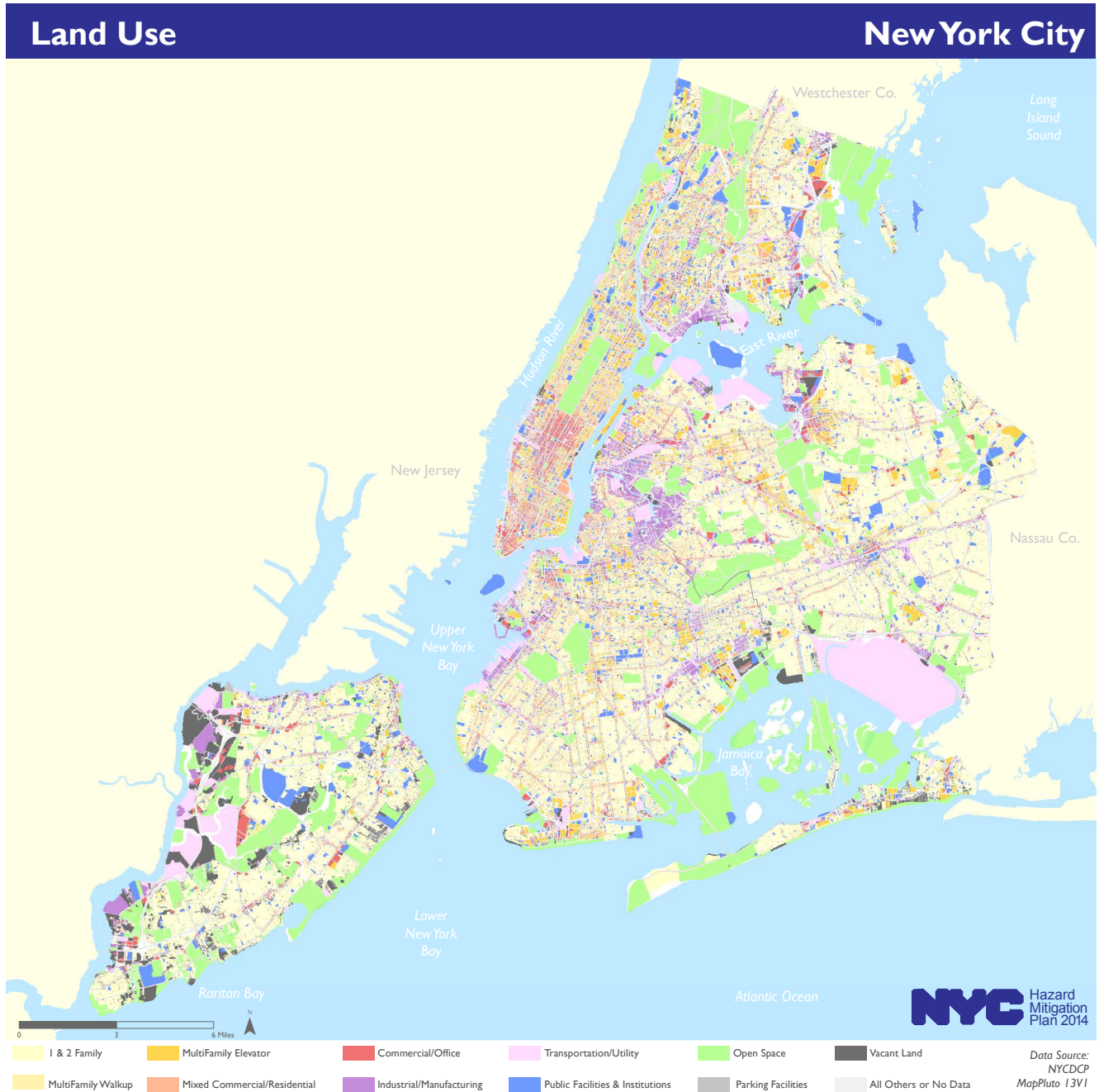
New York City's land area covers approximately 305 square miles (approximately 195,000 acres or 8.5 billion square feet). Excluding streets and major bodies of water, approximately 145,000 acres (about 6.3 billion square feet) of land, or lot area, is available for use.

Table 3.4.12 provides a summary of land use in New York City. Figure 3.4.18 shows the spatial distribution of land uses in New York City. Table 3.4.13 through Table 3.4.17 provide summaries of land use by borough and Figure 3.4.19 through Figure 3.4.23 show the spatial distribution of land use by borough.

**Table 3.4.12: Summary of New York City Land Use (Source: MapPluto 13V1)**

| Land Use               | Lots           |               | Total Lot Area       |               | Total Building Area  |               |
|------------------------|----------------|---------------|----------------------|---------------|----------------------|---------------|
|                        | #              | %             | Sq. Feet             | %             | Sq. Feet             | %             |
| Residential            | 706,448        | 82.3%         | 2,670,789,776        | 42.3%         | 2,945,754,292        | 54.5%         |
| Mixed use              | 48,598         | 5.7%          | 210,278,605          | 3.3%          | 710,919,018          | 13.2%         |
| Commercial             | 24,415         | 2.8%          | 273,798,156          | 4.3%          | 768,821,829          | 14.2%         |
| Industrial             | 11,894         | 1.4%          | 235,574,986          | 3.7%          | 253,099,490          | 4.7%          |
| Transportation/utility | 6,618          | 0.8%          | 572,328,288          | 9.1%          | 77,765,685           | 1.4%          |
| Public facilities      | 12,145         | 1.4%          | 453,401,868          | 7.2%          | 564,756,051          | 10.5%         |
| Open space             | 4,942          | 0.6%          | 1,439,258,407        | 22.8%         | 38,664,041           | 0.7%          |
| Parking                | 11,310         | 1.3%          | 87,700,962           | 1.4%          | 36,250,028           | 0.7%          |
| Vacant land            | 27,962         | 3.3%          | 316,745,985          | 5.0%          | 309,190              | 0.0%          |
| All others or no data  | 3,547          | 0.4%          | 61,346,674           | 1.0%          | 5,170,025            | 0.1%          |
| <b>Total</b>           | <b>857,879</b> | <b>100.0%</b> | <b>6,321,223,705</b> | <b>100.0%</b> | <b>5,401,509,649</b> | <b>100.0%</b> |

Figure 3.4.18: Land Use in New York City



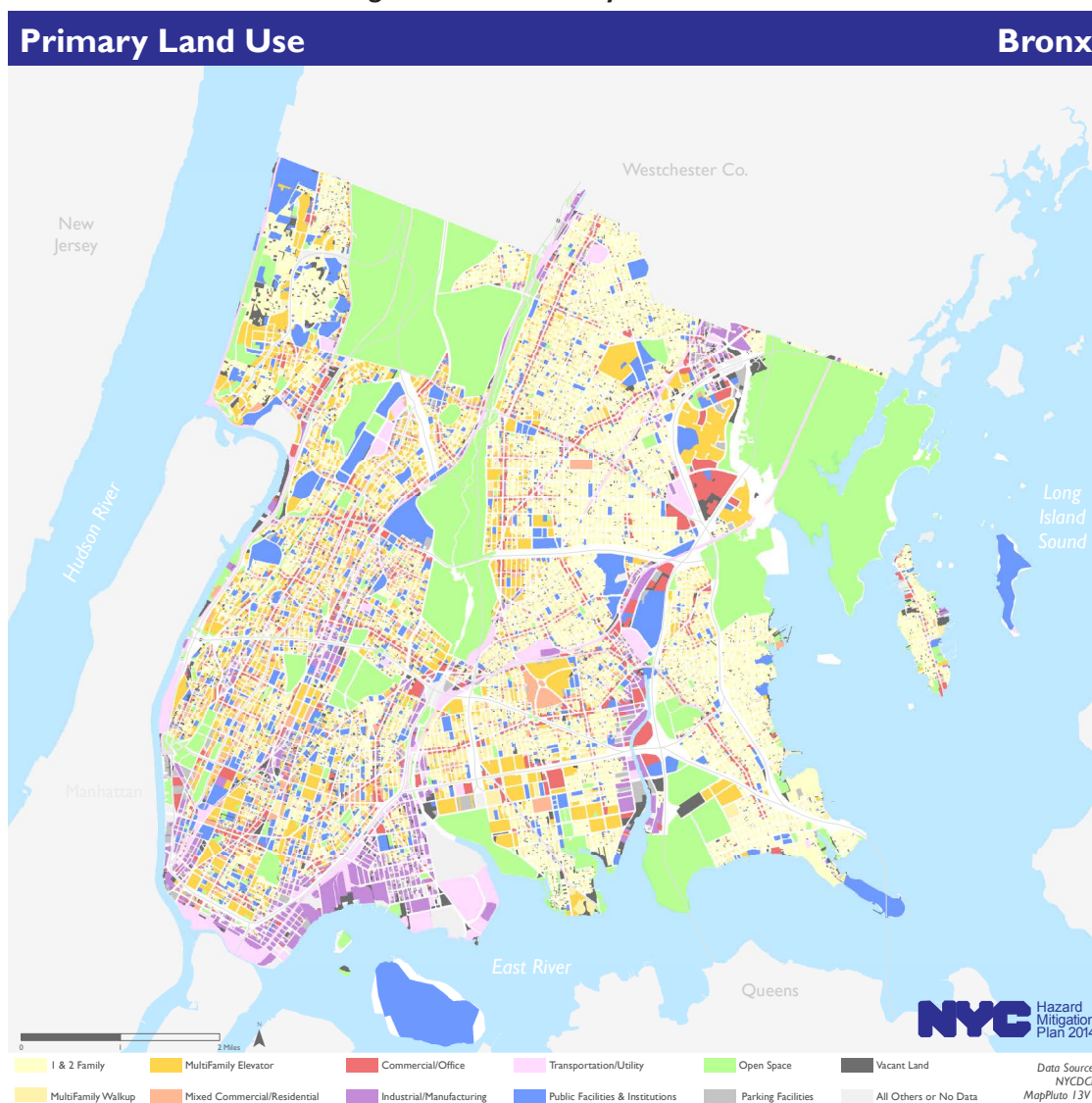
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**Table 3.4.13: Land Use in the Bronx**

| Land Use               | Lots          |               | Total Lot Area     |               | Total Building Area |               |
|------------------------|---------------|---------------|--------------------|---------------|---------------------|---------------|
|                        | #             | %             | Sq. Feet           | %             | Sq. Feet            | %             |
| Residential            | 71,134        | 79.2%         | 304,776,816        | 34.8%         | 438,820,942         | 62.0%         |
| Mixed use              | 3,713         | 4.1%          | 28,483,111         | 3.3%          | 89,278,981          | 12.6%         |
| Commercial             | 3,094         | 3.4%          | 40,728,881         | 4.7%          | 39,503,688          | 5.6%          |
| Industrial             | 1,391         | 1.5%          | 33,224,900         | 3.8%          | 29,575,150          | 4.2%          |
| Transportation/utility | 1,078         | 1.2%          | 49,234,393         | 5.6%          | 5,921,865           | 0.8%          |
| Public facilities      | 1,872         | 2.1%          | 97,205,716         | 11.1%         | 87,666,684          | 12.4%         |
| Open space             | 678           | 0.8%          | 259,228,999        | 29.6%         | 5,244,881           | 0.7%          |
| Parking                | 2,149         | 2.4%          | 18,565,420         | 2.1%          | 9,349,936           | 1.3%          |
| Vacant land            | 4,140         | 4.6%          | 27,606,562         | 3.2%          | 5,840               | 0.0%          |
| All others or no data  | 556           | 0.6%          | 16,753,289         | 1.9%          | 2,247,933           | 0.3%          |
| <b>Total</b>           | <b>89,805</b> | <b>100.0%</b> | <b>875,808,086</b> | <b>100.0%</b> | <b>707,615,900</b>  | <b>100.0%</b> |

**Figure 3.4.19: Primary Land Use in the Bronx**



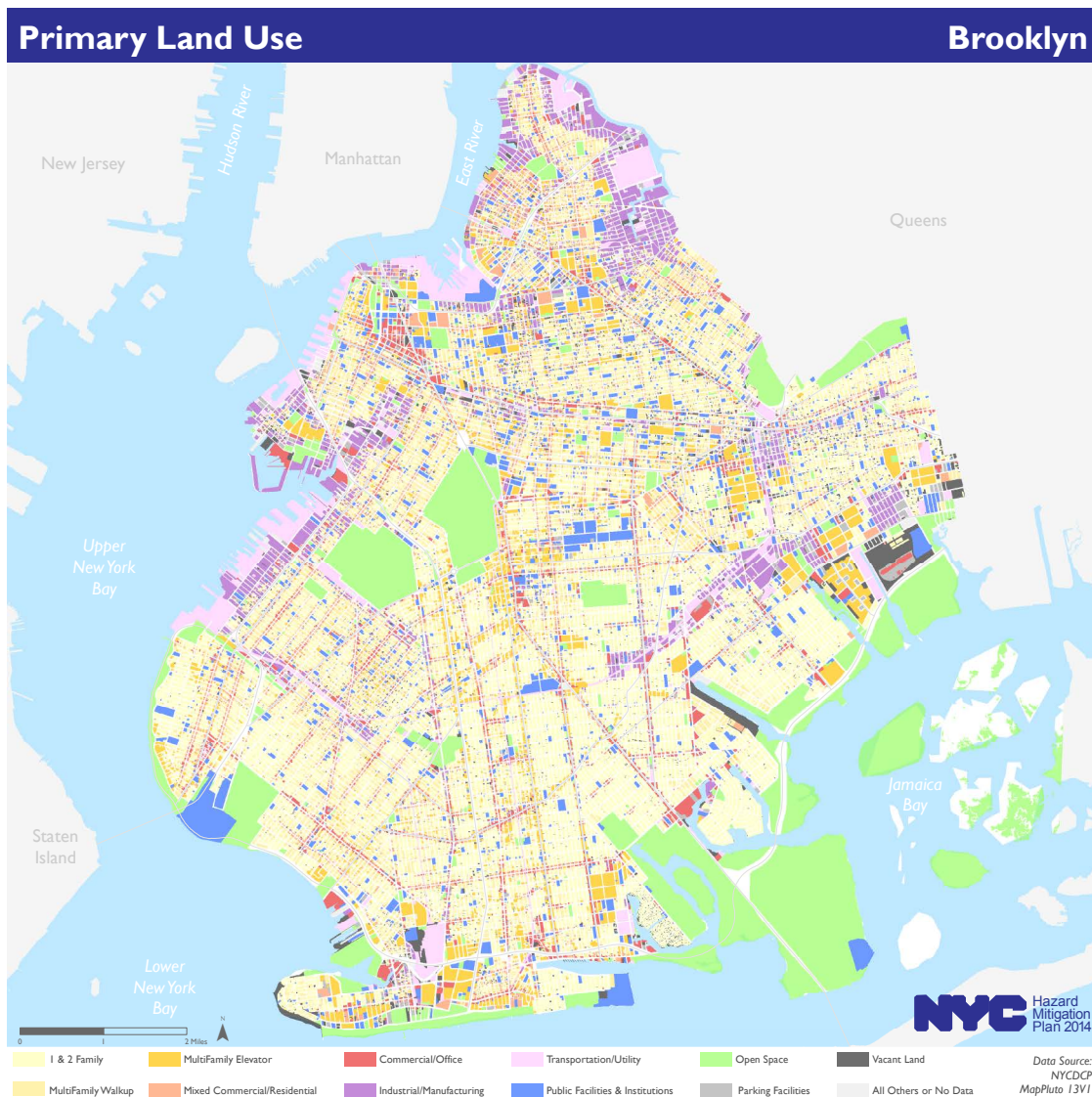
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**Table 3.4.14: Land Use in Brooklyn**

| Land Use               | Lots           |               | Total Lot Area       |               | Total Building Area  |               |
|------------------------|----------------|---------------|----------------------|---------------|----------------------|---------------|
|                        | #              | %             | Sq. Feet             | %             | Sq. Feet             | %             |
| Residential            | 223,627        | 80.6%         | 661,319,515          | 46.7%         | 909,807,601          | 63.7%         |
| Mixed use              | 21,947         | 7.9%          | 67,760,668           | 4.8%          | 154,272,703          | 10.8%         |
| Commercial             | 6,981          | 2.5%          | 56,233,060           | 4.0%          | 79,447,276           | 5.6%          |
| Industrial             | 4,927          | 1.8%          | 75,478,979           | 5.3%          | 87,279,742           | 6.1%          |
| Transportation/utility | 2,042          | 0.7%          | 78,897,991           | 5.6%          | 30,398,414           | 2.1%          |
| Public facilities      | 4,294          | 1.5%          | 101,755,643          | 7.2%          | 152,837,003          | 10.7%         |
| Open space             | 901            | 0.3%          | 296,985,642          | 21.0%         | 5,645,328            | 0.4%          |
| Parking                | 3,992          | 1.4%          | 26,692,757           | 1.9%          | 8,494,343            | 0.6%          |
| Vacant land            | 7,231          | 2.6%          | 37,761,387           | 2.7%          | 90,422               | 0.0%          |
| All others or no data  | 1,585          | 0.6%          | 13,539,583           | 1.0%          | 1,113,913            | 0.1%          |
| <b>Total</b>           | <b>277,527</b> | <b>100.0%</b> | <b>1,416,425,227</b> | <b>100.0%</b> | <b>1,429,386,745</b> | <b>100.0%</b> |

**Figure 3.4.20: Primary Land Use in Brooklyn**



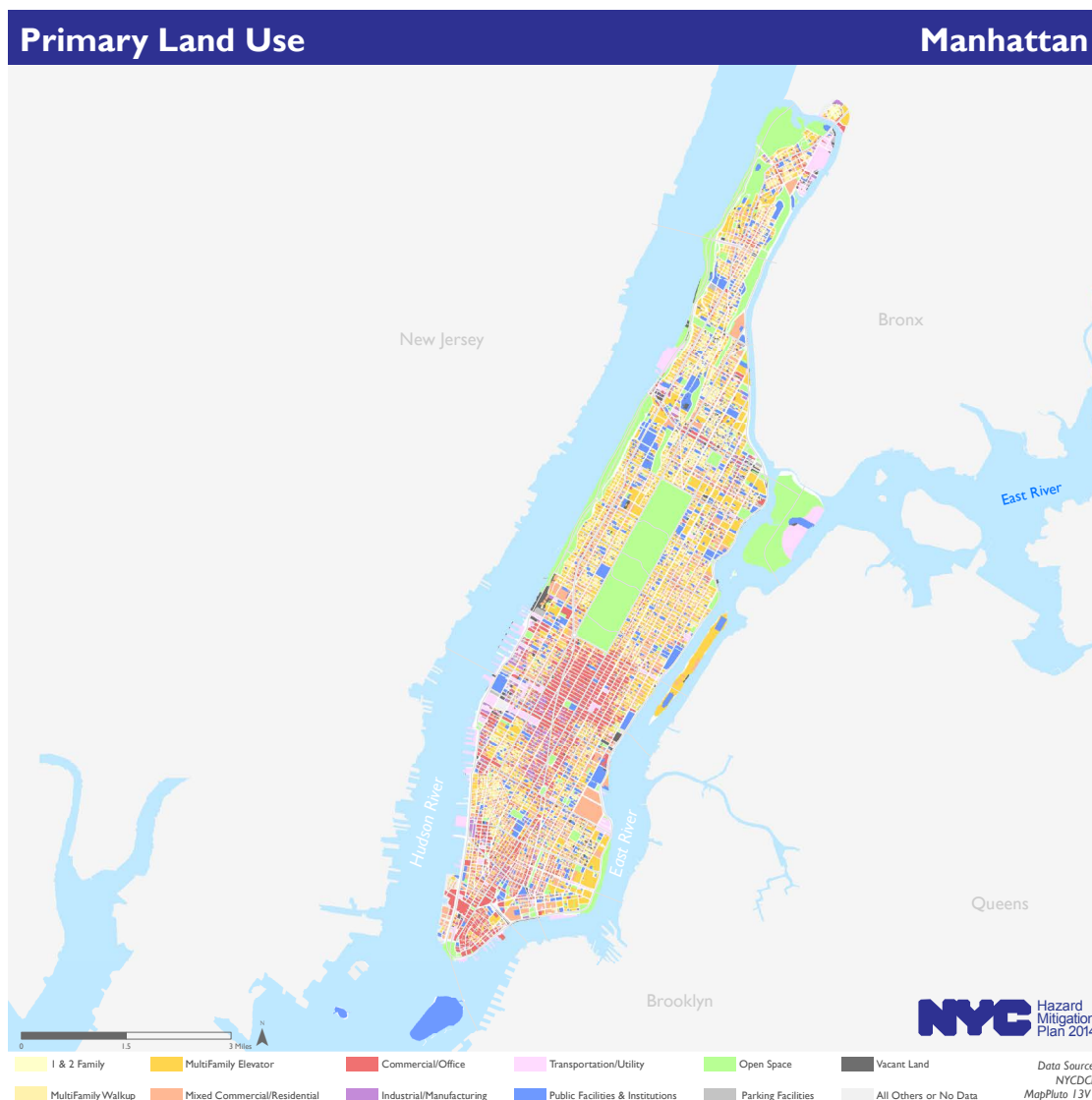
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Table 3.4.15: Land Use in Manhattan

| Land Use               | Lots   |        | Total Lot Area |        | Total Building Area |        |
|------------------------|--------|--------|----------------|--------|---------------------|--------|
|                        | #      | %      | Sq. Feet       | %      | Sq. Feet            | %      |
| Residential            | 20,751 | 48.2%  | 118,618,032    | 26.1%  | 547,869,319         | 31.7%  |
| Mixed use              | 10,230 | 23.8%  | 65,584,904     | 14.4%  | 382,099,796         | 22.1%  |
| Commercial             | 5,222  | 12.1%  | 51,142,279     | 11.3%  | 543,694,466         | 31.4%  |
| Industrial             | 1,368  | 3.2%   | 8,785,415      | 1.9%   | 53,848,942          | 3.1%   |
| Transportation/utility | 465    | 1.1%   | 26,610,097     | 5.9%   | 12,277,771          | 0.7%   |
| Public facilities      | 2,470  | 5.7%   | 55,172,864     | 12.1%  | 175,799,142         | 10.2%  |
| Open space             | 375    | 0.9%   | 107,563,333    | 23.7%  | 2,558,288           | 0.1%   |
| Parking                | 787    | 1.8%   | 7,005,522      | 1.5%   | 9,934,116           | 0.6%   |
| Vacant land            | 1,222  | 2.8%   | 8,146,293      | 1.8%   | 65,466              | 0.0%   |
| All others or no data  | 178    | 0.4%   | 5,601,020      | 1.2%   | 1,193,753           | 0.1%   |
| Total                  | 43,068 | 100.0% | 454,229,759    | 100.0% | 1,729,341,059       | 100.0% |

Figure 3.4.21: Primary Land Use in Manhattan



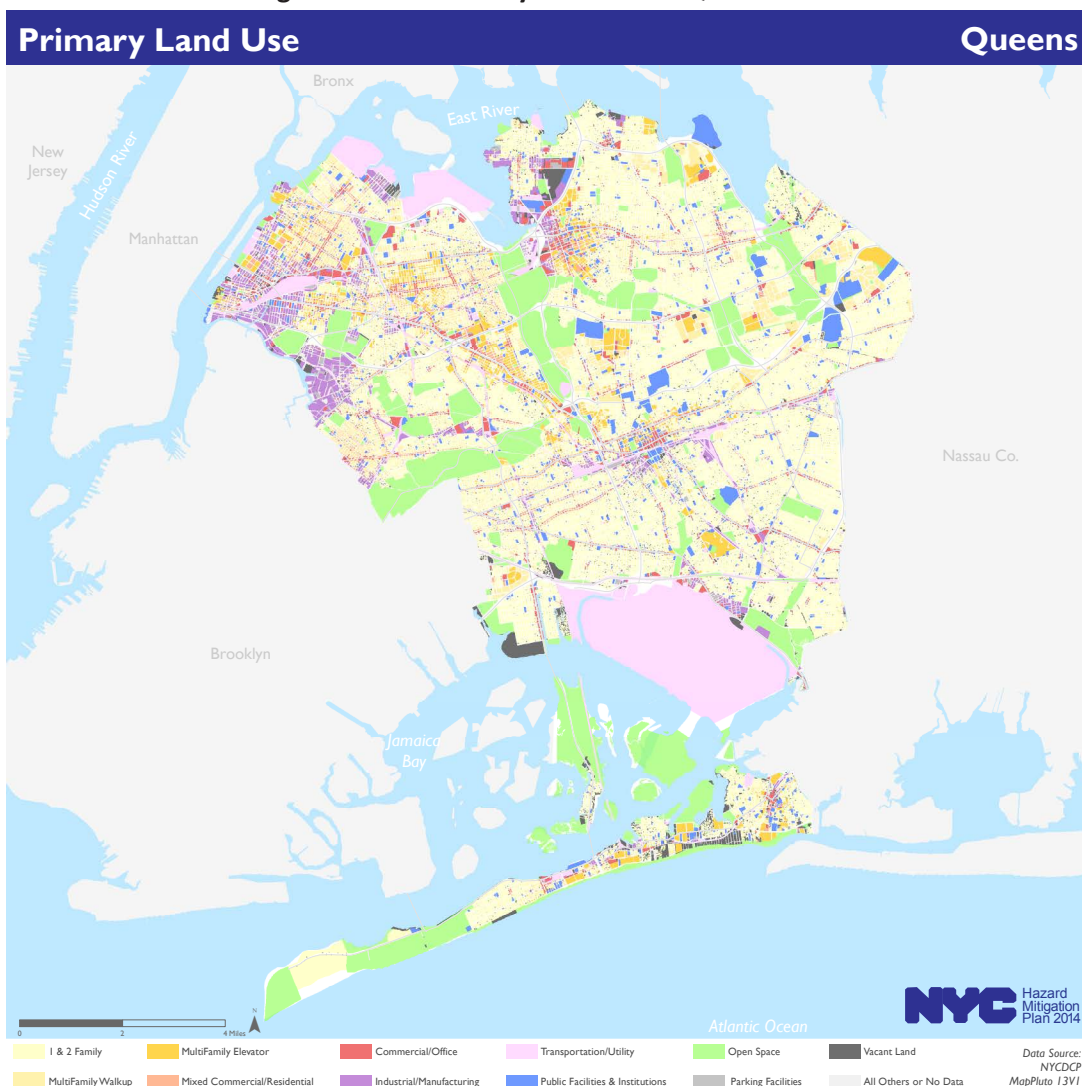
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**Table 3.4.16: Land Use in Queens**

| Land Use               | Lots           |               | Total Lot Area       |               | Total Building Area  |               |
|------------------------|----------------|---------------|----------------------|---------------|----------------------|---------------|
|                        | #              | %             | Sq. Feet             | %             | Sq. Feet             | %             |
| Residential            | 283,320        | 87.4%         | 1,091,534,788        | 47.9%         | 817,198,316          | 67.4%         |
| Mixed use              | 11,242         | 3.5%          | 40,568,446           | 1.8%          | 79,491,910           | 6.6%          |
| Commercial             | 6,936          | 2.1%          | 79,129,747           | 3.5%          | 86,426,240           | 7.1%          |
| Industrial             | 3,776          | 1.2%          | 80,264,714           | 3.5%          | 75,403,381           | 6.2%          |
| Transportation/utility | 2,255          | 0.7%          | 312,714,375          | 13.7%         | 26,093,616           | 2.2%          |
| Public facilities      | 2,819          | 0.9%          | 112,680,780          | 4.9%          | 96,416,810           | 8.0%          |
| Open space             | 1,101          | 0.3%          | 459,623,438          | 20.2%         | 23,330,687           | 1.9%          |
| Parking                | 3,629          | 1.1%          | 27,312,525           | 1.2%          | 7,672,391            | 0.6%          |
| Vacant land            | 8,358          | 2.6%          | 62,420,571           | 2.7%          | 146,362              | 0.0%          |
| All others or no data  | 820            | 0.3%          | 14,453,785           | 0.6%          | 547,666              | 0.0%          |
| <b>Total</b>           | <b>324,256</b> | <b>100.0%</b> | <b>2,280,703,169</b> | <b>100.0%</b> | <b>1,212,727,379</b> | <b>100.0%</b> |

**Figure 3.4.22: Primary Land Use in Queens**



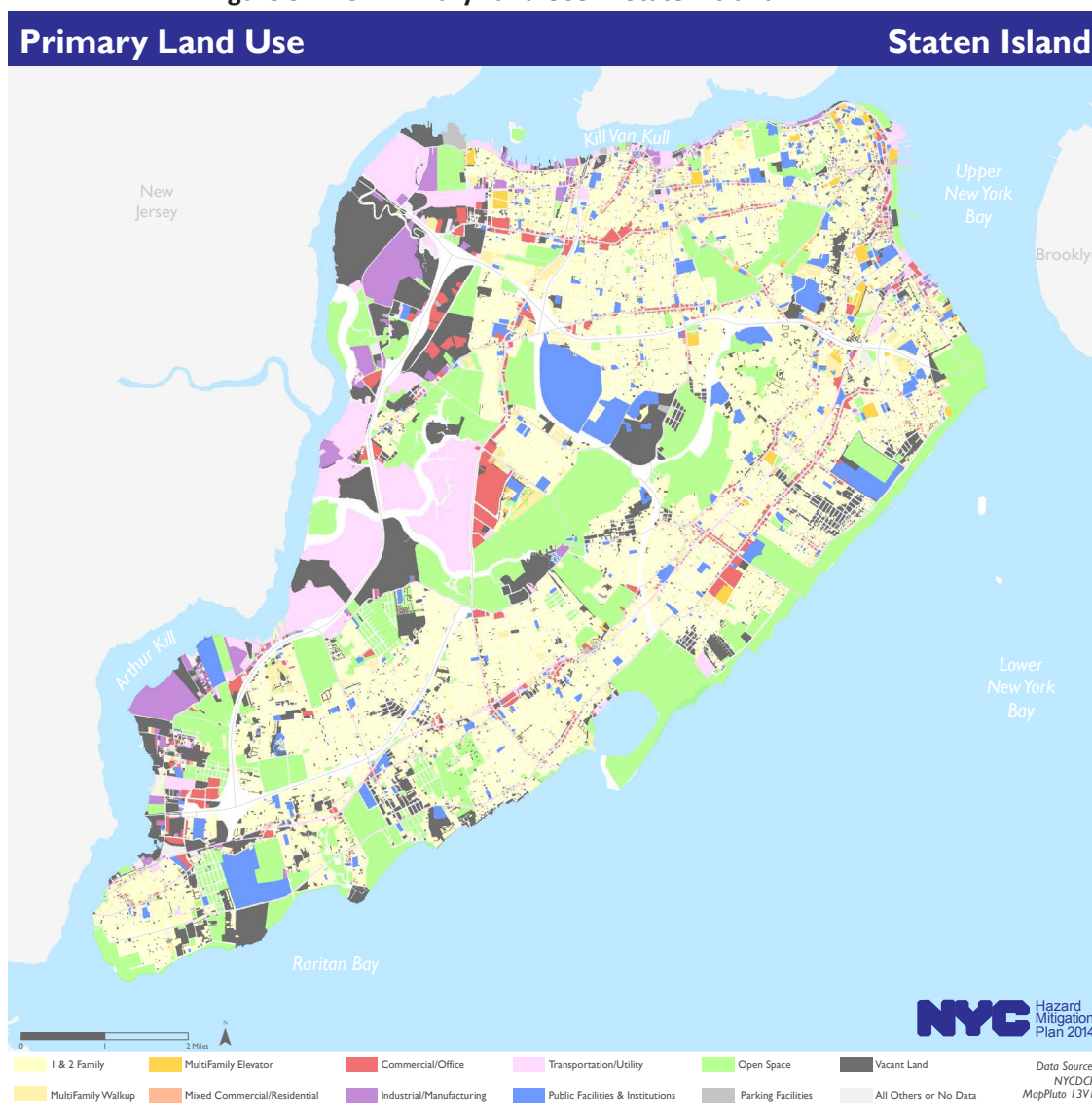
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**Table 3.4.17: Land Use in Staten Island**

| Land Use               | Lots           |               | Total Lot Area       |               | Total Building Area  |               |
|------------------------|----------------|---------------|----------------------|---------------|----------------------|---------------|
|                        | #              | %             | Sq. Feet             | %             | Sq. Feet             | %             |
| Residential            | 107,616        | 87.3%         | 494,540,625          | 38.2%         | 494,540,625          | 38.2%         |
| Mixed use              | 1,466          | 1.2%          | 7,881,476            | 0.6%          | 7,881,476            | 0.6%          |
| Commercial             | 2,182          | 1.8%          | 46,564,191           | 3.6%          | 46,564,191           | 3.6%          |
| Industrial             | 432            | 0.4%          | 37,820,978           | 2.9%          | 37,820,978           | 2.9%          |
| Transportation/utility | 778            | 0.6%          | 104,871,432          | 8.1%          | 104,871,432          | 8.1%          |
| Public facilities      | 690            | 0.6%          | 86,586,864           | 6.7%          | 86,586,864           | 6.7%          |
| Open space             | 1,887          | 1.5%          | 315,856,994          | 24.4%         | 315,856,994          | 24.4%         |
| Parking                | 753            | 0.6%          | 8,124,738            | 0.6%          | 8,124,738            | 0.6%          |
| Vacant land            | 7,011          | 5.7%          | 180,811,171          | 14.0%         | 180,811,171          | 14.0%         |
| All others or no data  | 408            | 0.3%          | 10,998,997           | 0.8%          | 10,998,997           | 0.8%          |
| <b>Total</b>           | <b>123,223</b> | <b>100.0%</b> | <b>1,294,057,465</b> | <b>100.0%</b> | <b>1,294,057,465</b> | <b>100.0%</b> |

**Figure 3.4.23: Primary Land Use in Staten Island**





## ii. Buildings

## a. Building Stock and Construction Type

New York City has a diverse building stock encompassing nearly a million structures of almost every imaginable type and combination of uses (See Table 3.4.18). These buildings are New York City's homes, workplaces, museums, historic landmarks, community centers, and places of worship—and they are also critical contributors to the rich and varied character of communities across the city.

**Table 3.4.18: New York City Number of Buildings by Borough Summary Data (Source: MapPluto 13V1 2013)**

| Borough       | Number of Buildings | % of city |
|---------------|---------------------|-----------|
| Brooklyn      | 316,287             | 31.7      |
| Bronx         | 102,580             | 10.3      |
| Manhattan     | 46,301              | 4.6       |
| Queens        | 397,286             | 39.8      |
| Staten Island | 135,269             | 13.6      |
| Total         | 997,723             | 100.0     |

*Note: Table 3.4.9 uses New York City Department of Finance's (DOF) parcel data to determine the number of buildings in NYC. Due to different methodologies and variations in the data sets, these numbers will differ from the number of buildings modeled in HAZUS.*

Buildings can be categorized by their construction type. In New York City, materials used in building construction are often referred to as "combustible" or "non-combustible." Combustible buildings use lighter stud-frame construction or wood joists on masonry bearing walls. Heavier non-combustible buildings have steel or masonry and concrete frames.

Construction type is an important determinant of structural vulnerability to the effects of some hazards. For example, low-rise buildings tend to be constructed of lighter, wood stud-frame materials, which are more prone to structural damage and fire from electrical shorts caused by flooding than steel, masonry, or concrete frames, which are characteristic of more recent and denser building types.

As shown in Table 3.4.19, roughly half the buildings in NYC are combustibles and half are non-combustibles. Table 3.4.19 uses 2013 New York City parcels data to show a summary of New York City's building stock based on Hazards U.S. Multi-Hazard (HAZUS-MH) categories for construction and occupation type. According to this analysis, of the 801,298 buildings with a known construction type, 49% are masonry and 50% are wood. Manhattan is the only borough that commonly sees a third construction type—steel—which comprises 9% of the total buildings in the borough. As Figure 3.4.24 indicates, Manhattan has very few wood structures (only 5% of the total 38,249 buildings), whereas 85% of the structures are masonry. Staten Island is the inverse, with 92% of structures made from wood, a common construction type for the single-family residential buildings that are prevalent in that borough.

**Table 3.4.19: New York City Building Stock Summary Data (Source: MapPluto 13V1 2013)**

| Borough                                   | Bronx                    | Brooklyn                 | Manhattan                | Queens                   | Staten Island            | Total                      |
|---|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|----------------------------|
| <b>HAZUS-MH Construction Type (known)</b> |                          |                          |                          |                          |                          |                            |
| Masonry                                   | 178,601                  | 56,452                   | 32,481                   | 117,462                  | 8,253                    | 393,249                    |
| Wood frame                                | 79,011                   | 25,148                   | 1,933                    | 188,744                  | 103,876                  | 398,712                    |
| Steel                                     | 1,400                    | 335                      | 3,284                    | 1,504                    | 331                      | 6,854                      |
| Concrete                                  | 652                      | 390                      | 542                      | 397                      | 291                      | 2,272                      |
| Manufactured housing                      | 58                       | 31                       | 9                        | 75                       | 38                       | 211                        |
| <b>Total</b>                              | <b>259,722</b>           | <b>82,356</b>            | <b>38,249</b>            | <b>308,182</b>           | <b>112,789</b>           | <b>801,298</b>             |
| <b>HAZUS-MH Occupation Type (known)</b>   |                          |                          |                          |                          |                          |                            |
| Residential                               | 74,507                   | 242,024                  | 31,273                   | 291,680                  | 108,217                  | 747,701                    |
| Commercial                                | 8,284                    | 20,649                   | 7,829                    | 18,264                   | 6,358                    | 61,384                     |
| Industrial                                | 866                      | 2,542                    | 751                      | 2,633                    | 486                      | 7,278                      |
| Religion                                  | 729                      | 1,906                    | 805                      | 1,324                    | 218                      | 4,982                      |
| Educational                               | 478                      | 1,106                    | 659                      | 644                      | 199                      | 3,086                      |
| Government                                | 118                      | 211                      | 222                      | 171                      | 71                       | 793                        |
| <b>Total</b>                              | <b>84,982</b>            | <b>268,438</b>           | <b>41,539</b>            | <b>314,716</b>           | <b>115,549</b>           | <b>825,224</b>             |
| <b>Value (\$)</b>                         |                          |                          |                          |                          |                          |                            |
| Total building market value               | \$71,967,721,908         | \$231,659,712,807        | \$402,716,508,225        | \$249,063,864,554        | \$65,034,758,932         | \$1,020,442,566,426        |
| Total building content value              | \$50,612,689,861         | \$144,298,565,503        | \$309,714,342,696        | \$163,048,002,129        | \$40,753,569,150         | \$708,427,169,339          |
| <b>Total</b>                              | <b>\$122,580,411,769</b> | <b>\$375,958,278,310</b> | <b>\$712,430,850,921</b> | <b>\$412,111,866,683</b> | <b>\$105,788,328,082</b> | <b>\$1,728,869,735,765</b> |

Note: While the summary table uses best available parcels data, the number of buildings is undercounted since there can be multiple buildings on one parcel and the data only provides information for the primary building on the parcel.

**b. Building Age**

Buildings in New York City can also be categorized by their age (see Figure 3.4.25). The vast majority of the city's building stock—approximately 80%—was built before the 1961 Zoning Resolution that helped to modernize building regulations and improve safety standards.

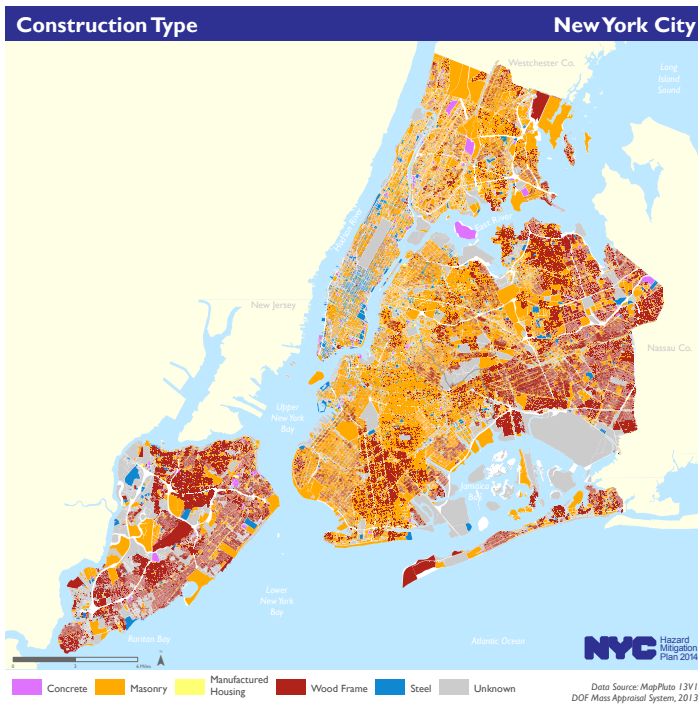
Building age is an important indicator of structural vulnerability to the effects of some hazards. This is in part because different rules relating to building construction and materials were in effect at different times. For example, in New York City, light-frame buildings built decades ago according to less stringent codes tend to sustain more structural damages during a hazard than newer, heavier buildings made with non-combustible materials like steel, concrete, and masonry, which are constructed to modern standards (particularly those enacted since the 1961 Zoning Resolution and Build-

ing Code of 1968). As larger buildings continued to be constructed to accommodate the city's growing population, the City amended its Building Code to increase fire protection requirements in areas with high concentrations of residents. Additionally, the City has been actively incorporating resiliency into its building regulations since 1983, when FEMA first released its Flood Insurance Rate Maps (FIRMs) for New York City, setting the boundaries of the 100-year floodplain. In 2008, the New York City Construction Code was adopted and applies to all new construction within the city. Many of the new code provisions address natural hazard mitigation, including new standards to protect buildings from drought, earthquakes, extreme temperatures, flooding, wind, and winter weather.

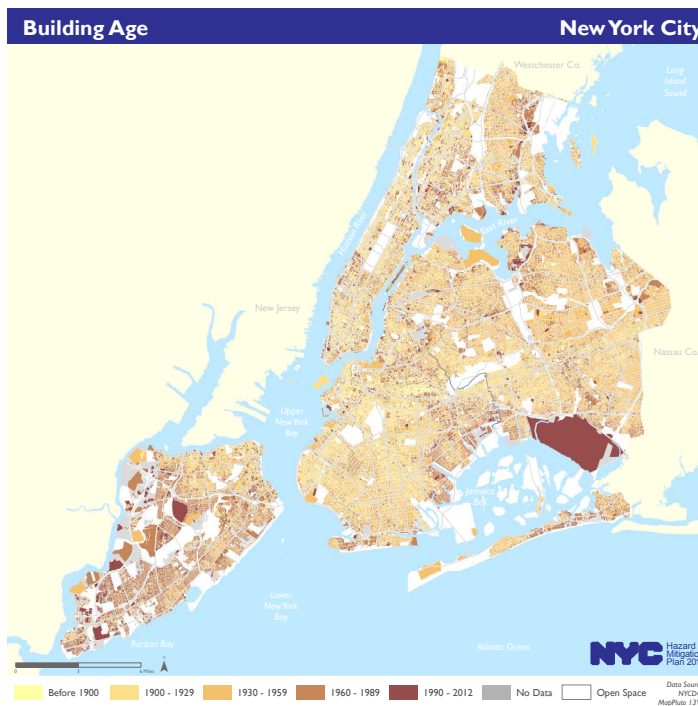
## 4. NEW YORK CITY'S HAZARD ENVIRONMENT

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**Figure 3.4.24: New York City Buildings by Construction Type**



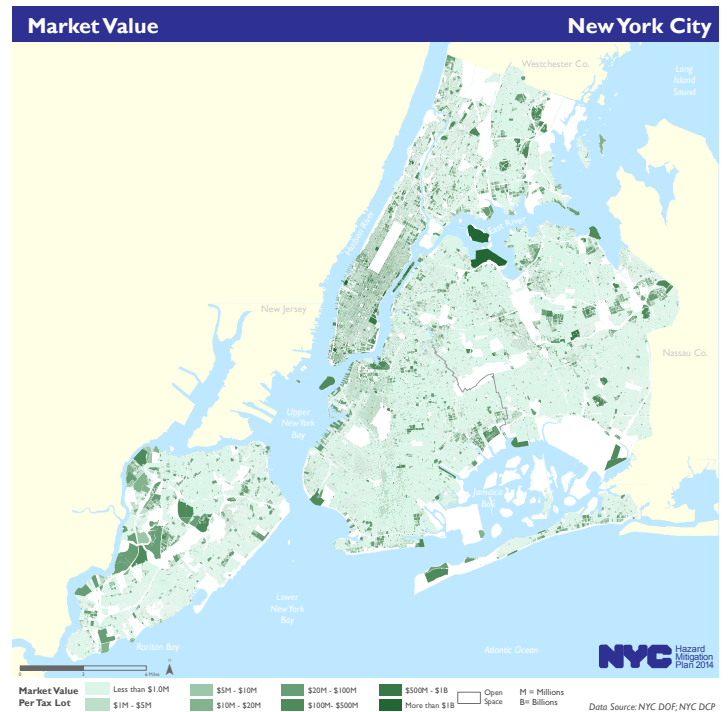
**Figure 3.4.25: New York City Buildings by Age**



### c. Building Value

According to the New York City Department of Finance's latest available data, New York City's total building and market value is slightly over one trillion dollars. By applying HAZUS-MH assumptions for determining the content value within these buildings, it can be estimated that New York City's total content value is \$708 billion. Manhattan accounts for the largest proportion with approximately 40% of the city's building value and 44% of its contents value (see Figure 3.4.26).

**Figure 3.4.26: Market Value of Buildings in New York City**



However, overall value exceeds the sum of building and contents value. The businesses and industries housed in many of these buildings, especially in Manhattan's financial district and midtown, are sometimes worth billions more.

### d. New York City Construction Code

Enacted in 1968, the New York City Building Code was one of the country's most stringent building codes. However, decades of piecemeal modifications produced a long, cumbersome code that was difficult to interpret. In 2008, after several years of revisions, the city adopted the New York City Construction Code to ensure an up-to-date and comprehensive building code to meet the present and future challenges of

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New York City's dense urban environment. The revised code helped address natural hazard mitigation, including new standards that applied to all new construction within the city to protect buildings from drought, earthquakes, extreme temperatures, flooding, wind, and winter weather.

- **Drought**

The Construction Code encourages water conservation by providing rebates to encourage the use of products and engineering that reduce consumption, such as waterless urinals and rain/wastewater recycling for non-potable uses, in the construction of new, energy efficient, sustainable buildings.

- **Earthquakes**

The NYC 1995 building code update (Local Law 17/19) contained the first seismic provisions in the New York City Building Code which considered soil and foundation conditions for new construction. The Department of Buildings has further addressed structural vulnerability to earthquakes in the 2008 Construction Codes, which are based on the 2003 International Building Code requirements (with local modifications for buildings constructed after July 1, 2009). Additionally, the 2014 NYC Building Code (BC) will provide a new seismic standard that presents risk-based requirements, and enhanced design requirements for liquefaction.

- **Extreme Temperatures**

The Construction Code promotes sustainable elements in the design of new and old buildings. It allows the construction of "green roofs," a thin layer of vegetation installed on a roof to help absorb rainwater, provide insulation, and combat the heat island effect, whereas the previous code required special permission before a green roof could be constructed. The Construction Code also requires heat-reflective coverings on roofs with a slope less than 25%. These two provisions will help New York City reduce the urban heat island effect and mitigate extreme heat. Changes to zoning provisions in 2012 (the Zone Green Text Amendment) allow for green roofs to be excluded from zoning height limitations.

- **Flooding**

To protect against heavy rainfall events, the Construction Code requires the installation of overflow drains to safeguard roofs should primary drains fail. The new requirement for secondary drainage systems also requires that the structural members of roofs are able to support the load of accumulated rainwater.

For construction in flood zones, Appendix G of the Construction Code establishes regulations that require flood-resistant construction in all new, substantially damaged, or substantially improved buildings pursuant to the latest national standards, meeting or exceeding state and federal flood regulations. In addition, the Construction Code requires critical facilities located in flood zones, such as fire stations and hospitals, be elevated to protect the structures. Local law 990-2012 modified Appendix G of the Construction Code to adopt the Preliminary Flood Insurance Rate Maps as the standard for determining flood risk in advance of the issuance of final maps by FEMA, thus exceeding federal requirements in the interim period. In addition, a new set of zoning regulations was established in 2013 to facilitate reconstruction and retrofitting of existing buildings in flood zones, and to remove obstacles for safer, more resilient new buildings in flood zones.

- **Wind**

The Construction Code updates wind load requirements and brings them in line with current wind-design practices used throughout the United States. It also establishes wind exposure categories that take into account the influence of surrounding ground surface irregularities and building heights in wind design.

- **Winter Storms**

The Construction Code updates snow-load requirements to incorporate thermal factors for heated and unheated buildings, as well as provisions for snowdrifts caused by parapets and adjacent buildings.

#### *iii. Energy Systems*

New York City's energy infrastructure—comprised of electric, natural gas, and steam networks—is one of the oldest and most concentrated in the nation. Yet it is still among the most reliable. Every day, pipelines bring in natural gas from across the country; power lines link the city to the larger regional grid, generators burn gas to produce electricity, steam travels from large boilers and cogeneration facilities to buildings through miles of underground service pipes. On average, New Yorkers spend roughly \$19 billion per year on the energy to power, heat, and cool their city.

#### **a. Electricity**

The electric system consists of three major elements: generation, which produces electricity; transmission, which transports electricity at high voltages to large substations; and distribution, which carries electricity from large substations to smaller ones and ultimately to homes, businesses, and other customers. The city's electrical distribution system is a combination of underground networks and overhead utility lines.

New York City is a "load pocket," which means transmission lines cannot carry enough energy into the city to meet its peak load. Regulations require in-city generation to supply 80% of the forecasted demand. Transmission lines connecting the city to upstate New York, Long Island, and New Jersey import the balance. New York City's transmission and distribution system is unique in that approximately 70% of the 130,000 miles of lines are underground.

The system is owned, operated, and regulated by a wide array of private and public entities. The following parties own and operate nearly all of the in-city generation:

- US Power Generating Company
- NRG Energy
- TransCanada
- New York Power Authority
- Astoria Generating Co (US Power Gen Co)

- Con Edison
- Riverbay Corp
- Calpine
- NextEra Energy Resources
- Brooklyn Navy Yard Cogeneration

The following parties own and operate New York City's electric transmission and distribution system:

- Con Edison (majority of New York City electric customers)
- Long Island Power Authority/National Grid (customers in Rockaway Peninsula, Queens)

#### **b. Natural Gas**

Natural gas is responsible for approximately 65% of heating and a significant percentage of cooking needs in buildings throughout New York City. It also fuels more than 98% of in-city electricity production by power plants.

The route that natural gas takes to reach New York City is complex. A system of four privately owned interstate pipelines transports natural gas from the Gulf Coast, Western Canada, and other production areas into the city at interconnection points called "city gates." From the various city gates, high-pressure gas flows through an intra-city transmission system known as the New York Facilities. Gas that is destined for New York City's power plants generally is drawn at high pressure directly from the New York Facilities. To reach most other customers, gas is delivered through a set of regulator stations that reduce the pressure of the gas and send it into a vast network of underground distribution mains. The low-pressure system is composed of cast-iron and bare-steel mains—outdated infrastructure that gradually is being replaced by the system's operators—and is located mostly in the oldest parts of the city. Newer, high-pressure mains tend to be made of coated steel and plastic.

In New York City, Con Edison owns and operates the gas distribution system in Manhattan, the Bronx, and

parts of Northern Queens. National Grid owns and operates the system in the rest of the city.

#### c. Steam

Con Edison is the only steam operator in New York City and its system in the city is the largest district steam system in the United States. Con Edison provides over 1,700 customers in Manhattan south of 96<sup>th</sup> Street—including 10 hospitals and many of the city's largest institutions—with energy for heat, hot water, and, in some cases, air conditioning. The most concentrated steam distribution centers are located in the Financial District and Midtown Manhattan. For customers, the advantage of the steam system is that it allows them to avoid owning and maintaining their own boiler systems. Instead, these customers are only responsible for maintaining on-site steam traps and condensate pumps.

Con Edison's six natural gas- and fuel oil-fired steam-generating facilities in Manhattan, Brooklyn, and Queens can collectively produce over 10 million pounds of steam per hour, either cogenerating this steam along with electricity, or producing steam alone in massive boilers. A network of 105 miles of underground pipes transports steam to customers.

#### iv. Telecommunication Systems

New York City's telecommunications—made up of services such as internet, information services, phone services, and cable television—is an essential component of the city's basic infrastructure. Telecommunications not only serve New York's population of 8.2 million, but also the city's 3.9 million workers, 250,000 businesses, and more than 50 million annual visitors. The city's telecommunications infrastructure also plays a critical global role: It is estimated that New York City accounts for approximately 3% of the world's web traffic, even though the city is home to only 0.1 percent of its population.

Generally, telecommunications services are provided through physical properties such as wire-line, wireless, satellite, cable, and broadcasting equipment. New York City's telecommunications system is comprised of four main components: critical facilities, cabling, cell sites, and equipment in individual buildings:

- **Critical facilities** are large distribution and switching centers. They provide connectivity across all major services, and each supports tens of thousands of customers.
- **Cabling** provides the connections essential to telecommunications and can be strung overhead via utility poles or run underground. New York's oldest cabling is lead-encased copper, with sections ranging from 10 to 90 years old. 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—which includes parts of all five boroughs. 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.
- **Cell sites** are typically placed on the roofs of buildings and have three components: an antenna, electronics, and backhaul circuits (cables that connect the cell site to the larger telecommunications network).
- **Equipment in homes, offices, and other buildings** distributes signals transmitted via cabling from critical facilities to individual customers.

New York City's telecommunication networks and services are provided, used, protected, and regulated by both private and public sector entities.

All three tiers of government—federal, state, and city—are involved in the regulation of the telecommunications industry. At the federal level, the Federal Communications Commission (FCC) has significant authority over wireless, long-distance phone, and internet services. At the state level, New York State Public Service Commission (PSC) has authority regarding local traditional landline telephone service. At the local level, the Department of Information Technology and Telecommunications (DoITT) is responsible for provid-

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ing IT services, infrastructure, and telecommunications for City agencies and overseeing franchises that permit communication companies to use public rights of way (above and below city streets) to place infrastructure necessary for providing communication services. The Department of Transportation (DOT) 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.

Though federal, state, and city agencies have shared authority in the city's telecommunications sector, none currently has comprehensive responsibility for the entire system, and none is charged with ensuring that required service is available during emergencies. While the FCC has a Communications Security, Reliability, and Interoperability Council that promotes best practices for resiliency, it does not require compliance with these standards. Currently, there is no single entity that is prioritizing or enforcing resiliency across the entire system.

Although New York City's telecommunications systems are generally very reliable, a large volume of traffic is routed through a small number of collocation facilities in Lower Manhattan. This centralization may increase the network's vulnerability.

Multiple companies provide voice, data, and video services (see Table 3.4.20). The primary fixed-line telephone provider in New York City is Verizon, although there are a number of other companies that provide this service to residential and business customers.

**Table 3.4.20: Telecommunications Companies in New York City**

| Major Wireless Carriers | Cable and Internet Providers     |
|-------------------------|----------------------------------|
| AT&T                    | Cablevision                      |
| Sprint/Nextel           | RCN Telecom Services of New York |
| T-Mobile                | Time Warner Cable                |
| Verizon Wireless        | Verizon -FiOS                    |
| Metro-PCS               | Comcast                          |

Telecommunications 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 the city's healthcare system.

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#### v. Transportation Systems

New York City's transportation system is sprawling and complex, comprised of large, interconnected rail, roadway, and air and water networks. All these transportation elements are essential for daily travel and during hazard events.

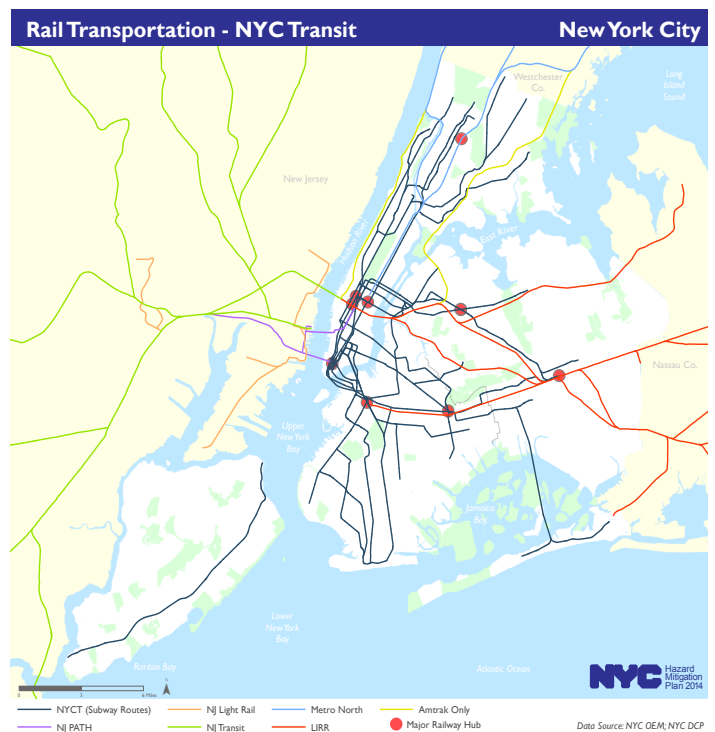
##### a. Rail Network

New York City has one of the most complex rail systems in the country. It is made up of interconnected subway and railroad networks that carry two-thirds of all rail riders in the nation. Approximately 5.3 million daily subway riders and approximately 850,000 daily commuter rail riders commute into and within New York City each day (see Table 3.4.21). The Metropolitan Transportation Authority (MTA), the largest transit authority in the nation, operates the three main rail systems: New York City Transit (NYCT), which operates the subway; Long Island Rail Road (LIRR); and Metro-North Railroad (MNR) (see Figure 3.4.27). In addition, the Port Authority of New York and New Jersey (PANYNJ) provides commuter rail service between New Jersey and New York City on the Port Authority Trans-Hudson (PATH) train. Amtrak's rail system helps connect New York City to other major cities around the nation. Not surprisingly, Penn Station is the busiest station in the Amtrak rail system.

The city's rail transportation is dependent on electricity for power. For example the subway system alone consumes 1.8 billion kilowatt hours each year.

Rail infrastructure is located both underground and above-ground. Due to historical development patterns and operational needs, many parts of the city's rail and

Figure 3.4.27: New York City Rail Network



subway infrastructure are located near the waterfront or in low-lying areas, making them particularly vulnerable to storm and flood risks.

##### b. Roadway Network

The New York City Department of Transportation (DOT), New York State Department of Transportation (NYS DOT), MTA, and PANYNJ manage roadway travel in New York City. The roadway network contains 6,000 miles of streets and 12,000 traffic signals (see Figure 3.4.28). Bridges and tunnels are vital components of roadway transportation, providing inter-borough connections for vehicles and public transit as well as ac-

Table 3.14.21: New York City Rail Ridership (Source: MTA, NJ Transit, and Port Authority 2013)

| Operator                 | Average Daily Ridership | Annual Ridership |
|--------------------------|-------------------------|------------------|
| MTA New York City Subway | 5,380,184               | 1,654,582,265    |
| MTA Long Island Railroad | 285,082                 | 81,753,411       |
| MTA Metro North          | 281,333                 | 82,953,628       |
| NJ Transit Penn Station* | 79,616                  | N/A              |
| PATH - New York          | 105,297                 | 31,634,954       |
| Amtrak Penn Station      | N/A                     | 9,493,414        |

\* Reflects average weekday boarding at Penn Station and ridership information for fiscal year 2012

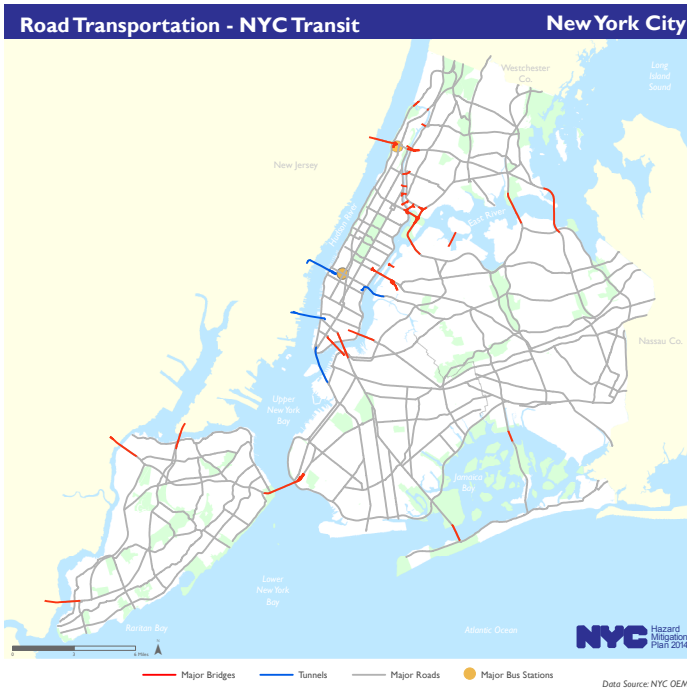


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cess to and from New York City. In total, the city has 2,027 bridges, many of which are over a century old. DOT manages 787 bridge structures including six tunnels. DOT also maintains approximately 5,800 miles of streets, sidewalks, and highways. The MTA operates 304 bus routes throughout the city and oversees seven bridges and two tunnels that service more than 300 million vehicles each year. PANYNJ manages most of the transportation between New York and New Jersey

**Figure 3.4.28: Major Elements of the New York City Road Network**



including four bridges, two tunnels, and two bus terminals. Figure 3.4.28 represents the major roads, bridges, tunnels, and bus stations in New York City.

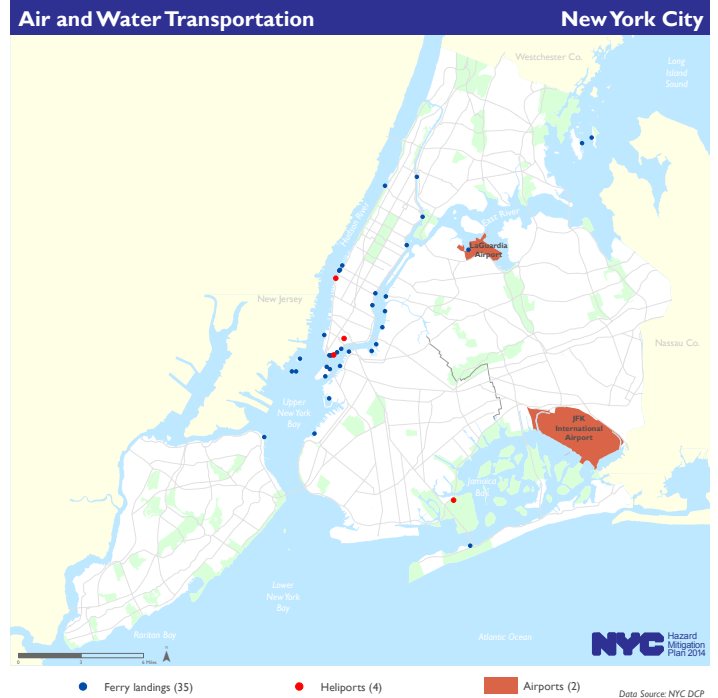
#### c. Air and Maritime Transportation

Airports, port facilities, and ferry landings are located throughout the New York City region (see Figure 3.4.29). New York City has two major airports, LaGuardia Airport (LGA) and John F. Kennedy International Airport (JFK), both in Queens. In 2012, 75 million passengers traveled through these two airports. Newark Liberty Airport, located in New Jersey, also serves the New York City area. PANYNJ operates all three airports in the area.

The Port of New York and New Jersey, managed by PA-

NYNJ and used by private and public operators, is the largest port complex on the East Coast. In 2012, more than 34 million tons of ocean-borne general cargo with an estimated value of \$171 billion moved through the port. There are three passenger cruise terminals in the port—two in New York and the third in New Jersey. In addition, there are more than 50 piers, docks, and ferry terminals that are owned by New York City agencies such as The Department of Parks & Recreation (DPR),

**Figure 3.4.29: Air and Water Transportation Assets in New York City**



DOT, and the New York City Economic Development Corporation (EDC).

Ferries are an increasingly popular mode of transit with the expansion of both private and publicly operated vessels between New Jersey and New York City and within the five boroughs. There are 47 active ferry landings in New York City providing services for the city and region. Ferries are a regular mode of transit for many commuters. The largest commuter ferry is the Staten Island Ferry, which is operated by DOT and carries more than 22 million passengers each year on a 5.2-mile route between Staten Island and Lower Manhattan. This ferry is the only non-vehicular mode of transportation between Staten Island and Manhattan.

*vi. Water Systems***a. Water Supply**

New York City's drinking water is world-renowned for its quality. Each day, more than 1 billion gallons of drinking water is delivered to the taps of the city's 8.2 million residents, approximately one million people living in Westchester, Putnam, Ulster, and Orange counties, as well as the millions of tourists and commuters who visit the city throughout the year. In all, the system supplies nearly half the population of New York State with water.

The Department of Environmental Protection (DEP) manages the City's water supply system and ensures the steady flow of clean drinking water from large upstate watersheds—some more than 125 miles from the city—through a complex network of aqueducts and tunnels to in-city reservoirs (see Figure 3.4.30).

The Croton watershed was the city's first upstate water supply and is located entirely east of the Hudson River in Westchester, Putnam, and Dutchess Counties, with a small portion in Connecticut. The watershed contains 13 reservoirs and three controlled lakes. Historically, 10% of the city's average daily water demand has been provided by the Croton system. As of the writing of this report, the system is offline temporarily while the City constructs a water treatment plant to filter the Croton water. Once completed, Croton water will be filtered and disinfected before flowing into Jerome Park Reservoir in the Bronx.

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

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

Because waters from the Catskill and Delaware watersheds mix at Kensico Reservoir, they are frequently referred to as one system: the Catskill/Delaware system. In 2012, all of the city's drinking water came from the Catskill/Delaware system.

The City designed and built a water supply system that has various interconnections, permitting exchange of water from one to another, to increase flexibility and resiliency.

Water is distributed from these reservoirs to the city through three aqueducts and then delivered to Water Tunnels 1 and 2 that are responsible for bringing water to city residents. Water Tunnel 1, completed in 1917, is 18 miles long and carries between 500 and 600 million gallons of water each day. Water tunnel 2, completed in 1936, is 20 miles long carries between 700 and 800 million gallons of water each day. Both tunnels have been in continuous service since they were originally built. In 1970, the city began construction a third tunnel, which will be completed in 2020, to increase redundancy and enable inspection and repair of Tunnels 1 and 2 as needed.

Additionally, to ensure a redundant and reliable supply of water to Staten Island the city is replacing the two existing water siphons that provide backup water supply for Tunnel 2, with one siphon that will be positioned approximately 50 feet deeper than the existing ones. Positioning the new water siphon at a lower depth will protect it from the New York Harbor deepening project.

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Within the city, 7,000 miles of water mains and pipes distribute water throughout the five boroughs. These mains and pipes are buried and pressurized, which protects them from flooding. Furthermore, there is necessary redundancy built into the system so that water supply can be diverted to different pipes within the system to ensure the constant flow of water.

New York City's water distribution system is almost entirely dependent on gravity, minimizing the need for pumping. Water travels from reservoirs with sufficient pressure to reach up to the sixth floor of most buildings. High-rise buildings rely on rooftop water towers or pump systems to provide water to upper floors.

#### b. Wastewater Treatment

Every day, 1.3 billion gallons of wastewater goes down toilets and drains in homes, schools, businesses, and

factories and then flows into New York City's sewer system. In some New York City neighborhoods, separate storm sewers carry runoff from the streets directly to local streams, rivers, and bays. However, like most old urban centers, the city relies on a combined sewer system—which makes up 60% of the city sewer infrastructure—to collect sanitary and industrial wastewater, rainwater, and street runoff together and convey all of it to wastewater treatment plants. While sanitary waste enters the sewer system through direct connections from buildings, stormwater enters the system from catch basins that direct flow to the city's sewer system.

All of the city's 14 wastewater treatment plants are located along the waterfront at relatively low elevations (see Figure 3.4.31). Waterfront locations significantly reduce the cost and environmental impact of treating wastewater in New York City, making it easier for flow to arrive by gravity and treated effluent to be discharged into waterways (though in low-lying areas the city has 96 pumping stations that lift wastewater and stormwater to a higher elevation and help it continue on its journey). Secondly, but also importantly, the waterfront locations allow sludge to be transported efficiently by boat to DEP facilities for additional treatment.

New York City's wastewater treatment plants remove most pollutants from wastewater before releasing it to local waterways. At the plants, physical and biological processes closely duplicate how wetlands, rivers, streams, and lakes naturally purify water. Treatment at these plants is quick, taking only about seven hours to complete, whereas in the natural environment this process could take many weeks (and, at any rate, nature alone cannot handle the volume of wastewater New York City produces).

Under normal conditions, the system is adequate to perform full treatment on the combined volume of sewage and stormwater. During periods of heavy rain or snow, however, when flow exceeds two times dry-weather capacity, the volume of sewage and stormwater can quickly exceed the capacity of the wastewater treatment plants. When this occurs, the mix of excess stormwater and untreated sewage flows directly into the city's waterways in what is called "combined

Figure 3.4.30: New York City's Water Supply System



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sewer overflow" (CSO) events.

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

The City's Bluebelt program complements its Green Infrastructure program. Bluebelts are natural areas that often enhance existing drainage corridors (such as streams, ponds, and other wetland areas) and convey, treat, and retain stormwater in place of traditional "grey" infrastructure. Bluebelts engineer these natural features to slow the flow of water and use vegetation and other elements to absorb and filter impurities. The Bluebelt program started in Staten Island, where there

are now almost 10,000 acres in place, and is expanding in Staten Island and into other parts of the city, including southeastern Queens.

**Figure 3.4.31: Wastewater Treatment Plants in New York City**



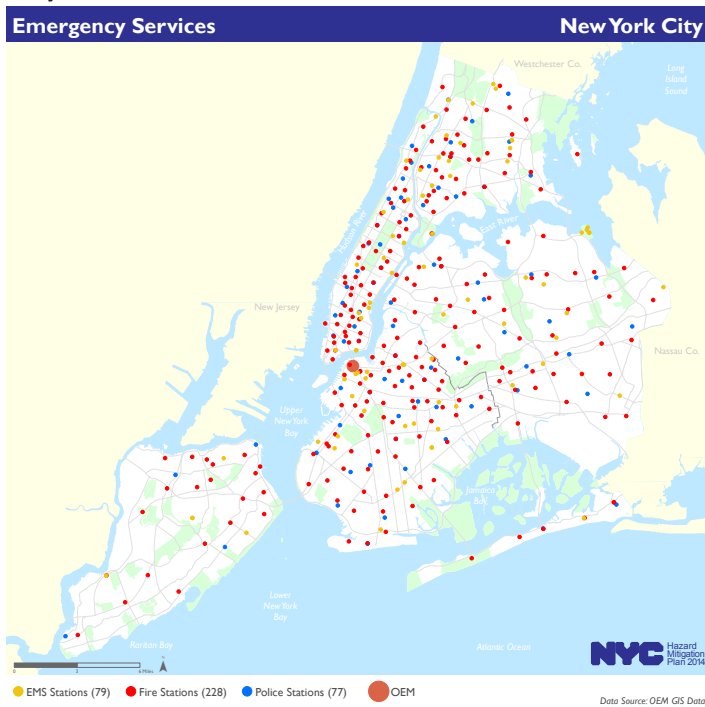
## 4. NEW YORK CITY'S HAZARD ENVIRONMENT

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#### vii. Emergency Facilities

New York City's emergency services include the Police Department (NYPD), Fire Department (FDNY), Fire Department Emergency Medical Services (FDNY-EMS), and the Office of Emergency Management (OEM). A number of other City agencies—including DOHMH, DEP, and DOB—also have emergency-response functions. Emergency services are generally well dispersed across the city and correlate with population density. Figure 3.4.32 shows the locations of police and fire stations as well as OEM's headquarters.

**Figure 3.4.32: Emergency Service Providers in New York City**



#### viii. Healthcare Facilities

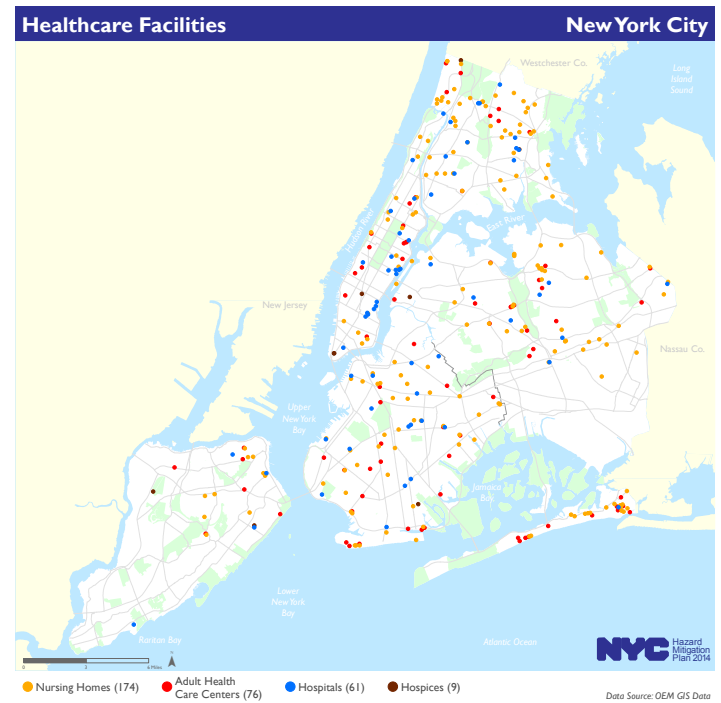
New York City has one of the greatest concentrations of healthcare facilities in the country. There are 61 hospitals, 174 nursing homes, 76 adult day care centers, and nine hospices citywide (see Figure 3.4.33). Additionally, 1,400 residential-based providers care for more than 80,000 patients at any given time. Included in this category are nursing homes and other residential providers offering treatment, care, and supportive housing for individuals with substance abuse problems, developmental disabilities, or other behavioral or mental health challenges.

Community-based providers deliver the healthcare services that keep most New Yorkers well on a day-to-day basis. In the majority of cases, these providers are the ones with which patients interact most frequently. These providers offer services from over 10,000 buildings across the five boroughs. During and after emergencies, health care facilities function as the city's most critical assets.

#### ix. Educational Institutions

New York City has 2,753 educational facilities. As Figure 3.4.34 through Figure 3.4.36 show, there are 102

**Figure 3.4.33: Healthcare Facilities in New York City**



colleges, 848 private schools, and 1,803 public schools. According to the 2011 ACS, approximately, 40% of all New York City households have children enrolled in elementary school (grades 1 to 8) and 20% have children in high school (grades 9 to 12). In New York City, public school facilities not only educate, they also have a public safety function, serving as emergency shelters during hazard events.

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Figure 3.4.34: Colleges in New York City

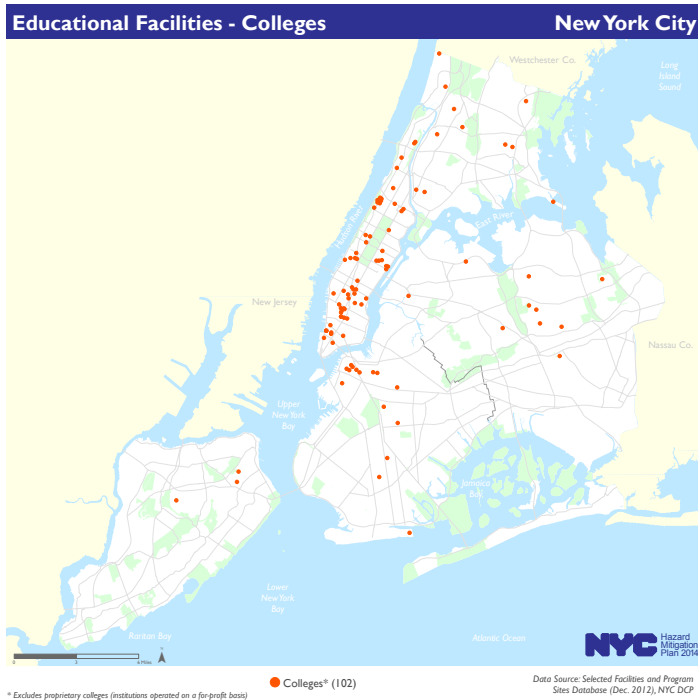


Figure 3.4.35: Private Schools in New York City

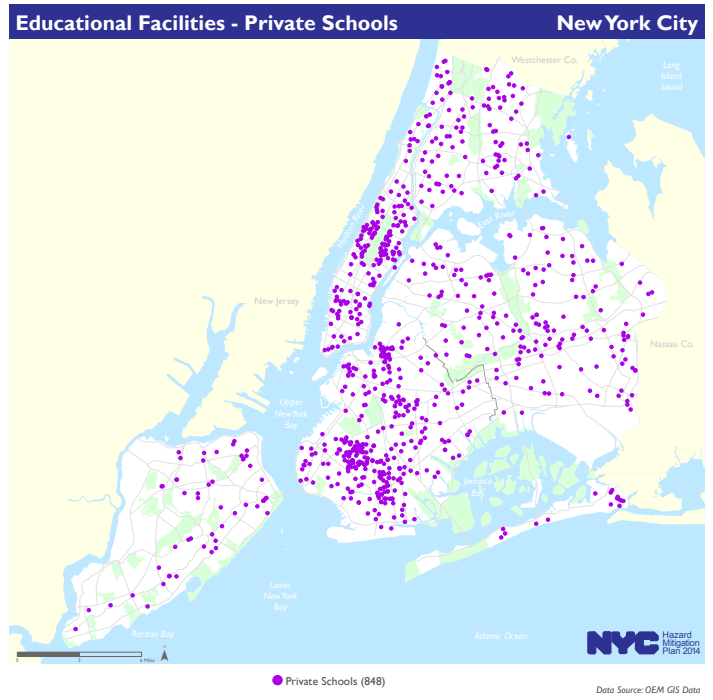
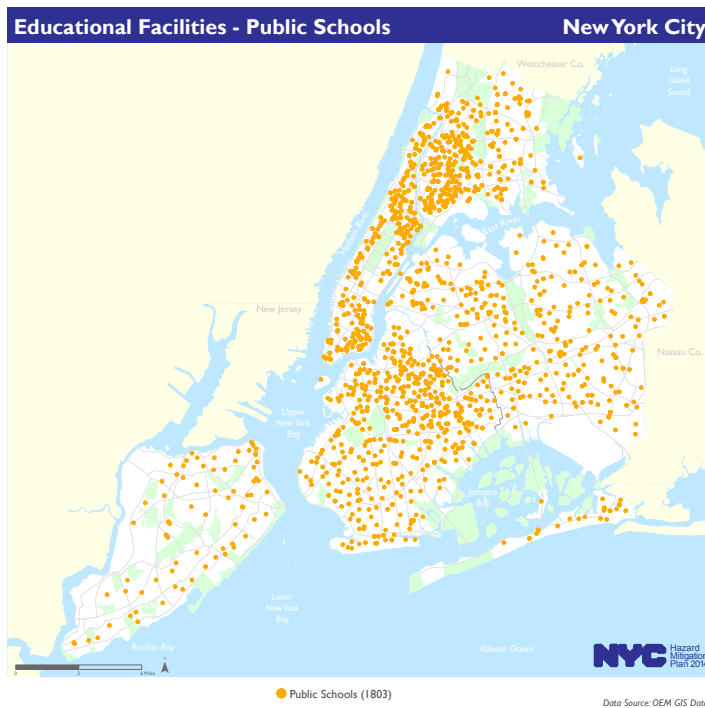


Figure 3.4.36: Public Schools in New York City



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#### x. Cultural Facilities

New York City has one of the greatest concentrations of cultural institutions in the world. The map below (Figure 3.4.37) displays some of New York City's most visited museums, zoos, stadiums, iconic buildings, theaters, and concert halls.

**Figure 3.4.37: Major Cultural Facilities in New York City**



**D. The Future Environment**

New York City's future environment will be affected by climate change, population growth, and land-use development trends.

**1. Impact of Climate Change**

Today and in the future, climate change poses significant risks to New York City. People, homes, businesses, streets, power plants, and other assets are vulnerable to a range of climate hazards, including heat waves, torrential downpours, high winds, and more frequent and severe snow storms and storm surges. Hurricane Sandy was a reminder of the tragic impact weather extremes can have. While it is not possible to attribute any single extreme event such as Sandy to climate

Drawing on the latest climate models, recent observations about climate trends, and new information about greenhouse gas emissions, the NPCC produced [Climate Risk Information 2013](#) (see end of section 4 for website link) for sea level rise, heat waves, and precipitation, summarized below.

*Sea Level Rise*

New York City's sea levels are rising, and, according to the NPCC, this trend is expected to continue in the coming decades (see Table 3.4.22). Middle-range projections for the 2020s indicate a 4- to 8-inch rise in sea levels, while high-end sea level rise projections show sea levels rising as much as 11 inches. By mid-century, sea levels could rise as much as 2.5 feet (31 inches), especially if the polar ice sheets melt at a more rap-

**Table 3.4.22: NPCC Sea Level Rise Projections 2013**

| Sea Level Rise |          | 2020s   |   | 2050s   |   |
|----------------|----------|---|---|---|---|
|                |          | Middle Range<br>(25 <sup>th</sup> -75 <sup>th</sup> percentile) | High End<br>(90 <sup>th</sup> percentile) | Middle Range<br>(25 <sup>th</sup> -75 <sup>th</sup> percentile) | High End<br>(90 <sup>th</sup> percentile) |
|                | Baseline |   |   |   |   |
|                | 0        | +4 to 8 inches  | +11 inches                                | +11 to 24 inches  | +31 inches                                |

change, it is undeniable that sea level rise already occurring in the New York City area, in part related to climate change, increased the extent and magnitude of flooding from the storm.

In 2008, to help respond to climate change in New York City and accomplish the goals outlined in PlaNYC, the City's long-term sustainability plan, the City convened the New York City Panel on Climate Change (NPCC). This body of leading climate and social scientists and risk management experts was charged with advising the Mayor and the New York City Climate Change Adaptation Task Force on issues related to climate change and adaptation. In 2009 the NPCC produced a ground-breaking set of climate projections specific to New York City.

In January 2013, the City reconvened the NPCC on an emergency basis to update its projections to inform planning for rebuilding and resiliency after Sandy.

id rate than previously anticipated. That magnitude of sea level rise would threaten low-lying communities in New York City with regular and highly disruptive tidal flooding, and make flooding as severe as from today's 100-year storm at the Battery up to five times more likely. For example, by the 2020s, 6,600 acres (27%) of the city's parkland could lie in the 100-year floodplain, increasing to over 7,400 acres (or 31%) by the 2050s.

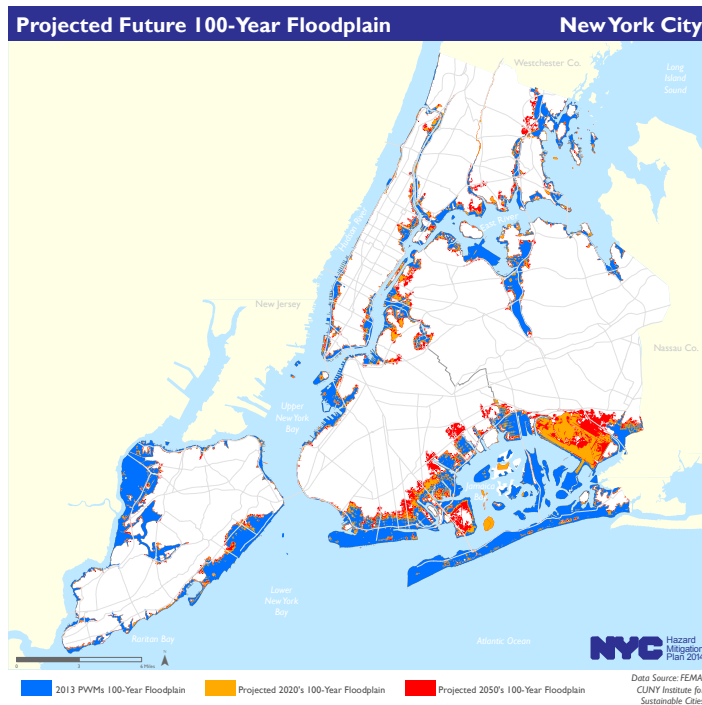
FEMA's Flood Insurance Rate Maps (FIRMs) show flood-prone land areas called floodplains, geographic areas classified according to levels of flood risk and/or type of flooding. Coastal flooding (areas near the coast at risk to flood) and riverine flooding (areas near streams and rivers at risk to flood) are the most common types of flooding in New York. The 100-year floodplain on FIRMS is the area where there is a 1% or greater chance of a flood—the so-called 100-year flood—in any given year. This is also referred to as the Special Flood Hazard Area (SFHA). Structures located



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**Figure 3.4.38: Future Flood Maps for the 2020s and 2050s**



within this area are required to carry flood insurance if they have a federally backed mortgage. The 500-year floodplain is the area with a 0.2% or greater chance of flooding in any given year.

#### *Future Flood Maps*

The City worked with the NPCC to develop a series of "future flood maps" for New York City that will help guide the city's resiliency and mitigation efforts (see Figure 3.4.38). These forward-looking maps are created by using a simplified bathtub model approach of combining the NPCC's "high end" sea level rise projections with FEMA's FIRMs. The future flood maps illustrate how the 100-year floodplain could increase over the next several decades with high-end projections for sea level rise. Because these maps were not developed using advanced coastal modeling, the accuracy of the flood projections is limited. The maps are not suitable for evaluating risks to individual properties, but they are extremely useful for understanding the general extent of future flood risks.

The future flood maps show that by the 2020s, the area that could be flooded in a 100-year storm could expand to 59 square miles (up 23% from the Prelim-

**Table 3.4.23: NPCC Projections for Heat Waves and Cold Events 2013**

| Heat Waves and Cold Events               | Baseline<br>(1971-2000) | 2020s  |  | 2050s  |  |
|--|-------------------------|--|--|--|--|
|  |                         | Middle Range<br>(25 <sup>th</sup> -75 <sup>th</sup> per-<br>centage) | High End<br>(90 <sup>th</sup> per-<br>centage) | Middle Range<br>(25 <sup>th</sup> -75 <sup>th</sup> per-<br>centage) | High End<br>(90 <sup>th</sup> per-<br>centage) |
| Number of days per year at or above 90°F | 18                      | 26 to 31   | 33   | 39 to 52   | 57   |
| Number of heat waves per year            | 2                       | 3 to 4   | 4  | 5 to 7   | 7  |
| Average duration (days)                  | 4                       | 5  | 5  | 5 to 6   | 6  |
| Number of days below 32°F                | 72                      | 52 to 58   | 60   | 42 to 48   | 52   |

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inary FIRMs) and encompass approximately 88,000 buildings (up 31%). By the 2050s, with more than 2.5 feet of sea level rise, New York City's 100-year floodplain could be 72 square miles—a staggering 24% or nearly a quarter of the city—an area that today contains approximately 114,000 buildings (almost twice as many as on the Preliminary FIRMs). This area currently accounts for 97% of the city's power generation capacity, 20% of its hospital beds, and a large share of its public housing. Over 800,000 New Yorkers, or 10% of the city's current population, now live in the 100-year floodplain projected for the 2050s—a number of flood-vulnerable residents that is greater than the total number of people living in the entire city of Boston.

#### Heat Waves

Meanwhile, the NPCC predicts that by the 2050s the city could have as many days at or above 90 degrees annually as Birmingham, Alabama, has today—a three-fold increase over what New York currently experiences. Heat waves—three or more consecutive days of daily high temperatures at or above 90 degrees—could more than triple in frequency, lasting on average one and a half times longer than they do today (see Table 3.4.23).

#### Precipitation

The NPCC projects that total annual precipitation will

increase slightly in the coming decades (up to 10% by the 2020s and up to 15% by mid-century). It is very likely (more than 90% probable) that the New York City area will see an increase in heavy downpours by mid-century, according to the NPCC (see Table 3.4.24).

#### 2. Population Projections

New York City has a dynamic population, with several hundred thousand people coming and going each year. Beginning with the 1990 Census, there has been a net increase in population for every decennial Census (see Figure 3.4.39). This pattern is anticipated to continue well into the future based on the latest projections released by New York City Department of City Planning (see Figure 3.4.40 and Figure 3.4.41). By 2040, it is projected that New York City's population will increase by almost 10% and surpass 9 million for the first time in history. The Boroughs of the Bronx, Brooklyn, Queens, and Staten Island are anticipated to be home to more residents than at any point in their respective histories. Only Manhattan's estimated population is not expected to surpass its historical high which was established in 1910. The population increase is not expected to be distributed equally throughout the five boroughs. Approximately 62% of the total net increase in population is expected to take place in the boroughs of Brooklyn and the Bronx, while Staten Island will have the lowest share at four percent.

**Table 3.4.24: NPCC Projections for Precipitation and Intense Precipitation 2013**

|                       |  | Baseline<br>(1971 – 2000) | 2020s   |   | 2050s   |   |
|-----------------------|--|---------------------------|---|---|---|---|
|                       |  |                           | Middle Range<br>(25 <sup>th</sup> -75 <sup>th</sup> percentage) | High End<br>(90 <sup>th</sup> percentile) | Middle Range<br>(25 <sup>th</sup> -75 <sup>th</sup> percentage) | High End<br>(90 <sup>th</sup> percentage) |
| Precipitation         |  | 50.1 inches               | +0 to 10%   | +10%                                      | +5 to 10%   | +15%                                      |
| Intense Precipitation | Days per year with rainfall exceeding 2 inches | 3                         | 3 to 4  | 5   | 4   | 5   |

Figure 3.4.39: Percent Change in Population per Census Tract 2000 to 2010

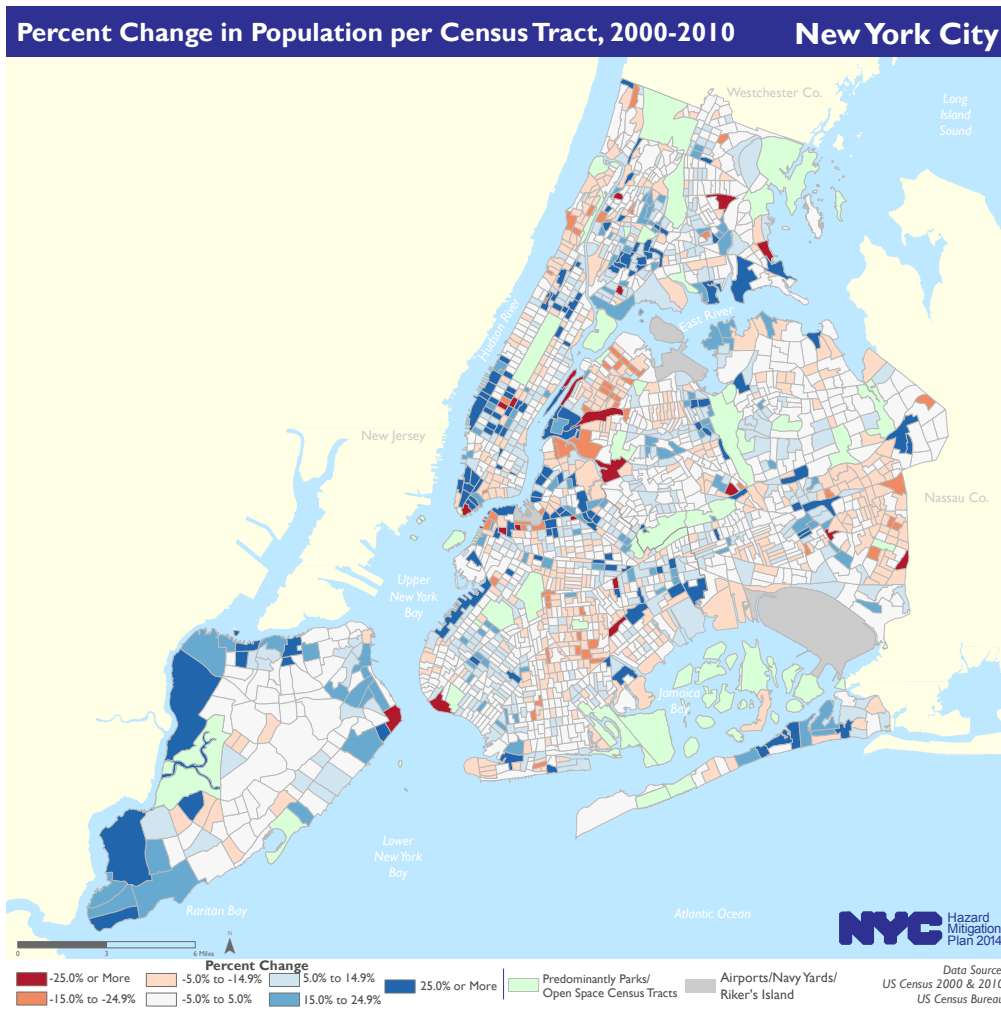
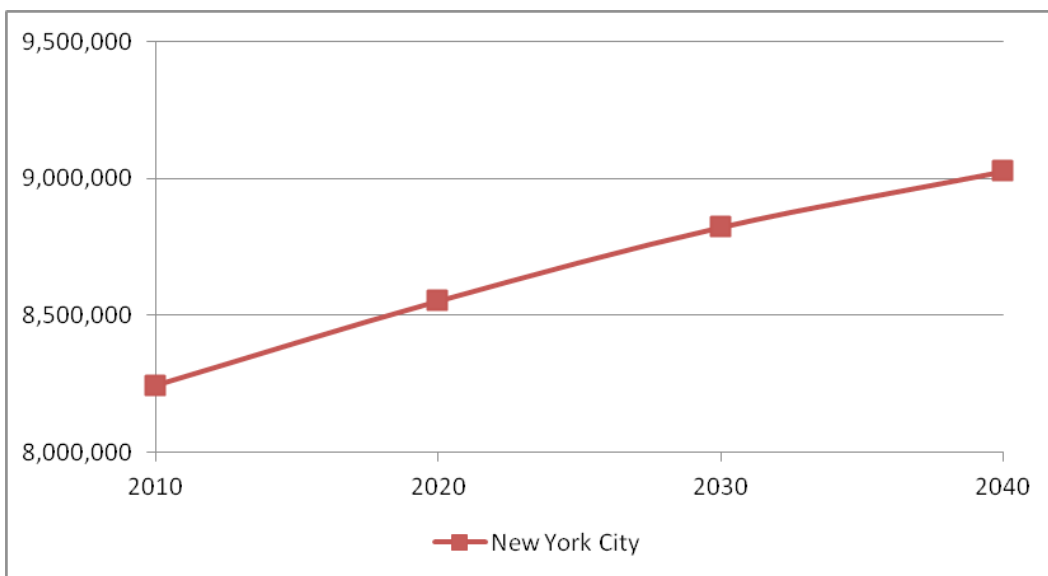


Figure 3.4.40: New York City Population, 2010-2040



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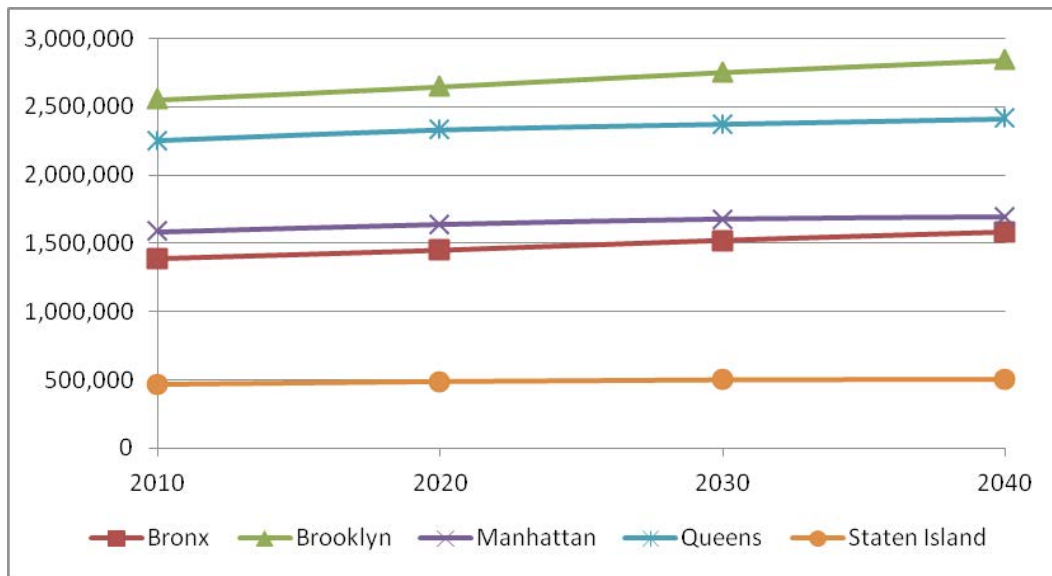
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By 2040, the age composition of New York City will be different than it has been in recent history. The most dramatic change is projected to take place amongst the population that will be 65 years or older. Between now and 2040, this age group will increase by approximately 40%. This is mainly due to the aging of the large baby boomer cohort, who will all be at least 75 years by this date, as well as an expected lower fertility rate and improvements in life expectancy. Currently, this age group makes up approximately 12 percent of New York City's population. In 2040, it is expected to in-

crease to over 15%. Between 2010 and 2040, residents who are 65 and older in Staten Island will increase by 65%, which is the largest percentage increase in the five boroughs. By 2040, nearly 20% of the population in Staten Island will be 65 or older. This figure today stands at slightly less than 13% (see Figure 3.4.42).

Overall, the school-age population (ages 5-7) of New York City is projected to increase by approximately six percent by 2040. However, given the general increase in population, the share of school-age

**Figure 3.4.41: New York City Population by Borough, 2010-2040**



**Figure 3.4.42: New York City 65 and Over Population by Borough, 2010-2040**

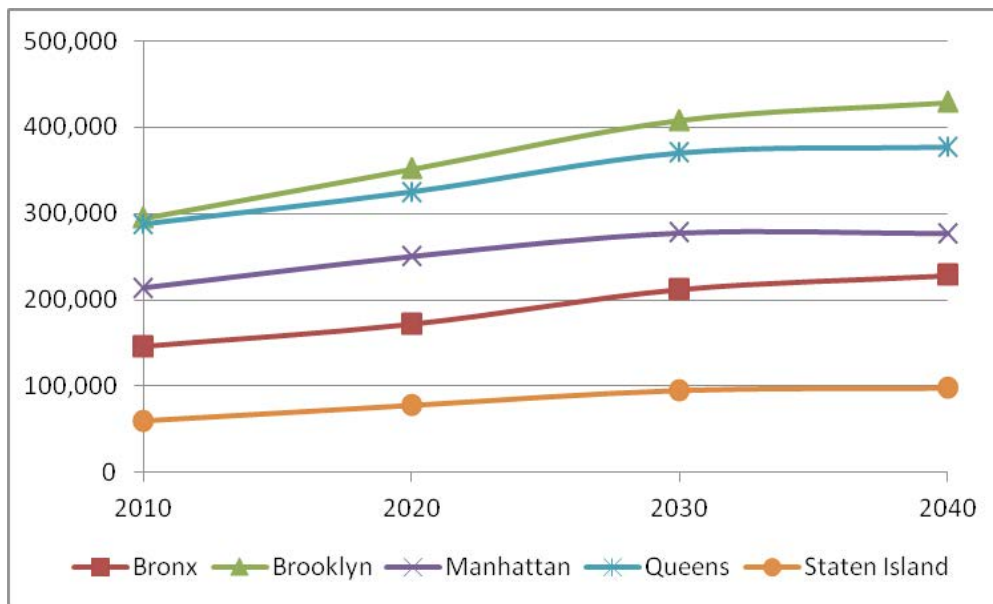
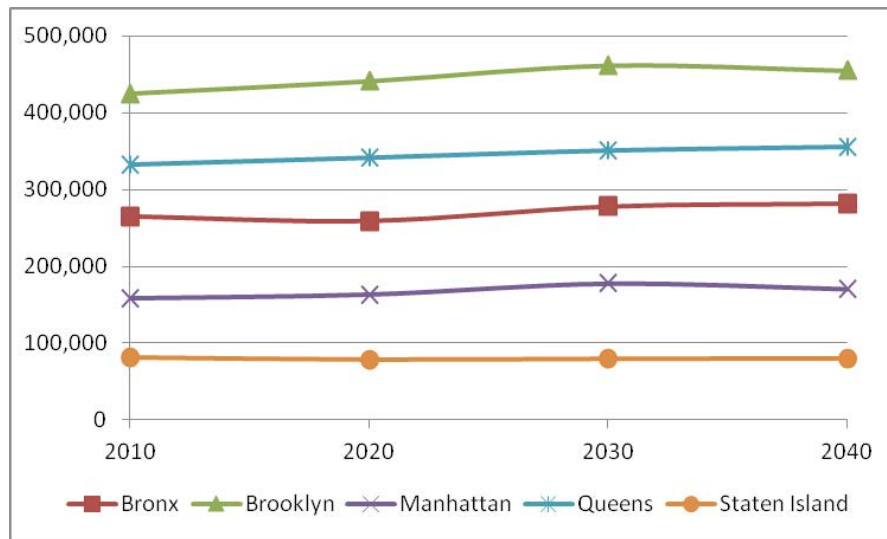


Figure 3.4.43: New York City School-Age Population (ages 5 to 17) by Borough, 2010-2040



population in New York City will slightly decrease by 2040. At the borough level, the share of this age group in the Bronx, Brooklyn, and Staten Island is expected to decline, while Queens and Manhattan will remain largely unchanged (see Figure 3.4.43).

3. Development Trends

New York City's land use and development trends are influenced by changes in the economy and the population, as well as the changing climate, and are guided by strategic planning initiatives designed to accommodate future growth and climate change challenges.

In the decades to come, New York City will be home to approximately nine million residents. To accommodate anticipated growth while addressing both the causes and implications of climate change, the City in 2007 released *A Greener, Greater New York*. The report launched a long-term strategy, known as PlaNYC, for how the City will address the physical challenges of population growth, aging infrastructure, and climate change.

PlaNYC contains over 100 initiatives designed to achieve sustainability goals for areas including land, water, transportation, energy, and air quality. With regard to land use planning and development, PlaNYC aims to guide housing and commercial development to transit-accessible areas; discourage further

development of areas with limited transit access; redevelop vacant, underutilized, and brownfield sites; and preserve and create affordable housing.

Since the 2009 HMP, the City has continued to further these development goals and through more than 120 area-wide and targeted rezonings spanning almost 40% of the city's landmass, excluding parks and open space.

In neighborhoods well-served by transit, balanced rezonings tailored zoning regulations to protect and preserve existing character of neighborhoods while allowing for growth opportunities along major transit corridors (see Figure 3.4.44). Since the issuance of PlaNYC, over 87% of all new units constructed were located within a half-mile of transit and, as of 2013, rezoning initiatives have produced 27,000 new housing units. These contextual rezonings included neighborhoods such as the East Village, Lower East Side, and East Harlem in Manhattan; Bedford Stuyvesant, Flatbush, and Park Slope in Brooklyn; Morris Park, Williamsbridge, and Baychester in the Bronx; Astoria, Sunnyside/Woodside, and Maspeth in Queens; and St. George and Stapleton in Staten Island.

In more auto-dependent neighborhoods distant from transit, rezoning initiatives limited the potential for growth while promoting contextually appropriate buildings in neighborhoods including eastern Queens, South-

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ern Brooklyn, northern Bronx, and much of Staten Island.

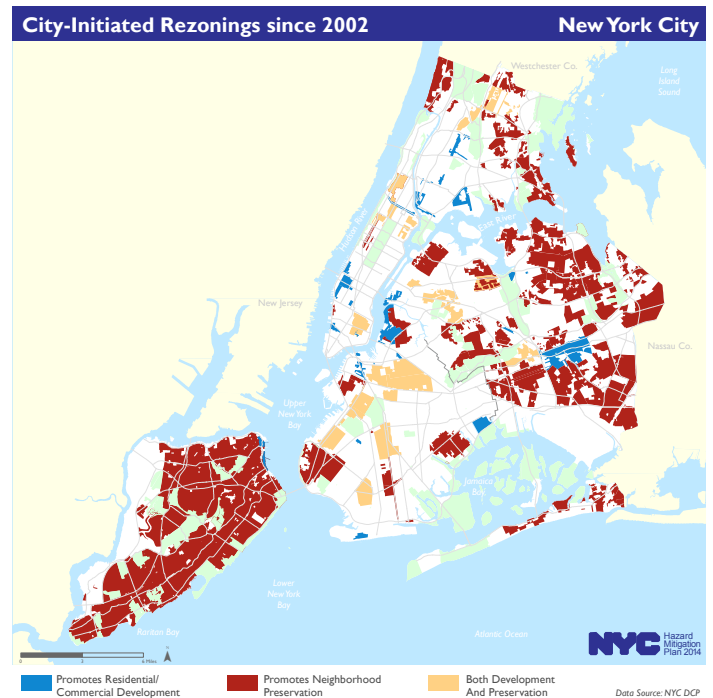
Other land use and development plans were targeted on the creation and enhancement of central and regional business districts near transit throughout the five boroughs, and encouraging mixed-use development there. These plans include Hudson Yards and Harlem's 125th Street in Manhattan, Downtown Brooklyn and Greenpoint-Williamsburg in Brooklyn, Jamaica and Long Island City in Queens, and the Lower Concourse in the South Bronx. Early results of these plans have transformed vacant and underutilized land areas into vibrant, mixed-use neighborhoods.

The recent revitalizations along the waterfront are part of a longer history of waterfront planning in New York City. Since the early 1990s, New York City's waterfront areas, notably in Manhattan and western Queens and Brooklyn, have been of particular strategic importance for the City's development vision. Rezoning in Greenpoint-Williamsburg, Long Island City/Hunter's Point, and Coney Island, for instance, have created opportunities for new housing, retail, and publicly accessible parks and open space on waterfront property, helping the city accommodate growth, create economic opportunities, and improve quality of life for visitors and residents alike.

With 520 miles of coastline, bordering the ocean, as well as rivers, inlets and bays, it is no surprise that the City's waterfront is among its greatest assets.

Many of PlaNYC initiatives have helped to enliven the waterfront by opening up access to miles of the shoreline that had been closed off to the public for decades, building new waterfront parks in all five boroughs and cleaning the City's waterways after years of decline and disuse. These strategies have enabled redevelopment to take place along the waterfront, creating much needed employment and housing opportunities for the City. Yet, waterfront neighborhoods face risks from coastal hazards today. With anticipated sea level rise and greater frequency of the most intense coastal storms, these risks are likely to in-

Figure 3.4.44: City-Initiated Rezoning since 2002



crease in the future. For further information regarding the vulnerability of coastal development please see the vulnerability assessment sections of the following risk profiles: coastal erosion, coastal storms, and flooding.

The City has taken steps to reduce climate change risks and initiated numerous projects and initiatives to increase the resilience of the city's built environment, infrastructure and natural resources, particularly along the waterfront.

In June 2013, following Hurricane Sandy, the City's Special Initiative for Rebuilding and Resiliency report, *A Stronger, More Resilient New York*, made a series of recommendations to enhance coastal protection by increasing coastal edge elevations, protecting against storm surge, and improving coastal design and governance. The *Stronger, More Resilient* report drew upon the work carried out by the Department of City Planning's own coastal vulnerabilities and resiliency measures which was contained in *Urban Waterfront Adaptive Strategies* (UWAS) study, also released in 2013.

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The *Stronger, More Resilient New York* and *UWAS* build on the accomplishments of 2011 *Vision 2020 New York City Comprehensive Plan*, the City's blueprint for revitalization of the waterfront. Crafted in collaboration with the City, state and federal agencies as well as non-governmental advisory groups and members of the general public, *Vision 2020* puts forth broad strategies and hundreds of specific recommendations for improving the waterfront and waterways both at the citywide and neighborhood scale. These strategies ensure the integration of public access in new commercial and residential developments, while simultaneously addressing the challenges of climate change and sea level rise.

These recent studies build on a strong tradition of waterfront planning in New York City. The first comprehensive waterfront plan, released in 1992, proposed ways to reclaim the shoreline for public access and productive uses. The 1992 Comprehensive Waterfront Plan built on the successful examples that existed at the time, including: Battery Park City, Roosevelt Island, and Pier 17 at the South Street Seaport. The 1992 plan proposed many important projects and recommended regulatory changes that have provided a foundation for contemporary waterfront planning and policies and laid the groundwork for the City's Waterfront Revitalization Program (WRP).

The WRP is the city's formal statement of policies for balancing economic development, natural resource protection, and public access on the shoreline. When a proposed project in a coastal zone requires a local, state, or federal discretionary action, a determination of the project's consistency with the policies and intent of the WRP must be made before the project can move forward. Revisions to the WRP in 2013 require proposed projects to analyze the risks associated with climate change and sea level rise and encourage applicants to minimize these risks through strategies that will enhance their ability to withstand and quickly recover from storm-related events.

The most recent example of resilient waterfront planning policy followed Hurricane Sandy, when the City adopted the Flood Resiliency Zoning Text

Amendment to increase the city's resilience to climate-related events including coastal flooding and storm surge. The zoning text amendment encourages flood-resilient building construction throughout designated flood zones by enabling new and existing buildings to comply with new, higher flood elevations issued by the Federal Emergency Management Agency (FEMA) as well as new requirements in the New York City Building Code. Building to these new standards will reduce vulnerability to future floods as well as help avoid higher flood insurance premiums.

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## 5. COASTAL EROSION

### CHAPTER 3: RISK ASSESSMENT



#### 5. Coastal Erosion

##### A. Hazard Profile

###### i. Hazard Description

Coastal erosion is the loss or displacement of land along the coastline resulting from beach-ocean interaction often coupled with human activity.

In its natural state, the coastal system is in dynamic equilibrium. Sand and sediment are moved from one location to another, driven primarily by wind, waves, long shore currents, tides, runoff of surface waters, or groundwater seepage. However, the sand and sediment do not leave the system altogether unless human activities, such as dredging, permanently remove them from a particular location. Coastal storms may take away significant amounts of sand, creating steep, narrow beaches. As long as sand is not removed from the entire system during storms, waves will return the sand during calmer periods, widening beaches and creating gentle slopes.

The removal and deposition of sand changes beach shape and structure. Sand may be transported to land-side dunes, deep ocean trenches, other beaches, and deep ocean bottoms.

Human activity may worsen coastal erosion through poor land use methods. Building without considering the impact on erosion or without an understanding of the changed hydrodynamics may increase erosion or shift it to adjacent areas. In many cases, ill-conceived coastal erosion control structures, built with the intention of *preventing* erosion in one location, may actually *increase* erosion in adjacent locations.

Coastal erosion poses many challenges to coastal communities when valuable property is lost to this dynamic process. Beach erosion control and restoration are thus leading concerns in coastal communities.

###### ii. Severity

Coastal erosion can be gradual or occur rapidly—as it does during storms, for instance. During storms, erosion can be severe, and during the most intense storms entire beaches may be lost while other portions of the

shoreline may become unstable and collapse into the waterways.

Long-term erosion is often difficult to measure since it can vary significantly from year to year. Human activities, such as dredging and beach nourishment projects, also make it difficult to determine how much beach is being lost through natural processes.

Geologists measure erosion in two ways: as a rate of linear retreat (feet of shoreline recession per year) or volumetric loss (cubic yards of eroded sediment per linear foot of shoreline frontage per year). According to the Evaluation of Erosion Hazards study conducted by the Heinz Center (2000), the average annual erosion rate on the Atlantic coast is roughly two to three feet per year. Along New York City's coastline, erosion rates vary significantly depending on location (see Location, below).

###### iii. Probability

Long-term shoreline change is a continuous process and therefore 100% certain for the locations in New York City described below. The probability of rapid erosion events will vary based on a number of factors including the recurrence intervals for coastal storms (see section 6. Coastal Storms).

###### iv. Location

Areas along the city's southern shore are most at risk of coastal erosion. These areas are exposed to the effects of wave action from the Atlantic Ocean as well as from the waters of Lower New York, Gravesend, Raritan, and Jamaica Bays. Some of the highest erosion rates have been observed near stabilized inlets and hardened structures, which disrupt the natural movement of sand. Because so many factors are involved in coastal erosion—including seasonal fluctuations and human activity—sand movement will not be consistent year after year in the same location, or between nearby locations.

To protect against the effects of coastal erosion, the New York State Department of Environmental Conservation (NYS DEC) has developed the Coastal Erosion Hazard Area (CEHA) permit program. This program identifies coastal locations that are particularly vulner-

## 5. COASTAL EROSION

### CHAPTER 3: RISK ASSESSMENT

able to erosion and provides written approval of regulated activities or land disturbance to properties within these areas.

NYS DEC has identified three distinct CEHAs for New York City:

- Coney Island, Brooklyn
- Rockaway Peninsula, Queens
- South shore, Staten Island

Approximately 1,428 acres are located within these three CEHAs, representing 0.7% of New York City's land area.

Within the CEHAs, NYS DEC manages and regulates the following:

- Natural Protective Feature Areas (NPFAs), such as the near shore, beaches, bluffs, primary dunes, and secondary dunes. NPFAs protect natural habitats, infrastructure, and built structures from wind and water erosion and storm-induced high water.
- Structural Hazard Areas (SHAs), which are areas landward of the NPFAs that have demonstrated a long-term average recession rate of one foot or greater per year.

The United States Army Corps of Engineers (USACE) monitors coastal erosion rates for each of the CEHAs in New York City. The most recent values that New York City has for coastal erosion were obtained from USACE and measured between 1966 and 1988. During this period, erosion rates along the western Rockaway Peninsula were around two feet per year, while erosion rates along the eastern Rockaway Peninsula were closer to five feet per year. Along the ocean shore of Coney Island, the erosion rate was measured at 1.3 feet per year, although historically the rate was higher (2.5 feet per year between 1836 and 1966). The shoreline is generally stable along the South shore of Staten Island, with several exceptions, including Oakwood Beach and Annandale, which are eroding faster than the citywide average. As Figure 3.5.45: Shoreline Change for Annandale, Staten Island, 1924 to 2012 (Source: DoITT, OEM

GIS), below, shows, parts of the Annandale shoreline retreated as much as 125 feet between 1924 and 2012.

CEHA maps depict regulated areas, including the landward limit of the NPFAs and SHAs, and indicate the recession rate in feet per year, where applicable. The maps now available were last updated in 1988, although they are currently being evaluated and revised to reflect changes in NPFA and SHA boundaries and in natural protective features. The map updates also require a comparison of historical imagery to more recent imagery to determine long-term shoreline recession rates.

CEHA maps for New York City were obtained from NYS DEC's Coastal Erosion Management Unit on January 14, 2008. The maps are dated 1988, with legend updates in 1991. CEHA maps were available only in hard-copy format. For the purposes of this plan, CEHAs were translated from the hard-copy format into GIS format to enable more efficient viewing, sharing, and estimation of assets within the CEHA (see Figure 3.5.46, Figure 3.5.47, and Figure 3.5.48). This was not a formal translation of the hard-copy data into GIS format, and the resulting images are for analysis purposes only and do not serve as official digital representations of the CEHA boundaries in New York City. On the CEHA maps presented here, the CEHA boundaries were drawn at the location of NPFAs. The maps do not designate SHAs.

#### v. Historic Occurrences

Coastal erosion is an ongoing natural process frequently exacerbated by human activity. However, large-scale erosion events can be caused by significant coastal storms, such as nor'easters or hurricanes (see section 6. Coastal Storms).

### B. Vulnerability Assessment

#### i. Social Environment

Since coastal erosion is a gradual process, it typically does not pose an immediate risk to human life, safety, or well-being. Special needs populations are not necessarily at an increased risk from coastal erosion.

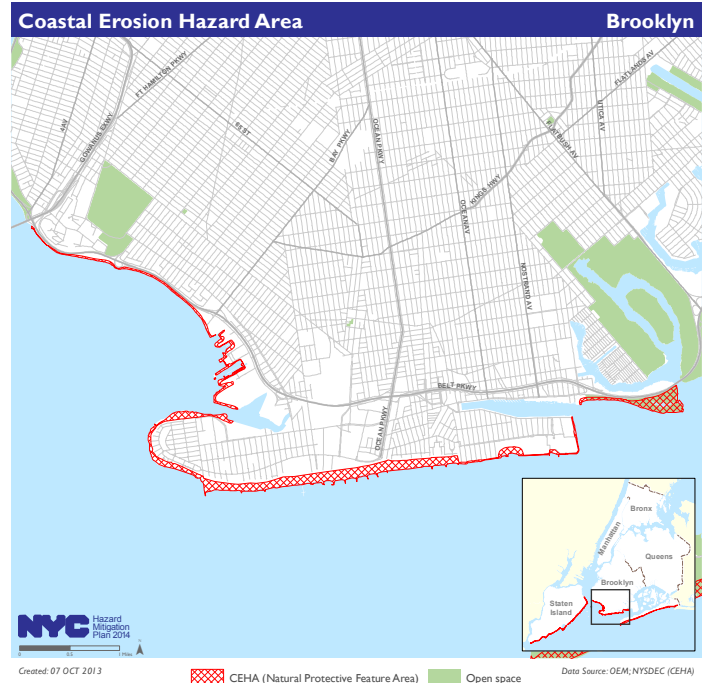
## 5. COASTAL EROSION

### CHAPTER 3: RISK ASSESSMENT

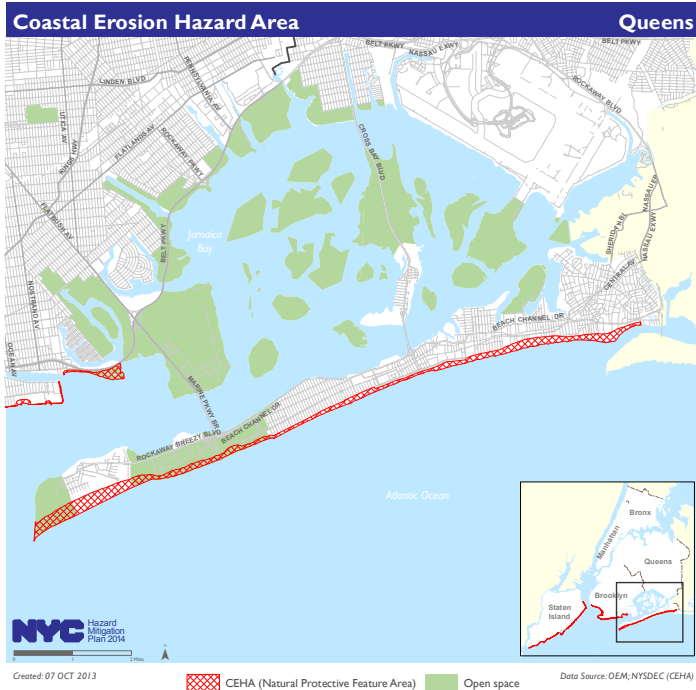
**Figure 3.5.45: Shoreline Change for Annandale, Staten Island, 1924 to 2012 (Source: DoITT, OEM GIS)**



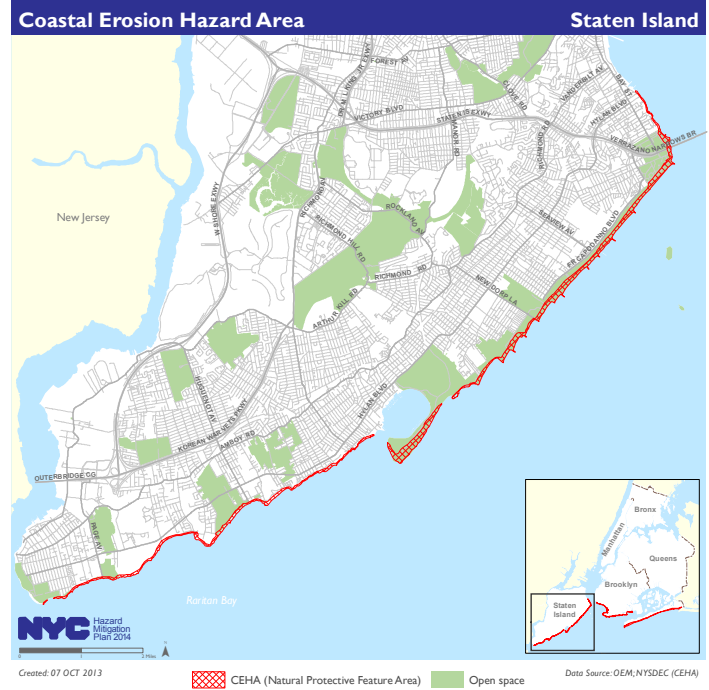
**Figure 3.5.46: Brooklyn Coastal Erosion Hazard Areas (Source: NYS DEC, OEM GIS)**



**Figure 3.5.47: Queens Coastal Erosion Hazard Areas (Source: NYS DEC, OEM GIS)**



**Figure 3.5.48: Staten Island Coastal Erosion Hazard Areas (Source: NYS DEC, OEM GIS)**



**ii. Built Environment**

Coastal erosion can cause extensive damage to public and private property because it brings structures closer to the water's edge. If erosion is not mitigated, the structures will become inundated with water, resulting in damage or destruction. As the force of water begins to affect the structure, it also places the building's foundation, utilities, and contents at risk.

Shoreline protection and proper structure placement are crucial to withstanding the forces of coastal erosion. Engineering structures—such as seawalls, riprap, armoring, and bulkheads—are used to reduce the risk of erosion in New York City.

In New York City, there are 207 buildings whose footprints intersect a CEHA, although many are just barely touching it (see Table 3.5.25). Buildings with only one edge touching the CEHA might not actually be at risk but may appear to be at risk due to inaccuracies in the data. On the other hand, if a building *centroid* is located within the CEHA—which means the majority of the building footprint is within the CEHA—the building is considered exposed. Buildings that fall within this category—GIS analysis shows 135 such structures in New York City—are considered vulnerable building stock. The majority of these 135 structures, with the exception of one hotel complex on the Rockaway Peninsula, are not permanently occupied or of high value; they are, for instance, structures such as public bathrooms and beach concession stands.

**iii. Natural Environment**

Erosion can cause extensive damage to coastal natural resources.

Under natural conditions, beaches (particularly barrier islands or spits like the Rockaway Peninsula) are dynamic features of the landscape. The shape and location of the coastline changes over time, and erosion is one of the processes by which this occurs. In a natural state, some areas erode and some areas accrete, but overall the two processes are in balance.

Although coastal erosion is a natural phenomenon, human activity may exacerbate it. The construction of hardened structures—such as seawalls, jetties, and groins—can contribute to erosion. Shoreline stabilization structures prevent the natural migration of the beach and thereby contribute to a significant imbalance between erosion and accretion, with some areas eroding much faster than they would under natural conditions. These structures may block sand movement, deflect or increase wave energies, and remove vegetation.

Human activities may also contribute to coastal erosion by damaging or destroying natural protective features such as wetlands, dunes, beaches, sand bars, and barrier islands or spits. Increased erosion rates due to human development may also contribute to the loss of habitat or disrupt migration routes for marine and terrestrial animal species.

**Table 3.5.25: Acreage and Buildings within NYS DEC-mapped Coastal Erosion Hazard Areas (Source: OEM GIS)**

| Coastal Erosion Hazard Area (CEHA) | Acreage Exposed | Exposed Building Footprints | Exposed Building Centroids |
|------------------------------------|-----------------|-----------------------------|----------------------------|
| Coney Island, Brooklyn             | 305             | 53                          | 22                         |
| Rockaway Peninsula, Queens         | 708             | 26                          | 17                         |
| South shore, Staten Island         | 415             | 146                         | 96                         |
| <b>Total</b>                       | <b>1,428</b>    | <b>207</b>                  | <b>135</b>                 |

#### iv. Future Environment

According to the New York City Panel on Climate Change, the sea level around New York City has risen 1.1 feet since 1900 and is expected to rise up to an additional 2.5 feet by the middle of the 21<sup>st</sup> century. Sea level rise is expected to exacerbate coastal erosion in the future, especially during significant storms.

However, exactly how much erosion is directly attributable to sea level rise is unclear. Over planning time frames of 30 to 50 years, the effect of sea level rise is less significant than that of other contributors to shoreline change, and a higher rate of sea level rise is not expected to substantially change the observed rates of shoreline change in the areas experiencing the most severe erosion. Clearly, future erosion rates remain difficult to predict, underscoring the need to establish more baseline data and monitoring stations along the coast to determine annual shoreline changes.

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6. Coastal Storms

A. Hazard Profile

i. Hazard Description

Coastal storms, both tropical cyclones and nor'easters, can and do affect New York City. In fact, the city's densely populated and highly developed coastline makes it one of the most vulnerable cities in the United States to damage from coastal storms.

*Tropical Cyclones*

*Tropical Cyclones*

Tropical cyclones are organized areas of precipitation and thunderstorms that form over warm tropical ocean waters. These storms rotate counterclockwise around a low-pressure center. They are classified as follows:

- A **tropical depression** is an organized system of clouds and thunderstorms with a defined surface circulation and maximum sustained winds of 38 miles per hour (mph) or less.
- A **tropical storm** is an organized system of strong thunderstorms with a defined surface circulation and maximum sustained winds of 39 to 73 mph.
- A **hurricane** is an intense tropical weather system of strong thunderstorms, a well-defined surface circulation, and maximum sustained winds of 74 mph or greater.

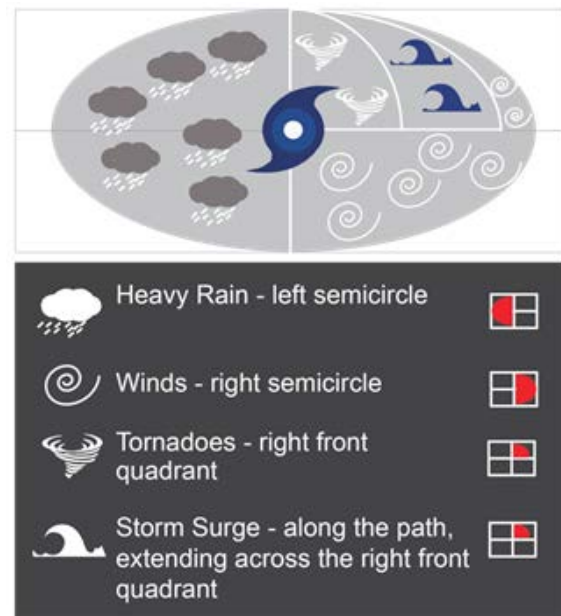
A number of conditions must be in place for tropical cyclones to form and maintain their intensity. Most importantly, water temperatures must be greater than 80°F. In the North Atlantic Basin—where storms that affect New York City originate—these conditions are most likely to occur off the coast of Africa, in the Caribbean Sea, and in the Gulf of Mexico.

Once tropical cyclones form, they often track northward or westward until they reach the mid-latitudes (usually the northern Gulf of Mexico, southeastern United States, or the northwest Atlantic), where they turn northward or eastward due to the prevailing winds. However, when certain meteorological condi-

tions coincide, they may track up the East Coast of the United States and reach New York City.

Hurricanes that affect New York City typically occur during what is known as the Atlantic hurricane season, which lasts from June through November. There are an average of 11 tropical storms and six hurricanes per year in the North Atlantic Basin. New York City is at highest risk between August and October when meteorological conditions in the North Atlantic Basin are most favorable for storm formation and water temperatures are warmest. Although water temperatures rarely reach 80°F as far north as New York City during this time of the year, they are generally warm enough so that strong hurricanes will not lose a significant amount of energy before making landfall. According to the National Hurricane Center (NHC), the Atlantic hurricane season is currently in a period of heightened activity that started around 1995.

Figure 3.6.49: Primary Hazards of Tropical Cyclones (Source: OEM)



\*These hazards can occur anywhere in the storm, but the figure shows where impacts are typically greatest.

When tropical systems make landfall, the primary hazards are heavy rain, wind, tornadoes, and storm surge (see Figure 3.6.49). The most dangerous conditions typically occur near the center of circulation, or eye wall (region surrounding the eye), and in the right-front quadrant of the storm, where the speed of for-

## 6. COASTAL STORMS

### CHAPTER 3: RISK ASSESSMENT

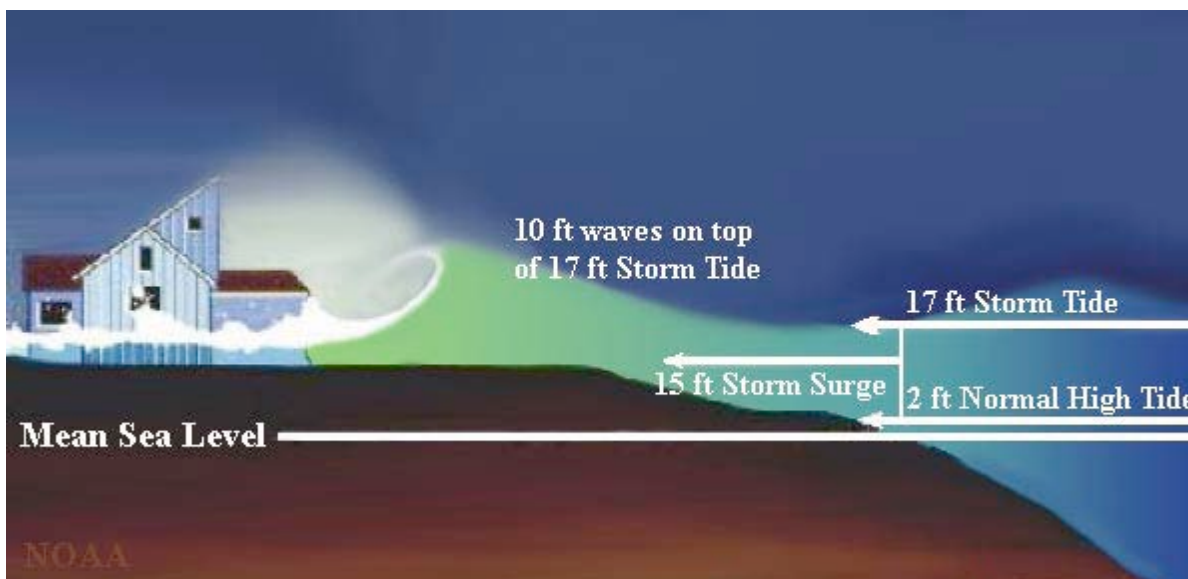
ward motion adds to the effect of the wind and storm surge.

Heavy rain from tropical systems can occur throughout the storm, with the highest values typically expected on the left side of the eye (left semicircle). The amount of rainfall from a particular storm is less dependent on the storm's classification than it is on its speed, size, and the geography of the area it moves over. Heavy rain can cause freshwater flooding, when rivers and streams overflow their banks, or it can cause inland (flash) flooding in low-lying areas when the rainfall rate exceeds the capacity of the ground or drainage systems to absorb the water.

Storm surge is the storm-related hazard that causes the most significant damage and greatest number of deaths. Storm surge is an abnormal rise in water level above the normal astronomical tide level as it is pushed towards the shore by the force of the winds and low pressure of a storm. It is measured as the difference between normal astronomical tide levels and observed storm water levels, or storm tide.

The intensity of the storm surge is dependent on several storm characteristics, including the maximum sustained winds, forward speed, size of the wind field, direction of the storm's track at landfall, and the geography of the coastline. The most significant storm surge typically occurs near the eye and in the right-front quadrant of the storm. This advancing surge com-

**Figure 3.6.50: Combined Effects of Storm Surge, Tide, and Wave Action (Source: NOAA)**



The strongest winds associated with tropical systems typically occur on the right side of the storm (right semicircle). Strong winds can knock down trees and power lines and cause structural damage to buildings and property. Flying debris carried by winds is also a threat to human life and property.

Tornadoes may form in the eye wall or in thunderstorms embedded in rain bands far away from the center, most commonly in the right-front quadrant of the storm. In general, tornadoes produced by tropical cyclones are relatively weak and short in duration, but they can still pose a significant risk.

Storm surge is the storm-related hazard that causes the most significant damage and greatest number of deaths. Storm surge is an abnormal rise in water level above the normal astronomical tide level as it is pushed towards the shore by the force of the winds and low pressure of a storm. It is measured as the difference between normal astronomical tide levels and observed storm water levels, or storm tide.

Inundation caused by storm surge is the height (or depth) of water above ground level. This is calculated by subtracting the local land elevation (referenced to a vertical datum) from the total storm tide height. For example, a storm tide height of 20 feet at an elevation

## 6. COASTAL STORMS

### CHAPTER 3: RISK ASSESSMENT

of five feet would result in 15 feet of inundation.

Beaches along the open ocean are not only exposed to stillwater flooding from the surge and tides, they are also exposed to powerful wave action, which is superimposed on the storm tide. Wave action exerts a tremendous force on the beach, local buildings, property, and infrastructure (see Figure 3.6.50).

#### *Nor'easters*

A nor'easter is a type of coastal storm that primarily affects the Mid-Atlantic and New England states, most commonly between October and April. Like tropical cyclones, these storms are associated with heavy precipitation and a counterclockwise rotation around a center of low pressure. However, unlike tropical cyclones, nor'easters form outside of the tropics, typically over the central or western United States, northern Gulf of Mexico, or northwestern Atlantic. In addition, they can originate and sustain themselves over land and form during the cooler months of the year.

When these storms reach the Northeast or Mid-Atlantic coast, the counterclockwise circulation brings winds from a northeasterly direction—hence the name nor'easters. Although nor'easters are typically weaker than hurricanes, they may be larger, have longer durations, and more widespread impacts. Furthermore, nor'easters strike the New York City area more frequently than hurricanes do. Thus, the cumulative destructive potential of nor'easters may be greater than that of hurricanes.

Nor'easters can bring heavy precipitation, inland flooding, and winds that are often strong enough to knock down trees and power lines and cause structural damage to buildings. They may also bring coastal flooding from storm surge and large waves. While nor'easters do not commonly have tornadoes associated with them, they do bring the threat of heavy snowfall (see section 15. Winter Storms). If a wintertime nor'easter moves up the coast and follows a track west of New York City, wintry precipitation will often change to rain. However, if the storm maintains a track just off the coast of the city, snow or mixed precipitation is likely to occur.

#### *Coastal Geography and Storm Surge Risk*

New York City is particularly vulnerable to storm surge

because of a geographic characteristic called the New York Bight. A bight is a curve in the shoreline of an open coast that funnels and increases the speed and intensity of storm surge. The New York Bight is located at the point where the New York and New Jersey coastlines meet, creating nearly a right angle. For New York City, the worst-case-scenario hurricane track has a storm making landfall just to the south along the coast of New Jersey, putting the city in the right-front quadrant of the storm and funneling the storm surge directly into Raritan Bay and New York Harbor (see Figure 3.6.51). This, in fact, is precisely what happened during Hurricane Sandy in 2012 and a primary reason the storm had such a disastrous impact on New York City (see section 12. Hurricane Sandy Retrospective Analysis).

**Figure 3.6.51: New York Bight with a Hypothetical Storm Approaching New Jersey (Source: OEM)**



#### **ii. Severity**

##### *Tropical Cyclones*

Once a tropical cyclone reaches hurricane status (winds  $\geq 74$ mph), the National Weather Service (NWS) uses the Saffir-Simpson Hurricane Wind Scale to classify its severity. This system, shown in Table 3.6.26, categorizes

a hurricane's current intensity on a scale ranging from one to five based on the storm's maximum sustained wind speed, and it describes potential property damages for the various ratings. Hurricanes categorized 3 or higher are considered major hurricanes.

Although the Saffir-Simpson Hurricane Wind scale is a practical way of measuring hurricane strength, there are other factors that contribute to a hurricane's impact on a given location. These include the storm's size (proportional to the radius of maximum winds) and speed of forward motion. For example, a larger, slower-moving storm may cause more widespread damage than a smaller, faster-moving storm with higher sustained winds because the winds will impact a location for a longer period. Furthermore, the radius of maximum winds and forward speed determine the wind fetch (the distance the wind blows across the water surface) and duration, and thus also affect wave heights and storm surge. The greater the distance and longer the time the winds blow across a body of water, the larger the waves and higher the storm surge.

The direction a storm is moving when it reaches New York City—or bearing—also contributes to the impact it will have. A storm's bearing will determine which part of the storm hits the city and the direction of the winds, which, in turn, will also affect the height of the storm surge.

#### *Nor'easters*

Nor'easters do not have a universally recognized classification system. However, their strength and severity are influenced by factors similar to those that influence the strength and severity of hurricanes.

### iii. Probability

#### *Tropical Cyclones*

The NHC has calculated return periods for both hurricanes and major hurricanes (Category 3 or higher) for various locations along the East Coast of the United States. These return periods are equal to the average amount of time between the passages of two hurricane eyes within a 50-nautical-mile (57.54-mile) radius of a given location. According to these NHC probability models, New York City is currently expected to experi-

ence a hurricane on average once every 19 years. The same models predict a recurrence interval of 74 years for major hurricanes. A Category 5 hurricane is not expected to occur in the New York City area because such a storm is not meteorologically sustainable north of Virginia. A Category 4 hurricane is also unlikely, although still possible.

#### *Nor'easters*

New York City typically experiences several nor'easters every year, and these storms can range significantly in intensity. Most of these storms are relatively weak but still have the potential to produce significant rainfall or snowfall and minor-to-moderate damage. The probability of more severe nor'easters is lower, but they do strike New York City on occasion.

### iv. Location

Within New York City, vulnerability to coastal storms is highly variable, depending to a large extent on location. To predict storm surge and help guide the City's planning for coastal storms, the Office of Emergency Management (OEM) utilizes outputs from a NHC computer model called SLOSH (Sea, Lake, and Overland Surges from Hurricanes). The SLOSH model calculates surge heights for storms moving in different directions and varying in strength from Category 1 to Category 4. SLOSH is not used for nor'easters, although similar criteria will apply when estimating storm surge extent or heights from nor'easters of varying magnitudes.

The SLOSH calculations are based on differing wind speeds for Category 1-4 storms, radius of maximum winds, forward speeds, changes in pressure, and angles of approach. The SLOSH model calculates surge levels as if that location were hit by the most intense part of the storm. The culmination of these factors results in a worst-case scenario for storm surge in the SLOSH model.

Figure 3.6.52 shows the areas of the city that would experience inundation from different storm categories, based on calculations from the SLOSH model. Figure 3.6.53 shows the inundation depths from storm surge for the worst-case scenario for each hurricane category (inundation depth = storm tide height – land eleva-

**Table 3.6.26: Saffir-Simpson Hurricane Wind Scale, Including Tropical Storms (Source: National Hurricane Center)**

| Category       | Winds (mph) | Damage          | Damage Description   |
|----------------|-------------|-----------------|--|
| Tropical storm | 39 to 73    | Minor           | <ul style="list-style-type: none"> <li>• Minor damage to trees, power lines, and poorly constructed homes</li> </ul>   |
| 1              | 74 to 95    | Moderate        | <ul style="list-style-type: none"> <li>• Well-constructed frame homes could have damage to roof, shingles, vinyl siding, and gutters</li> <li>• Large branches of trees will snap, and shallowly rooted trees may be toppled</li> <li>• Extensive damage to power lines and poles likely will result in power outages that could last a few to several days</li> </ul>   |
| 2              | 96 to 110   | Moderate-Severe | <ul style="list-style-type: none"> <li>• Well-constructed frame homes could sustain major roof and siding damage</li> <li>• Many shallowly rooted trees will be snapped or uprooted and block numerous roads</li> <li>• Near-total power loss is expected, with outages that could last from several days to weeks</li> </ul>  |
| 3              | 111 to 130  | Extensive       | <ul style="list-style-type: none"> <li>• Well-built framed homes may incur major damage or removal of roof decking and gable ends</li> <li>• Many trees will be snapped or uprooted, blocking numerous roads</li> <li>• Electricity and water will be unavailable for several days to weeks after the storm passes</li> </ul>  |
| 4              | 131 to 155  | Extreme         | <ul style="list-style-type: none"> <li>• Well-built framed homes can sustain severe damage with loss of most of the roof structure and/or some exterior walls</li> <li>• Most trees will be snapped or uprooted and power poles downed</li> <li>• Fallen trees and power poles will isolate residential areas</li> <li>• Power outages will last weeks to possibly months</li> <li>• Most of the area will be uninhabitable for weeks or months</li> </ul> |
| *5             | >155        | Catastrophic    | <ul style="list-style-type: none"> <li>• A high percentage of framed homes will be destroyed, with total roof failure and wall collapse</li> <li>• Fallen trees and power poles will isolate residential areas</li> <li>• Power outages will last for weeks to possibly months</li> <li>• Most of the area will be uninhabitable for weeks or months</li> </ul>  |

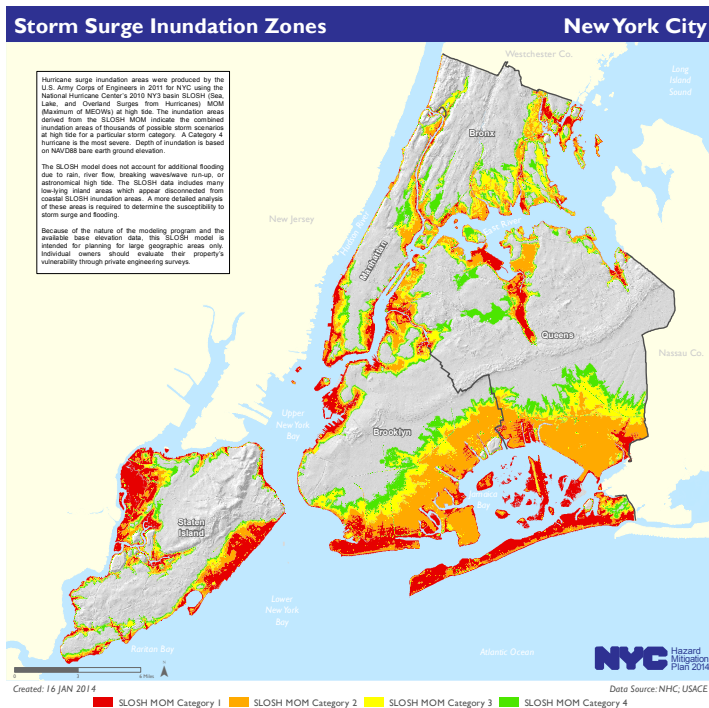
Notes:

\*Not expected to occur in the New York City area because such a storm is not meteorologically sustainable north of Virginia.

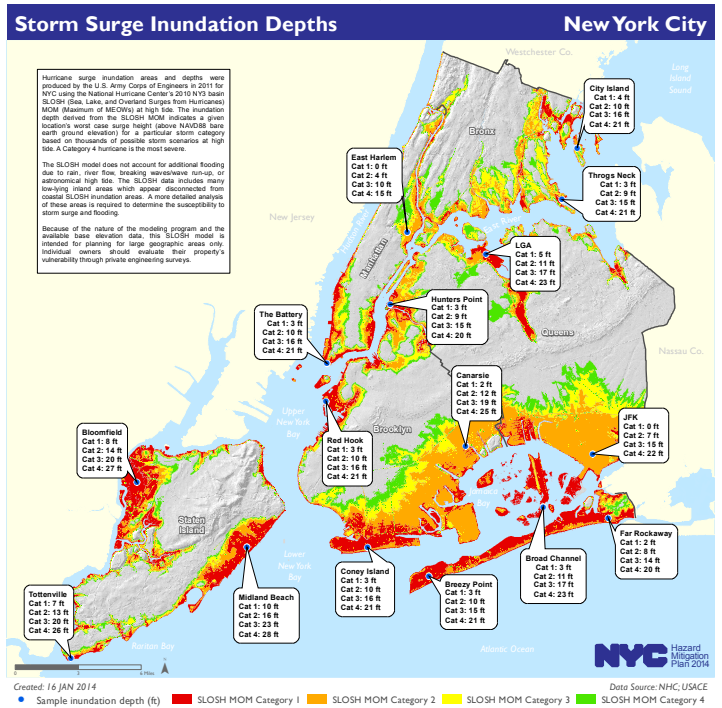
## 6. COASTAL STORMS

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**Figure 3.6.52: New York City Storm Surge Inundation Zones (Source: OEM GIS)**



**Figure 3.6.53: Storm Surge Inundation Zones with Selected Inundation Depths for Storm Categories (Source: OEM GIS)**



tion), using output from the SLOSH analysis.

To prepare for coastal storms, OEM utilizes SLOSH data to develop the *New York City Coastal Storm Plan* (CSP), which defines the areas that may be required to evacuate in the event of a storm. These zones are based on a SLOSH output called Maximum Envelope of Water (MEOW). MEOWs show the maximum surge inundation from a set of hypothetical storms with fixed intensity and bearing but varied size, forward speed, and landfall locations. The evacuation zones employ a range of possible scenarios from the MEOWs, whereas the SLOSH maps only display one scenario for each category. The storm surge inundation maps represent the worst-case scenario storm surge, or MOM (Maximum of MEOWs). The City updated its evacuation zones in June 2013. Unlike the prior set of evacuation zones, which were in place when Hurricane Sandy struck in 2012, the storm's bearing is a significant input into the calculation of the new zones.

## 6. COASTAL STORMS

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#### v. Historic Occurrences

Table 3.6.27, below, reviews coastal storms that have affected New York City since 1785 (details vary based on available data).

**Table 3.6.27: Coastal Storms Affecting New York City 1785 to 2012**

| Date               | Event   | Location  | Description   |
|--------------------|---|-----------|---|
| September 23, 1785 | The Equinoctial Storm                                     | Manhattan | <ul style="list-style-type: none"> <li>Large ships driven onto Governors Island</li> </ul>  |
| August 19, 1788    | Unnamed coastal storm                                     | Citywide  | <ul style="list-style-type: none"> <li>West side of Battery “almost laid in ruins”</li> </ul>   |
| September 23, 1815 | The Great September Gale                                  | Citywide  | <ul style="list-style-type: none"> <li>Montauk Lighthouse heavily damaged</li> </ul>  |
| September 3, 1821  | Norfolk and Long Island Hurricane                         | Citywide  | <ul style="list-style-type: none"> <li>Storm tide rises 13 feet in one hour and causes the East River and the Hudson River to converge across lower Manhattan</li> <li>Widespread flooding as far north as Canal Street</li> </ul>  |
| June 4, 1825       | Unnamed coastal storm                                     | Citywide  | <ul style="list-style-type: none"> <li>Ships wreck off New York coast</li> <li>Some trees down</li> </ul>   |
| November 13, 1846  | Great Havana Hurricane                                    | Citywide  | <ul style="list-style-type: none"> <li>100 yards of the Battery wash away</li> </ul>  |
| October 6, 1849    | Unnamed coastal storm                                     | Citywide  | <ul style="list-style-type: none"> <li>Considerable structural damage</li> </ul>  |
| July 18, 1850      | Unnamed coastal storm                                     | Citywide  | <ul style="list-style-type: none"> <li>Coney Island bathhouses demolished</li> </ul>  |
| August 23, 1893    | Unnamed hurricane   | Citywide  | <ul style="list-style-type: none"> <li>Destroys Hog Island (near the Rockaway Peninsula)</li> </ul>   |
| September 21, 1938 | The Great Hurricane of '38, a.k.a the Long Island Express | Citywide  | <ul style="list-style-type: none"> <li>Most powerful hurricane to make landfall near New York City</li> <li>Eye crosses over Long Island, giving the storm its nickname</li> <li>Kills 200 to 300 people, including 10 in New York City</li> <li>Electricity knocked out north of 59th Street in Manhattan</li> <li>100 large trees in Central Park destroyed</li> <li>Shinnecock Inlet on Long Island was created</li> </ul> |
| August 31, 1954    | Hurricane Carol   | Citywide  | <ul style="list-style-type: none"> <li>Makes landfall in eastern Long Island and southeastern Connecticut</li> <li>Sustained winds of more than 100 mph and gusts 115 to 120 mph</li> <li>The most destructive hurricane to hit the northeast to this date</li> </ul>   |
| September 10, 1954 | Hurricane Edna  | Citywide  | <ul style="list-style-type: none"> <li>Passes east of Long Island, producing 9 inches of rain</li> </ul>  |
| September 12, 1960 | Hurricane Donna   | Citywide  | <ul style="list-style-type: none"> <li>Creates an 11-foot storm tide in New York Harbor and causes extensive pier damage</li> </ul>   |

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| Date               | Event                       | Location                               | Description  |
|--------------------|-----------------------------|--|--|
| March 7, 1962      | Ash Wednesday Nor'easter    | Citywide                               | <ul style="list-style-type: none"> <li>• One of most intense winter storms to ever hit the East Coast</li> <li>• Wave heights reach 40 feet offshore of New York City</li> <li>• Significant damage reported from North Carolina to southern New England</li> </ul>  |
| June 22, 1972      | Tropical Storm Agnes        | Citywide                               | <ul style="list-style-type: none"> <li>• Agnes fuses with another storm system in the northeastern U.S., flooding areas from North Carolina to New York State</li> <li>• Causes 122 deaths and more than \$6 billion in damage (adjusted for inflation)</li> </ul>   |
| September 27, 1985 | Hurricane Gloria            | Citywide                               | <ul style="list-style-type: none"> <li>• Makes landfall on Long Island at 80 mph</li> <li>• Produces a modest storm surge of 4 to 7 feet above normal across the Atlantic</li> <li>• Could have produced a much stronger and intense surge if it had hit at high tide</li> <li>• Causes largest single power loss in U.S. history to date</li> <li>• Total damage estimated at \$900 million</li> <li>• Some moderate beach erosion</li> </ul> |
| December 21, 1992  | Nor'easter                  | Citywide                               | <ul style="list-style-type: none"> <li>• Flooding, coastal erosion, and debris</li> <li>• Damage to residential and commercial structures, utility lines, roads, and other infrastructure</li> </ul>   |
| August 21, 1995    | Hurricane Felix             | Citywide                               | <ul style="list-style-type: none"> <li>• Lingers off the East Coast for nearly a week, menacing the northeastern United States before drifting out to sea</li> </ul>   |
| June 18, 1996      | Hurricane Bertha            | Citywide                               | <ul style="list-style-type: none"> <li>• Weakening storm brings heavy rain to the city</li> </ul>  |
| January 3, 1999    | Nor'easter                  | Citywide                               | <ul style="list-style-type: none"> <li>• 2.42 inches of rain</li> <li>• 50 vehicle accidents in Queens</li> </ul>  |
| September 16, 1999 | Tropical Storm Floyd        | Citywide                               | <ul style="list-style-type: none"> <li>• Floods subway tunnels across the city, causing service disruptions</li> <li>• Drops 10 to 15 inches of rain in 24 hours</li> <li>• Public schools close for the day</li> </ul>  |
| September 18, 2003 | Tropical Storm Isabel       | Brooklyn, Bronx, Queens, Staten Island | <ul style="list-style-type: none"> <li>• A fallen tree branch in the Bronx seriously injures a man</li> <li>• Total damage exceeds \$1 billion along East Coast</li> </ul>   |
| April 15, 2007     | Nor'easter                  | Citywide                               | <ul style="list-style-type: none"> <li>• Produces 7 inches of rain at LaGuardia Airport and 8.41 inches of rain in Central Park, with high winds and storm surge</li> </ul>  |
| October 28, 2009   | Remnants of Hurricane Danny | Citywide                               | <ul style="list-style-type: none"> <li>• 2.75 inches of rain in Sheepshead Bay, Brooklyn</li> </ul>  |
| August 24, 2011    | Tropical Storm Irene        | Citywide                               | <ul style="list-style-type: none"> <li>• 6.87 inches of rain in Central Park, with wind gusts exceeding 50 mph</li> <li>• \$1.3 billion in damage statewide</li> </ul>   |

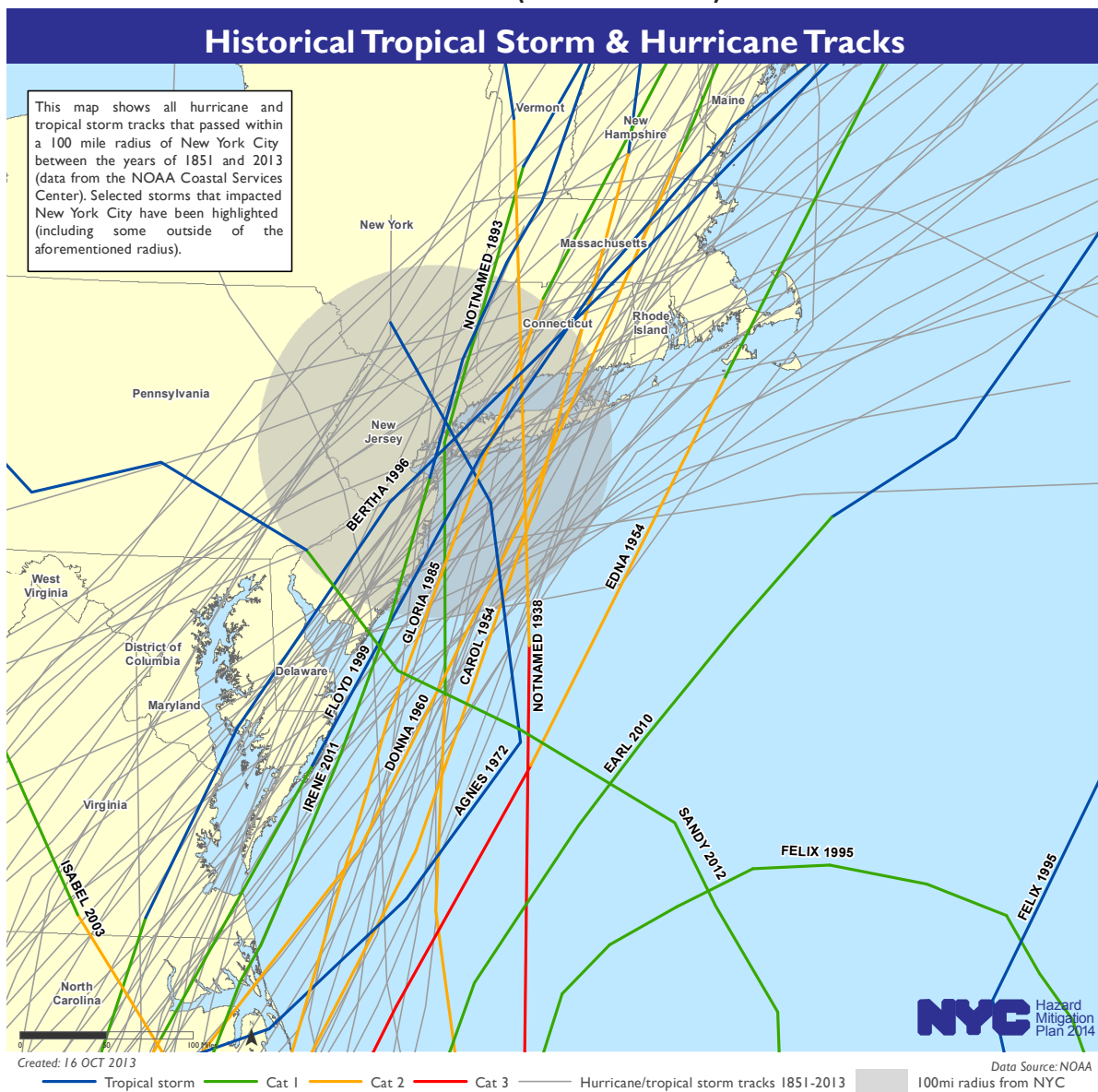


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| Date             | Event           | Location | Description  |
|------------------|-----------------|----------|--|
| October 29, 2012 | Hurricane Sandy | Citywide | <ul style="list-style-type: none"> <li>• Costliest natural disaster in New York City history</li> <li>• Wind gusts exceed 60 mph at Central Park and LaGuardia and Kennedy Airports and reach more than 80 mph in some parts of the city</li> <li>• 11- to 14-foot storm tide in New York City—in some spots the highest in recorded history</li> <li>• 44 deaths in New York City</li> <li>• Widespread flooding, building damage, and power outages</li> </ul> |

**Figure 3.6.54: Tropical Storm and Hurricane Tracks within a 100-mile Radius of New York City 1851 to 2013 (Source: OEM GIS)**



## B. Vulnerability Assessment

### i. Social Environment

Coastal storms can have a significant impact on the population of New York City. Based on population figures from the 2010 Census, nearly 2.5 million New York City residents live within a storm surge inundation zone, putting them at increased risk (see Table 3.6.28).

**Table 3.6.28: New York City Residents in Storm Surge Inundation Zones (Source: OEM GIS)**

| Storm Surge Inundation Zone | Population (2010 Census) |
|-----------------------------|--------------------------|
| Category 1                  | 318,000                  |
| Category 2                  | 796,000                  |
| Category 3                  | 674,000                  |
| Category 4                  | 702,000                  |
| <b>Total</b>                | <b>2,490,000</b>         |

New York City residents, particularly special needs populations such as the elderly, physically or mentally disabled, or people with underlying health conditions, may be exposed to significant safety and health risks during and after the passage of a storm. Health risks may result from direct exposure to storm impacts; people may drown in rising waters, get struck by flying debris and falling trees, or electrocuted by fallen power lines. People may also be forced to shelter in inadequate housing with no heat or hot water. They may be exposed to contaminated floodwaters, spoiled food or mold, or they may experience the disruption of basic services (Lane et al. 2013). Rain, wind, and runoff may also contribute to high levels of turbidity (suspended pollutants) in local reservoirs, which interferes with the disinfection of drinking water.

Risk factors that increase vulnerability to coastal storms include lack of mobility, lack of access to medical resources, lack of information, and language barriers. The elderly are among the most vulnerable groups because they often lack mobility or the means to evacuate. In addition, the elderly are most likely to be physically disabled or have pre-existing medical conditions that may make evacuation more difficult, particularly for those living in elevator buildings experiencing util-

ity outages.

New York City has a large population of immigrants, many of whom do not speak English fluently. Language barriers may result in difficulty receiving warnings, and may further inhibit the translation of warnings to action (see section 4. *New York City's Hazard Environment*).

Special needs populations are also at an increased risk due to their reliance on healthcare facilities (hospitals, nursing homes, adult care facilities, and pharmacies), which may shut down or operate at reduced capacity during coastal storms. Patients and residents of such facilities are at risk due to power loss, especially people requiring life-support equipment that runs on electricity, such as ventilators. Since many of these facilities are located in storm surge inundation zones (see Table 3.6.33), they are at an increased risk if backup generators and essential equipment are located on lower floors that are more likely to flood.

Not only can coastal storms affect residents of healthcare facilities, they can strain the healthcare system as a whole. As the number of patients goes up, the amount of available space goes down, and people may be unable to receive essential medical treatment. Furthermore, evacuation of patients, especially those with critical ailments or injuries, can be particularly challenging.

People who are unable to evacuate during a storm and instead shelter in place are at increased risk during coastal storms for several reasons, including delayed response from medical personnel due to lack of transportation or access to certain areas, non-functioning medical facilities, or high volume of calls. In addition, power outages may disable systems that use electric pumps to distribute water to upper floors of high-rises, leaving people without potable water or water for washing and flushing. Residents may be stranded if they live in a high rise and lose elevator power.

When storm-related damage to essential utilities or building systems precedes hot or cold weather, health risks are increased greatly by the lack of air conditioning or space heating, respectively. If residents remain stranded in flooded or damaged homes after the storm

passes, they may be exposed to secondary health hazards such as contaminated drinking water or growth of toxic mold. Additional health risks may result from food spoilage if people are without power for an extended period after the storm.

Following a major storm or other disaster, those who are significantly affected may also experience mental health problems such as post-traumatic stress disorder and other anxiety and mood disorders. These effects are most common during the months immediately following the storm, but can potentially last much longer depending on the severity of the storm, the nature of exposure, chronic stressors related to the storm (such as prolonged displacement or power disruption), pre-existing mental health issues, and access to adequate care and assistance.

#### ii. Built Environment

Both buildings and infrastructure are subject to significant damage during coastal storms.

##### *Buildings*

The vulnerability of buildings to storm surge and storm damage depends on building characteristics, including height, construction type, age, and location (SIRR, 2013). In general, low-rise buildings are more vulnerable to damage and destruction than mid-rise and high-rise buildings. Low-rise buildings have proportionally more floor area on or closer to the ground, and by their very nature tend to house primary uses on the ground floor. In addition, low-rise buildings are often built from combustible materials, and buildings of this type are more prone to structural damage than buildings with the steel, masonry or concrete frames characteristic of high-rise buildings (see section 4. [New York City's Hazard Environment](#)).

During Hurricane Sandy, much of the damage to buildings was due to surge force and depth of inundation. Sandy flooded an area that included 9% of the city's building stock. Much of the Sandy-related damage was non-structural in nature, largely due to flooding of building systems and electrical equipment located on the ground floors or in basements.

Building age is an important indicator of structural vul-

nerability. Older buildings are more likely to sustain significant damage than newer buildings, primarily due to the fact that building and zoning standards have become more stringent over time. During Hurricane Sandy, for example, structures built before New York City's 1961 Zoning Resolution and the 1983 federal standards associated with Flood Insurance Rate Maps (FIRMs) from the Federal Emergency Management Agency (FEMA) suffered more severe damage than newer buildings. This proved to be the case with many New York City Housing Authority (NYCHA) facilities.

The susceptibility of the built environment to flood damage also depends on specific characteristics of the storm itself as well as the location of buildings. For example, buildings along the coast subject to the force of wave action are much more likely to sustain serious damage than buildings subject to stillwater flooding only.

##### *Potential Losses to Buildings from Coastal Storms*

Losses to buildings in various potential storm scenarios were calculated using HAZUS-MH (see section 3. [Hazard Risk Assessment Organization](#)). The HAZUS-MH hurricane module is a wind model and does not include damages from storm surge. Damage calculations are based on the effects of wind, wind-driven rain, and other wind-related hazards such as projectile impacts. Even though the module is for hurricanes, it can apply to any coastal storms that produce wind-related damages.

The general damage classes provided by HAZUS-MH for the hurricane module are: None, Minor, Moderate, Severe, and Destruction. These classes are an attempt to simplify a range of wind-related structural damages into several basic groups. Table 3.6.29 outlines damage states for residential structures.

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**Table 3.6.29: Damage States for Residential Structures (Source: HAZUS-MH Hurricane Technical Manual)**

| Damage State | Qualitative Damage Description   | Roof Cover Failure | Window Door Failures                     | Roof Deck     | Missile Impacts on Walls   | Roof Structure Failure | Wall Structure Failure |
|--------------|--|--------------------|--|---------------|----------------------------|------------------------|------------------------|
| 0            | <b>No Damage or Very Minor Damage</b><br>Little or no visible damage from the outside. No broken windows, or failed roof deck. Minimal loss of roof over, with no or very limited water penetration.   | ≤2%                | No                                       | No            | No                         | No                     | No                     |
| 1            | <b>Minor Damage</b><br>Maximum of one broken window, door or garage door. Moderate roof cover loss that can be covered to prevent additional water entering the building. Marks or dents on walls requiring painting or patching for repair. | >2% and ≤15%       | One window, door, or garage door failure | No            | <5 impacts                 | No                     | No                     |
| 2            | <b>Moderate Damage</b><br>Major roof cover damage, moderate window breakage. Minor roof sheathing failure. Some resulting damage to interior of building from water  | >15% and ≤50%      | > one and ≤ the larger of 20% & 3        | 1 to 3 panels | Typically 5 to 10 impacts  | No                     | No                     |
| 3            | <b>Severe Damage</b><br>Major window damage or roof sheathing loss. Major roof cover loss. Extensive damage to interior from water.  | >50%               | > the larger of 20% & 3 and ≤50%         | >3 and ≤25%   | Typically 10 to 20 impacts | No                     | No                     |
| 4            | <b>Destruction</b><br>Complete roof failure and/or, failure of wall frame. Loss of more than 50% of roof sheathing.  | Typically >50%     | >50%                                     | >25%          | Typically >20 impacts      | Yes                    | Yes                    |

All of the coastal storm results are based on a probabilistic analysis because the historic record of deterministic events for our immediate area is limited. Probabilistic analysis in HAZUS-MH allows for a summary of results from seven discrete return periods: 10, 20, 50, 100, 200, 500, and 1,000 years (see Table 3.3.4 in section 3. Hazard Risk Assessment Organization). Output such as building damage counts (see Table 3.6.30) or dollar losses (see Table 3.6.31) may be analyzed for any of these return periods.

Since the New York City area does not frequently experience hurricane-level wind events, annualized losses (see section 3. Hazard Risk Assessment Organization) can also be helpful in estimating the impact over time of such events (see Table 3.6.32 and Figure 3.6.55).

**Table 3.6.30: HAZUS-MH Calculation of Approximate Number of Buildings Damaged due to Wind from a Coastal Storm, by Return Period.**

| Return Period (years) | Minor   | Moderate | Severe | Destruction | Total Damaged | % of Building Stock Damaged |
|-----------------------|---------|----------|--------|-------------|---------------|-----------------------------|
| 10                    | 0       | 0        | 0      | 0           | 0             | 0.0%                        |
| 20                    | 1,800   | 100      | 0      | 0           | 1,900         | 0.2%                        |
| 50                    | 8,300   | 800      | 100    | 0           | 9,200         | 0.9%                        |
| 100                   | 33,800  | 5,600    | 200    | 0           | 39,600        | 3.7%                        |
| 200                   | 95,100  | 20,800   | 900    | 100         | 116,900       | 10.9%                       |
| 500                   | 214,100 | 74,300   | 5,900  | 1,800       | 296,100       | 27.6%                       |
| 1,000                 | 278,200 | 139,000  | 22,600 | 8,700       | 448,500       | 41.8%                       |

Notes: Output rounded to the nearest hundred buildings.

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**Table 3.6.31: HAZUS-MH Calculation of Economic Losses due to Wind from a Coastal Storm, by Return Period  
(Source: OEM GIS)**

| Return Period (years) | Building Damage (\$) | Contents Damage (\$) | Inventory Loss (\$) | Income Loss (\$) | Total (\$)            |
|-----------------------|----------------------|----------------------|---------------------|------------------|-----------------------|
| <b>10</b>             | 0                    | 0                    | 0                   | 0                | <b>0</b>              |
| <b>20</b>             | 27,764,000           | 1,745,000            | 0                   | 332,000          | <b>29,841,000</b>     |
| <b>50</b>             | 803,789,000          | 50,340,000           | 2,000               | 50,998,000       | <b>905,128,000</b>    |
| <b>100</b>            | 3,061,473,000        | 244,777,000          | 420,000             | 256,471,000      | <b>3,563,142,000</b>  |
| <b>200</b>            | 8,088,942,000        | 825,247,000          | 3,127,000           | 873,512,000      | <b>9,790,829,000</b>  |
| <b>500</b>            | 22,028,575,000       | 3,649,592,000        | 25,684,000          | 2,859,507,000    | <b>28,563,358,000</b> |
| <b>1,000</b>          | 38,448,295,000       | 9,978,726,000        | 56,005,000          | 5,077,610,000    | <b>53,560,636,000</b> |

Notes: Economic loss values are calculated to the nearest \$1,000.

**Table 3.6.32: HAZUS-MH Calculation of Annualized Economic Losses due to Wind from a Coastal Storm, by Borough  
(Source: OEM GIS)**

| Borough           | Structural Damage (\$) | Contents Damage (\$) | Inventory Loss (\$) | Income Loss (\$)  | Total (\$)         |
|-------------------|------------------------|----------------------|---------------------|-------------------|--------------------|
| Bronx             | 28,098,000             | 6,143,000            | 32,000              | 3,478,000         | 37,752,000         |
| Kings             | 62,762,000             | 14,400,000           | 116,000             | 7,741,000         | 85,019,000         |
| New York          | 37,748,000             | 6,150,000            | 32,000              | 4,733,000         | 48,663,000         |
| Queens            | 63,918,000             | 15,577,000           | 86,000              | 7,327,000         | 86,907,000         |
| Richmond          | 12,447,000             | 3,062,000            | 11,000              | 1,275,000         | 16,795,000         |
| <b>City Total</b> | <b>204,972,000</b>     | <b>45,333,000</b>    | <b>277,000</b>      | <b>24,555,000</b> | <b>275,136,000</b> |

**Figure 3.6.55: HAZUS-MH Results for Annualized Losses to Buildings due to Wind from a Coastal Storm, by Census Tract (Source: OEM GIS)**

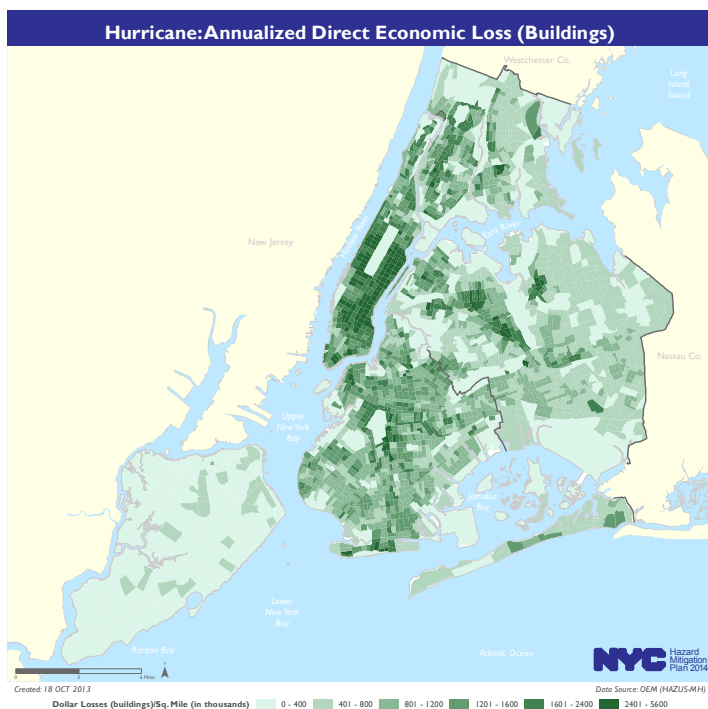


Table 3.6.33 shows the total number of critical facilities and key assets located within storm surge inundation zones for Categories 1 through 4 storms. These facilities and assets are at risk from storm surge and severe damage during coastal storms.

*Infrastructure*

Much of New York City's aging transportation and utility infrastructure is also highly vulnerable to significant damage from coastal storms. Within the transportation sector, at particular risk are subway tunnels, subway stations, and bus depots in low-lying, flood-prone areas, as well as bridges and passenger car tunnels. Shortages in the supply of liquid fuels may also result due to disruptions in the supply chain, as were experienced during Hurricane Sandy.

Vulnerable utilities include above-ground telecommunications and power distribution infrastructure (power lines and electric substations), which are directly exposed to wind, flooding, or falling trees and debris. Underground power and telecommunications are not as exposed, but still may be at risk of flooding in vulnerable locations. Furthermore, all of the City's 26 power generation plants are located in SLOSH zones, including eight in the SLOSH zone for a Category 1 storm (see Table 3.6.33).

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**Table 3.6.33: Critical Assets within Storm Surge Inundation Zones (Source: OEM GIS)**

| Asset Type                       | SLOSH Cat 1 | SLOSH Cat 2 | SLOSH Cat 3 | SLOSH Cat 4 | In SLOSH Zone | Not In SLOSH Zone | Total        | % In SLOSH Zone |
|----------------------------------|-------------|-------------|-------------|-------------|---------------|-------------------|--------------|-----------------|
| Airports (perimeter)*            | 1           | 1           | 0           | 0           | 2             | 0                 | 2            | 100%            |
| Nursing homes (FP)               | 13          | 23          | 14          | 16          | 66            | 107               | 173          | 38%             |
| Hospitals (FP)                   | 4           | 7           | 10          | 4           | 25            | 36                | 61           | 41%             |
| Police stations (FP)             | 2           | 6           | 13          | 4           | 25            | 52                | 77           | 32%             |
| Fire stations (FP)               | 17          | 20          | 16          | 18          | 71            | 157               | 228          | 31%             |
| EMS stations (FP)                | 7           | 6           | 10          | 6           | 29            | 50                | 79           | 37%             |
| Wastewater treatment plants (FP) | 12          | 2           | 0           | 0           | 14            | 0                 | 14           | 100%            |
| Power plants (est. FP)           | 8           | 16          | 2           | 0           | 26            | 0                 | 26           | 100%            |
| DOE school facilities            | 51          | 219         | 177         | 150         | 597           | 1,216             | 1,813        | 33%             |
| Private schools                  | 23          | 63          | 80          | 74          | 240           | 608               | 848          | 28%             |
| Colleges                         | 4           | 9           | 10          | 11          | 34            | 89                | 123          | 28%             |
| Ferry landings**                 | 47          | 0           | 0           | 0           | 47            | 0                 | 47           | 100%            |
| Subway stations (point)          | 31          | 32          | 37          | 52          | 152           | 338               | 490          | 31%             |
| Rail stations                    | 9           | 2           | 2           | 2           | 15            | 27                | 42           | 36%             |
| Cultural facilities (DCP)***     | 2           | 2           | 3           | 4           | 11            | 26                | 37           | 30%             |
| Bus depots                       | 6           | 13          | 2           | 2           | 23            | 7                 | 30           | 77%             |
| Bridges****                      | N/A         | N/A         | N/A         | N/A         | 61            | 9                 | 70           | 87%             |
| Tunnels****                      | N/A         | N/A         | N/A         | N/A         | 4             | 0                 | 4            | 100%            |
| Major roads (mi)****             | N/A         | N/A         | N/A         | N/A         | 479           | 408               | 887          | 54%             |
| <b>City total</b>                | <b>237</b>  | <b>421</b>  | <b>376</b>  | <b>343</b>  | <b>1,921</b>  | <b>3,130</b>      | <b>5,051</b> | <b>38%</b>      |

Notes:

Unless otherwise noted, a facility point was used to do a spatial calculation. This may result in some inaccuracies in category designation. Assets types with "FP" indicate that the actual facility footprint was used in the calculation (FPs were estimated for power plants).

\*Based on airport perimeter—significant storm surge impact only.

\*\*Active New York City commuter/commercial/recreational ferry landings only (including Ellis and Liberty Islands). All landings assumed to be in Category 1 slosh zone.

\*\*\*Determination made by OEM and DCP on which assets to include.

\*\*\*\*Estimated only. Based on visual review of bridge/tunnel segments with ortho photo. Considered not in a zone if all New York City approaches are fully clear of inundation. Major roads do not include bridge/tunnel spans.

#### iii. Natural Environment

Coastal storms can have significant impacts on natural areas and coastal ecosystems. Significant storms have the potential to permanently submerge wetlands and cause barrier islands to narrow or split. Erosion of beaches and dunes, wetland loss, and barrier island breaching are all direct impacts of coastal storms that can damage or destroy coastal habitats and disrupt migration patterns of terrestrial animals. The loss of these natural storm barriers also leaves wooded areas and parks farther inland more exposed to the impacts of wind and storm surge.

Marine and aquatic species are also vulnerable. Following the passage of a storm, contaminated runoff may lead to elevated levels of dissolved nutrients in coastal waters. This reduces the amount of dissolved oxygen in the water and may result in localized fish kills. Sources of contaminated runoff include chemical spills or leaks from commercial or industrial areas and overflow from sewers and wastewater treatment plants. Large volumes of debris in local waterways can also be hazardous to local species. Large-scale changes in the population, distribution, and migrations of marine and aquatic species are possible over the long term.

#### iv. Future Environment

When considering the prospect of coastal storms in the future, planners and emergency managers must understand how climate change will affect the probability of these storms for New York City and the impacts the storms will have if they do make landfall in or near the city.

As the climate continues to warm, ocean surface temperatures are projected to increase. As a result, storms may become more intense. Although it is still unclear how all of the climatic variables affecting hurricanes will change, there is a general consensus among climate scientists that the frequency of the most intense hurricanes (not the frequency of hurricanes in general) may increase globally and in the North Atlantic Basin.

Scientists are less certain as to how the probability of these storms will change at the local level, including potential changes in storm tracks. Several recent studies have found a possible link between melting

Arctic sea ice and storm tracks. This evidence suggests that melting sea ice may change the pattern of the Jet Stream, which, in turn, can shift the tracks of storms in the Atlantic. However, this research is in its early stages and is still only suggestive at this point.

Although there is still uncertainty about how probability will change, scientists are fairly certain that the impacts of coastal storms will worsen in the future when combined with sea level rise due to climate change (NPCC, 2013). Climate change contributes to sea level rise in several ways. As ocean water warms, it expands and increases in volume, which in turn causes sea level to rise. Global warming is also causing land glaciers and polar ice caps to melt at a faster rate, which increases the amount of water in the oceans. Since 1900, relative sea level has risen approximately 1.1 feet in New York City owing in part to climate change and in part to local factors such as land subsidence. By the middle of the 21<sup>st</sup> century, sea level around New York City could rise up to 2.5 additional feet, according to high-end projections from the New York City Panel on Climate Change. As sea levels continue to rise, coastal flooding from future storms will cause more extensive damage than from an equivalent storm today because sea level will already be higher to begin with.



## 6. COASTAL STORMS

### CHAPTER 3: RISK ASSESSMENT

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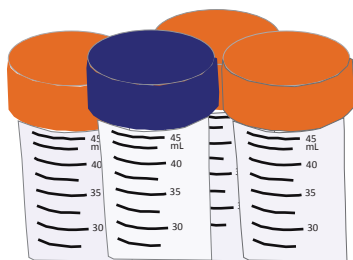
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## 7. Disease Outbreaks

### A. Hazard Profile

#### i. Hazard Description

A disease outbreak occurs when disease cases exceed what would normally

be expected in a defined community, geographic area, or season. The spread, duration, and severity of outbreaks vary tremendously depending on the disease and other factors. There are several ways diseases can spread, including airborne transmission, direct contact, and indirect contact. Disease outbreaks can cause sudden, pervasive illness in all age groups, but they can disproportionately impact some populations that are more susceptible to an outbreak.

Traditionally, major disease outbreaks have been caused by bacterial or viral organisms. Improvements in sanitation in New York City have significantly reduced the likelihood of a bacterial outbreak, such as cholera or typhoid, although there are still periodic outbreaks of food-borne illnesses. In contrast, viral outbreaks are still a regular threat. Each year seasonal influenza outbreaks affect New York City. In addition, several global viral threats are being monitored by the New York City Department of Health and Mental Hygiene (DOHMH) for the potential to develop into pandemics that could spread to New York.

Disease outbreaks that could affect New York City include:

#### *Pandemic and Severe Seasonal Influenza*

Influenza pandemics occur when there is a significant genetic change in a circulating strain of influenza. Because people have not previously been exposed to this new strain, they do not possess immunity to it and are therefore susceptible to contracting the illness. The new strain of influenza can spread rapidly from person to person, with a large portion of the population vulnerable to infection.

Symptoms of influenza include fever, achiness, respiratory difficulties, and extreme fatigue, and for some people these symptoms can last up to two weeks.

Transmission of the disease occurs when people come into contact with infected droplets expelled by coughing and sneezing or with contaminated materials and surfaces.

An influenza pandemic may be mild/moderate or severe. The pandemic of 1918 is the most recent example of a severe outbreak. Mild/moderate outbreaks occurred in 1957 to 1958, 1967 to 1968, and 2009.

Current influenza strains being monitored globally for pandemic potential include H5N1 and H7N9. However, the next pandemic strain might as yet be unidentified and remain so until an outbreak occurs, as was the case with H1N1 in 2009 and 2010.

#### *Coronavirus*

First identified in humans in the mid-1960s, coronaviruses are common viruses that most people get at some point in their lives. Transmission occurs when people come into contact with infected droplets expelled by coughing and sneezing or with contaminated materials and surfaces. Human coronaviruses usually cause mild to moderate upper-respiratory tract illnesses. However, occasional forms of coronavirus can cause very serious illness. In 2003, infection with the coronavirus known as Severe Acute Respiratory Syndrome (SARS-CoV) was characterized by high fever, headache, coughing, and breathing difficulties, and was in many patients severe or fatal. The most recently identified high-risk coronavirus is known as Middle Eastern Respiratory Syndrome (MERS-CoV) and is concentrated in Saudi Arabia as of the writing of this report, with some travel-associated cases outside of the Middle East.

#### *Novel Viral Outbreak*

Novel viral outbreaks occur when a previously unknown viral disease is identified. One example is West Nile virus, a mosquito-borne virus that appeared in 1999 and can cause serious health conditions including encephalitis and meningitis. West Nile is most prevalent during peak mosquito season, June 1 to October 31. The City closely monitors suspected cases of the disease in humans and has a vigorous prevention and response program.

#### *Bacterial Outbreaks*

In addition to naturally occurring disease outbreaks, there can be outbreaks caused by the use of biological agents by terrorists. For example, anthrax, caused by the bacterium *Bacillus anthracis*, is a disease commonly found in livestock, but the bacteria has been manufactured for use as a bioterror weapon. There are three types of anthrax: cutaneous, inhalation, and gastrointestinal. In New York City, infection might result from exposure to animal skins or wool, but the most likely exposure would come from the intentional release of spores through an act of bioterrorism.

As with anthrax, plague outbreaks can occur from either natural or intentional exposure. They are caused by the bacterium *Yersinia pestis*, usually found in rodent fleas. Humans can be naturally exposed when bitten by a rodent flea or when handling infected animals. There are three forms of plague: bubonic, septicemic, and pneumonic. Symptoms vary by form but include fever, chills, and headache, with a high rate of death in untreated patients. The intentional release of plague as an act of bioterrorism could lead to significant illness and mortality among New York City residents.

#### **ii. Severity**

The extent of an outbreak can be classified as endemic, epidemic, or pandemic. Endemic refers to the usual presence of a disease within a specific population or area. An epidemic is the sometimes-sudden increase in the number of cases of a disease that exceeds what is normally expected. A pandemic refers to an epidemic that has spread across the region and over several countries.

An outbreak's severity is not only dependent on disease characteristics but also on the availability of countermeasures. Pandemic influenza has two forms of pharmacologic countermeasures: antiviral medications for infected persons and vaccination to prevent infection in the first place. Coronaviruses, however, currently lack either vaccinations or frontline treatments. Strict enforcement of infection control, especially in healthcare or communal settings, is the primary method of outbreak prevention. Bacterial outbreaks like anthrax or plague are counteracted by antibacterial treatments.

#### **iii. Probability**

Although it is difficult to predict the next disease outbreak, history has shown that outbreaks are not uncommon. Influenza pandemics have occurred every 10 to 60 years, with three occurring in the 20th century (1918, 1957 to 1958, and 1967 to 1968) and one in the 21st century (2009 to 2010). Even though substantial improvements have been made in medicine over the past century, several factors increase the probability of future occurrences: population growth, increases of populations that do not have access to healthcare, evolution of antibiotic-resistant bacteria, and globalization.

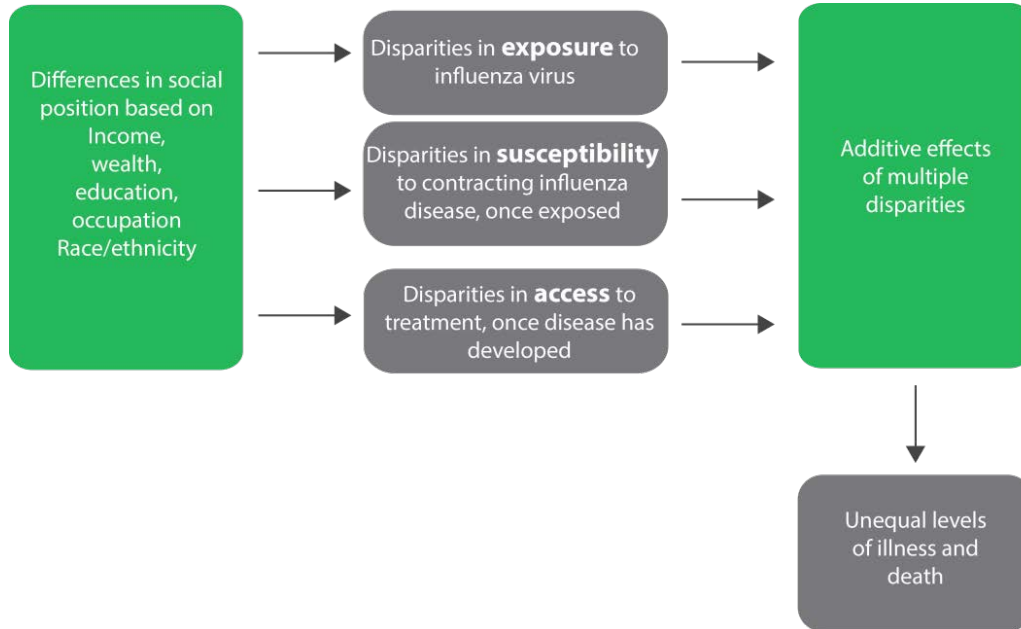
#### **iv. Location**

New York City is exceptionally vulnerable to disease outbreaks due to its dense population combined with the fact that it is a major port of entry. Airports, transit hubs, and mass transit can increase exposure to disease outbreaks because people from all over come into contact with each other in these locations. Whether natural or intentional, infectious disease outbreaks pose serious threats to the city and could strain the capacity of healthcare facilities to respond.

Based on a recent study conducted by DOHMH, some clusters of residents in the city may be more vulnerable to respiratory outbreaks such as pandemic influenza. For this study, DOHMH drew on Blumenshine's (2008) conceptual model of pandemic influenza vulnerability, which shows that increased exposure, increased susceptibility, and lack of access to care are all vulnerability indicators (see Figure 3.7.56). DOHMH generated individual-level vulnerability scores using micro data from the American Community Survey and the Behavior Risk Factor Surveillance System, and then mapped the overall density of those most vulnerable to a pandemic in New York City (see Figure 3.7.57).

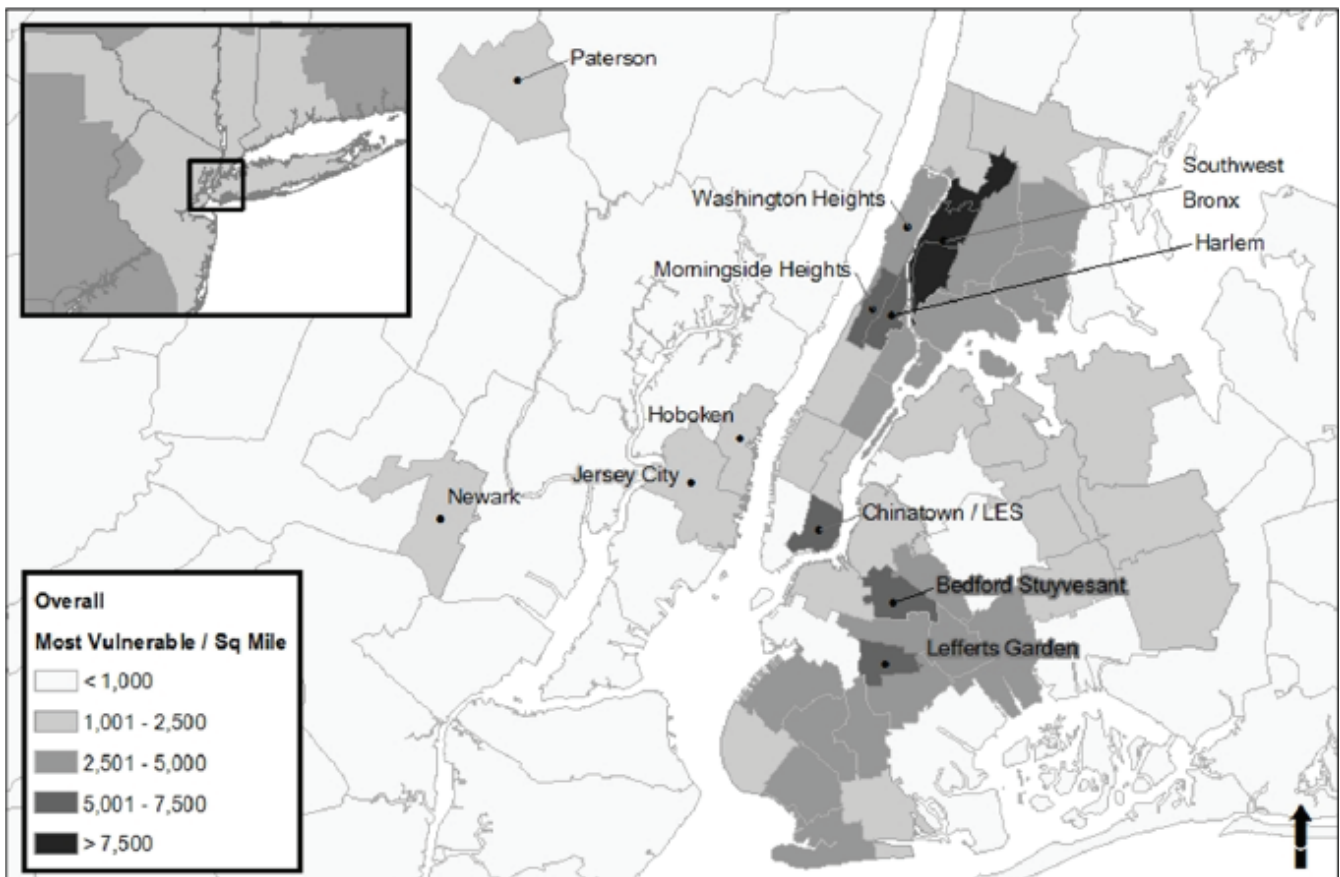
DOHMH identified three tiers of population clusters vulnerable to pandemic flu outbreaks. Concentrations of those most vulnerable to the spread of pandemic influenza (tier one) are highest in the southwest Bronx. The second tier of neighborhoods vulnerable to pandemic influenza outbreak includes Morningside Heights, Chinatown, Lower East Side, Lefferts Garden, and Bedford-Stuyvesant. The third tier of neighbor-

Figure 3.7.56: Conceptual Model of Vulnerability during an Influenza Pandemic



Source: Blumenshine et al. 2008: 709.

Figure 3.7.57: Density of Populations with Vulnerability to Influenza Pandemic



hoods vulnerable to the spread of pandemic influenza includes Harlem and Coney Island.

#### **v. Historic Occurrences**

Throughout New York City's history there have been disease outbreaks, beginning in 1668 with the first cases of yellow fever (see Table 3.7.34). In fact, outbreaks of yellow fever in the 1700s and 1800s led to the creation of the New York City Board of Health in 1805. As the city's water and sanitary conditions improved, disease outbreaks, especially bacterial, were reduced.

A more recent disease outbreak was the H1N1 influenza pandemic in 2009. First identified in Mexico in April 2009, it spread to New York City in late April, followed by a global pandemic that lasted through the spring and into early summer in New York City. DOHMH estimates that as many as one million New Yorkers were infected.

Table 3.7.34: Selected Disease Outbreaks in New York City 1668 to 2013

| Year          | Event              | Description   |
|---------------|--------------------|---|
| 1668          | Yellow fever       | <ul style="list-style-type: none"> <li>• First yellow fever epidemic in New York City</li> <li>• Symptoms include yellowed complexions and vomiting black bile</li> <li>• Described as an "autumnal bilious fever in infectious form"</li> <li>• Governor Francis Lovelace of New York establishes "General Day of Humiliation" in response to the rapid spread of fever</li> </ul> |
| 1799          | The Great Epidemic | <ul style="list-style-type: none"> <li>• Major yellow fever epidemic</li> <li>• Kills 2,086 from late July to November</li> </ul>   |
| 1805          | Yellow fever       | <ul style="list-style-type: none"> <li>• Mayor De Witt Clinton establishes the New York City Board of Health in response to the outbreak</li> <li>• Board of Health orders evacuation of neighborhoods and collects mortality statistics</li> </ul>   |
| 1819          | Yellow fever       | <ul style="list-style-type: none"> <li>• Major epidemic</li> <li>• Board of Health evacuates impacted districts and creates barriers to neighborhoods that led to the initial spread</li> </ul>   |
| 1832          | Cholera            | <ul style="list-style-type: none"> <li>• Outbreak begins on June 26</li> <li>• Disease peaks at 100 deaths per day by July</li> <li>• More than 3,500 deaths occur in the city</li> <li>• 80,000 people flee the city during the epidemic</li> </ul>  |
| 1848 to 1849  | Cholera            | <ul style="list-style-type: none"> <li>• Outbreak begins December 1848 and by June 1849 reaches epidemic level</li> <li>• Board of Health creates makeshift cholera hospitals and convinces police to remove thousands of hogs from crowded tenement areas</li> </ul>   |
| 1866          | Cholera            | <ul style="list-style-type: none"> <li>• Outbreak causes 1,137 deaths</li> <li>• Disease spread is limited by the Metropolitan Board of Health and the enforcement of sanitation laws</li> </ul>  |
| 1900 to 1920  | Tuberculosis       | <ul style="list-style-type: none"> <li>• In 1900, tuberculosis (TB) is the leading cause of death among adults in New York City</li> <li>• Department of Health (DOH) opens TB clinics</li> <li>• Death rates are reduced by half by 1920</li> </ul>  |
| 1907 and 1915 | Typhoid fever      | <ul style="list-style-type: none"> <li>• Mary Mallon, a cook nicknamed "Typhoid Mary," is deemed the carrier responsible for the spread of the disease</li> <li>• 53 cases and 3 fatalities in the city</li> </ul>  |
| 1916          | Polio              | <ul style="list-style-type: none"> <li>• Polio reaches epidemic proportions in the summer of 1916</li> <li>• 8,991 cases and 2,448 deaths in the city</li> </ul>  |

## 7. DISEASE OUTBREAKS

### CHAPTER 3: RISK ASSESSMENT

| Year            | Event   | Description   |
|-----------------|---|---|
| 1918            | Spanish flu                                   | <ul style="list-style-type: none"> <li>Spanish flu pandemic occurs worldwide</li> <li>DOH staff diminished due to the entry of the United States into World War I—many doctors and nurses leave the city to join the Red Cross and Army Medical Corps</li> <li>12,000 New York City residents die from influenza-related causes</li> </ul>  |
| 1957 to 1958    | Asian flu                                     | <ul style="list-style-type: none"> <li>800,000 cases of Asian flu, representing</li> <li>10% of New York City's population</li> </ul>   |
| 1968 to 1969    | Hong Kong flu                                 | <ul style="list-style-type: none"> <li>Mild flu pandemic results in 33,800 deaths in the United States</li> <li>Virus is similar to 1957 Asian flu, which provides some immunity</li> <li>Begins in December 1968 during school vacation, which may have limited the spread of the illness</li> </ul>   |
| 1981 to present | AIDS<br>(Acquired Immune Deficiency Syndrome) | <ul style="list-style-type: none"> <li>First 41 cases identified by the Center for Disease Control (CDC) in 1981</li> <li>By 1983, health officials learn that the disease is spread by sexual contact or sharing hypodermic needles</li> <li>DOH creates initiatives to limit access to hypodermic needles</li> <li>By 1986 DOH launches major prevention and treatment programs</li> <li>In the 1990s, DOHMH provides access to potent antiretroviral therapies, leading to a significant drop in the city's AIDS-related deaths</li> </ul> |
| 1999            | West Nile virus                               | <ul style="list-style-type: none"> <li>Mosquito-borne virus</li> <li>62 cases and seven fatalities</li> </ul>   |
| 2001            | Anthrax                                       | <ul style="list-style-type: none"> <li>The nation's first anthrax case is in New York City</li> <li>8 people infected, including the child of a media employee</li> </ul>   |
| 2009 to 2010    | H1N1  | <ul style="list-style-type: none"> <li>DOHMH estimates that as many as one million New York City residents were infected</li> </ul>   |

#### B. Vulnerability Assessment

##### i. Social Environment

Disease outbreaks affect the population in many ways, and some groups may be more vulnerable than others. An examination of the spread of pandemic influenza illustrates this phenomenon. Blumenshine's conceptual model of pandemic influenza vulnerability identifies mechanisms by which income, race, and other social attributes influence exposure, susceptibility, and access to treatment during an outbreak. DOHMH's vulnerability study builds on this model, determining 10 causes of vulnerability (see Figure 3.7.58).

##### Exposure

Transmission of pandemic flu is typically airborne, but pandemic flu can also spread through direct and indirect contact. Low-income populations may be more vulnerable to outbreaks than others. They are more likely to have crowded living conditions and workplaces, and they are also more likely to depend on public transportation—all factors that inhibit their ability to distance themselves from others and thus increase their chance of exposure. Since frequent contact with infected populations increases the risk of exposure, healthcare providers, care givers, and first responders are also vulnerable.

##### Susceptibility

Certain populations are more susceptible to contracting pandemic flu. These populations include the very old, the very young, and people with pre-existing conditions such as diabetes, cardiovascular disease, or HIV. Stress levels, environmental conditions, and social behavior also play an important role. For example, high-stress work situations, poor or unsafe housing, or drug addiction and alcoholism can increase the likelihood and severity of infection.

##### Access to Treatment

Lack of access to treatment may also increase vulnerability to pandemic flu. In general, people who do not have health insurance, low-income populations, immigrants, and people with disabilities have less access to

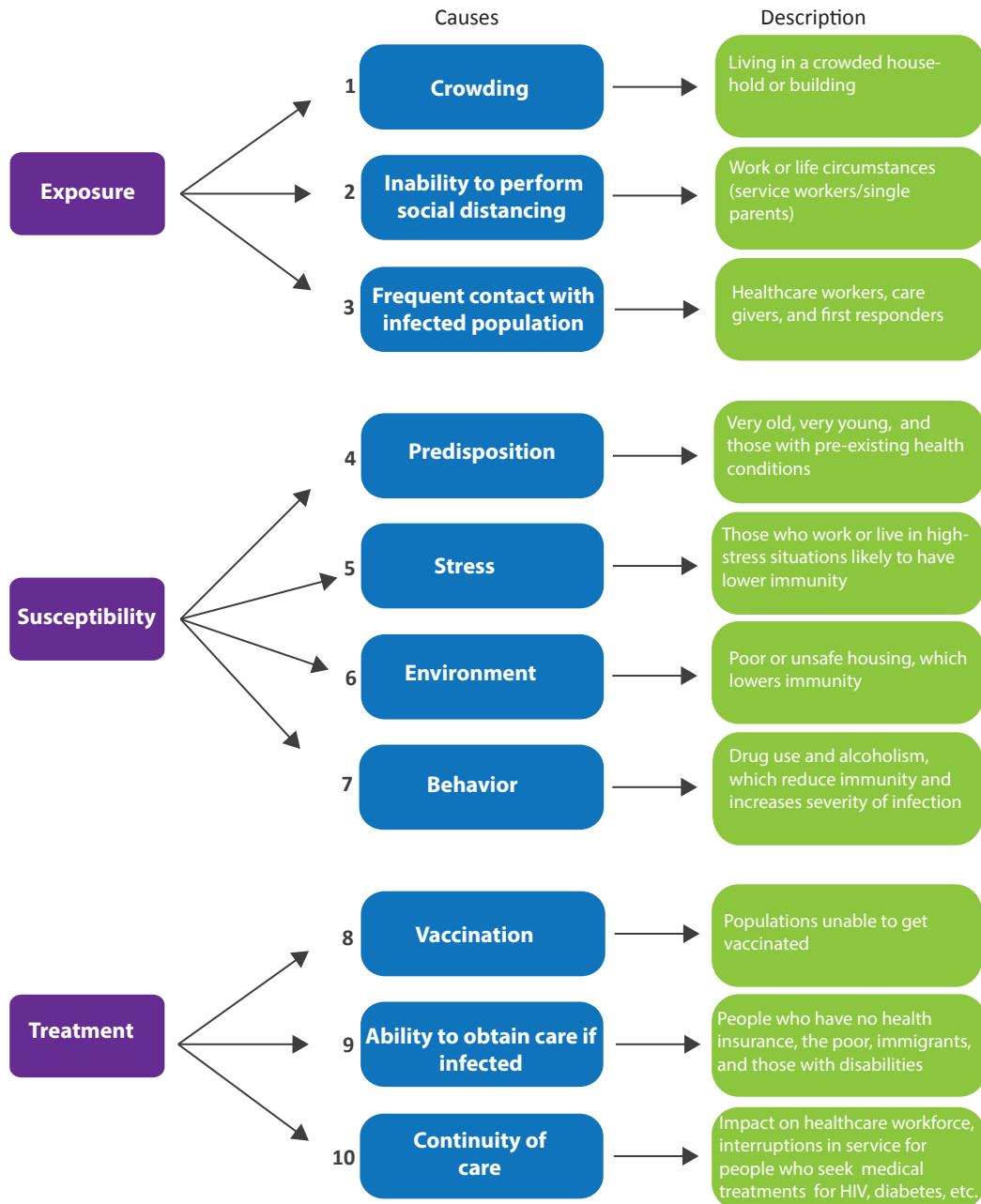
treatment. In addition, populations unable or unwilling to get vaccinations or to obtain care if infected may be more vulnerable. Several studies have shown that African Americans get vaccinated at a lower rate than the rest of the population (Blumenshine et al).

The ability of healthcare facilities to maintain continuity of care is another important factor. Pandemic flu outbreaks can disrupt the continuity of care for those with pre-existing conditions (such as diabetes and HIV) because pandemics impact healthcare workers.

A disease with a high mortality or morbidity rate could have catastrophic economic impacts. The loss of the ability to acquire goods and services could affect every household in the state. Furthermore, disease outbreaks sometimes occur in waves, affecting the stability of certain economic sectors and their ability to recover before the next wave hits.



Figure 3.7.58: Conceptual Vulnerability Matrix (Source: DOHMH)



#### ii. Built Environment

In general, a disease outbreak will have little effect on property, with the possible exception that owner absenteeism, neglect, and lack of maintenance due to owner illness may cause property deterioration.

However, a disease outbreak has the potential to affect critical infrastructure. It may contribute to the disruption of basic services, including garbage collection and repairs to infrastructure (power, telephone, cable, etc.), should service workers fall ill. Because infrastructure sectors are interdependent, the impairment of one sector may cause the impairment of others.

A disease outbreak could have a direct impact on critical facilities. It would affect the operations of health-care providers, which could, in turn, affect patient care. Increased employee and staff absences could, and most likely would, have an impact on service provision.

#### iii. Natural Environment

The environmental impacts of disease outbreaks largely depend on the type and severity of the disease. The condition of parks and open space could deteriorate should park maintenance workers succumb to illness. With catastrophic pandemics, the necessity for mass burials of animals or humans could affect the environment.

#### iv. Future Environment

In the future, population increase and density may exacerbate the exposure and susceptibility of people to disease outbreaks. In addition, global travel may amplify the probability of frequent outbreaks due to increased opportunities for exposure and transmission.

Climate change can also affect the spread of infectious diseases. According to the Natural Resources Defense Council (NRDC), warmer temperatures, shifting rainfall patterns, and high humidity increase the spread of vector-borne diseases such as West Nile virus.

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## 8. Drought

### A. Hazard Profile

#### i. Hazard Description

The National Weather Service describes four types of drought: meteorological, agricultural, hydrological, and socioeconomic – most of which can significantly affect New York City.

Meteorological, or climatological, drought is defined in terms of the departure from a normal precipitation pattern and the duration of the hazard. This type of drought has a slow onset—it usually takes at least three months to develop—and may last for several seasons or years.

Agricultural drought links meteorological drought to agricultural impacts due to precipitation shortages and soil-water deficits. This type of drought has minimal direct impact on New York City because there is no significant agricultural activity within the city's boundaries.

Hydrological droughts, which often lag behind meteorological and agricultural droughts, involve deficiencies in surface water and sub-surface water supplies. The frequency and severity of hydrological drought is often defined on a watershed basin scale. Although climate is a primary contributor, other factors—such as changes in land use, land degradation, and the construction of dams—all affect the hydrological characteristics of the basin.

Finally, there is socioeconomic drought, which occurs when a water shortage begins to affect the population, individually and collectively.

Drought differs from other hazards in many ways. For one thing, its effects take a considerable time to develop, and the extent of the hazard can linger for prolonged periods after the drought itself has ceased. Moreover, while most definitions of socioeconomic drought associate the hazard with supply, demand, and economic good, the absence of a definitive and universally accepted definition complicates the determination of whether a drought is occurring and the level of its severity. Finally, compared to other natural

hazards, the geographical area, impacts, and the duration of drought are difficult to quantify. This is especially true in New York City because its water comes from three upstate sources.

#### ii. Severity

The New York City Department of Environmental Protection (DEP) has developed the *New York City Drought Management Plan* to guide the City's response to a drought. The current *Drought Management Plan* has three phases: drought watch, drought warning, and drought emergency. Drought emergency is further subdivided into three stages, each with increasingly severe mandated water-use restrictions. The *Drought Management Plan* establishes guidelines for declaring a watch, warning, or emergency and the appropriate response for each phase. Factors such as prevailing hydrological and meteorological conditions, as well as certain operational considerations, inform the guidelines.

DEP declares a drought watch when there is less than a 50% probability that either of the two largest reservoir systems—the Delaware (Cannonsville, Neversink, Pepacton, and Rondout reservoirs) or the Catskill (Ashokan and Schoharie reservoirs)—will fill by the following June 1, the start of the water year.

DEP declares a drought warning when there is less than a 33% probability that either the Delaware or the Catskill system will fill by the start of the water year.

DEP declares a drought emergency when there is a reasonable probability that, without the implementation of stringent measures to reduce consumption, a protracted dry period would drain the city's reservoirs. DEP estimates this probability during dry periods in consultation with the New York State Drought Management Task Force and the New York State Disaster Preparedness Commission. Analyses of the historical record, the pattern of the dry-period months, water quality, sub-system storage balances, delivery system status, system construction, maintenance operations, snow cover, precipitation patterns, use forecasts, and other factors inform the estimation.

As of the writing of this report, DEP is updating the *Drought Management Plan*, which will be renamed

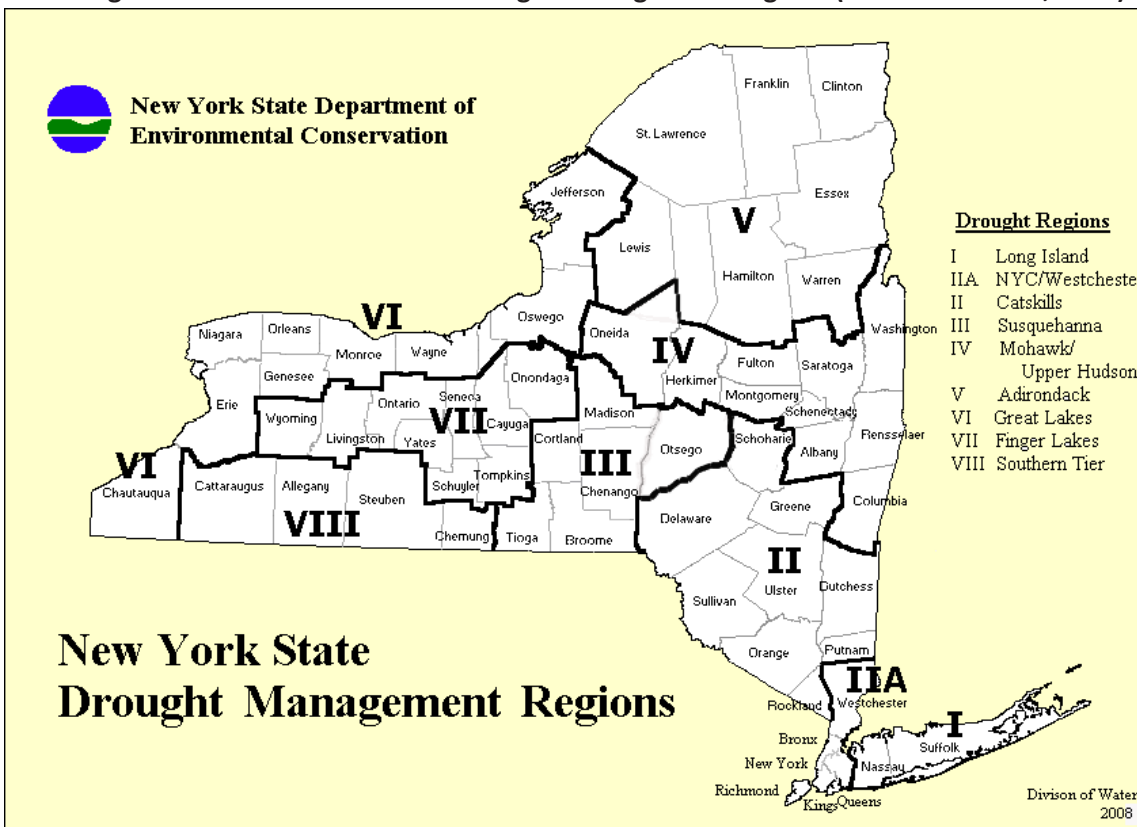
## 8. DROUGHT

### CHAPTER 3: RISK ASSESSMENT

the *Water Shortage and Contingency Plan* and will be ready in early 2014. In addition to covering water supply problems due to drought, the updated plan will also address issues related to infrastructure failure and planned system repairs.

weather that brings 62% of normal precipitation or less occurs one year out of 50 in New York City.

Figure 3.8.59: New York State Drought Management Regions (Source: NYS DEC, 2008)



### iii. Probability

Occasional drought is a normal, recurrent feature of virtually every climate in the United States. According to the New York State Department of Environmental Conservation (NYS DEC), New York's average annual precipitation ranges from 28 inches in the Lake Champlain Valley to 60 inches in the Catskills. This precipitation feeds the state's streams, lakes, and coasts.

However, even with a temperate, moist climate, normal fluctuations in regional weather patterns can lead to periods of dry weather. The last severe droughts in New York State occurred in the mid-1960s and again in the early and mid-1980s. According to the *National Drought Atlas*, a guide to the severity, frequency, and duration of droughts for the continental United States,

### iv. Location

Droughts tend to affect New York City on a city-wide basis. This is in large part because the city gets its water from outside its borders. As described in New York City's Hazard Environment in Chapter 3, major components of the city's water supply system are located upstate, making the system vulnerable to weather conditions to the north. As part of its *New York State Drought Plan*, NYS DEC subdivided the state into drought management regions. New York City is located in Drought Region IIA; however, most of its watershed lies to the north in Region II (see Figure 3.8.59).

## v. Historic Occurrences

Table 3.8.35, below, indicates that there were several significant droughts between 1963 and 2003.

**Table 3.8.35: Droughts in New York City 1963 to 2003**

| Date      | Event             | Location | Description   |
|-----------|-------------------|----------|---|
| 1963–1965 | Drought emergency | Citywide | <ul style="list-style-type: none"> <li>Intense water conservation campaign November 1963 to May 1964</li> <li>August 18, 1965, federal government declares water shortage disaster in New York City</li> <li>New York State's only federal disaster declaration for a drought</li> </ul>  |
| 1980–1982 | Drought emergency | Citywide | <ul style="list-style-type: none"> <li>Drought watch issued in October 1980</li> <li>Drought warning issued in November</li> <li>Drought emergency put into effect when water storage levels drop to 33% on January 1, 1981</li> <li>Downgraded to warning January 18, 1982, and to watch November 11, 1982</li> </ul>  |
| 1985–1986 | Drought emergency | Citywide | <ul style="list-style-type: none"> <li>Drought watch issued February 25, 1985, when water storage levels drop to 50%</li> <li>In span of two months, drought conditions upgraded from drought watch to drought warning to drought emergency</li> <li>Downgraded to warning November 1985</li> <li>Normal conditions restored February 25, 1986</li> <li>No damages recorded for this event</li> <li><i>New York State Drought Plan</i> revised based on lessons learned from this and earlier 1980s droughts</li> </ul> |
| 1989      | Drought emergency | Citywide | <ul style="list-style-type: none"> <li>Drought watch issued January 17, when water-storage facilities were at 58%</li> <li>Drought conditions upgraded to drought emergency (Stage II) March 22</li> <li>Conditions restored to normal May 15</li> </ul>  |
| 1991      | Drought warning   | Citywide | <ul style="list-style-type: none"> <li>Drought watch issued September 25, when water-storage facilities were at 53%</li> <li>DEP subsequently issues drought warning</li> </ul>   |
| 1995      | Drought warning   | Citywide | <ul style="list-style-type: none"> <li>Drought watch issued July 5, when water-storage capacities fall to 84%</li> <li>Drought warning issued September 13</li> <li>Normal conditions restored November 14</li> </ul>   |
| 2001–2003 | Drought emergency | Citywide | <ul style="list-style-type: none"> <li>Drought watch issued December 23, 2001, with water-storage levels at 44%</li> <li>One month later DEP issues drought warning</li> <li>Drought emergency issued April 1, 2002</li> <li>Over next eight months, increased precipitation and reduced water consumption alleviate drought conditions</li> <li>Normal conditions restored January 2, 2003</li> </ul>  |

Since 2003, the city has experienced two episodes of abnormally dry weather, formally defined by the National Climatic Data Center as "under moderate drought conditions." The first of these episodes began on June 29, 2010, and lasted four months, and the second began on March 20, 2012, and lasted two and a half months. However, neither episode was severe enough to be classified as a drought watch, warning, or emergency.

#### B. Vulnerability Assessment

Each drought produces a unique set of impacts on New York City, depending not only on its severity, duration, and spatial extent but also on ever-changing social conditions. As shown in Figure 3.8.60: Drought Impacts on Social, Economic, Built, Natural, and Future Environments, drought can directly or indirectly affect New York City's social, economic, built, natural, and future environments.

##### i. Social Environment

Drought can negatively affect the population of New York City in many ways. The harmful effects of this hazard may be particularly acute among vulnerable populations including the very young, seniors, low-income populations, and those with pre-existing health conditions.

Severe droughts can adversely affect public health. They can lead to a diminished quantity and quality of potable water, which can, in turn, increase the likelihood of dehydration. Compromised sanitation and hygiene from water shortages can result in increased illness and disease. According to the Centers for Disease Control (CDC), decreased rainfall can cause groundwater and surface water to become polluted with viruses, protozoa, and bacteria, increasing the risk of disease outbreaks.

Prolonged drought can also diminish air quality, according to the CDC, increasing particulates suspended in the air from dust and wildfires. Wildfires can increase airborne particles that can irritate bronchial passages and lungs, increasing chronic respiratory illnesses and the risk of acute respiratory infection.

The health effects of drought may be most pronounced

among those with pre-existing health conditions, who may be more susceptible to illness and the spread of disease. Poor air quality due to dust and wildfires may exacerbate conditions for people with chronic respiratory disease such as asthma. Given the prolonged and chronic nature of droughts, there may be indirect health effects that are not readily identified, making it challenging to monitor and plan for these events.

Droughts may also affect the population by compromising the availability of food and nutrition. Limits on growing season and low crop yields, along with increasing food prices, could result in food shortages. This could adversely affect low-income populations, which may lack the resources to contend with these drought impacts.

Water shortages may also increase recreational risks for swimmers and boaters.

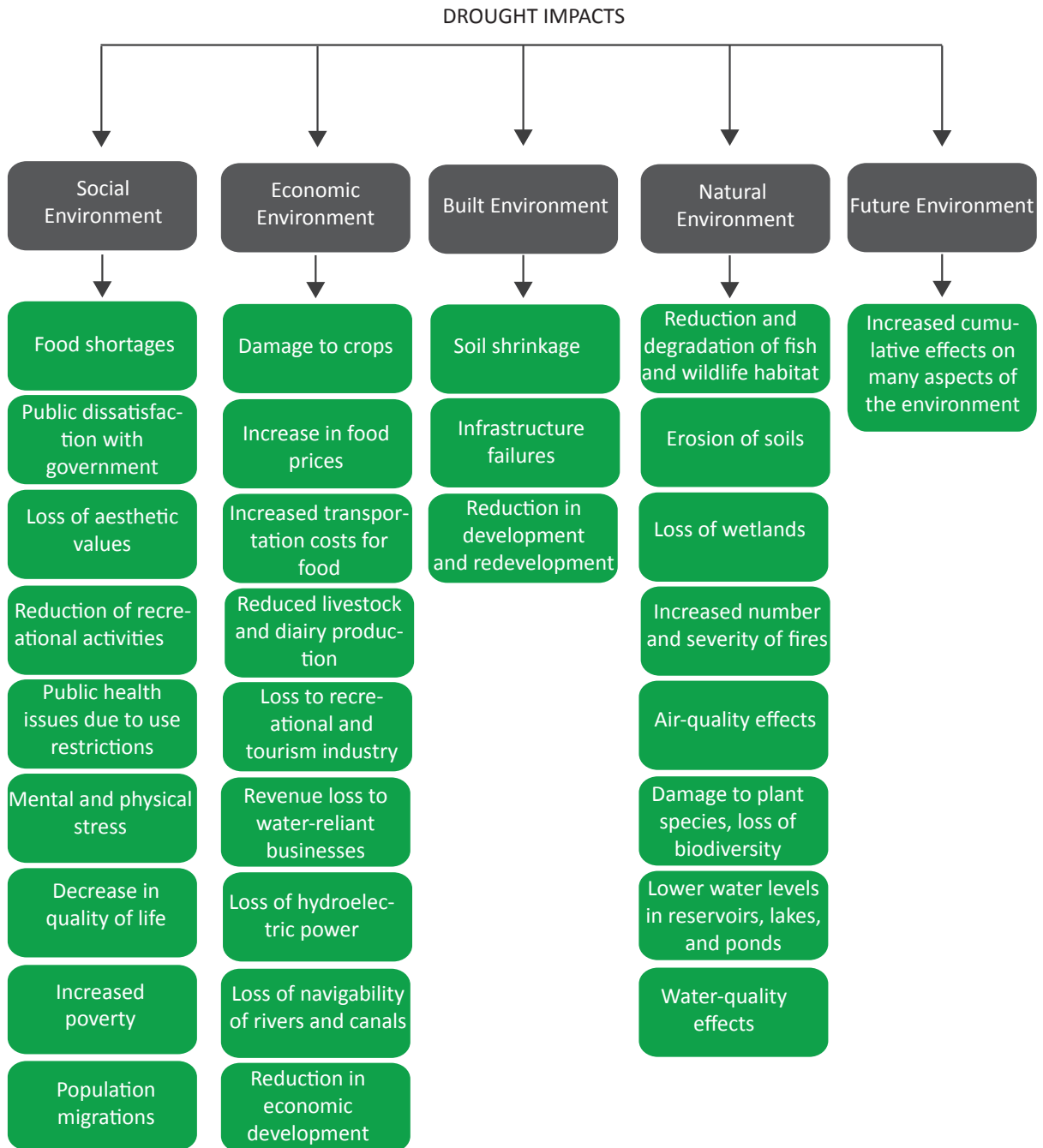
Drought can also have direct and indirect economic impacts. Businesses reliant on water—such as car washes, landscapers, and manufacturers—may be forced to suspend all or a portion of their activities due to reduced water levels and subsequent curtailment of water usage. The indirect impacts associated with drought may be far-reaching.

##### ii. Built Environment

In general, drought does not cause structural damage and does not affect infrastructure such as highways, bridges, and electric conveyance systems. Drought can, however, impact water-borne transportation systems, including ferries and barges, due to periods of low water. In addition, droughts can affect the functioning of the energy and steam supply systems in New York City. A number of power-generation plants rely on potable water to produce power. In the event of a drought, water use restrictions can cause a disruption or reduction in power supply. The steam system in New York City relies heavily on water at certain times of year. During the winter months, the steam system consumes a peak of 1.6 million gallons of water per hour.

Drought can also cause severe soil shrinkage, which can compromise the foundation upon which infrastructure stands, including retaining walls and bulk-

Figure 3.8.60: Drought Impacts on Social, Economic, Built, Natural, and Future Environments





heads. (For more information on infrastructure impacts, see [Section 3.18 Infrastructure Failures](#).) However, soil shrinkage only causes real damage if soils shrink and swell as the moisture content decreases and increases. According to the U.S. Geological Survey, New York City soils typically are not high-swelling in nature. Therefore, there is a very low risk of structural damage associated with drought.

Droughts can affect green roofs, though. In New York City, green roofs contain vegetation that provides insulation, combats the urban heat island effect, and improves air quality. Droughts impair and imperil plants on green roofs, disrupting their ability to reduce air pollution and provide other benefits.

#### iii. Natural Environment

Drought has a much more severe impact on the natural environment than it does on the built environment. Effects may include loss of wetlands, damage to plant species, and reduction in biodiversity. For example, New York City's waterfront mainly consists of wetlands that range from approximately 5,600 acres to just over 10,000 acres, located in Jamaica Bay, on Staten Island, and along the Long Island Sound. These wetlands provide wildlife protection and improve water quality. In Jamaica Bay Park alone, 325 species of birds, 50 species of butterflies, and 100 species of finfish inhabit the wetlands.

Droughts can threaten community gardens. There are nearly 500 community gardens in New York City. Like green roofs, these gardens help reduce air pollution and combat the urban heat island effect, and they also increase access to fresh produce.

Drought can also impact the natural environment by contributing to erosion, wildfires, poor air quality, poor water quality, and soil shrinkage.

#### iv. Future Environment

Climate change projections indicate future disruptions in precipitation patterns and increasing temperatures. According to the New York City Panel on Climate Change (NPCC), by the 2050s it is more likely than not that late-summer short-duration droughts will increase in New York City.

## 8. DROUGHT

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## 9. Earthquakes

### A. Hazard Profile

#### i. Hazard Description

The infrequency of major earthquakes, coupled with the relatively more frequent occurrence of moderate-magnitude events

in the recent past, has led to a public perception that New York City is not vulnerable to damaging earthquakes. While the city does not sit on a seismically active plate boundary like California or Alaska do, it is nonetheless susceptible to earthquakes that originate in or near the city. Population density, the sheer volume of built and critical assets, the lack of seismic design provisions prior to the first seismic code in 1995, and the interdependency of sometimes aged infrastructure amplify the city's risk.

An earthquake is a sudden, rapid shaking of the earth caused by the breaking and shifting of rock beneath the surface. Most earthquakes originate from pre-existing faults, or from a new break in the rocks that make up the earth's crust, along which rocks on either side of faults move past each other. As the rock is strained from geological processes over long periods of time, there is a buildup of potential energy. Eventually, this accumulated energy becomes so great that it is abruptly released in the form of seismic waves. These waves travel away from the earthquake's source, or "focus," deep underground, causing the shaking at the earth's surface that geologists call "ground acceleration." The point on the earth's surface that is directly above the focus is called the epicenter.

Ground acceleration caused by earthquakes has the potential to damage or destroy buildings and infrastructure and can result in loss of life. Earthquakes can also trigger landslides and liquefaction of soils under certain conditions. Liquefaction occurs when unconsolidated, water-saturated soils exhibit fluid-like or significantly softened properties due to the intense shaking and vibrations during an earthquake. Together, ground shaking, landslides, and liquefaction can damage or destroy buildings, disrupt utilities, trigger fires, and endanger public safety.

Aftershocks are earthquakes that follow the largest shock of an earthquake sequence. They are typically less intense than the main shock, and can continue over weeks, months, or years after the initial earthquake is felt.

#### ii. Severity

The term "magnitude" is used to describe the size (released strain energy) at the focus of an earthquake, and "intensity" is used to describe the overall felt severity of shaking during an earthquake. An earthquake's magnitude is a measurement of the energy released at the source of the earthquake expressed by ratings on the Richter or more recent magnitude scales; one such recent scale is the moment magnitude scale, which is now uniformly used by the United States Geological Survey (USGS) unless otherwise specified. Magnitude is determined from measurements on seismographs, and expressed in decimal fractions. Magnitude scales have theoretically no upper limit, but no observed magnitude has ever reached or exceeded a magnitude of 10.

While the Magnitude scale measures the size of an earthquake at its source, the Modified Mercalli Intensity (MMI) scale is empirical and measures the shaking damages of an earthquake on people, animals, objects, buildings, and, in most severe cases, seismic effects on the landscape. As shown in Table 3.9.36, MMI ratings range from I to XII. One of the strongest earthquakes to occur near New York City was on August 10, 1884. It had an estimated magnitude of 5.2 on the Richter scale, based on correlations to the reported maximum intensities of VI to VII on the MMI scale.

In addition to the *qualitative* measure of damage from seismic shaking by intensity—the MMI rating—there are also *quantitative* measures of ground shaking. One such measure is the "peak ground acceleration" (PGA). PGA is the maximum acceleration experienced by the ground during the course of the earthquake motion and can be described by its changing velocity as a function of time. Acceleration is measured because many seismic building codes stipulate how much horizontal inertial force (or mass times the acceleration) a building should be able to withstand during an earthquake without life-threatening damage. PGA is expressed as a percentage of acceleration force of the earth's gravity

Table 3.9.36: MMI Scale Rating (Source: USGS Earthquake Hazards Program, 2013)

| MMI  | Damage/Perception  |
|------|--|
| I    | <ul style="list-style-type: none"> <li>Not felt except by a very few under especially favorable conditions</li> </ul>  |
| II   | <ul style="list-style-type: none"> <li>Felt only by a few people at rest, especially on upper floors of buildings</li> </ul>   |
| III  | <ul style="list-style-type: none"> <li>Felt quite noticeably by people indoors, especially on upper floors of buildings</li> <li>Many people do not recognize it as an earthquake</li> <li>Standing motor cars may rock slightly</li> <li>Vibrations similar to the passing of a truck</li> </ul>  |
| IV   | <ul style="list-style-type: none"> <li>Felt indoors by many, outdoors by few during the day</li> <li>At night, some awakened</li> <li>Dishes, windows, doors disturbed; walls make cracking sound</li> <li>Sensation like heavy truck striking building</li> <li>Standing motor cars rock noticeably</li> </ul>                                  |
| V    | <ul style="list-style-type: none"> <li>Felt by nearly everyone; many awakened</li> <li>Some dishes, windows broken</li> <li>Unstable objects overturned</li> <li>Pendulum clocks may stop</li> </ul>   |
| VI   | <ul style="list-style-type: none"> <li>Felt by all; many frightened</li> <li>Some heavy furniture moved</li> <li>Few instances of fallen plaster</li> <li>Damage slight</li> </ul>   |
| VII  | <ul style="list-style-type: none"> <li>Damage negligible in buildings of good design and construction</li> <li>Slight to moderate damage in well-built ordinary structures</li> <li>Considerable damage in poorly built or badly designed structures</li> <li>Some chimneys broken</li> </ul>  |
| VIII | <ul style="list-style-type: none"> <li>Damage slight in specially designed structures</li> <li>Considerable damage in ordinary substantial buildings, with partial collapse</li> <li>Damage great in poorly built structures</li> <li>Fall of chimneys, factory stacks, columns, monuments, walls</li> <li>Heavy furniture overturned</li> </ul> |
| IX   | <ul style="list-style-type: none"> <li>Damage considerable in specially designed structures</li> <li>Well-designed frame structures thrown out of plumb</li> <li>Damage great in substantial buildings, with partial collapse</li> <li>Buildings shifted off foundations</li> </ul>  |
| X    | <ul style="list-style-type: none"> <li>Some well-built wooden structures destroyed</li> <li>Most masonry and frame structures destroyed with foundations</li> <li>Rails bent</li> </ul>  |
| XI   | <ul style="list-style-type: none"> <li>Few, if any, masonry or frame structures remain standing</li> <li>Bridges destroyed</li> <li>Rails bent greatly</li> </ul>  |
| XII  | <ul style="list-style-type: none"> <li>Total damage</li> <li>Lines of sight and level are distorted</li> <li>Objects thrown into the air</li> </ul>  |

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(%g). Table 3.9.37 shows the approximate relationship between MMI and PGA near an earthquake epicenter.

While PGA is an important measure for ground acceleration, Spectral Acceleration (SA) is now more commonly used as the measure of ground motion in modern seismic building codes because it more closely relates to what a building of a certain mass, height, and structural stiffness (and related natural response period) experiences during an earthquake. It can be used as a better indicator of damage to specific building types and heights. SA for a building is modeled by replacing the building with an inverted pendulum of a cer-

and the total thickness of sediments above hard bedrock affect the wave speed and velocity. In stiff or hard soil, the wave generally will travel at a higher velocity. With soft soils, the wave will slow, traveling at lower velocities. With slower waves, the seismic energy is modified, resulting in waves with greater amplitude. This amplification tends to result in greater earthquake damage unless the building is designed to take this soil effect into account. Thick soil sediments tend to increase the amount of shaking at long spectral periods (affecting tall buildings), while they can reduce the ground motions at very short periods (high frequencies). The combination of softer and thicker soil can

**Table 3.9.37: Approximate Relationship between MMI and PGA (Source: USGS Earthquakes Hazard Program, 2013)**

| MMI  | Acceleration (%g)<br>(PGA) | Perceived Shaking | Potential Damage  |
|------|----------------------------|-------------------|-------------------|
| I    | < .17                      | Not felt          | None              |
| II   | .17–1.4                    | Weak              | None              |
| III  | .17–1.4                    | Weak              | None              |
| IV   | 1.4–3.9                    | Light             | None              |
| V    | 3.9–9.2                    | Moderate          | Very light        |
| VI   | 9.2–18                     | Strong            | Light             |
| VII  | 18–34                      | Very strong       | Moderate          |
| VIII | 34–65                      | Severe            | Moderate to heavy |
| IX   | 65–124                     | Violent           | Heavy             |
| X    | > 124                      | Extreme           | Very heavy        |
| XI   | > 124                      | Extreme           | Very heavy        |
| XII  | > 124                      | Extreme           | Very heavy        |

tain mass on a mass-less vertical rod having the same natural period of vibration and the same mechanical damping as the building. A very approximate rule for the natural spectral period  $T_b$  (seconds) of a building as function of the number of stories  $n$  in the building is:  $T_b$  (sec) =  $0.1n$ . For example, a 2-story building tends to have a natural period of about 0.2 seconds (frequency of 5Hz), while a 10 story building tends to have a natural period near  $T_b=1$  second (frequency of 1 Hz).

Soil and rock type can also impact the severity of earthquake shaking at a given location. As the earthquake's waves move into the soils, the softness of the ground

increase the shaking of waves produced by an earthquake at certain spectral ground motion periods. The greatest amplification of the spectral ground acceleration SA tends to occur at the ground motion periods of  $T_o = 4H / V_s$  where  $H$  (feet) is the thickness of the near-surface soil layer that has a seismic shear wave velocity of  $V_s$  (feet/seconds).

There are unique geologic characteristics in the NYC metropolitan area that can create significant soil amplification effects. The two main characteristics are: (a) the sharp stiffness contrast of overburden soils with very hard regional bedrock, and (b) the bedrock mo-

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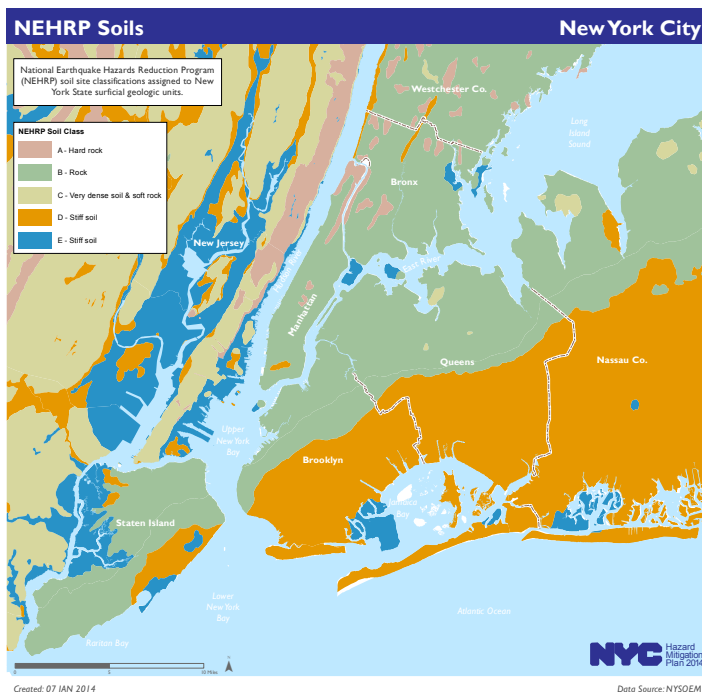
### CHAPTER 3: RISK ASSESSMENT

tions, expected to be of relatively short duration, high frequency, and moderate intensity. Hence, if the soil is soft above the bedrock at shallow depths (say less than 100 feet), there will be resonance in the short period range, affecting mostly “short” or “stiff” structures. There are some NYC-specific modifications in the upcoming (2014) NYC code that try to address this issue in a simplified manner, since this condition is not typically encountered in the seismically more active west coast.

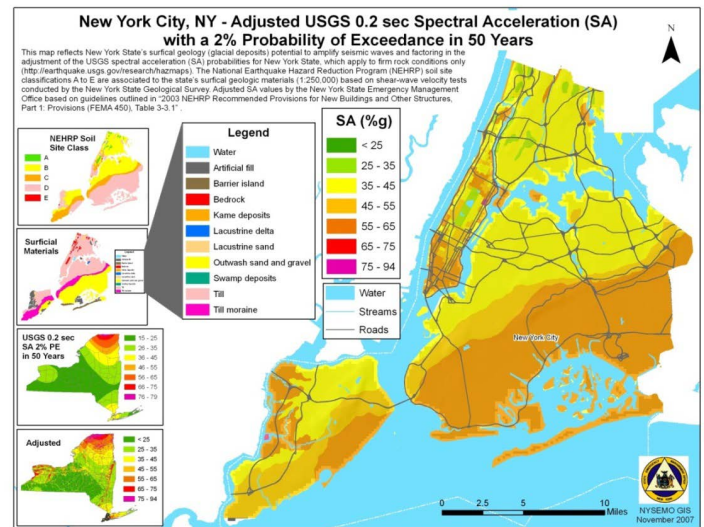
The National Earthquake Hazard Reduction Program (NEHRP) soil classification system describes how soils affect seismic waves as they propagate from the bedrock to the ground surface. A map of the NERP soil classifications for New York State is shown below in Figure 3.9.61. As indicated on the map, Class A soils (pink on the map) tend to reduce ground motions, whereas Class E soils (shown in blue) tend to further amplify and magnify seismic waves. New York City has a variety of NEHRP soil site classes, ranging from hard rock to soft soil. Most of New York City is classified as class B (rock) and class D (stiff soil).

The New York State Office of Emergency Management

**Figure 3.9.61: New York State Soil Classifications (Source: NYS OEM 2014)**



**Figure 3.9.62: Adjusted USGS 0.2 Sec SA for New York City (Source: NYS OEM, 2011)**



ment (NYS OEM) created county-specific seismic hazard maps that reflect the soil's ability to affect seismic waves and the resulting SA that may be experienced by a building. The maps are based on USGS data and the New York State Geological Survey shear-wave tests of the surficial soils. These maps facilitate a better understanding of local seismic hazards by identifying areas of higher vulnerability within the city. The seismic hazard map for New York City shown below (Figure 3.9.62) indicates that SA values of 25% to 75% of gravity have the potential to occur in New York City. It presents the adjusted USGS 0.2 sec SA with a 2% probability of exceedance within 50 years.

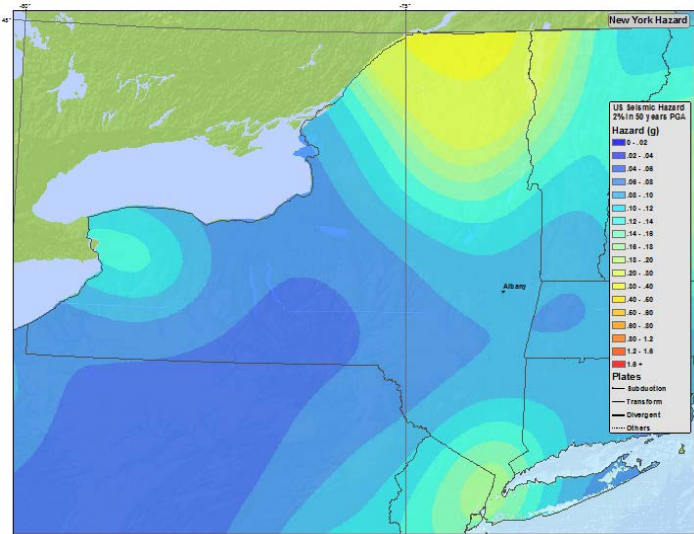
### iii. Probability

PGA can not only be used to measure severity, it can also be used as a measure for the probabilistic assessment of earthquake hazards. Probabilistic seismic hazard maps, whether for PGA or another measure, project the likelihood of a certain level of ground shaking to be reached or exceeded at a certain location over a given period. As shown in the seismic hazard map for New York City (see Figure 3.9.63), a PGA value of 16% to 18% g (1g=earth gravity) has a 2% chance of being exceeded over 50 years. Such earthquake ground motions would likely produce strong to very strong perceived shaking and light to moderate physical damage. The probabilistic seismic hazard maps are for a given stiff soil condition, and the ground motions must be

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**Figure 3.9.63: Earthquake Peak Ground Acceleration (% gravity) 2% Probability of Exceedance in 50 years (Source: [http://earthquake.usgs.gov/earthquakes/states/new\\_york/hazards.php](http://earthquake.usgs.gov/earthquakes/states/new_york/hazards.php) )**



further modified for the specific soil conditions at any given site.

Although New York City has a low risk of large magnitude earthquakes, overall seismic risk is higher because of the city's tremendous assets, concentration of buildings, and construction types (most buildings have not been seismically designed). A 2008 analysis by the Federal Emergency Management Agency (FEMA 366b, 2008) ranks New York State as the fourth most at-risk U.S. state for annualized building-related earthquake losses. The analysis also ranks the New York City/New Jersey/Long Island metropolitan region as the 21<sup>st</sup> most at-risk metropolitan region.

The risk of earthquakes in the New York City area might be greater than once believed. According to a 2008 study by Columbia University's Lamont-Doherty Earth Observatory, there are subtle but seismically active faults in the area. Although New York City is not located along a major fault, according to seismologists the existence of these many smaller active faults may increase the probability of a large earthquake.

The Lamont-Doherty Earth Observatory located hundreds of small events; including magnitude 3 earthquakes that occurred from 1677 to 2007. The smaller earthquakes tended to occur along a series of small, old faults in harder rocky soil. The study asserts that

these faults are still active and capable of producing severe earthquakes. According to the study, the probabilities of occurrence in a 50-year period would be 7% (magnitude 6) and 1.5% (magnitude 7).

#### iv. Location

According to the USGS Earthquake Hazards Program, around 90% of earthquakes occur at the boundaries where the earth's tectonic plates meet, although it is possible for earthquakes to occur entirely within plates. New York City is situated well within the North American plate, far from the plate boundary, which is located approximately 2,000 miles east in the Atlantic Ocean. Seismic research is being conducted into the causes of earthquakes in regions far from plate margins.

Regardless of where they are centered, earthquakes can affect locations beyond their point of origin. For example, two earthquakes that recently occurred (one in Virginia in 2011 and one in Canada in 2013) were felt in New York City. Figure 3.9.64 shows the distribution of historical earthquake epicenters for areas of New York, Connecticut, and New Jersey.

Earthquakes are possible in any of New York City's counties. However, the risk of earthquakes is not the same throughout the city, as evidenced by higher SA values in certain areas as shown in Figure 3.9.62. These areas would likely experience more damage depending on their proximity to an earthquake's epicenter.

Areas with large numbers of unreinforced masonry buildings are also at greater risk from earthquakes. This building type is not as sturdy and does not absorb energy as well as other structure types such as wood, steel, or reinforced concrete (see Built Environment, below). Brooklyn has the largest number of unreinforced masonry buildings. According to the New York City Area Consortium for Earthquake Loss Mitigation (NYCEM), 79% of all buildings in Manhattan are unreinforced masonry buildings. Neighborhoods in Lower Manhattan—such as Soho, Greenwich Village, Chinatown, Little Italy, and Noho—have many unreinforced masonry buildings. In addition, both the Upper West Side and Upper East Side have many unreinforced masonry buildings. The 125<sup>th</sup> Street fault runs from 125<sup>th</sup> Street and Broadway east, crossing the East River and extending through Randall's Island. The area around

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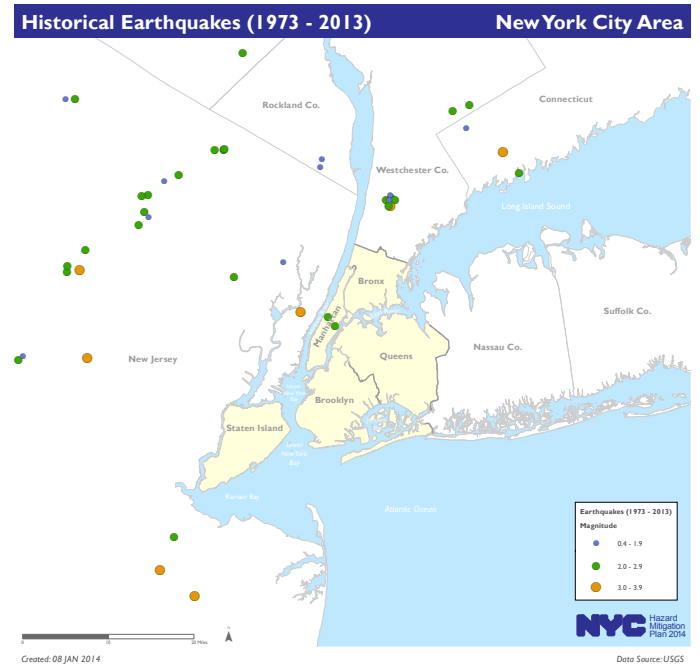
125<sup>th</sup> Street has a large number of unreinforced masonry buildings.

#### v. Historic Occurrences

More than 400 earthquakes with a magnitude greater than 2.0 are on record in New York State between 1700 and 1986, but many more have occurred. Stronger earthquakes are rarer. From 1973 to 2012 there were only two damaging earthquakes in the state with magnitude of 5.0 or greater.

Many smaller earthquakes have been felt in New York City, as shown in Table 3.9.38. For example, in 2001 an earthquake with a 2.4 magnitude occurred in the Upper East Side near the 125<sup>th</sup> Street fault. The earthquake caused only minor damage, but it was the first one on record in Manhattan.

**Figure 3.9.64: Location of Earthquakes in New York City and Surrounding Areas 1973 to 2012 (Source: NYS HMP 2014)**





## 9. EARTHQUAKES

### CHAPTER 3: RISK ASSESSMENT

**Table 3.9.38: Earthquakes Felt in New York City 1737 to 2013 (Source: Lamont-Doherty Earth Observatory of Columbia University and USGS Historic World Earthquakes, 2013)**

| Date              | Location            | Magnitude (ML)** | Max. Intensity (MM) | Description  |
|-------------------|---------------------|------------------|---------------------|--|
| December 19, 1737 | New York City       | 5.2              | VII                 | <ul style="list-style-type: none"> <li>Bells ring, several chimneys fall</li> </ul>  |
| October 26, 1845  | Greater NYC area*   | 3.8              | VI                  | <ul style="list-style-type: none"> <li>No information</li> </ul>   |
| 1847              | Greater NYC area*   | 4.5              | V                   | <ul style="list-style-type: none"> <li>Most likely offshore</li> </ul>   |
| September 9, 1848 | Greater NYC area*   | 4.4              | V                   | <ul style="list-style-type: none"> <li>Felt by many people in New York City</li> </ul>   |
| August 10, 1884   | Citywide            | 5.2              | VII                 | <ul style="list-style-type: none"> <li>Chimneys and bricks fall, walls crack.</li> <li>Felt from Virginia to Maine</li> </ul>          |
| July 19, 1937     | Western Long Island | 3.5              | IV                  | <ul style="list-style-type: none"> <li>One or a few earthquakes occur beneath Long Island</li> </ul>                                   |
| March 10, 1979    | Central New Jersey  | 3.2              | V-VI                | <ul style="list-style-type: none"> <li>Felt in some locations in Manhattan</li> <li>Referred to as the "Chelsea earthquake"</li> </ul> |
| October 19, 1985  | Ardsley, NY         | 4.0              | IV                  | <ul style="list-style-type: none"> <li>Felt by many people in New York City</li> </ul>   |
| January 17, 2001  | Manhattan           | 2.4              | IV                  | <ul style="list-style-type: none"> <li>Felt in Upper East Side of Manhattan and Long Island City, Queens</li> </ul>                    |
| October 27, 2001  | Manhattan           | 2.6              | IV                  | <ul style="list-style-type: none"> <li>Felt in the following locations: Upper West Side of Manhattan and Astoria, Queens</li> </ul>    |
| April 20, 2002    | Au Sable Forks, NY  | Mw 5.1           | VII                 | <ul style="list-style-type: none"> <li>Vibrations felt in New York City</li> </ul>   |
| August 23, 2011   | Virginia            | Mw 5.8           | VIII                | <ul style="list-style-type: none"> <li>Vibrations felt in New York City</li> </ul>   |
| May 17, 2013      | Quebec              | Mw 5.0           | N/A                 | <ul style="list-style-type: none"> <li>Vibrations felt in New York City</li> </ul>   |

\*Location is poorly determined; may be uncertain by 50 miles.

\*\* All magnitudes are local Richter magnitude MI, except for the three most recent listed earthquakes, which are moment magnitudes.

#### B. Vulnerability Assessment

##### i. Social Environment

Unlike some other natural hazards, earthquakes often occur with little or no warning, placing the population at immediate risk. Moreover, since earthquakes have not occurred as frequently as other natural hazard events, the risk to public safety may be higher because the general public may not be as prepared or know how to respond.

Earthquakes can have enormous impact on public safety and health. A high-magnitude earthquake could cause significant injuries and casualties. Earthquakes can also disrupt emergency and medical services, putting individuals that depend on these services at even greater risk. Some of the long-term health risks that earthquakes pose include post-traumatic stress disorder and other mental health problems such as depression and anxiety.

Earthquakes can also impact the economy, causing significant losses of many types. They can displace and disrupt businesses and utility operations, and they can impair people's ability to generate income due to disruptions brought on by the event. Property owners may incur losses due to repairs and lost rental income. The effects of downtime in the city that is a major financial center can potentially affect the world's economy.

Several monuments and landmarks of our nation are hosted in this city and they could be damaged in an earthquake, having a cultural impact in our nation.

##### ii. Built Environment

Earthquakes can significantly affect both buildings and infrastructure.

###### *Buildings*

As mentioned above, a building's construction is a key factor in determining how well it can withstand the forces produced by earthquakes. Structures designed with consideration to seismic loads and that follow the NYC Building Code are expected to provide a minimum

of life safety under a very rare earthquake and general occupancy conditions for less severe earthquakes. Structures not designed for earthquake loads are inherently vulnerable to seismic events. In particular, unreinforced masonry buildings are most at risk because the walls are prone to collapse outward. Steel and wood buildings have a greater ability to absorb the energy from an earthquake. In addition, proper foundation ties on wood buildings are important for reducing the risk of collapse during an earthquake.

Masonry buildings make up roughly 48% of the all buildings in New York City. The greatest number of masonry buildings are in Brooklyn (178,920), followed by Queens (115,062), the Bronx (54,434), Manhattan (28,762), and Staten Island (8,870). This estimation is refined further in the HAZUS-MH analysis described below.

The first seismic provisions in the New York City Building Code were signed into law in 1995 (Local Law 17/19). These provisions impose design and construction regulations that resist the effects of earthquakes. Since then, the Department of Buildings (DOB) has further addressed structural vulnerability for earthquakes in the revised 2008 New York City Construction Codes. The 2008 code requirements are based on the 2003 International Building Code requirements with local modifications for buildings constructed after July 1, 2009.

The 2008 Construction Codes not only make buildings stronger, but also more flexible and resilient. For example, the soil type and building foundation are taken into account, and seismic detailing is required to ensure the joints and connections of a building hold up during an earthquake. Unreinforced masonry is no longer allowed for new buildings. Inspections are also required during construction to ensure seismic features are built correctly. Furthermore, just as they were under the old code, critical facilities such as firehouses and hospitals will be designed under the revised code to not only survive an earthquake, but remain open and functional afterwards (see section 4. [New York City's Hazard Environment](#)). In fall of 2014, DOB will be revising the Building Code and moving towards a

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new concept: the risk-based approach, following the model of the American Civil Engineers (ASCE) Standard 7-2010. The new seismic standard presents risk-based requirements, and enhanced design requirements for liquefaction.

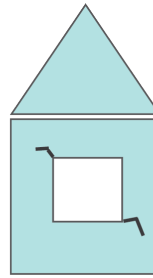
**HAZUS-MH Earthquake-Impact Building Summary:**  
HAZUS-MH was used to estimate losses and structural vulnerability for earthquakes in New York City. NEHRP soils data was loaded to further improve the accuracy of the results. No modifications were made to the existing HAZUS-MH damage functions relating to earthquake building damage.

For the hazard definition, a set of probabilistic scenarios were modeled to focus on damage to buildings (see section 3. [Hazard Risk Assessment Organization](#)). The probabilistic earthquake model in HAZUS-MH also allows for the output of annualized dollar losses. Potential damages were calculated for return periods of 100, 250, 500, 1,000, and 2,500 years (see Table 3.9.39). As is the case with every HAZUS-MH model, there are limitations to the data generated.

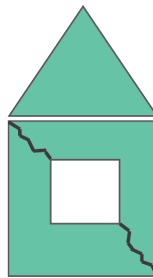
The overall damage state categories for the HAZUS-MH earthquake module are None, Slight, Moderate, Extensive, and Complete. Included below is a graphic depiction of structural damage states (Figure 3.9.65).

Definitions of structural damage states for a single building class (in this case, Type W1-wood, light frame) are included here for reference:

**Figure 3.9.65: HAZUS-MH Earthquake Damage States**  
(Source: HAZUS-MH Earthquake User Manual Figure 9.17)



**Slight:** Small plaster or gypsum board cracks at corners of door and window openings and wall-ceiling intersections; small cracks in masonry chimneys and masonry veneer.



**Moderate:** Large plaster or gypsum board cracks at corners of door and window openings; small diagonal cracks across shear wall panels (stucco and gypsum); large cracks in brick chimneys; toppling of tall masonry chimneys.



**Extensive:** Large diagonal cracks across shear wall panels or large cracks at plywood joints; permanent lateral movement of floors and roof; toppling of most brick chimneys; cracks in foundations; splitting of wood sill plates and/or slippage of structure over foundations; partial collapse of room-over-garage or other soft-story configurations; small foundation cracks.



**Complete:** Structure may have large permanent lateral displacement, may collapse, or be in imminent danger of collapse due to wall failure or the failure of the lateral load resisting system; some structures may have slipped off foundations; large foundation cracks.

**Table 3.9.39: Number of Buildings Damaged from Earthquakes by Return Period for New York City (Source: NYC OEM 2013)**

| Recurrence Interval | Construction Type    | Slight         | Moderate      | Extensive     | Complete     | Total Damaged  | % of Buildings Damaged |
|---------------------|----------------------|----------------|---------------|---------------|--------------|----------------|------------------------|
| 100-year            | Unreinforced Masonry | 0              | 0             | 0             | 0            | 0              | 0.00%                  |
|                     | Total                | <b>0</b>       | <b>0</b>      | <b>0</b>      | <b>0</b>     | <b>0</b>       | <b>0.00%</b>           |
| 250-year            | Unreinforced Masonry | 3,100          | 1,100         | 100           | 0            | 4,300          | 2.27%                  |
|                     | Total                | <b>5,800</b>   | <b>1,500</b>  | <b>200</b>    | <b>0</b>     | <b>7,500</b>   | <b>0.70%</b>           |
| 500-year            | Unreinforced Masonry | 11,300         | 4,800         | 800           | 100          | 17,000         | 8.98%                  |
|                     | Total                | <b>26,000</b>  | <b>7,500</b>  | <b>1,000</b>  | <b>100</b>   | <b>34,600</b>  | <b>3.22%</b>           |
| 1,000-year          | Unreinforced Masonry | 21,300         | 11,100        | 2,500         | 400          | 35,300         | 18.64%                 |
|                     | Total                | <b>66,600</b>  | <b>22,000</b> | <b>3,600</b>  | <b>400</b>   | <b>92,600</b>  | <b>8.63%</b>           |
| 2,500-year          | Unreinforced Masonry | 35,600         | 25,900        | 8,500         | 2,100        | 72,100         | 38.08%                 |
|                     | Total                | <b>159,300</b> | <b>69,600</b> | <b>15,900</b> | <b>2,600</b> | <b>247,400</b> | <b>23.05%</b>          |

Notes: Output rounded to the nearest hundred buildings to minimize potential errors in precision.

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Table 3.9.40 and Table 3.9.41 describe the potential impact of a variety of hypothetical earthquake scenarios with the epicenter located at the epicenter of the August 10, 1884 earthquake in New York City. This model, which also utilized HAZUS-MH software, was adapted from the NYCEM study, published in 2003.

**Table 3.9.40: Summary of Deterministic Results of NYCEM Study (Source: NYCEM, 2003)**

| Richter Scale | Building Damage (billion) | Income Loss (billion) | Total (billion) | Hospitalization (people) | Shelter Required (people) | Fires | Buildings Completely Damaged | Debris (million tons) |
|---------------|---------------------------|-----------------------|-----------------|--------------------------|---------------------------|-------|------------------------------|-----------------------|
| 5             | \$4.4                     | \$0.4                 | <b>\$4.8</b>    | 24                       | 2800                      | 500   | 45                           | 1.6                   |
| 6             | \$28.5                    | \$10.8                | <b>\$39.3</b>   | 2,296                    | 197,705                   | 900   | 2,600                        | 31.9                  |
| 7             | \$139.8                   | \$57.1                | <b>\$196.8</b>  | 13,171                   | 766,746                   | 1,200 | 12,800                       | 132.1                 |

**Table 3.9.41: Summary of Probabilistic Results of NYCEM Study (Source: NYCEM, 2003)**

| Return Period     | Building Damage (billion) | Income Loss (billion) | Total (billion) | Hospitalization (people) | Shelter Required (people) | Fires | Debris (million tons) |
|-------------------|---------------------------|-----------------------|-----------------|--------------------------|---------------------------|-------|-----------------------|
| 100-year          | \$0.1                     | \$0.1                 | <b>\$0.2</b>    | 0                        | 0                         | 0     | 0.2                   |
| 500-year          | \$6.1                     | \$2.0                 | <b>\$8.1</b>    | 28                       | 575                       | 50    | 3.1                   |
| 2,500-year        | \$64.3                    | \$20.4                | <b>\$84.8</b>   | 1,430                    | 84,626                    | 900   | 34.0                  |
| Annualized Losses | \$0.1                     | \$0.1                 | <b>\$0.2</b>    | N/A                      | N/A                       | N/A   | N/A                   |

#### *Infrastructure*

Earthquakes can also compromise infrastructure including bridges, tunnels, utility systems, dams, and highways. Some existing bridges in New York City have been partially retrofitted to improve seismic performance as part of other capital improvements. But the seismic vulnerability of the city's interlinked infrastructure networks is still poorly understood and remains of concern, even as this infrastructure undergoes changes, upgrades and renewal.

Upstate dams, reservoirs, and aqueducts also could incur serious damage from an earthquake, affecting the water supply to New York City. In addition, the Indian Point nuclear facility is located 24 miles north of the city and according to seismologists sits above two active seismic zones. These zones are capable of generating a magnitude 6 earthquake, which may increase the risk of harmful radiation exposure. According to the operators of Indian Point (Entergy Corporation), the nuclear plant is “designed with a margin of safety beyond the strongest earthquake anticipated for the area.”

#### **iii. Natural Environment**

Earthquakes can severely damage the natural environment. They can destroy trees and parks, for example, and diminish the aesthetic value of natural features. Earthquakes can also have secondary impacts that could harm the natural environment; these include fires caused by gas pipe explosions, broken water pipes, hazardous waste releases, and landslides. Should earthquakes affect nearby nuclear power plants and/or used-nuclear-fuel onsite-storage facilities and cause the release of substantial amounts of radioactive materials into the air and water, such release would not only affect the population and economy, but also could have long-term effects on water, land, the biosphere, and the general ecology of the region including in and around New York City.

#### **iv. Future Environment**

As New York City's substantial stock of seismically vulnerable (pre-seismic code) buildings gets gradually replaced with new structures that conform to seismic building code specifications, the per-dollar-of-asset

vulnerability tends to gradually decline. On the other hand, as the value and volume of built assets increase, the total seismic exposure, and hence risk, may still increase.

As for New York City's infrastructure, aging components of infrastructure may amplify the structural impacts of earthquakes in the future. However, the City has invested in the retrofit of existing bridges to improve seismic performance, and these investments should reduce the impacts of an earthquake in the future.

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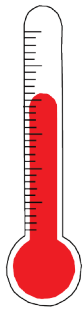
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## 10. Extreme Temperatures

### A. Hazard Profile

#### i. Hazard Description

Extreme temperatures, both hot and cold, have a significant effect on human health and infrastructure in New York City.

#### *Extreme Heat*

Extreme heat is one of the leading weather-related killers in the United States. Extreme heat events are most common between June and August when temperatures that are significantly above average are sustained for a prolonged period; these events may also occur in May or September, although this is rare. A heat wave is defined as three or more consecutive days when daily high temperatures reach 90°F or higher.

The effects of extreme heat are exacerbated by high levels of humidity (the amount of moisture in the air). The higher the temperature, the more moisture the air can hold. High humidity lowers the body's ability to cool itself, and can make the temperature feel hotter than it actually is. The combined effect of the temperature and humidity is known as the heat index, or the apparent "feels like" temperature.

The built environment of New York City greatly contributes to the phenomenon known as the "urban heat-island effect." Heat islands develop in areas with extensive built surfaces (concrete, asphalt, and metal). Incoming solar radiation is trapped during the day and is then re-radiated at night. This slows the cooling process, keeping nighttime air temperatures higher than in more rural surrounding areas. Other by-products of the city's activities—such as exhaust fumes, burning furnaces, heating units, smokestacks, and even New York City's dense population—contribute to the phenomenon. In addition, the city's numerous tall buildings often block the cooling winds from the Atlantic Ocean. In infrared satellite photographs of New York City, particularly at night, the city appears as a distinct heat island, as much as 20°F warmer than the surrounding suburbs.

In many cases, extreme heat events are also associated with poor air quality. High humidity and poor air quality are common in New York City during the summer months, when high atmospheric pressure traps hazy and humid air and pollutants near the ground.

#### *Extreme Cold*

An extreme cold event typically involves an extended period with temperatures at or below 32°F. In New York City, extended periods of sub-freezing temperatures are most common between December and March. As the temperature drops and wind speed increases, heat can leave the body more rapidly. This phenomenon, known as the wind-chill effect, can exacerbate the impact of an extreme cold event.

#### ii. Severity

#### *Extreme heat*

The National Weather Service (NWS) uses a heat index chart (see Table 3.10.42) to determine what effects the temperature and humidity will have on the population (see Table 3.10.43). The heat index values, however, are calculated in the shade and are not adjusted for different levels of sun exposure. Thus, exposure to full sunshine can make it feel even hotter than the heat index reading. During hot weather the actual heat stress experienced by any individual would depend on the temperature in their location, exposure to sunlight and radiant heat from nearby surfaces, air movement, and their level of physical activity.



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Table 3.10.42: NWS Heat Index (Source: NWS, 2013)

|                       |    | Temperature (°F) |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |  |
|-----------------------|----|------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|--|
|                       |    | 80               | 82  | 84  | 86  | 88  | 90  | 92  | 94  | 96  | 98  | 100 | 102 | 104 | 106 | 108 | 110 |  |
| Relative Humidity (%) | 40 | 80               | 81  | 83  | 85  | 88  | 91  | 94  | 97  | 101 | 105 | 109 | 114 | 119 | 124 | 130 | 136 |  |
|                       | 45 | 80               | 82  | 84  | 87  | 89  | 93  | 96  | 100 | 104 | 109 | 114 | 119 | 124 | 130 | 137 |     |  |
|                       | 50 | 81               | 83  | 85  | 88  | 91  | 95  | 99  | 103 | 108 | 113 | 118 | 124 | 131 | 137 |     |     |  |
|                       | 55 | 81               | 84  | 86  | 89  | 93  | 97  | 101 | 106 | 112 | 117 | 124 | 130 | 137 |     |     |     |  |
|                       | 60 | 82               | 84  | 88  | 91  | 95  | 100 | 105 | 110 | 116 | 123 | 129 | 137 |     |     |     |     |  |
|                       | 65 | 82               | 85  | 89  | 93  | 98  | 103 | 108 | 114 | 121 | 128 | 136 |     |     |     |     |     |  |
|                       | 70 | 83               | 86  | 90  | 95  | 100 | 105 | 112 | 119 | 126 | 134 |     |     |     |     |     |     |  |
|                       | 75 | 84               | 88  | 92  | 97  | 103 | 109 | 116 | 124 | 132 |     |     |     |     |     |     |     |  |
|                       | 80 | 84               | 89  | 94  | 100 | 106 | 113 | 121 | 129 |     |     |     |     |     |     |     |     |  |
|                       | 85 | 85               | 90  | 96  | 102 | 110 | 117 | 126 | 135 |     |     |     |     |     |     |     |     |  |
|                       | 90 | 86               | 91  | 98  | 105 | 113 | 122 | 131 |     |     |     |     |     |     |     |     |     |  |
| 95                    | 86 | 93               | 100 | 108 | 117 | 127 |     |     |     |     |     |     |     |     |     |     |     |  |
| 100                   | 87 | 95               | 103 | 112 | 121 | 132 |     |     |     |     |     |     |     |     |     |     |     |  |

Likelihood of Heat Disorders with Prolonged Exposure or Strenuous Activity

Caution
  Extreme Caution
  Danger
  Extreme Danger

Table 3.10.43: Health Hazards Associated with Heat Index Values (Source: NWS, 2013)

| Category        | Heat Index   | Health Hazards   |
|-----------------|--------------|--|
| Extreme Danger  | 130°F-Higher | Heat stroke/sunstroke is likely with continued exposure  |
| Danger          | 105°F-129°F  | Sunstroke, muscle cramps, and/or heat exhaustion possible with prolonged exposure and/or physical activity |
| Extreme Caution | 90°F-105°F   | Sunstroke, muscle cramps, and/or heat exhaustion possible with prolonged exposure and/or physical activity |
| Caution         | 80°F-90°F    | Fatigue possible with prolonged exposure and/or physical activity  |

**Table 3.10.44: NWS Extreme Heat Products for the New York City Region (Source: NWS, 2013)**

| Product                | Criteria  |
|------------------------|---|
| Heat Advisory          | Issued within 24 hours prior to onset of any of the following conditions: <ul style="list-style-type: none"> <li>Heat index of 100°F-104°F for any period</li> <li>Heat index of 95°F-99°F or greater for two consecutive days</li> </ul> |
| Excessive Heat Watch   | Issued 24-48 hours prior to onset of the following condition: <ul style="list-style-type: none"> <li>Heat index of at least 105°F for at least two consecutive hours</li> </ul>   |
| Excessive Heat Warning | Issued within 24 hours of onset of the following condition: <ul style="list-style-type: none"> <li>Heat index of at least 105°F for at least two consecutive hours</li> </ul>   |

New York City receives advisories from the NWS when the predicted heat index is 100°F or greater for one or more days, or the predicted heat index is 95°F or greater for two or more days (see Table 3.10.44). These advisories are based on historical weather analysis and mortality data analysis conducted by the New York City Department of Health and Mental Hygiene (DOHMH). To aid in the prediction of and response to extreme heat events, the NWS has worked with DOHMH and the New York City Office of Emergency Management (OEM) to craft standards for products used in New York City's Heat Emergency Plan (see Social Environment, below). Upon issuing an extreme heat advisory, the NWS does the following:

- Includes heat index values and city forecasts
- Issues special weather statements including who is most at risk, safety rules for reducing risk, and the extent of the hazard and heat index values
- Assists state/local health officials in preparing for civil emergency messages

*Extreme Cold*

The NWS created a wind-chill chart (see Table 3.10.45) that measures the apparent temperature felt on exposed skin due to the combination of air temperature and wind speed. When conditions warrant, the NWS issues wind-chill products for the New York City region (see Table 3.10.46). Although rare, these conditions have occurred throughout New York City's history (see Table 3.10.47).

**Table 3.10.45: NWS Wind-Chill Chart (Source: NWS, 2013)**

|            |    | Temperature (°F) |    |    |    |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
|------------|----|------------------|----|----|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
|            |    | Calm             | 40 | 35 | 30 | 25  | 20  | 15  | 10  | 5   | 0   | -5  | -10 | -15 | -20 | -25 | -30 | -35 | -40 | -45 |
| Wind (mph) | 5  | 36               | 31 | 25 | 19 | 13  | 7   | 1   | -5  | -11 | -16 | -22 | -28 | -34 | -40 | -46 | -52 | -57 | -63 |     |
|            | 10 | 34               | 27 | 21 | 15 | 9   | 3   | -4  | -10 | -16 | -22 | -28 | -35 | -41 | -47 | -53 | -59 | -66 | -72 |     |
|            | 15 | 32               | 25 | 19 | 13 | 6   | 0   | -7  | -13 | -19 | -26 | -32 | -39 | -45 | -51 | -58 | -64 | -71 | -77 |     |
|            | 20 | 30               | 24 | 17 | 11 | 4   | -2  | -9  | -15 | -22 | -29 | -35 | -42 | -48 | -55 | -61 | -68 | -74 | -81 |     |
|            | 25 | 29               | 23 | 16 | 9  | 3   | -4  | -11 | -17 | -24 | -31 | -37 | -44 | -51 | -58 | -64 | -71 | -78 | -84 |     |
|            | 30 | 28               | 22 | 15 | 8  | 1   | -5  | -12 | -19 | -26 | -33 | -39 | -46 | -53 | -60 | -67 | -73 | -80 | -87 |     |
|            | 35 | 28               | 21 | 14 | 7  | 0   | -7  | -14 | -21 | -27 | -34 | -41 | -48 | -55 | -62 | -69 | -76 | -82 | -89 |     |
|            | 40 | 27               | 20 | 13 | 6  | -1  | -8  | -15 | -22 | -29 | -36 | -43 | -50 | -57 | -64 | -71 | -78 | -84 | -91 |     |
|            | 45 | 26               | 19 | 12 | 5  | -2  | -9  | -16 | -23 | -30 | -37 | -44 | -51 | -58 | -65 | -72 | -79 | -86 | -93 |     |
|            | 50 | 26               | 19 | 12 | 4  | -3  | -10 | -17 | -24 | -31 | -38 | -45 | -52 | -60 | -67 | -74 | -81 | -88 | -95 |     |
| 55         | 25 | 18               | 11 | 4  | -3 | -11 | -18 | -25 | -32 | -39 | -46 | -54 | -61 | -68 | -75 | -82 | -89 | -97 |     |     |
| 60         | 25 | 17               | 10 | 3  | -4 | -11 | -19 | -26 | -33 | -40 | -48 | -55 | -62 | -69 | -76 | -84 | -91 | -98 |     |     |

**Table 3.10.46: NWS Wind-Chill Products for the New York City Region (Source: NWS, 2013)**

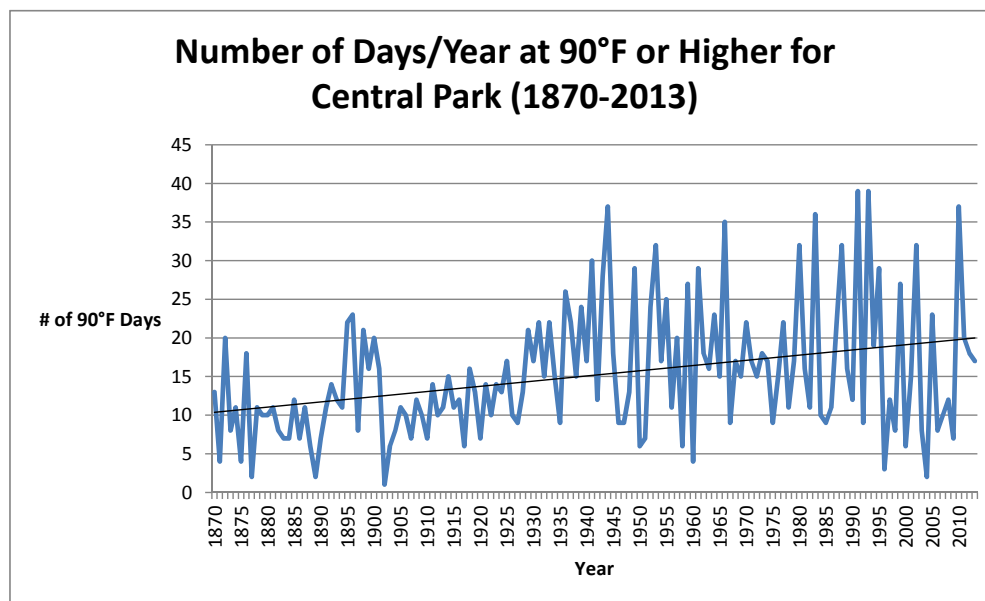
| Product             | Description   |
|---------------------|---|
| Wind Chill Advisory | Issued when wind-chill values are expected to fall to between -15°F and -24°F |
| Wind Chill Warning  | Issued when wind-chill values are expected to fall to -25°F or colder         |

**iii. Probability**

*Extreme Heat*

Official temperature readings for New York City are taken at Belvedere Castle in Central Park, although temperatures vary throughout the city. Current averages are calculated for the baseline period of 1971 to 2000. Based on data from the New York City Panel on Climate Change (NPCC), New York City currently averages 18 days per year with temperatures at or above 90°F. The city can also expect an average of two heat waves per year with an average duration of four days. Based on historical data from NWS, the annual number of days with high temperatures of 90°F or higher

Figure 3.10.66: Number of Days with Temperatures of 90°F or Higher at Central Park, 1870 to 2013 (Source: NWS, 2013)



at Central Park has been increasing since the late 19<sup>th</sup> century (see Figure 3.10.66). The number, duration, and intensity of heat waves and days at or above 90°F are expected to continue to increase in the future as a result of climate change (see Future Environment, below).

#### *Extreme Cold*

According to the NPCC, using the baseline period of 1971 to 2000, the city currently experiences an average of 72 days per year with minimum temperatures at or below 32°F. This number is expected to decrease in the future as a result of climate change (see Future Environment, below).

#### **iv. Location**

##### *Extreme Heat*

Extreme heat affects all of New York City, although some locations are more at risk than others. For example, sea breezes keep areas near the ocean shoreline cooler during the summer months. Thus, places like John F. Kennedy International Airport (JFK) and the Rockaway Peninsula experience fewer days at or above 90°F annually than locations farther from the ocean,

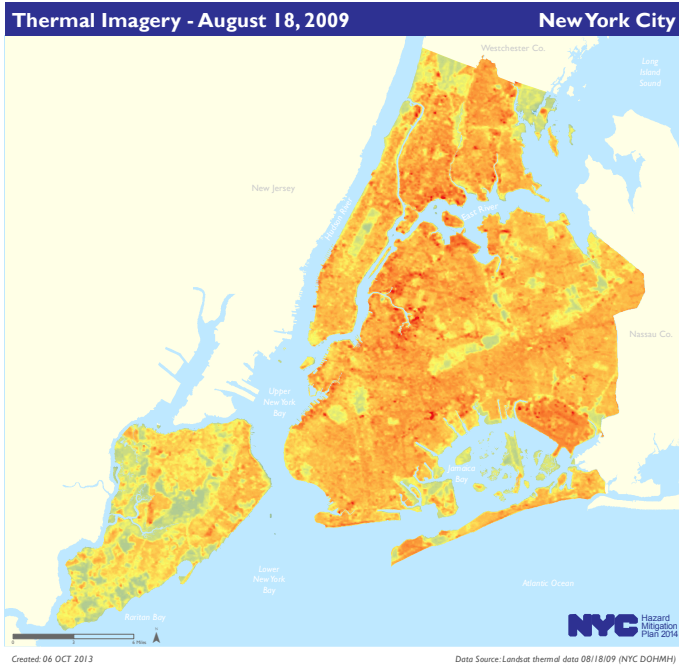
such as Central Park and LaGuardia Airport (LGA).

In addition to keeping all of New York City warmer than surrounding areas, the urban heat island effect also makes some city neighborhoods warmer than others. Not surprisingly, the warmest neighborhoods typically have the densest development (highest concentrations of heat-trapping built structures) and the least vegetation. Figure 3.10.67 is a thermal image of New York City, taken on August 18, 2009, one of the hotter days of that year, and Figure 3.10.68 displays the city's vegetative cover. Comparing the two images reveals that hotspots are generally areas that lack vegetation. These areas are at greatest risk from extreme heat events.

##### *Extreme Cold*

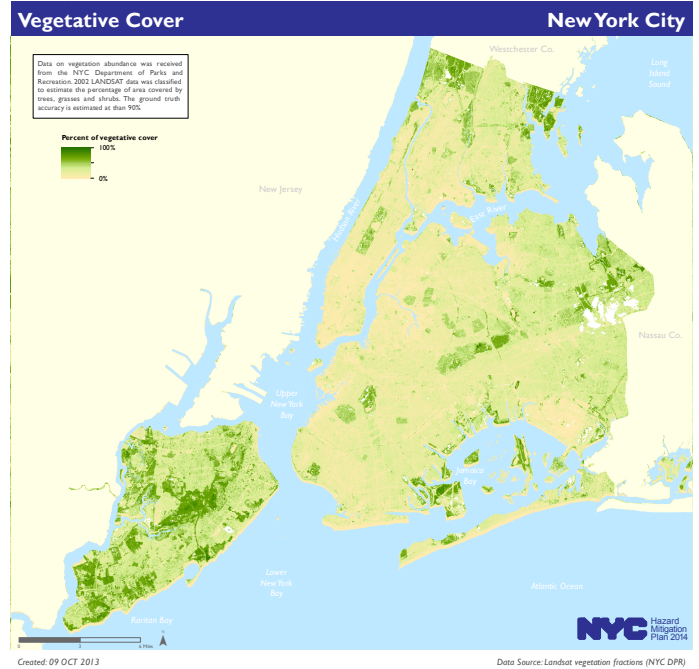
There is generally less variation across the city with extreme cold events than there is with extreme heat events. In general, all of New York City experiences a moderation of cold temperatures due to the combination of the urban heat island effect and proximity to the ocean. Areas along the immediate ocean shoreline are often slightly warmer than areas several miles inland during the colder months of the year. However,

**Figure 3.10.67: New York City Thermal Imagery Taken August 18, 2009 (Source: DOHMH)**



Notes: \*Warmer locations are orange and red, while cooler areas are green and yellow.

**Figure 3.10.68: New York City Vegetative Cover (Source: OEM)**



wind-chill temperatures along the immediate coast may be lower than those of areas several miles inland due to higher winds near the water, even if the actual air temperature is higher. Lower-density neighborhoods of the city with greater natural cover and less asphalt may also be a few degrees colder, although this effect is less pronounced during the colder months.

**iv. Historic Occurrences**

Table 3.10.47 describes instances of extreme temperatures in New York City since 1995. Note that thresholds for the activation of the City's Heat Emergency Plan (see Social Environment, below) were adopted in 2007 and require the issuance of at least a heat advisory from NWS. For extreme heat events in 2007 or later, Table 3.10.47 only includes those for which these criteria were met.

## 10. EXTREME TEMPERATURES

### CHAPTER 3: RISK ASSESSMENT

**Table 3.10.47: Extreme Temperatures in New York City 1995 to 2013**

| Start            | Event        | Location | Description   |
|------------------|--------------|----------|---|
| July 13, 1995    | Extreme heat | Citywide | <ul style="list-style-type: none"> <li>• Temperatures rise to a record high of 102°F in Central Park</li> <li>• 7 people die, and hundreds more are treated for heat-related illness</li> </ul>   |
| July 4, 1999     | Extreme heat | Citywide | <ul style="list-style-type: none"> <li>• 3 consecutive days of hot, humid weather</li> <li>• On July 4, temperatures reach the mid to upper 90s with heat indices from 100 to 105°F</li> <li>• 31 deaths reported</li> </ul>  |
| January 17, 2000 | Extreme cold | Citywide | <ul style="list-style-type: none"> <li>• Temperatures drop to 3°F in Central Park and do not rise above 20°F for 2 days</li> <li>• Strong, gusty northwest winds combine with well-below-normal temperatures to produce wind-chill values of -15°F to -30°F</li> <li>• 3 deaths reported</li> </ul>   |
| January 27, 2000 | Extreme cold | Citywide | <ul style="list-style-type: none"> <li>• Strong winds combine with temperatures in the teens and single digits to produce wind-chill values of -30°F at JFK and -28°F at LGA</li> <li>• No deaths reported</li> </ul>   |
| August 5, 2001   | Extreme heat | Citywide | <ul style="list-style-type: none"> <li>• 6 consecutive days of temperatures at or above 90° F in Central Park</li> <li>• High temperatures in Central Park reach 103°F on August 9, with heat indices between 105 and 110° F</li> <li>• OEM opens cooling centers throughout the city</li> <li>• 4 deaths reported</li> </ul>   |
| July 2, 2002     | Extreme heat | Citywide | <ul style="list-style-type: none"> <li>• Temperatures rise into the mid and upper 90s across the region</li> <li>• Overnight low temperatures remain in the lower 80s</li> <li>• On July 4, the temperature reaches 98°F at LGA, setting a new record</li> <li>• Heat indices of 100 to 105°F</li> <li>• OEM opens cooling centers throughout the city</li> <li>• No deaths reported</li> </ul>     |
| July 29, 2004    | Extreme heat | Citywide | <ul style="list-style-type: none"> <li>• 8 consecutive days of temperatures at or above 90°F in Central Park</li> <li>• High temperatures in the mid to upper 90s with heat indices as high as 100 to 105°F on July 29</li> <li>• No deaths reported</li> </ul>   |
| July 31, 2006    | Extreme heat | Citywide | <ul style="list-style-type: none"> <li>• 4 consecutive days with temperatures at or above 90°F in Central Park</li> <li>• Temperatures of 95°F to 100°F with heat indices of 105 to 115°F</li> <li>• OEM opens 383 cooling centers throughout the city</li> <li>• 40 heat stroke deaths and roughly 100 excess natural-cause deaths reported</li> <li>• Scattered power outages reported</li> </ul> |
| February 4, 2007 | Extreme cold | Citywide | <ul style="list-style-type: none"> <li>• Subfreezing temperatures for 5 consecutive days</li> <li>• Temperature drops into the single digits with a wind chill of -5°F to -10°F on February 5</li> <li>• 11 deaths reported during and following this period</li> </ul>   |
| March 6, 2007    | Extreme cold | Citywide | <ul style="list-style-type: none"> <li>• Daily temperatures below freezing for 2 consecutive days, averaging 19 degrees below normal for 4 consecutive days</li> <li>• Temperature drops to 11°F with a wind chill of -6°F in Central Park on March 6</li> <li>• 1 death reported</li> </ul>  |
| June 7, 2008     | Extreme heat | Citywide | <ul style="list-style-type: none"> <li>• 4 consecutive days with temperatures at or above 90°F in Central Park</li> <li>• Temperatures in the mid-90s with heat indices around 100°F</li> <li>• OEM activates Heat Emergency Plan and opens cooling centers throughout the city</li> <li>• 10 heat-stroke deaths reported in summer 2008</li> </ul>   |

## 10. EXTREME TEMPERATURES

### CHAPTER 3: RISK ASSESSMENT

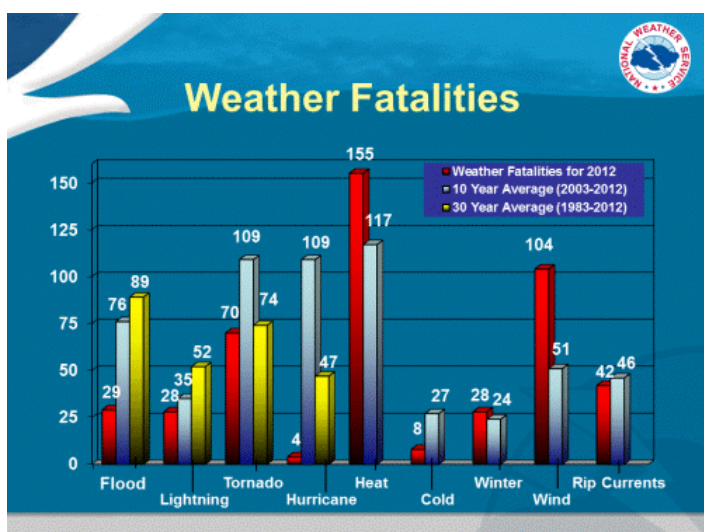
| Start           | Event        | Location | Description   |
|-----------------|--------------|----------|---|
| August 16, 2009 | Extreme heat | Citywide | <ul style="list-style-type: none"> <li>4 consecutive days with temperatures at or above 90°F in Central Park</li> <li>Heat indices reach the mid-90s</li> <li>OEM activates Heat Emergency Plan and opens cooling centers throughout the city</li> </ul>  |
| June 27, 2010   | Extreme heat | Citywide | <ul style="list-style-type: none"> <li>3 consecutive days with temperatures at or above 90°F in Central Park</li> <li>Heat indices reach the upper 90s</li> <li>OEM activates Heat Emergency Plan and opens 488 cooling centers throughout the city</li> </ul>  |
| July 4, 2010    | Extreme heat | Citywide | <ul style="list-style-type: none"> <li>4 consecutive days with temperatures at or above 90°F, with a maximum of 103°F and heat index values between 105°F and 110°F in Central Park on July 6</li> <li>OEM activates Heat Emergency Plan and opens 480 cooling centers throughout the city</li> <li>10 heat-stroke deaths reported</li> </ul>   |
| July 16, 2010   | Extreme heat | Citywide | <ul style="list-style-type: none"> <li>4 consecutive days with temperatures at or above 90°F</li> <li>Heat indices 100°F to 105°F on July 16</li> <li>OEM activates Heat Emergency Plan and opens 453 cooling centers throughout the city</li> </ul>  |
| August 4, 2010  | Extreme heat | Citywide | <ul style="list-style-type: none"> <li>3 consecutive days with temperatures at or above 90°F in Central Park</li> <li>Heat indices reach the upper 90s</li> <li>OEM activates Heat Emergency Plan and opens 436 cooling centers throughout the city</li> </ul>  |
| July 21, 2011   | Extreme heat | Citywide | <ul style="list-style-type: none"> <li>4 consecutive days with temperatures at or above 90°F,</li> <li>Maximum temperature of 104°F with heat index of 115°F on July 2 in Central Park</li> <li>OEM activates Heat Emergency Plan and opens 504 cooling centers throughout the city</li> <li>30 heat-stroke deaths reported</li> </ul>  |
| June 20, 2012   | Extreme heat | Citywide | <ul style="list-style-type: none"> <li>3 consecutive days with temperatures at or above 90°F</li> <li>Temperatures in the mid-90s with heat indices in the upper 90s in Central Park</li> <li>OEM activates Heat Emergency Plan and opens more than 400 cooling centers throughout the city</li> </ul>  |
| June 29, 2012   | Extreme heat | Citywide | <ul style="list-style-type: none"> <li>3 consecutive days with temperatures at or above 90°F and heat indices as high as 100°F in Central Park</li> <li>OEM activates Heat Emergency Plan and opens cooling centers throughout the city</li> </ul>  |
| July 4, 2012    | Extreme heat | Citywide | <ul style="list-style-type: none"> <li>4 consecutive days with temperatures at or above 90°F in Central Park</li> <li>Temperatures in the mid-to-upper 90s with heat indices in the upper 90s in Central Park</li> <li>OEM activates Heat Emergency Plan and opens cooling centers throughout the city</li> </ul>   |
| July 16, 2012   | Extreme heat | Citywide | <ul style="list-style-type: none"> <li>3 consecutive days with temperatures at or above 90°F at Central Park</li> <li>Temperature reaches 100°F in Central Park and 101°F at LaGuardia Airport on July 18, with heat index reaching or exceeding 105°F at both locations</li> </ul>   |
| July 4, 2013    | Extreme heat | Citywide | <ul style="list-style-type: none"> <li>3 consecutive days with temperatures at or above 90°F and heat indices above 95°F in Central Park</li> </ul>   |
| July 14, 2013   | Extreme Heat | Citywide | <ul style="list-style-type: none"> <li>7 consecutive days with temperatures at or above 90°F in Central Park</li> <li>Maximum of 98°F in Central Park on July 18, with heat indices 100°F to 105°F</li> <li>July 17 through July 20 set daily records for highest minimum temperature, not dropping below 80°F at night</li> <li>OEM activates Heat Emergency Plan and opens cooling centers throughout the city</li> </ul> |

**B. Vulnerability Assessment**

**i. Social Environment**

Extreme temperatures cause more fatalities in the United States than other natural hazards, with an average of 144 combined heat and cold-related deaths per year between 2003 and 2012 (see Figure 3.10.69). However, nationally, average annual mortality from extreme heat (117 deaths per year) was significantly higher than from extreme cold (27 deaths per year).

**Figure 3.10.69: Annual Weather Fatalities in the United States (Source: NOAA, 2013)**



*Extreme Heat*

Prolonged exposure to extreme heat may lead to serious health problems, including dehydration, heat exhaustion, and, in severe cases, heat stroke. Symptoms of heat exhaustion include confusion, dizziness, fatigue, nausea, headaches, and muscle cramps. If proper action is not taken, heat exhaustion may turn into heat stroke.

Heat stroke occurs when the body is no longer able to regulate its internal temperature, resulting in a body temperature of greater than 105°F. Common symptoms include seizures, disorientation, loss of consciousness, and complications involving the central nervous system. Heat stroke can cause permanent damage to

the brain and other vital organs and in many cases may result in death.

Heat exposure can aggravate underlying chronic health conditions such as asthma or cardiovascular disease, especially when it is associated with poor air quality. Thus, during heat waves, overall mortality rates often rise above what would be expected on normal summer days due to these secondary health impacts. For example, in 2006 there were approximately 100 excess natural-cause deaths attributed to a severe heat wave that also caused 40 heat-stroke deaths. The lack of air conditioning in particular greatly increases heat stress and the risk of heat related illness and death for vulnerable individuals. According to the Centers for Disease Control and Prevention (CDC), approximately 80% of heat-related deaths among New York City residents are those exposed in their homes.

New York City's urban environment exacerbates hazardous conditions resulting from extreme heat. For example, stagnant atmospheric conditions during the summer can contribute to poor air quality and increase the rate of heat-related illness and death. Consequently, people living in New York City are at greater risk from the effects of a heat wave than those living in less urbanized areas.

Each year, on average, there are 450 emergency department (ED) visits and 150 hospital admissions for heat-related illness, and 13 heat stroke deaths among New York City residents (see Table 3.10.48). Between 1997 and 2010, 152 heat-stroke deaths were reported by the New York City Office of the Chief Medical Examiner (OCME) and Bureau of Vital Statistics. These values do not include excess natural cause mortality due to secondary impacts of heat, which are generally more numerous than direct heat stroke deaths. DOHMH estimates that heat-related mortality due to secondary impacts increased by an average of 6.5% during 12 prolonged heat waves which occurred throughout this period, accounting for approximately 1,090 additional deaths.

## 10. EXTREME TEMPERATURES

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**Table 3.10.48: Hospital Admissions and ED Visits for Heat Illness and Heat Stroke Deaths, 2001-2011 (Source: DOHMH)**

| Year         | Hospital Admissions | Treated & Released from ED* | Heat Stroke Deaths |
|--------------|---------------------|-----------------------------|--------------------|
| 2001         | 203                 | –                           | 13                 |
| 2002         | 216                 | –                           | 16                 |
| 2003         | 152                 | –                           | 6                  |
| 2004         | 53                  | –                           | 1                  |
| 2005         | 170                 | 512                         | 7                  |
| 2006         | 322                 | 598                         | 50                 |
| 2007         | 90                  | 382                         | 1                  |
| 2008         | 150                 | 462                         | 10                 |
| 2009         | 54                  | 228                         | 2                  |
| 2010         | 247                 | 669                         | 11                 |
| 2011         | 237                 | –                           | 34                 |
| <b>Total</b> | <b>1894</b>         | <b>2851</b>                 | <b>151</b>         |

#### Notes

1. Hospital admissions calculated as NYC residents admitted to a NYC hospital and ED visits calculated as NYC residents treated and released from an NYC emergency department during the months of May-Sept.
2. \*ED data available from 2005 onwards. 2011 data not yet available.

Based on consultation with the NWS, the City activates its Heat Emergency Plan, which outlines the coordinated response to mitigate the effects of heat and humidity on critical infrastructure, at-risk populations, and New York City operations. When the heat index is predicted to be dangerously high, the City also opens cooling centers in air-conditioned public community centers, senior centers, and public libraries to offer heat relief.

#### *Extreme Cold*

Extreme cold can be dangerous and result in serious health issues. When exposed to cold temperatures for an extended period, the body loses heat faster than it

can generate it. This causes the body's internal temperature to drop, resulting in hypothermia. Early symptoms of hypothermia include shivering, fatigue, loss of coordination, and disorientation. If continued untreated, this condition becomes more serious, with recognizable symptoms including blue skin, dilated pupils, slow pulse and breathing, or loss of consciousness. Hypothermia can have serious impacts on the brain and often affects the victim's ability to move or think clearly. According to DOHMH, there were nearly 200 hypothermia-related hospital admissions and ED visits on average each year from 2005 to 2010.

Another serious condition brought on by extreme cold is frostbite, a freezing of the body's outer tissue. This most commonly occurs in the outer extremities like the nose, ears, cheeks, chin, fingers, and toes. Some symptoms of frostbite include numbness, tingling or stinging, aching, and discoloration of the skin. Frostbite can cause permanent damage to the body tissue and in severe cases may result in the need for amputation.

Cold exposure can also exacerbate underlying chronic illnesses, such as asthma and other respiratory diseases. Any utility disruption or building systems failure that leads to a lack of heat can greatly increase the risk of hypothermia and exacerbation of chronic heart and lung conditions among vulnerable residents. The use of gas stoves or other unvented fuel burning supplemental heat sources can cause dangerous exposures to carbon monoxide. During power outages, people living in healthcare facilities such as senior living centers and adult care facilities without backup power are also at increased risk. Icy conditions resulting from the cold may also contribute to falls and other injuries for those who venture outside.

DOHMH issues a Cold Weather Alert for the city when temperatures fall below 32°F between the hours of 4 PM and 8 AM. During extreme cold events, the City will also open warming centers and increase outreach to the homeless population. The New York City Police Department (NYPD) monitors the city for individuals in need of shelter and transports them to the nearest Department of Homeless Services shelter or 911 receiving hospital.



#### *Vulnerable Populations*

Although the health impacts of extreme temperatures can affect anyone who experiences prolonged exposure, certain populations are particularly at risk. Below are some groups that are especially vulnerable to the impacts of both extreme heat and extreme cold (for more information on vulnerable populations, see section 3.4: New York City's Hazard Environment).

- Individuals age 65 and older
- Infants and children under age five
- People with pre-existing medical conditions (including heart disease, diabetes, or respiratory problems such as chronic asthma)
- People who are obese (for extreme heat) or underweight (for extreme cold)
- People living in poverty (for poverty thresholds refer to the [U.S. Census Bureau](#) (website link provided at the end of section 10) and section 3.4: New York City's Hazard Environment)
- People without air conditioning (for heat) or those with inadequate heat (for cold)
- People who speak little or no English
- Outdoor workers (due to prolonged exposure and, in some cases, heavy physical exertion)
- The homeless (due to prolonged exposure and inadequate protection from the elements—both the New York City Heat and Winter Weather Emergency Plans include strategies for outreach to the homeless population)

Secondary impacts to the population may result from power outages brought on by the heat (see Built Environment, below). Additionally, people who rely on prescription medications are at increased risk if pharmacies are out of service due to an outage.

#### **ii. Built Environment**

A large portion of New York City's utility and transpor-

tation infrastructure is vulnerable to damage during extreme heat and cold events. Although buildings in New York City are generally not as susceptible, long-term exposure to extreme temperatures can cause damage to certain types of older, less heat- or cold-resistant building materials.

#### *Extreme Heat*

Extreme heat can cause railroad tracks and pavement on roads and bridges to crack or buckle, resulting in service disruptions and potentially hazardous travel conditions.

When temperatures rise above 90°F during summer months, demand for electricity also rises as people increase their usage of air conditioners and fans. The heat itself can also cause transmission lines to sag, overheat, or short out. This combination of factors stresses the electrical generation, transmission, and distribution infrastructure, which in turn increases the likelihood that sections or components of the electrical system will fail, causing power outages. Such outages may impair building functions such as air conditioning and refrigeration of food and certain types of medications. Increased power demand may also result in higher emissions of greenhouse gases from power-generating facilities, contributing to climate change.

Some people illegally open fire hydrants for use as sprinklers during hot weather. The resulting drop in system water pressure can reduce firefighting capabilities and create potentially life-threatening situations for the public. Hydrant spray caps reduce the discharge of open hydrants from approximately 1,000 gallons per minute to 25 gallons per minute. The New York City Fire Department (FDNY) distributes hydrant spray caps to the public to prevent water waste.

#### *Extreme Cold*

During the winter months, freezing temperatures and repeated freeze-thaw cycles can cause potholes, which may damage vehicles. Hazardous travel conditions may result if potholes are not tended to immediately. Frozen pipes, a common occurrence during extreme cold events, may cause service interruptions in water

supply, gas supply, and drainage. To limit these effects, utility providers monitor conditions, perform routine maintenance, and address problems as they arise. Additionally, when the temperature falls below 25°F for a 24-hour period, FDNY institutes a hydrant inspection program and takes corrective action to thaw frozen hydrants.

### **iii. Natural Environment**

Extreme temperatures are naturally occurring weather events (human activities and the built environment exacerbate the problem, but do not cause it). Thus, it is difficult to determine whether or not the temperatures themselves have any direct impacts on the natural environment. There can, however, be impacts on the natural environment that are related to secondary hazards associated with extreme heat events, such as poor air quality and drought. Extreme temperatures, particularly heat, also cause an increase in energy usage, which contributes to higher emissions of pollutants and greenhouse gases during these periods. Long-term temperature changes may cause shifts in habitat and, potentially, extinctions of certain types of local species which are not adapted to long stretches of extreme heat or cold. However, it is still uncertain what impacts short-duration extreme temperature events have, if any.

### **iv. Future Environment**

Scientists predict that extreme heat events in New York City will increase in frequency, intensity, and duration in the future, while extreme cold events will decrease in frequency, intensity, and duration. Table 3.10.49, adapted from the NPCC, illustrates this projected change through the middle of the 21<sup>st</sup> century. These projections are relative to the baseline period of 1971-2000, and include a middle-range estimate (25<sup>th</sup>-75<sup>th</sup> percentile) and a high-value estimate (90<sup>th</sup> percentile). According to these projections, New York City should expect, on average, up to an additional 8 to 15 days at 90°F or above by the 2020s, and up to an additional 21 to 39 days at 90°F or above by the 2050s (which would represent more than a 100% increase).

Furthermore, up to one to two additional heat waves per year are projected by the 2020s, and up to three

to five additional heat waves per year are projected by the 2050s. These heat waves are expected to last one to two days longer on average. As the climate warms, extreme heat events are also expected to become more common during peripheral summer months like May and September.

Extreme cold events, on the other hand, are expected to decrease. The annual average number of days with minimum temperatures below 32°F is expected to decrease by 12 to 20 days by the 2020s and 20 to 30 days by the 2050s.

The combination of more heat waves and changing demographics (such as the growth of the elderly population) is likely to result in higher rates of temperature-related mortality and illness in the future. A recent study (Li et al. 2013) projects that the number of heat-related deaths in Manhattan will increase at a relatively sharp rate throughout the 21<sup>st</sup> century while cold-related deaths will decrease at a more modest rate, resulting in a net increase in total mortality related to extreme temperatures. Relative to the 1980s, the study predicts a 37% to 49% increase in heat-related deaths and an 11% to 15% increase in temperature-related deaths by mid-century. By the end of the century, heat-related deaths are predicted to increase 50% to 91%, while total temperature-related deaths are expected to increase 16% to 31%.

Table 3.10.49: Quantitative Changes in Extreme Temperature Events (Source: NPCC, 2013)

| Heat Waves and Cold Events               | Baseline (1971-2000) | 2020s  |  | 2050s  |  |
|--|----------------------|--|--|--|--|
|  |                      | Middle Range (25 <sup>th</sup> -75 <sup>th</sup> percentage) | High End (90 <sup>th</sup> percentile) | Middle Range (25 <sup>th</sup> -75 <sup>th</sup> percentage) | High End (90 <sup>th</sup> percentage) |
| Number of days per year at or above 90°F | 18                   | 26 to 31   | 33                                     | 39 to 52   | 57                                     |
| Number of heat waves per year            | 2                    | 3 to 4   | 4                                      | 5 to 7   | 7                                      |
| Average duration (days)                  | 4                    | 5  | 5                                      | 5 to 6   | 6                                      |
| Number of days below 32°F                | 72                   | 52 to 58   | 60                                     | 42 to 48   | 52                                     |

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## 10. EXTREME TEMPERATURES

### CHAPTER 3: RISK ASSESSMENT

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## 11. Flooding

### A. Hazard Identification

#### i. Hazard Description

Floods occur more frequently than any other natural disaster in the United States. One in three federal disaster declarations is related to flooding, and many of them affect heavily populated coastal communities—including New York City.

#### *Flood Characteristics*

Flood events, the temporary inundation of normally dry land, can vary significantly in their causes, rates of development, duration, and geographic scale. Floods can be caused by excess water from oceans, rivers, groundwater, rainfall, or sewers and are commonly induced by a rain or storm event. Seasonal and intra-annual variations in tidal and hydrological cycles, along with effects attributed to climate change (such as sea level rise, intense precipitation, and more frequent, severe storms) can also contribute to flooding.

Some floods develop gradually, over a period of hours or days, such as those that can occur during hurricanes or other coastal storms. Other floods happen more quickly, sometimes in a matter of minutes, and are associated with a sudden event such as a thunderstorm. Similarly, the duration of a flood depends on many factors including paths for water to exit the flooded area, such as land gradients, waterways, sewers, or porous soils.

A flood can be site-specific, impacting a single building or component of a piece of infrastructure; local, impacting a block or neighborhood; or regional, affecting an entire river basin or stretch of coastline.

#### *Flood Types*

There are four types of flood events that can affect New York City:

- Coastal Flooding
- Tidal Flooding

- Riverine Flooding
- Inland Flooding

#### **Coastal Flooding**

Coastal floods affect areas along the ocean, bays, rivers, streams, or estuaries of tidal influence. In New York City, coastal floods are most commonly caused by storm surge from a strong coastal storm, such as a tropical storm, hurricane or a nor'easter. Storm surge is the increase in water levels brought about by the wind field and low pressure of a storm. When a storm approaches land, the storm surge "piles" up at the edge of the water body, raising water levels and leading to coastal flooding. The height of the surge can be measured by taking the difference between the observed storm tide and the astronomic, or normal, tide (see Figure 3.11.70). The geography of New York Harbor amplifies the impacts of a storm surge. The New York Bight—the 90-degree angle formed by the shorelines of Long Island and New Jersey—serves as a funnel directing surge into the New York City harbor (for more information on the New York Bight see section 6. Coastal Storms).

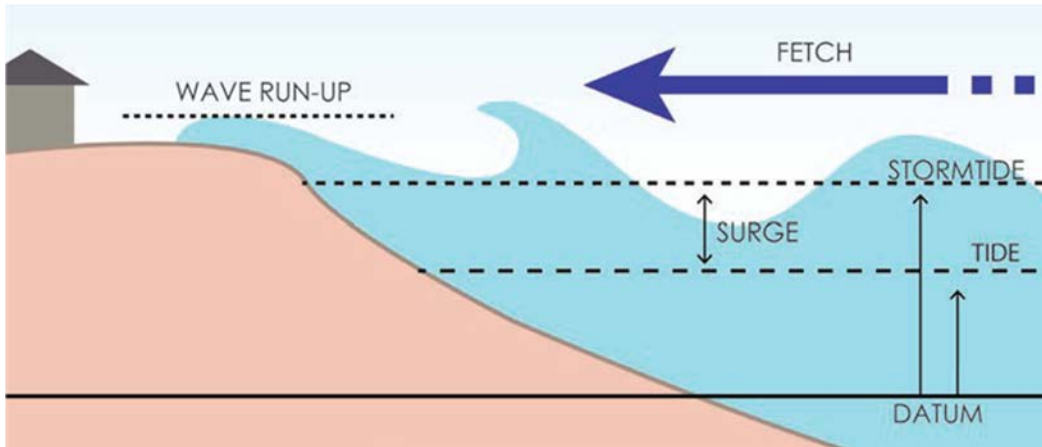
Storm surge can cause "stillwater" flooding, or a rise in water levels without significant waves, or it can result in flooding accompanied by waves. With or without waves, coastal flooding can cause erosion and structural damage and create hazardous conditions. The salt or brackish water that comes with coastal flooding can ruin mechanical and electrical equipment and harm vegetation. Sea level rise is projected to exacerbate coastal flooding hazards (see [Future Environment](#), below).

#### **Tidal Flooding**

Sea levels fluctuate daily due to gravitational forces and the orbital cycles of the moon, sun, and earth. Each day there are two high tides and two low tides. These daily high tides are at their highest twice a month, during what is known as "spring tides," when the earth, sun, and moon are aligned.

Flooding from high tides affects some low-lying sections of New York City today. The neighborhoods that are lowest-lying with extensive shoreline exposures are particularly vulnerable to tidal flooding. As sea lev-

Figure 3.11.70: Storm Surge Height, Wave Run Up, Storm Tide, and Tide (Source: Urban Waterfront Adaptation Strategy, 2013)



els rise, these neighborhoods can be expected to flood more frequently, while other low-lying neighborhoods that do not currently flood regularly with the tides could start to do so, in the absence of other measures. Regular tidal flooding could result in significant disruptions to neighborhoods and also bring about gradual erosion.

### Riverine Flooding

Riverine flooding occurs when freshwater rivers and streams exceed local flow capacity and water spills over their banks. Flooding from large rivers usually results from large-scale weather systems that generate prolonged rainfall over expansive areas. These same weather systems may cause flooding of smaller basins that drain into major rivers, contributing to riverine flooding. Narrow rivers and streams are susceptible to flooding from more localized weather systems that bring intense rainfall over small areas. While riverine flooding is the most common type of flood event across New York State, it occurs less frequently and severely in New York City, where most freshwater rivers and streams are short and drain small areas.

### Inland Flooding

Inland floods—commonly called "flash floods"—can be caused by short-term, high-intensity rainfall, often associated with sudden small-scale thunderstorms or hurricanes and other large-scale storms. Inland floods can also be caused by moderate rainfall over several days, typically brought on by weak-

er storms that drift slowly or stall over an area.

Inadequate drainage can also contribute to inland flooding. Drainage complications can be due to the condition or design capacity of the sewer and storm-water management infrastructure, or natural drainage conditions or the surface characteristics of an area. In New York City, impervious surfaces—such as buildings, streets, sidewalks, and parking lots—reduce the amount of rainfall absorbed into the ground and can increase surface runoff volumes into the city's aging drainage infrastructure, increasing the likelihood of inland flooding. This effect is most pronounced in low-lying areas with limited natural drainage capacity, including parts of the city that once were marshes or creeks but were filled in years ago.

### ii. Severity

Flood severity depends on flood type, cause, duration, and existing conditions, such as drainage design capacity and pathways for water to exit. The National Weather Service (NWS) categorizes flooding as minor, moderate, and major (see Table 3.11.50).

**Table 3.11.50: National Weather Service Flood Categories**

| Category | Description   |
|----------|---|
| Minor    | <ul style="list-style-type: none"> <li>Minimal or no property damage</li> <li>Possibly some public inconvenience</li> </ul>   |
| Moderate | <ul style="list-style-type: none"> <li>Inundation of secondary roads</li> <li>Transfer to higher elevation necessary to save property</li> <li>Some evacuation may be required</li> </ul>       |
| Major    | <ul style="list-style-type: none"> <li>Extensive inundation and property damage</li> <li>Often involves the evacuation of people and the closure of both primary and secondary roads</li> </ul> |

**iii. Probability**

Determining the likelihood of a flood occurring in any given year is a critical first step in developing flood mitigation practices. The foundation for flood probability analysis is an examination of the frequency of past flood events of different intensities and their recurrence intervals. The relationship between the probability of a flood and its impact on an area is complex and can range from low probability, high impact (as illustrated by Hurricane Sandy in 2012) to high probability, low impact (as demonstrated by monthly high-tide flooding).

*Coastal and Riverine Flooding*

The coastal and river flood risk probability is determined by a number of factors, including severe weather events, like hurricanes, and regular high tide. New York City relies on the Federal Emergency Management Agency (FEMA) Flood Insurance Rate Maps (FIRMs) for information on flood risk probability for coastal and riverine flooding. These maps represent the federal government's official assessment of flood risk in an area.

FIRMs are used to determine flood insurance rates and identify flood risk. The flood zones shown on the FIRMs are geographic areas classified according to levels of flood risk, with each zone reflecting the severity and/

or type of flooding (see Table 3.11.51). The 100-year floodplain, also referred to as the Special Flood Hazard Area (SFHA), is the area with a 1% or greater chance of experiencing coastal or riverine flooding in any given year; the 100-year floodplain is further broken down into subzones of various risk (see Table 3.11.51). Mandatory flood insurance purchase apply to structures with certain circumstances (if a structure has a mortgage with a federally backed loan) within the 100-year floodplain. The maps also show the 500-year floodplain, the area with a 0.2% or greater annual chance of flooding. The expected heights of flooding are shown on the maps as well. Floodplain management standards apply within the 100-year floodplain as long as they are in th SFHA and participating in the NFIP.

However, the terms "100-year" and "500-year" can be misleading and perhaps even provide a false sense of security. A 100-year flood is not the flood that happens once every 100 years. Rather, as defined above, it is the flood that has a 1% or greater chance of occurring in any given year. Experiencing a 100-year flood does not decrease the chance of a second 100-year flood occurring that same year or any year that follows. Even the 1% concept can be misleading—because when the years add up so does the probability. For example, a 100-year flood today, without considering future impacts from sea level rise or climate change, has a 26% chance of occurring at least once over the life of a 30-year mortgage. Similarly, a 100-year flood today has a 45% chance of occurring over the 60-year life of a power substation.



**Table 3.11.51: FIRM Flood Zone Categories**

| Flood Zone Category  | Description  |
|--|--|
| V/VE*  | Areas along coasts subject to inundation by a 1% annual chance flood with additional hazards associated with storm-induced waves over 3 feet high. Mandatory flood insurance purchase and floodplain management standards apply.   |
| Coastal A  | Areas landward of a V Zone or landward of an open coast without a mapped V-Zone subject to inundation by a 1% annual chance flood with additional hazards associated with storm-induced waves of 1.5 to 3 feet high. (These zones were not mapped on the 2007 effective FEMA FIRMs, but are included in the 2013 Preliminary Flood Insurance Rate Maps (Preliminary FIRMs) and will be included in future FEMA FIRMs for the New York Region.) |
| A/AE*  | Areas subject to inundation by a 1% annual chance flood without wave action less than 1.5 feet. Mandatory flood insurance purchase and floodplain management standards apply.  |
| B/X (shaded)   | Areas of moderate flood hazard subject to inundation by a 0.2% annual chance flood. Also called the 500-year flood zone.   |
| *"E" indicates on the FIRMs that there is a base flood elevation determined. |  |

FIRMs do not include sea level rise projections, and therefore do not reflect full future coastal and riverine flooding risk. The probability of coastal or riverine flooding is likely to increase in the future due to sea level rise and other climate change-related factors (see [Future Environment](#), below).

**Tidal Flooding**

The probability of tidal flooding is linked to the lunar cycle and proximity to a tidal area. Low-lying coastal sections of New York City have the highest probability of experiencing regular floods from high tides, with many areas already experiencing regular flooding today. As sea levels rise, it is probable that the lowest-lying areas of the city will gradually become more vulnerable to regular flooding from daily and monthly high tides, and parts of the city that currently do not flood will begin to do so.

**Inland Flooding**

Unlike coastal and tidal floods, inland floods can strike with little or no warning and are unrelated to the 100-year floodplain designation. It is therefore difficult to determine the probability of inland floods. However, over the last several years, storms and precipitation events of great magnitude have been occurring more frequently than they did in the

past. For instance, on June 7, 2013, the remnants of Tropical Storm Andrea brought 4.16 inches of rain to Central Park—an amount close to the total rain (4.41 inches) that typically falls during the entire month of June. The flooding that resulted forced officials to suspend subway service in northern Manhattan.

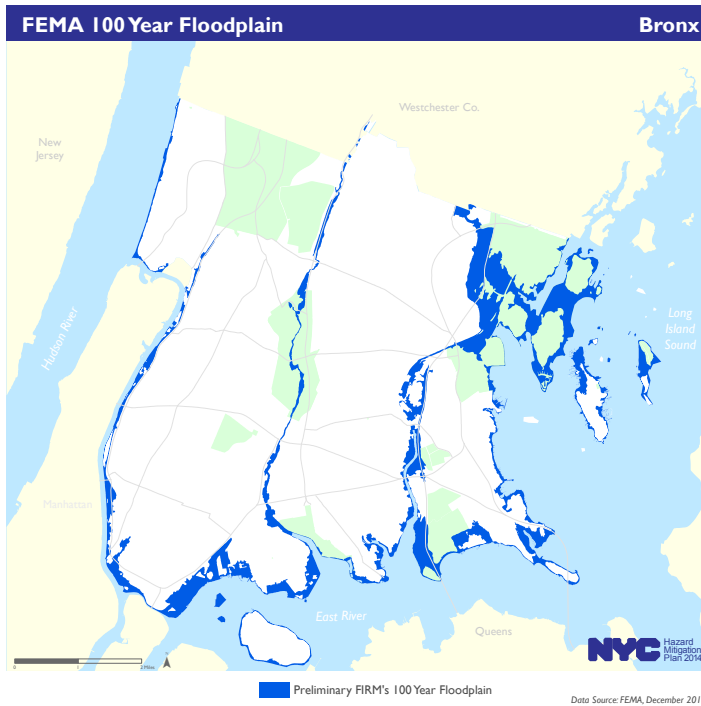
**iv. Location**

New York City's 520 miles of waterfront are incredibly diverse, and each area faces different levels and types of flood risk. Low-lying areas —such as Coney Island and Red Hook, in Brooklyn, Staten Island's east shore, southern portions of Queens, and portions of Lower Manhattan – are particularly vulnerable to flooding from storm surge and sea level rise. As shown in Figure 3.11.71 through Figure 3.11.75, all five boroughs have 100-year floodplain designations.

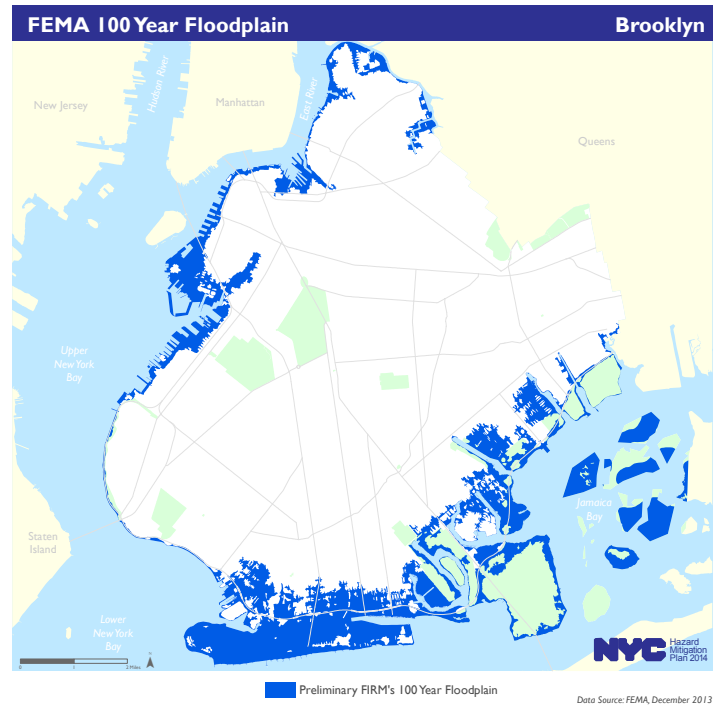
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**Figure 3.11.71: Bronx 100-Year Floodplain**



**Figure 3.11.72: Brooklyn 100-Year Floodplain**



**Figure 3.11.73: Manhattan 100-Year Floodplain**

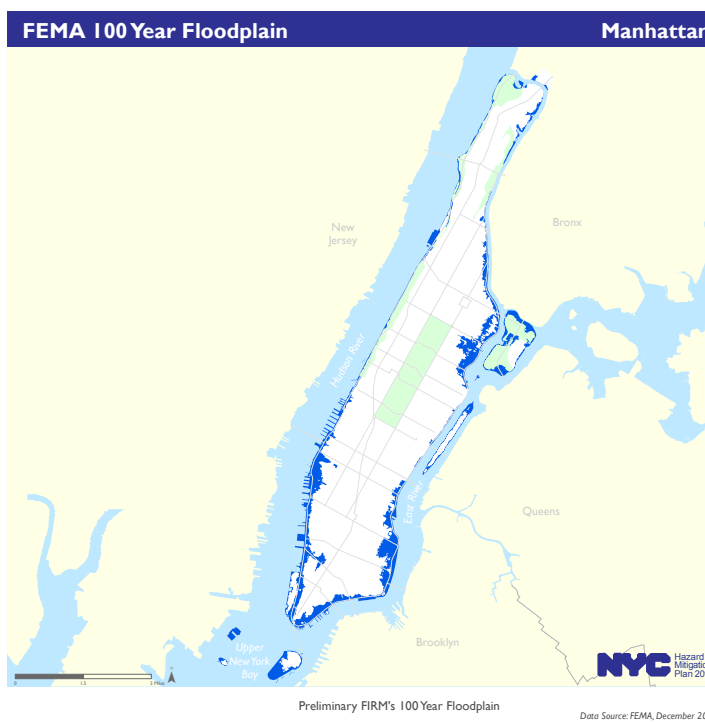


Figure 3.11.74: Queens 100-Year Floodplain

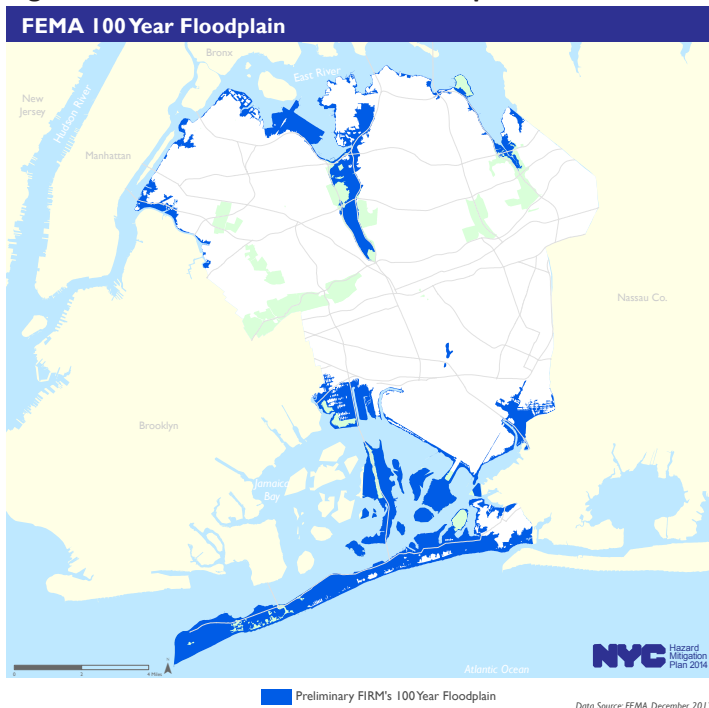
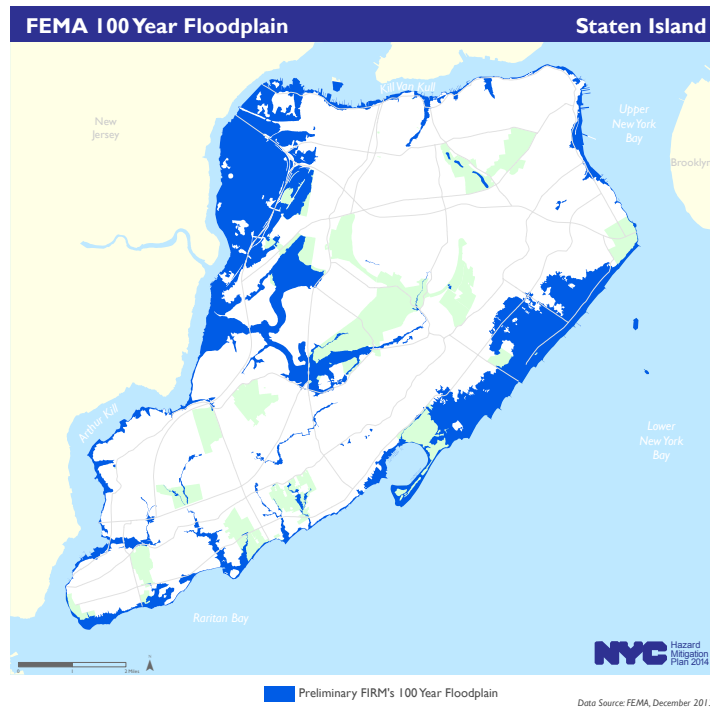


Figure 3.11.75: Staten Island 100-Year Floodplain



**Coastal Flooding**

All 520 miles of New York City's shoreline can be affected by coastal flooding, though the expected height of the 100-year flood event and the extent of the flood zone inland vary widely across the city.

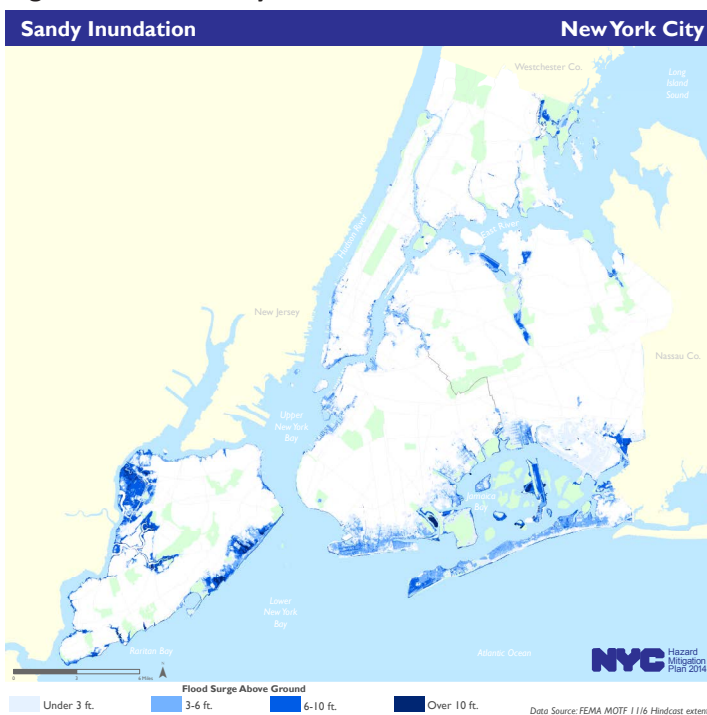
In the lowest-lying areas of the city, where slopes towards the coast are gradual, potential flood heights are high and the flood zone extends far inland; these areas include those around Jamaica Bay in southern Brooklyn and southern Queens, the West and East Shores of Staten Island, portions of Lower Manhattan and Brooklyn along the New York Harbor, and sections of east Harlem and the South Bronx along the Long Island Sound. In other areas, where slopes rise quickly upland from the coast, potential flood heights are lower and the flood zone does not extend significantly inland; these areas include the North Shore of Staten Island, Bay Ridge and Sunset Park in Brooklyn, and the North Shore of Queens.

Wave forces most directly affect sections of Queens, Brooklyn, and Staten Island along the Atlantic Ocean. These areas include Coney Island and the Rockaway Peninsula. Wave action also affects areas of the Bronx

along the Long Island Sound. The shoreline configuration has changed considerably over the past 50 years on the Rockaway Peninsula and around Jamaica Bay (as well as many other parts of the city) due to sediment movement, dredging, and filling. These changes affect wave propagation, particularly in areas such as Rockaway Point and Rockaway Inlet, where the configuration of the point controls the direction of incoming waves.

Inundation of low-lying coastal areas in the city is primarily the result of storm surges, which occur during hurricanes and nor'easters. Though Hurricane Sandy was an exceptional event, with its record-high water level of 14.06 feet above Mean Lower Low Water (MLLW – defined as the average of all high water heights observed over the National Tidal Datum Epoch), it provides insight into the potential impact of coastal flooding across the city. As Figure 3.11.76 illustrates, the areas of the city that experienced the greatest flood surge above ground (over 10 feet) are among the lowest-lying, including Staten Island's east shore and southern Brooklyn and Queens. (For more information on the combined effects of wind and storm surge on New York City, see Section 6. Coastal Storms).

Figure 3.11.76: Sandy Inundation Area



### Tidal Flooding

Low-lying neighborhoods throughout the city are vulnerable to regular flooding from high tides that result from the normal lunar cycle. As sea levels rise, these low-lying neighborhoods will gradually become more vulnerable to regular flooding from daily and monthly high tides if steps are not taken to prevent water from overtopping the shoreline. The risk of regular tidal flooding is most pronounced in neighborhoods around Jamaica Bay in southeastern Queens, particularly Broad Channel and Hamilton Beach, and on portions of the bay side of the Rockaway Peninsula, these areas are some of the lowest-lying in the city.

### Riverine Flooding

Riverine flooding affects only a small portion of flood-prone areas in New York City. Staten Island and the Bronx are the boroughs most vulnerable to riverine flooding due to the watershed characteristics in those boroughs. In the Bronx such flooding can come from the Bronx and Hutchinson Rivers, and on Staten Island from stream and river networks along the south shore and mid-island.

### Inland Flooding

In New York City, areas prone to inland flooding are often low-lying and have more impervious surfaces and issues with drainage design capacity and condition. Certain neighborhoods—particularly those located on historically filled wetlands or with limited drainage infrastructure—have been subject to inland floods for many years.

In recent years more intense rainfall events have caused inland flooding in a broader range of communities. For example, in Staten Island and parts of the Bronx, inland flooding has increased from heavy or rapid precipitation that overwhelms the flow capacity of rivers, streams, and local storm sewers. Parts of the city that have antiquated or not fully built-out storm sewer systems currently experience street flooding during heavy rainfalls. These parts of the city include sections of southern Brooklyn (such as areas in Sheepshead Bay) and southern Queens including portions of Broad Channel, Edgemere, Bayswater, Far Rockaway, Rockaway Beach, and Arverne, as well as surrounding neighborhoods in southeastern Queens, such as Rosedale and Jamaica. Such flooding may be exacerbated if rainfall intensity increases with climate change.

### National Flood Insurance Program (NFIP)

FEMA, through its administration of the National Flood Insurance Program (NFIP), sets insurance premiums and minimum building standards on the basis of the Flood Insurance Rate Maps (FIRMs) it produces. All property owners with a federally-backed mortgage on structures located within the 100-year floodplain shown on FIRMs are required to carry flood insurance.

As a participant in the NFIP, New York City has incorporated FEMA's flood resistant construction standards from the FIRMs into the New York City Building Code. In January 2014, the City updated the Building Code to require that new and substantially improved structures in the updated floodplain to be built to the standards of the Preliminary FIRMs with an additional freeboard requirement of up to two feet. In addition, the City has modified its zoning to enable flood-resilient construction.

Through the NFIP, FEMA collects a vast quantity of information on insured structures in New York City. This data includes the number and location of flood

insurance policies, number of claims per insured structure – including Repetitive Loss and Severe Repetitive Loss structures, and claim payment amount.

Repetitive Loss structures are those for which a policyholder receives two or more claim payments of \$1,000 or more after flood events within a 10-year period. Severe Repetitive Loss structures are those for which a policyholder receives at least two separate claim payments within 10 years, where the cumulative amount of the building portion of these claims exceeds the market value of the buildings, or there are at least four claim payments over \$5,000 that cumulatively exceeds \$20,000.

Figure 3.11.77 through Figure 3.11.79 spatially present several types of NFIP insurance data for each borough of New York City. Though each map represents a different variable related to the NFIP, they all show a relatively large concentration of claims and policies on Staten Island's East Shore, portions of Brooklyn and Queens facing the Atlantic Ocean and Jamaica Bay, and the low-lying southeastern section of the Bronx.

In just the last year (2012 to 2013), the city had 30,200 NFIP policies amounting to \$39 million in premiums in the city. Since 1976 there have been almost 43,000 claims. As of July 2013, there have been 16,400 claims filed since Sandy, totaling \$980 million in payouts.

As of July 2013, the city had 4,100 Repetitive Loss claims amounting to \$200 million in payouts, and 45% of these structures fell within the Preliminary FIRM 100-year floodplain. Of the repetitive loss claims, 70% were single-family homes, and 22% were 2 to 4 family homes (see Table 3.11.52). These claims were concentrated in Howard Beach, Breezy Point, and the Midland Beach areas. As of April 2012, there were 14 Severe Repetitive Loss structures, amounting to \$1.3 million in payouts. These areas are a high priority for flood mitigation.

**Table 3.11.52: Repetitive Loss Claims by Housing Type (2012 - 2013)**

| Housing Type      | Percentage of Repetitive Loss Claims (4,100 total) |
|-------------------|--|
| Single-family     | 70%  |
| 2- to 4-family    | 22%  |
| Assumed Condo     | 1%   |
| Other residential | 2%   |
| Non-residential   | 5%   |
| Unknown           | Less than 1%                                       |

In July 2012, the U.S. Congress passed the Biggert Waters Flood Insurance Reform Act, which calls on FEMA to make changes to the way the NFIP is administered. Some of these changes have been put in place, and others will be implemented in the coming year. The legislation requires the NFIP to raise rates to better reflect true flood risk, and make the program more financially stable. The changes will mean premium rate increases for some policyholders over time.

The City also participates in a Coordinating Technical Partnership (CTP) with FEMA Region II, managed by the Mayor's Office of Long-Term Planning and Sustainability (OLTPS), to update FEMA's FIRMs for New York City. The City is currently in the public comments period of this process—OLTPS receives comments from the public and will submit them to FEMA for review.

To help New Yorkers understand their flood risk, the City will launch a consumer education program. The program will include a public information campaign to build awareness about the changes to the FIRMs and what they mean in terms of flood risk and flood insurance requirements. The campaign will emphasize to policyholders that standard homeowners insurance and small business property policies do not cover damages caused by flooding. For insurance to play the appropriate role in providing individuals and businesses with financial protection from climate risks, consumers must be aware of their risks and the coverage their insurance policies include or exclude.

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Figure 3.11.77: NFIP Policies

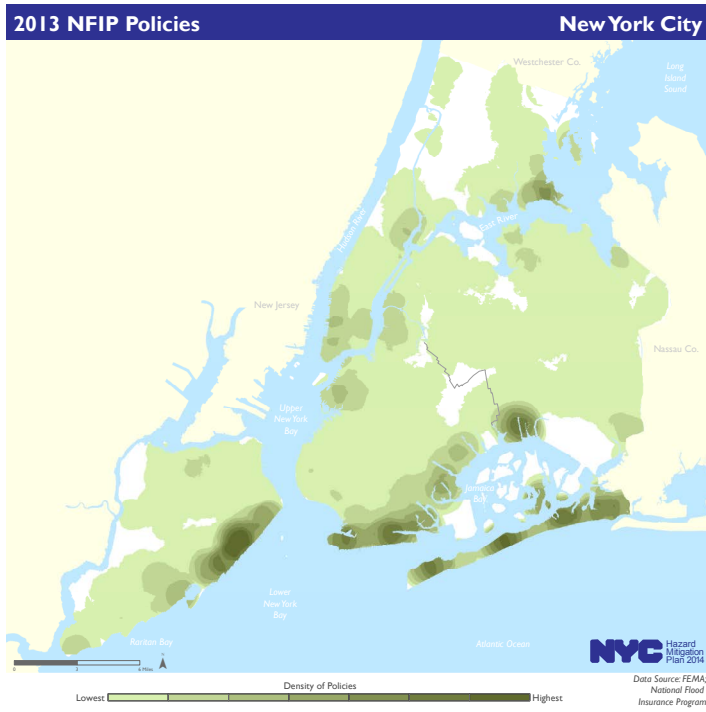


Figure 3.11.78: NFIP Policy Claims

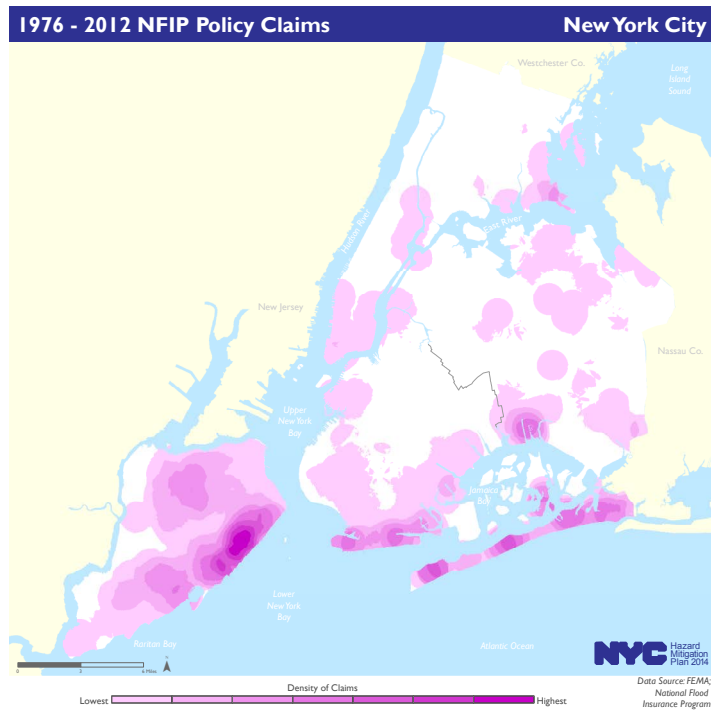
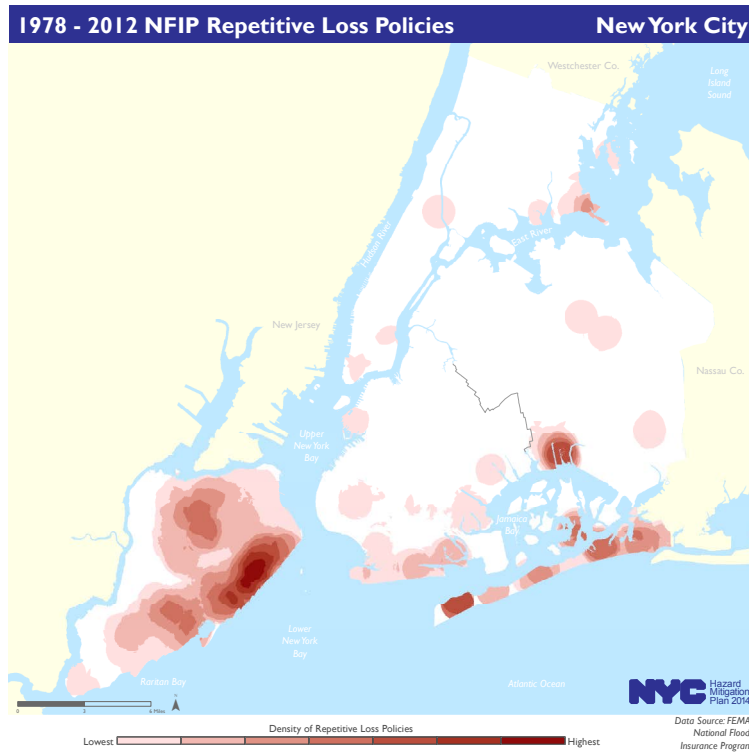


Figure 3.11.79: NFIP Repetitive Loss Properties



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#### v. Historic Occurrences

New York City has suffered from numerous floods over the last two decades, as Table 3.11.53, below, shows.

**Table 3.11.53: Selected Flood Events in New York City 1993 to 2013**

| Date              | Event                    | Location(s)                     | Description  |
|-------------------|--------------------------|---------------------------------|--|
| August 16, 1993   | Inland flood             | Manhattan                       | <ul style="list-style-type: none"> <li>Widespread rain embedded with thunderstorms</li> <li>Floodwaters partially cover cars, stranding several people on their car roofs</li> </ul>   |
| June 29, 1994     | Inland flood             | Citywide                        | <ul style="list-style-type: none"> <li>Torrential rains of nearly 2.5 inches produce substantial road and highway flooding</li> <li>Many basements flooded</li> </ul>  |
| June 22, 1995     | Inland flood             | Brooklyn, Queens                | <ul style="list-style-type: none"> <li>No information available</li> </ul>   |
| July 1, 1995      | Inland flood             | Staten Island                   | <ul style="list-style-type: none"> <li>Several homes damaged</li> <li>3 people injured at a movie theater when ceiling tiles fall because of standing water on the roof</li> </ul>   |
| July 17, 1995     | Inland flood             | Bronx, Manhattan, Queens        | <ul style="list-style-type: none"> <li>Rainfall of 2 to 4 inches</li> <li>Many roadways closed</li> </ul>  |
| July 23, 1995     | Inland flood             | Bronx, Queens                   | <ul style="list-style-type: none"> <li>No information available</li> </ul>   |
| October 21, 1995  | Inland flood             | Manhattan, Queens               | <ul style="list-style-type: none"> <li>No information available</li> </ul>   |
| November 14, 1995 | Coastal flood            | Queens                          | <ul style="list-style-type: none"> <li>No information available</li> </ul>   |
| January 12, 1996  | Inland flood             | Citywide                        | <ul style="list-style-type: none"> <li>No information available</li> </ul>   |
| January 27, 1996  | Inland flood             | Queens                          | <ul style="list-style-type: none"> <li>No information available</li> </ul>   |
| April 16, 1996    | Inland flood             | Citywide                        | <ul style="list-style-type: none"> <li>No information available</li> </ul>   |
| June 3, 1996      | Inland flood             | Citywide                        | <ul style="list-style-type: none"> <li>No information available</li> </ul>   |
| July 3, 1996      | Inland flood             | Queens, Staten Island           | <ul style="list-style-type: none"> <li>Cars trapped in floodwaters on the Long Island Expwy.</li> <li>Serious road flooding reported along Richmond Pkwy.</li> </ul>   |
| July 8, 1996      | Inland flood             | Manhattan                       | <ul style="list-style-type: none"> <li>High winds, large hailstones, and torrential rain</li> </ul>  |
| July 13, 1996     | Flood                    | Brooklyn                        | <ul style="list-style-type: none"> <li>Tropical Storm Bertha, serious, widespread flooding is reported along the Brooklyn-Queens Expwy.</li> </ul>   |
| July 31, 1996     | Inland flood             | Brooklyn, Queens, Staten Island | <ul style="list-style-type: none"> <li>2 to 5 inches of rain in 3 hours</li> <li>Several houses damaged in mudslides at Richmond town, Staten Island</li> <li>Serious widespread flash flooding of roads and numerous basements flooded across Brooklyn and Queens</li> </ul>  |
| September 8, 1996 | Inland flood             | Bronx, Brooklyn, Staten Island  | <ul style="list-style-type: none"> <li>Thunderstorms produce torrential rain</li> <li>Significant flash flooding of low-lying and poor drainage areas, including many streets</li> </ul>   |
| October 19, 1996  | Inland and coastal flood | Citywide                        | <ul style="list-style-type: none"> <li>Heavy rains</li> <li>3 to 5 inches of rainfall with isolated higher amounts</li> <li>Serious flooding of basements and first floors causes damage to 226 homes in Flushing and 70 homes in Springfield Gardens in Queens</li> <li>Numerous cars damaged in floodwaters</li> </ul> |

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| Date               | Event                   | Location(s)                             | Description  |
|--------------------|-------------------------|---|--|
| January 10, 1997   | Tidal and Coastal flood | Queens                                  | <ul style="list-style-type: none"> <li>Tidal flooding along Rockaway Blvd. in Brookville</li> <li>Moderate tidal flooding reported at Howard Beach</li> </ul>  |
| November 2, 1997   | Inland flood            | Staten Island                           | <ul style="list-style-type: none"> <li>Police scuba divers use rubber raft to rescue people from submerged car on Arthur Kill Road in Greenridge</li> </ul>  |
| January 23, 1998   | Inland flood            | Citywide                                | <ul style="list-style-type: none"> <li>Heavy rainfall of 2 to just over 4 inches</li> </ul>  |
| March 9, 1998      | Inland flood            | Citywide                                | <ul style="list-style-type: none"> <li>Widespread heavy rainfall including thunderstorms</li> <li>Many low-lying and poor drainage areas, including streets, are flooded</li> </ul>  |
| August 17, 1998    | Flood                   | Bronx, Manhattan, Queens, Staten Island | <ul style="list-style-type: none"> <li>Rainfall rates of up to 2 inches per hour</li> <li>LaGuardia Airport has 3.54 inches of rain</li> </ul>   |
| January 3, 1999    | Inland flood            | Citywide                                | <ul style="list-style-type: none"> <li>People require rescue from flooded basement apartments in Springfield Gardens, Queens</li> <li>Water rises within 6 inches of ceilings in several apartments</li> </ul>   |
| January 15, 1999   | Flood                   | Staten Island                           | <ul style="list-style-type: none"> <li>Heavy rain falls on frozen ground with partially clogged storm drains</li> <li>Up to 2 feet of water collects in many streets in South Beach</li> </ul>   |
| August 26, 1999    | Flood                   | Bronx, Manhattan, Queens                | <ul style="list-style-type: none"> <li>Flash flooding cripples public transit during the morning rush hour</li> <li>Subway service is severely disrupted as 3 to 5 feet of water collects at some subway stations</li> <li>52 inches of water measured at the 6 station at Cypress Avenue in the Bronx</li> <li>A 10- to 20-foot section of the northbound platform for the 6 line at 28th Street crumbles and washes away</li> <li>Metro-North Railroad forced to close in Mott Haven in the Bronx</li> </ul> |
| September 16, 1999 | Flood                   | Citywide                                | <ul style="list-style-type: none"> <li>Remnant of Hurricane Floyd</li> <li>Maximum rainfall rates of 1 to around 2 inches per hour for at least 3 consecutive hours</li> <li>5.02 inches of rain in Central Park</li> </ul>  |
| July 3, 2000       | Inland flood            | Brooklyn, Queens, Staten Island         | <ul style="list-style-type: none"> <li>Rainfall rates of up to an estimated 4 inches per hour for less than 1 hour</li> <li>Significant ponding of water traps people in two cars near the Verrazano-Narrows Bridge</li> <li>Significant low-lying and poor drainage flood</li> <li>Flooding on Cross Island Parkway near Whitestone Bridge</li> </ul>   |
| August 11, 2000    | Inland flood            | Bronx, Queens                           | <ul style="list-style-type: none"> <li>Slow-moving thunderstorms produce rainfall rates estimated at around 2 inches per hour, causing significant flooding of low-lying and poor drainage areas</li> <li>In the Bronx, cars are submerged in rising water, trapping many people</li> <li>NWS radar estimates 2 to 3 inches of rainfall from 2:30 AM to 3:30 AM, with up to 5 inches during the preceding 24 hours</li> </ul>  |
| August 27, 2000    | Inland flood            | Staten Island                           | <ul style="list-style-type: none"> <li>Heavy showers move very slowly east across northern Staten Island</li> <li>NWS radar estimates rainfall rates of 1.5 to 2 inches per hour for at least 2 consecutive hours</li> <li>Estimated rainfall of 3.5 to 4 inches results in serious widespread flooding of low-lying and poor drainage areas</li> </ul>  |



## 11. FLOODING

### CHAPTER 3: RISK ASSESSMENT

| Date               | Event        | Location(s)                                | Description  |
|--------------------|--------------|--|--|
| August 28, 2000    | Inland flood | Queens                                     | <ul style="list-style-type: none"> <li>• NWS radar estimates rainfall rates of 1.5 to 2.0 inches per hour</li> <li>• Total precipitation of 3.5 to 4 inches</li> <li>• Serious widespread flooding on Cross Island Pkwy. in Whitestone</li> <li>• Up to 5 feet of water ponds on streets in Bay Terrace</li> </ul> |
| September 3, 2000  | Inland flood | Queens                                     | <ul style="list-style-type: none"> <li>• Nearly stationary thunderstorms produce torrential rain</li> <li>• People have to be rescued from submerged cars on Northern Blvd.</li> <li>• Several residential basements in poor drainage areas are flooded</li> </ul>   |
| June 17, 2001      | Inland flood | Bronx, Brooklyn, Manhattan, Queens         | <ul style="list-style-type: none"> <li>• Remnants of Tropical Storm Allison</li> <li>• Rainfall rates of up to 3 inches per hour</li> <li>• Numerous reports of street and highway flooding</li> </ul>   |
| June 23, 2001      | Inland flood | Manhattan, Staten Island                   | <ul style="list-style-type: none"> <li>• Several people require rescue from their cars on Staten Island</li> <li>• Large segment of West Side Highway between 100th and 120th Streets in Manhattan closed</li> </ul>   |
| August 13, 2001    | Inland flood | Brooklyn, Manhattan, Queens                | <ul style="list-style-type: none"> <li>• Rainfall rates of more than 2 inches per hour in portions of northern Queens</li> <li>• Highly localized rainfall of 5 inches or more</li> <li>• Several healthcare facilities flood, including one area hospital and seven area nursing homes</li> </ul>                 |
| June 26, 2002      | Flood        | Bronx                                      | <ul style="list-style-type: none"> <li>• Widespread flash floods with thunderstorm</li> </ul>  |
| August 16, 2002    | Flood        | Bronx, Manhattan, Queens                   | <ul style="list-style-type: none"> <li>• 3 feet of water on Major Deegan Expwy. at Cross Bronx Expwy. interchange, which requires police rescues</li> <li>• Shutdown of the Henry Hudson Parkway from 96th Street to 125th Street</li> <li>• Significant flooding in Far Rockaway</li> </ul>                       |
| September 2, 2002  | Inland flood | Brooklyn, Queens                           | <ul style="list-style-type: none"> <li>• Significant street flooding in Greenpoint, Brooklyn, and on Brooklyn-Queens Expy.</li> <li>• Significant widespread street flooding in Woodside, Queens</li> </ul>  |
| July 22, 2003      | Inland flood | Queens, Staten Island                      | <ul style="list-style-type: none"> <li>• Significant street flooding in Bayside Hills and Ridgewood</li> <li>• Con Ed reports significant flooding that results in street closings near Richmond Avenue and Victory Blvd.</li> </ul>   |
| August 4, 2003     | Inland flood | Brooklyn, Manhattan, Queens, Staten Island | <ul style="list-style-type: none"> <li>• Rainfall rates of 2 to 3 inches per hour</li> <li>• N and R subway tunnels flood</li> <li>• Basements in Brooklyn flood</li> <li>• Sewers and septic back up onto streets in Annadale, Staten Island</li> </ul>   |
| August 17, 2003    | Inland flood | Brooklyn                                   | <ul style="list-style-type: none"> <li>• Isolated locations receive as much as 3 to 4 inches of rain in 2 hours</li> <li>• OEM reports water levels up to car doors on the Belt Pkwy. near Pennsylvania Avenue</li> </ul>  |
| September 23, 2003 | Inland flood | Bronx, Brooklyn, Manhattan, Queens         | <ul style="list-style-type: none"> <li>• Several lanes close on the FDR and Harlem River Drives in Manhattan, the Van Wyck Expy. in Queens, Ocean Parkway in Brooklyn, and several local streets in Riverdale in the Bronx</li> </ul>  |
| June 17, 2004      | Inland flood | Bronx, Brooklyn, Manhattan, Queens         | <ul style="list-style-type: none"> <li>• Significant flash flooding on roadways results in the need for people to be rescued from cars</li> </ul>  |

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### CHAPTER 3: RISK ASSESSMENT

| Date               | Event         | Location(s)                        | Description  |
|--------------------|---------------|------------------------------------|--|
| June 25, 2004      | Inland flood  | Queens, Staten Island              | <ul style="list-style-type: none"> <li>Several cars trapped in floodwaters</li> </ul>  |
| July 2, 2004       | Inland flood  | Bronx, Queens                      | <ul style="list-style-type: none"> <li>179th Street and Major Deegan Expwy. in the Bronx flood</li> <li>Bell Blvd. and 208 Place intersection in Queens flood with 2 people requiring rescue from cars</li> </ul>  |
| September 8, 2004  | Inland flood  | Bronx, Brooklyn, Manhattan, Queens | <ul style="list-style-type: none"> <li>Remnants of Hurricane Frances</li> <li>Rainfall of up to 6 inches</li> <li>Extensive flash flooding across the region, resulting in rescues of people from homes and cars</li> </ul>  |
| September 18, 2004 | Inland flood  | Citywide                           | <ul style="list-style-type: none"> <li>Remnants of Hurricane Ivan</li> <li>Torrential rains of up to 5 inches in some areas</li> </ul>   |
| September 28, 2004 | Inland flood  | Citywide                           | <ul style="list-style-type: none"> <li>Remnants of Hurricane Jeane drop 3 to 6 inches of rain across southeastern New York State</li> <li>Numerous roads and highways are closed</li> </ul>  |
| July 6, 2005       | Inland flood  | Brooklyn                           | <ul style="list-style-type: none"> <li>Slow-moving thunderstorms producing rainfall rates of around 2 inches per hour cause flash flooding of streets</li> </ul>   |
| October 14, 2005   | Inland flood  | Brooklyn, Queens                   | <ul style="list-style-type: none"> <li>Flooding along Ocean Pkwy. and the Grand Central Pkwy.</li> <li>Several trees and power poles lean from soggy ground</li> </ul>   |
| June 1, 2006       | Inland flood  | Staten Island                      | <ul style="list-style-type: none"> <li>Flash flooding on the West Shore Expwy.</li> </ul>  |
| June 2, 2006       | Inland flood  | Manhattan, Queens, Staten Island   | <ul style="list-style-type: none"> <li>Flash flooding on FDR Drive in Manhattan</li> <li>Flash flooding of roads, submerged vehicles, and a few houses on Staten Island surrounded by 5 feet of water</li> </ul>   |
| July 12, 2006      | Inland flood  | Citywide                           | <ul style="list-style-type: none"> <li>Flash flooding of the FDR Drive service road at 34th Street in Manhattan, with thunderstorm</li> <li>Wall collapse in Washington Heights in Manhattan</li> </ul>  |
| July 21, 2006      | Inland flood, | Citywide                           | <ul style="list-style-type: none"> <li>Partial flooding from thunderstorm resulted in road closures on the Staten Island Expwy., the Belt Pkwy., the Brooklyn-Queens Expwy., the Grand Central Pkwy., and Van Wyck Expwy.</li> <li>Subway service suspended in both directions on the R and W lines between Whitehall Street in Manhattan and Ditmars Blvd. in Queens</li> </ul> |
| August 10, 2006    | Inland flood  | Manhattan, Queens                  | <ul style="list-style-type: none"> <li>Flash flooding forces closure of subway lines 1, 2, 3, and 6.</li> </ul>  |
| August 25, 2006    | Inland flood  | Bronx, Queens                      | <ul style="list-style-type: none"> <li>Flash flooding along many major roads results in road closures</li> <li>Most significant flooding along the Major Deegan Expwy. and Cross Bronx Expwy.</li> </ul>   |
| October 28, 2006   | Inland flood  | Bronx                              | <ul style="list-style-type: none"> <li>Flash flooding along portions of the Bronx River Pkwy. and Bruckner Expwy.</li> </ul>   |
| November 8, 2006   | Inland flood  | Staten Island                      | <ul style="list-style-type: none"> <li>Heavy rain floods many basements and closes numerous streets</li> <li>Staten Island Railroad service is suspended because of flash flooding across tracks</li> </ul>  |
| April 15, 2007     | Flood         | Brooklyn, Manhattan, Queens        | <ul style="list-style-type: none"> <li>Nor'easter brings heavy rain and high winds.</li> <li>8.41 inches of rain in Central Park</li> <li>Street flooding along the Belt Pkwy. In Brooklyn/Queens and FDR Drive in Manhattan</li> </ul>  |

## 11. FLOODING

### CHAPTER 3: RISK ASSESSMENT

| Date              | Event                 | Location(s)                        | Description  |
|-------------------|-----------------------|------------------------------------|--|
| April 27, 2007    | Inland flood          | Bronx, Manhattan, Queens           | <ul style="list-style-type: none"> <li>• Rainfall of 2 to 3 inches</li> <li>• Flash flooding of the Jackie Robinson Pkwy. In Queens and West Side Hwy. In Manhattan</li> </ul>   |
| June 4, 2007      | Inland flood          | Bronx, Brooklyn, Manhattan, Queens | <ul style="list-style-type: none"> <li>• Heavy rain from the remnants of Tropical Storm Barry causes flash flooding in parts of southeast New York. Rainfall amounts of up to just under 4 inches in Central Park</li> </ul>   |
| June 27, 2007     | Inland flood          | Bronx, Queens                      | <ul style="list-style-type: none"> <li>• Severe thunderstorms produce flash flooding, hail, and high winds across parts of the region</li> </ul>   |
| July 11, 2007     | Inland flood          | Manhattan                          | <ul style="list-style-type: none"> <li>• Heavy rain</li> </ul>   |
| July 18, 2007     | Inland flood          | Bronx, Brooklyn, Manhattan, Queens | <ul style="list-style-type: none"> <li>• A cluster of heavy thunderstorms produces torrential rain that results in widespread and significant flash flooding across the region</li> <li>• Maximum rainfall rates are estimated at 2 to 3 inches per hour</li> <li>• Total rainfall of around 3 to 6 inches</li> </ul>                |
| August 8, 2007    | Inland flood          | Citywide                           | <ul style="list-style-type: none"> <li>• Storms produce copious amounts of rainfall, causing widespread, significant flash flooding, including several subway lines</li> <li>• Properties in Brooklyn experience damage from heavy rain and fallen trees</li> <li>• Large closures due to flooding along several highways</li> </ul> |
| October 11, 2007  | Inland flood          | Bronx, Brooklyn, Manhattan, Queens | <ul style="list-style-type: none"> <li>• A low-pressure system slowly moving north from the mid-Atlantic coast across New England produces flash flooding across parts of New York City</li> </ul>   |
| June 14, 2008     | Inland flood          | Citywide                           | <ul style="list-style-type: none"> <li>• Thunderstorm causes flash flooding</li> </ul>   |
| July 27, 2008     | Inland flood          | Staten Island                      | <ul style="list-style-type: none"> <li>• Caused by thunderstorms with torrential downpours</li> </ul>  |
| August 11, 2008   | Inland flood          | Citywide                           | <ul style="list-style-type: none"> <li>• Numerous thunderstorms with torrential rainfall lead to flash flooding</li> <li>• Reports of sinkholes and stranded cars</li> </ul>   |
| August 14, 2008   | Inland flood          | Queens                             | <ul style="list-style-type: none"> <li>• Thunderstorms producing torrential rainfall lead to flash flooding.</li> <li>• Total rainfall of almost 1.5 inches reported</li> </ul>  |
| August 15, 2008   | Inland flood          | Bronx, Manhattan                   | <ul style="list-style-type: none"> <li>• Thunderstorms producing torrential rainfall lead to flash flooding</li> <li>• Several highways closed</li> </ul>  |
| September 6, 2008 | Inland/Riverine flood | Citywide                           | <ul style="list-style-type: none"> <li>• Tropical Storm Hanna causes torrential rain from heavy showers and thunderstorms, resulting in flash flooding and some riverine flooding</li> <li>• Closures due to flooding along several highways and roads</li> </ul>  |
| July 29, 2009     | Inland flood          | Citywide                           | <ul style="list-style-type: none"> <li>• Thunderstorms produce very heavy rain leading to flash flooding</li> <li>• Several highways closed due to flooding</li> </ul>   |
| October 24, 2009  | Flood                 | Staten Island                      | <ul style="list-style-type: none"> <li>• Rainfall over 18 to 24 hours causes isolated flooding</li> </ul>  |
| March 13, 2010    | Coastal flood         | Bronx, Manhattan, Queens           | <ul style="list-style-type: none"> <li>• Automated Surface Observing System (ASOS) records 3.84 inches of rainfall in Central Park and 3.16 inches at LaGuardia Airport</li> </ul>   |

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### CHAPTER 3: RISK ASSESSMENT

| Date              | Event                      | Location(s)                        | Description   |
|-------------------|----------------------------|------------------------------------|---|
| March 28, 2010    | Heavy rain                 | Manhattan, Queens                  | <ul style="list-style-type: none"> <li>• A Nor'easter causes widespread flooding</li> <li>• Suspension of some subway lines reported</li> <li>• Closure of highways and roads due to flooding</li> </ul>  |
| March 30, 2010    | Heavy rain, flood          | Bronx, Queens                      | <ul style="list-style-type: none"> <li>• A Nor'easter causes widespread flooding</li> <li>• A mudslide on the MetroNorth railroad tracks</li> <li>• Total rainfall of 4.38 inches recorded in Central Park</li> </ul>   |
| August 22, 2010   | Inland flood               | Queens                             | <ul style="list-style-type: none"> <li>• Heavy rain and training thunderstorms</li> <li>• Several vehicles became stuck in floodwaters with occupants rescued by local fire department</li> </ul>   |
| October 1, 2010   | Flood, inland flood        | Bronx, Brooklyn, Manhattan, Queens | <ul style="list-style-type: none"> <li>• Remnants of Tropical Storm Nicole result in heavy rain and flooding</li> <li>• Suspension of some subway lines reported</li> <li>• Closure of highways and roads due to flooding</li> <li>• Total rainfall recorded by the ASOS at JFK and LaGuardia Airports of 3.08 inches and 3.06 inches respectively</li> </ul> |
| October 11, 2010  | Inland flood               | Brooklyn                           | <ul style="list-style-type: none"> <li>• A wave of low pressure along a cold front moving through the area causes heavy rain and flash flooding</li> </ul>  |
| August 14, 2011   | Inland flood               | Brooklyn, Queens, Staten Island    | <ul style="list-style-type: none"> <li>• Heavy rain results in flash flooding</li> </ul>  |
| August 28, 2011   | Coastal and tidal flooding | Bronx, Brooklyn, Manhattan, Queens | <ul style="list-style-type: none"> <li>• Hurricane Irene makes landfall locally as a tropical storm</li> <li>• Copious amounts of moisture within the storm produce extended periods of heavy rain, resulting in widespread moderate to major flooding</li> </ul>   |
| June 22, 2012     | Inland flood               | Staten Island                      | <ul style="list-style-type: none"> <li>• Showers and thunderstorms ahead of a cold front produce heavy rain, resulting in isolated flash flooding</li> </ul>  |
| July 18, 2012     | Inland flood               | Manhattan, Queens                  | <ul style="list-style-type: none"> <li>• Thunderstorms produce heavy rainfall and result in flash flooding</li> <li>• Closure of highways entrance/exit ramps due to flooding</li> </ul>  |
| October 29, 2012  | Coastal flood              | Citywide                           | <ul style="list-style-type: none"> <li>• Hurricane Sandy brings record-breaking storm surge and wave action, combined with high winds, to cause 44 deaths and untold number of injuries and inflict damages estimated at \$19 billion</li> <li>• 51 square miles of New York City flood—17 % of the city's total land mass</li> </ul>                         |
| May 8, 2013       | Inland flood               | Brooklyn                           | <ul style="list-style-type: none"> <li>• Thunderstorms training over area produce heavy rain that coincides with high tide, resulting in flash flooding across parts of southern Brooklyn</li> </ul>  |
| May 9, 2013       | Inland flood               | Queens                             | <ul style="list-style-type: none"> <li>• Showers and thunderstorms produce heavy rain, leading to flash flooding</li> </ul>   |
| May 23, 2013      | Inland flood               | Staten Island                      | <ul style="list-style-type: none"> <li>• Storms produce heavy rain, resulting in flash flooding</li> </ul>  |
| June 2, 2013      | Inland flood               | Manhattan                          | <ul style="list-style-type: none"> <li>• Showers and thunderstorms produce heavy rainfall, resulting in isolated flash flooding</li> </ul>  |
| June 6 to 8, 2013 | Flood                      | Manhattan                          | <ul style="list-style-type: none"> <li>• The remnants of Tropical Storm Andrea tracking up the Eastern Seaboard result in prolonged heavy rain</li> <li>• Total rainfall of 4.77 inches over the course of 3 days recorded by the ASOS in Central Park</li> <li>• 4.16 inches fall on June 7</li> </ul>   |

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### CHAPTER 3: RISK ASSESSMENT

#### B. Vulnerability Assessment

##### i. Social Environment

Of the over 8.2 million people that reside in New York City, just under 5 percent, or approximately 400,000, live in the 100-year floodplain (see Table 3.11.54) and are therefore at greater risk of coastal flooding hazards. However, proximity to the coastline is not the only determinant of vulnerability to flood risk. Socioeconomic and demographic characteristics are important factors in determining vulnerability; they can play a significant role in shaping risk perception and determining a population's capacity to take risk-reduction actions to minimize the impacts of a flood. In New York City, vulnerable populations include children, seniors, low-income residents, the “linguistically isolated” (those who speak English less than “very well”), those with disabilities or other pre-existing health conditions, and in-patient populations at hospitals and other healthcare facilities. For a detailed discussion of vulnerable populations, see [The Social Environment](#) in Section 3.4: New York City's Hazard Environment. Here, a close examination of the potential impact of a flood hazard for those over the age of 65 and those

ly restricted. Decreased mobility due to a disability or age-related fragility can prevent timely evacuation or movement to safer ground. In the aftermath of a flood, exposure to mold in flood-damaged buildings can have a greater impact on older populations, particularly those with respiratory infections, asthma, allergies, or other pre-existing health conditions.

Flood-risk vulnerability is acute among immigrant seniors. Almost 50% of New York City's older residents are foreign-born. As a group, older immigrants often earn lower wages, have less in retirement savings, and receive fewer benefits from traditional entitlement programs like Social Security and Medicare than native-born seniors. According to Center for Urban Futures, nearly two-thirds of immigrant residents age 65 and older have limited English proficiency and therefore may not be aware of critical city services and resources available during an emergency.

Hurricane Sandy tragically highlighted the vulnerability of seniors to flood hazards in New York City. Nearly half of the fatalities during Sandy were among adults aged 65 or older, most due to drowning. The Mayor's Special Initiative for Rebuilding and Resiliency

**Table 3.11.54: Population and Households in 100-Year Floodplain (Source: US Census 2010)**

|               | New York City |     | Bronx  |     | Brooklyn |     | Manhattan |     | Queens |     | Staten Island |      |
|---------------|---------------|-----|--------|-----|----------|-----|-----------|-----|--------|-----|---------------|------|
|               | Count         | %   | Count  | %   | Count    | %   | Count     | %   | Count  | %   | Count         | %    |
| Population    | 400,457       | 4.9 | 16,422 | 0.5 | 164,803  | 6.6 | 89,277    | 5.6 | 99,110 | 4.4 | 30,845        | 6.6% |
| Housing Units | 175,674       | 5.2 | 5,826  | 1.1 | 71,311   | 7.1 | 43,695    | 5.2 | 43,043 | 5.2 | 11,799        | 6.7% |

living below the poverty line helps to illustrate the potential impact of a flood on vulnerable populations.

#### Population over the Age of 65

Age plays a central role in determining an individual's ability to take risk-reduction actions in an emergency. New Yorkers over the age of 65—approximately 12% of the total population—are among the most vulnerable groups in a flood-related disaster. As a group, seniors are more likely to have health conditions and disabilities that require regular access to health services and medication. During major flooding events, these services are often disrupted or severe-

found that 27% of the households in the surge area included seniors— three percentage points higher than the percentage of seniors in the population of the city as a whole. Moreover, seniors living alone made up 12.1% of all households in the surge area.

Today, over 15% of those living in the 100-year floodplain shown on Preliminary FIRMs—or approximately 60,800 people—are over the age of 65 (see Table 3.11.55). Since the city's older adult population is growing more rapidly than the overall population, vulnerability to flooding in this age cohort is likely to increase in the future.

**Table 3.11.55: Population by Age Group within 100-Year Floodplain (Source: US Census 2010)**

|          | New York City |      | Bronx |      | Brooklyn |      | Manhattan |      | Queens |      | Staten Island |      |
|----------|---------------|------|-------|------|----------|------|-----------|------|--------|------|---------------|------|
|          | Count         | %    | Count | %    | Count    | %    | Count     | %    | Count  | %    | Count         | %    |
| Under 5  | 22,967        | 5.8  | 1,069 | 6.5  | 8,934    | 5.4  | 4,793     | 5.4  | 6,421  | 6.5  | 1,750         | 6.1  |
| Under 18 | 81,057        | 20.4 | 3,629 | 22.1 | 32,572   | 19.8 | 15,130    | 16.9 | 23,157 | 23.4 | 6,569         | 23.1 |
| Over 65  | 60,835        | 15.3 | 1,771 | 10.8 | 29,157   | 17.7 | 11,024    | 12.3 | 15,280 | 15.4 | 3,603         | 12.6 |

**Low-Income Population**

Low-income communities are disproportionately affected by almost all disasters, including floods. A flood can damage and/or destroy housing, businesses, and inventory. Floods can also damage critical infrastructure and disrupt vital services (see **Built Environment**, below). Low-income households have fewer resources to prepare for and recover from such disasters and therefore face higher health and safety risks along with economic hardships. In New York City, a one-person household earning \$11,500 or less and a four-person household earning \$23,000 or less are designated as low-income (see **The Social Environment** in Section 4.

rarily, during an evacuation or immediately following a storm—can pose a serious challenge. In fact, even in ordinary times, the overall amount of housing affordable to households earning less than \$30,000 per year is limited to just 22% of rental units in New York City. As a consequence, many low-income individuals and families continue to occupy their damaged homes after a flood to avoid devoting a greater allocation of income towards rent or even homelessness.

Yet occupying uninhabitable residences can increase the vulnerability of low-income households in other ways, including increasing exposure to mold and other hazardous materials. Health problems, in

**Table 3.11.56: Population below Poverty Level within 100-Year Floodplain (Source: ACS 5YR 2007- 2011)**

|               | Estimate of Population below Poverty Level | Estimate of Population for whom Poverty Status is Determined | % Below Poverty Level |
|---------------|--|--|-----------------------|
| New York City | 70,841                                     | 393,069  | 18.0%                 |
| Bronx         | 3,159                                      | 15,617   | 20.2%                 |
| Brooklyn      | 30,768                                     | 163,669  | 18.8%                 |
| Manhattan     | 19,061                                     | 86,546   | 22.0%                 |
| Queens        | 15,671                                     | 96,546   | 16.2%                 |
| Staten Island | 2,190                                      | 30,712   | 7.1%                  |

New York City's Hazard Environment). Approximately 18% of those living in the 100-year floodplain according to the Preliminary FIRMs—or 70,000 people—are estimated to be below poverty level (see Table 3.11.56).

Moreover, a significant percentage of low-income households are renters and thus have little control over investment in post-flood repairs. Of the over one million New Yorkers that make less than \$30,000 per year (roughly 60% of the median income in New York City), 82% are renters, compared with 18% who are owners. With the high cost of housing in New York City, finding alternative housing options—even tempo-

turn, can result in a loss wages or even loss of employment, further increasing economic vulnerability.

**ii. Built Environment**

New York City has one of the nation's densest and most diverse agglomerations of built assets. However, much of the city's building stock and infrastructure is vulnerable to inundation and structural damage during a flood.

**Buildings**

Flood risk varies by building height, construction type, and age. In general, low-rise buildings (one to two stories) are more vulnerable to structural damage than mid-rise (three to six stories) and high-rise (seven stories or higher) buildings. Moreover, low-rise buildings tend to house primary uses on the ground floor and therefore face higher risks of experiencing substantial damage. Low-rise buildings also tend to be constructed with lighter, wood-stud frames, which are more prone to structural damage and fire from electrical shorts caused by flooding than steel, ma-

they did sustain damage to building systems, such as generators and electrical equipment housed in basements or otherwise insufficiently elevated; repair to these systems was in many cases costly and disruptive. While severe damage to small buildings clearly has adverse consequences for owners and occupants, damage to larger buildings can also have lasting economic consequences, particularly in co-ops or condominiums, or where lost or damaged space represents a significant share of the building's cash flow.

FEMA's 2013 Preliminary FIRMS indicate that buildings in parts of New York City continue to be at risk

**Table 3.11.57: Building Type and Age within 100-Year Floodplain (Source: MapPluto 13V1; FEMA, Preliminary Working Maps)**

|           | 1 Floor     |                 | 2 Floors    |                 | 3-6 Floors  |                 | 7 Floors or Higher |                 |
|-----------|-------------|-----------------|-------------|-----------------|-------------|-----------------|--------------------|-----------------|
|           | Combustible | Non-Combustible | Combustible | Non-Combustible | Combustible | Non-Combustible | Combustible        | Non-Combustible |
| Pre-1961  | 21.0%       | 2.6%            | 35.6%       | 1.0%            | 7.4%        | 1.2%            | 0.1%               | 0.4%            |
| Post-1961 | 2.9%        | 0.9%            | 19.4%       | 0.5%            | 6.7%        | 0.7%            | 0.1%               | 0.6%            |

sonry, or concrete frames, which are characteristic of larger, more recent building types. Although wood buildings are less expensive to repair, reconstruct, and elevate than masonry buildings, new wood-frame housing is generally not permitted in New York City.

Older buildings are more likely to sustain significant flood damage than newer buildings primarily due to the increasingly stringent building and zoning standards that have been put into effect over time. Adherence to flood-resistant construction standards greatly reduces vulnerability to flood damage. While data on the elevation and floodproofing characteristics of buildings is limited, building age serves as a proxy indicator of structural vulnerability.

In fact, during Hurricane Sandy, older (constructed before 1961) one-story buildings—such as bungalows erected for seasonal use in many coastal areas of the city—sustained the most severe structural damage. Buildings matching these characteristics represent 21% of the buildings in the Preliminary FIRM 100-year floodplain (see Table 3.11.57). High-rise buildings generally experienced less structural damage, but

of flooding. The 100-year floodplain on the Preliminary FIRMs encompasses approximately 68,200 buildings, or over 542 million square feet of floor area. These buildings contain substantial value and house important functions such as housing, offices, schools, and hospitals. Approximately 254,300 residential units, home to approximately 400,000 New Yorkers, are located within the 100-year floodplain.

The analysis from the changes since the last FIRM identified an 89% increase in buildings, 82% increase in residents, and a 42% increase in building floor area in the 100-year floodplain compared to the 2007 effective FIRMs.

However, the Preliminary FIRMs do not reflect the full flooding risk to New York City's buildings. That is because these maps are based on historical storm profiles and do not take into account potential changes in coastal storms or projected sea level rise. Based on recent high-end projections for sea level rise, the city's floodplain could expand to include, for example, more than 88,000 buildings by the 2020s and more than 114,000 buildings by the 2050s.

**Infrastructure**

New York City's infrastructure, too, is vulnerable to flood risks, according to the Preliminary FIRMs. Table 3.11.58 displays the vast number of critical assets located within the 100-year floodplain. These assets have a 1% or greater chance of being flooded in any given year.

**Table 3.11.58: Critical Assets in the 100-Year Floodplain**

| Critical Asset                             | In 100 Year Floodplain | % In 100 Year Floodplain |
|--|------------------------|--------------------------|
| Subway stations (includes PATH Stations)   | 27                     | 5%                       |
| Rail stations                              | 8                      | 19%                      |
| Bridges and tunnels                        | 32                     | 43%                      |
| Major roads (miles)                        | 157                    | 18%                      |
| Airports                                   | 2                      | 100%                     |
| Ferry landings                             | 47                     | 100%                     |
| Emergency services—police stations         | 2                      | 3%                       |
| Emergency services—fire stations           | 15                     | 7%                       |
| Emergency services—EMS stations            | 9                      | 11%                      |
| Educational—colleges                       | 4                      | 4%                       |
| Educational—public schools                 | 96                     | 5%                       |
| Educational—private schools                | 26                     | 3%                       |
| Healthcare—hospitals                       | 4                      | 7%                       |
| Healthcare—nursing homes                   | 15                     | 9%                       |
| Healthcare—hospice                         | 1                      | 1%                       |
| Healthcare—adult healthcare centers        | 15                     | 20%                      |
| Infrastructure—power plants                | 16                     | 62%                      |
| Infrastructure—wastewater treatment plants | 7                      | 50%                      |
| Telecommunications                         | 10                     | 10%                      |
| Cultural Facilities                        | 4                      | 11%                      |
| Bus Depot                                  | 5                      | 17%                      |

However, the Preliminary FIRMs do not reflect the full flooding risk to New York City's building stock and critical infrastructure. That is because these maps are based on historical storm profiles and do not take into account potential changes in coastal storms or projected sea level rise. Based on recent high-end projections for sea level rise, the city's floodplain could expand to include, for example, more than 88,000 buildings by the 2020s and more than 114,000 buildings by the 2050s.

*Water Systems*

Much of the city's critical wastewater and waste management infrastructure is located in the 100-year floodplain. These critical facilities are often sited along the waterfront out of operational necessity or were built there years ago during the development of the infrastructure network.

For example, all of the city's 14 wastewater treatment plants are located along the waterfront at low elevations because waterfront adjacency significantly reduces the cost and environmental impact of treating wastewater in New York City. Therefore, all 14 of the city's wastewater treatment plants have assets in the Preliminary FIRM 100-year floodplain that are potentially vulnerable to inundation by storm surge. If not properly adapted, the majority of New York City's wastewater treatment infrastructure is at risk of being damaged in severe storms or floods, which can lead to combined sewer overflows and contamination of the waterways. Floodwaters from a surge can cause significant damage not only to wastewater management facilities but to the critical equipment they house. The corrosive impact of seawater on electrical systems creates disruptions in the power supply at these facilities that could potentially result in an overflow of partially treated or untreated sewage into waterways.

Additionally, a significant share of both municipal and private solid waste management facilities, as well as other industrial facilities that store and use hazardous materials, are located within the 100-year floodplain. Flooding at facilities that store hazardous materials and solid waste—but don't properly manage such materials—can cause dispersion of contaminants, with adverse effects on employees, nearby populations, and natural resources.



*Transportation Systems*

To facilitate operational needs, many parts of New York City's transportation system, such as ferry terminals, are located near the waterfront. Some transportation assets are built in low-lying areas or even below sea level. For example, rail and vehicular tunnels and subway stations—which make up a significant portion of the city's transportation network—are all located underground. According to the Preliminary FIRMs, approximately 12% of the city's roadway networks, all of the major tunnel portals other than those for the Lincoln Tunnel, portions of both New York City airports, a variety of commuter rail assets, all three heliports, and numerous subway entrances and vent structures (principally in Lower Manhattan) are located in the 100-year floodplain. These assets are vulnerable to flooding from both coastal surge and heavy downpours.

Locations where tunnel entrances are in low-lying areas or in areas with poor subsurface drainage are particularly vulnerable to flooding. 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 pose only a moderate risk to roads and bridges, which may experience more frequent temporary flooding, but not more lasting damage. New York City's vast street network is also vulnerable to flooding from heavy precipitation, storm surge, or, as in the case of neighborhoods such as Hamilton Beach and Broad Channel in Queens, high tides.

*Energy Infrastructure*

Much of the city's underground electric and steam distribution systems and generating facilities are located near the coast, and are thus vulnerable to storm surge and floodwaters. Approximately 88% of the city's steam generating capacity lies within the Preliminary FIRM 100-year floodplain. In the electric system, 53% of in-city electric generation capacity, 37% of transmission substation capacity, and 12% of large distribution substation capacity are within the 100-year floodplain. Sea-level-rise projections indicate the numbers of at-risk facilities will continue to grow in the coming decades.

For the natural gas system, the biggest risk that storm

surge poses is to the distribution infrastructure. Although flooding itself will not stop the flow of gas, service can be compromised if water enters pipes.

Moreover, the generation of much of the city's electricity and steam power is dependent on natural gas and liquid fuel. Any disruption to the fuel supply chains can result in a disruption in power and steam production. Given the location of key terminals, pipelines, and refineries—and the importance of waterfront access for the movement of fuels into New York City—the greatest risk to the liquid fuel supply is storm surge. Of the 39 terminals in the New York metropolitan area, nearly all lie within FEMA's 100-year floodplain as mapped on the 1983 FIRMs.

*Telecommunication Infrastructure*

New York City's telecommunication services—telephone, wireless, internet, and cable—are vulnerable to flooding, particularly from storm surge. Though telecommunication facilities are generally farther from the floodplain than other sorts of infrastructure, almost 13% of the city's critical telecommunication facilities lie in the 100-year floodplain. Moreover, the high dependency of telecommunications on the power network significantly increases risk of service interruption during a flood.

Vulnerability is projected to increase with climate change. For example, by the 2020s, the percentage of critical facilities in the 100-year floodplain is expected to grow to approximately 18%; by the 2050s, the percentage is expected to climb to 24%. With up to 2.5 feet 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.

**Potential Loss Estimates**

The HAZUS-MH (see [Vulnerability Assessment Methodology](#) in Section 3. Hazard Risk Assessment Organization) flood model provides damage estimates based on the depth of flooding for a given location. It is assumed that damages are a result of standing water (the model does not account for damage that may be inflicted by water moving at high speed). This methodology should not be treated as or confused with a storm surge model.

This analysis focuses on the impacts of the 1% annual chance flooding event (a.k.a. the 100-year flood).

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**Table 3.11.59: HAZUS-MH Calculation of Approximate Number of Buildings Damaged from a 100-Year Flood, by Borough (Source: OEM GIS)**

| County       | Number of Buildings Damaged By Percentage of Total Replacement Cost |              |              |              |              |            | Total Damaged | % of Buildings Damaged |
|--------------|---|--------------|--------------|--------------|--------------|------------|---------------|------------------------|
|              | 1-10%   | 11-20%       | 21-30%       | 31-40%       | 41-50%       | >50%       |               |                        |
| Bronx        | 0   | 400          | 500          | 100          | 300          | 100        | 1,400         | 68.0%                  |
| Kings        | 100   | 1,700        | 2,400        | 700          | 200          | 100        | 5,200         | 31.9%                  |
| New York     | 0   | 200          | 100          | 100          | 0            | 0          | 400           | 48.3%                  |
| Queens       | 0   | 2,100        | 3,500        | 1,600        | 900          | 100        | 8,200         | 52.0%                  |
| Richmond     | 0   | 400          | 1,000        | 1,000        | 700          | 300        | 3,400         | 58.5%                  |
| <b>Total</b> | <b>100</b>  | <b>4,800</b> | <b>7,500</b> | <b>3,500</b> | <b>2,100</b> | <b>600</b> | <b>18,600</b> | <b>45.5%</b>           |

Notes:

1. Geographic extent based on Preliminary FIRMs.
2. Output rounded to the nearest 100 buildings.
3. Percentage of buildings damaged is out of the total number of buildings in the 100-year floodplain for each borough, not the total number of buildings in the entire borough.

At the time of the analysis, FEMA was in the process of completing updates to the FIRMs for New York City. Although the new maps were not in effect at the time of publication, FEMA had already produced Preliminary FIRMs, published in May 2013, which contained the best available data to date.

As part of the City's Cooperating Technical Partnership (CTP) with FEMA, non-regulatory products were created and incorporated into the Hazard Mitigation Plan. The flood depth grid for the 1% annual chance flood event (both coastal and riverine areas) was imported into the Hazus analysis.

Damages from flooding are categorized by percentage of total building replacement cost. These determinations are based on the depth of flooding in relation to the height of the first finished floor of a building.

Of the buildings in the 100-year floodplain, slightly less than half are predicted to have damage based on the HAZUS-MH output; 2.5% of these buildings are predicted to have significant damage to more than 50% of the structure (Table 3.11.59).

Table 3.11.60 and Figure 3.11.80 through Figure 3.11.85 highlight the key findings from the HAZUS-

**Table 3.11.60: HAZUS-MH Calculation of Direct Economic Losses from a 100-Year Flood, by Borough and Damage Type (Source: OEM GIS)**

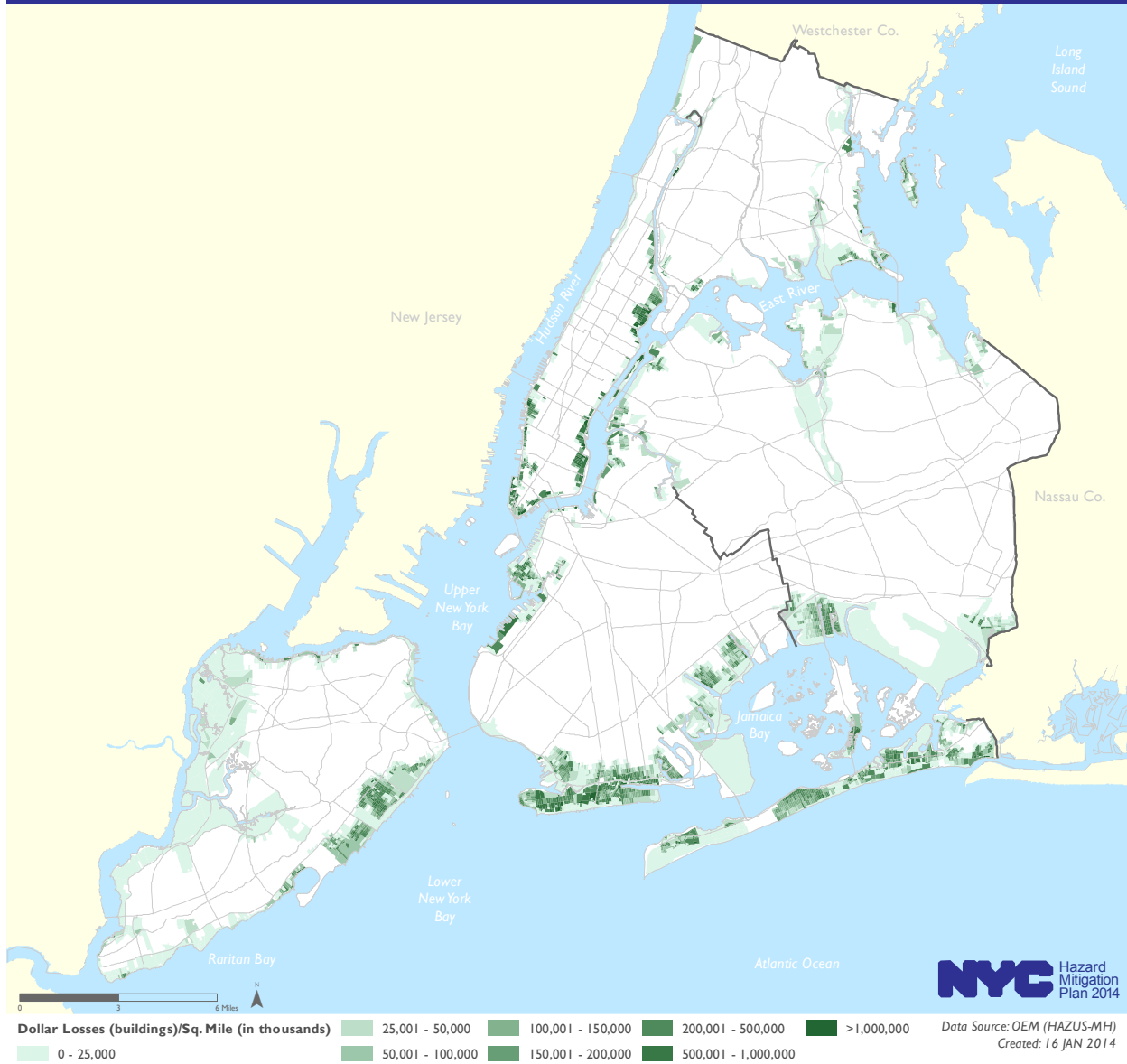
| County       | Structural Damage (\$) | Contents Damage (\$) | Inventory Loss (\$) | Income Loss (\$)   | Total (\$)            |
|--------------|------------------------|----------------------|---------------------|--------------------|-----------------------|
| Bronx        | 311,701,000            | 468,127,000          | 12,383,000          | 4,818,000          | 797,029,000           |
| Kings        | 1,797,533,000          | 2,531,775,000        | 54,996,000          | 37,681,000         | 4,421,985,000         |
| New York     | 1,752,441,000          | 2,551,056,000        | 16,976,000          | 39,581,000         | 4,360,054,000         |
| Queens       | 1,262,787,000          | 1,374,693,000        | 22,777,000          | 15,251,000         | 2,765,508,000         |
| Richmond     | 661,322,000            | 776,794,000          | 16,171,000          | 7,010,000          | 1,461,297,000         |
| <b>Total</b> | <b>5,785,784,000</b>   | <b>7,702,445,000</b> | <b>123,303,000</b>  | <b>104,341,000</b> | <b>13,715,873,000</b> |

Notes:

1. Geographic extent based on Preliminary FIRMs.
2. Economic loss values are calculated to the nearest \$1,000.

Figure 3.11.80: HAZUS-MH Results for Economic Losses from a 100-Year Flood in New York City.

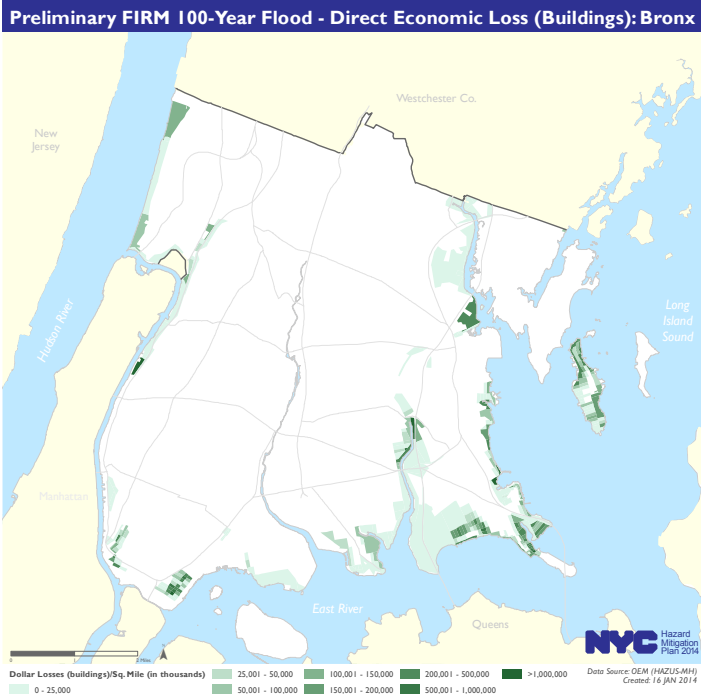
**Preliminary FIRM 100-Year Flood - Direct Economic Loss (Buildings): New York City**



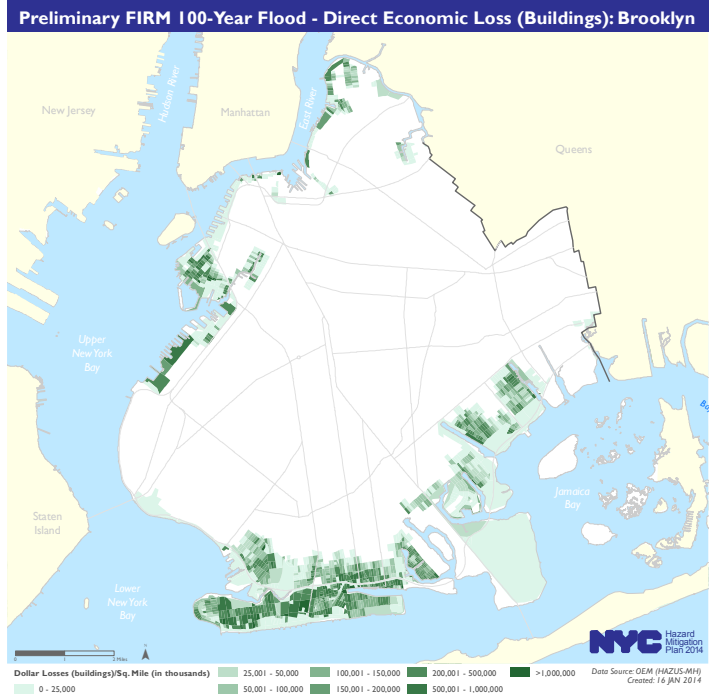
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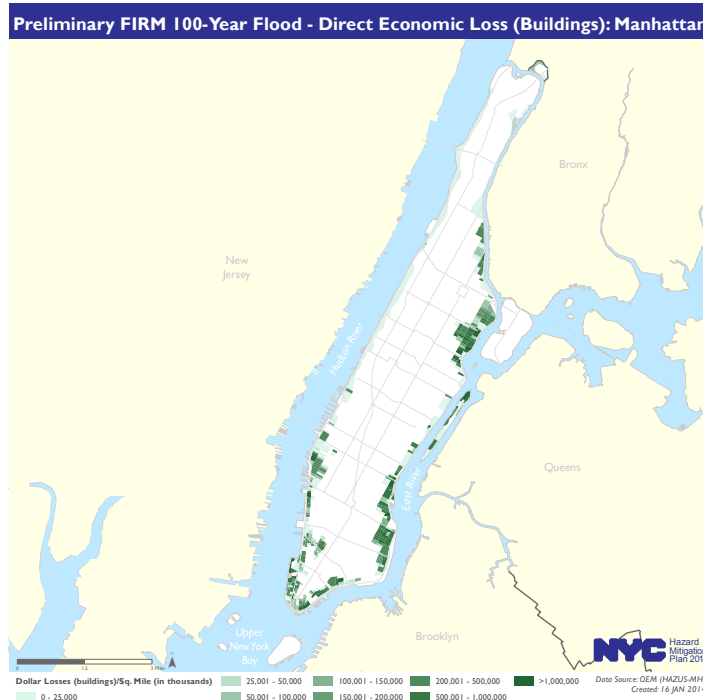
**Figure 3.11.81: HAZUS-MH Results for Economic Losses from a 100-year Flood in the Bronx**



**Figure 3.11.82: HAZUS-MH Results for Economic Losses from a 100-Year Flood in Brooklyn**



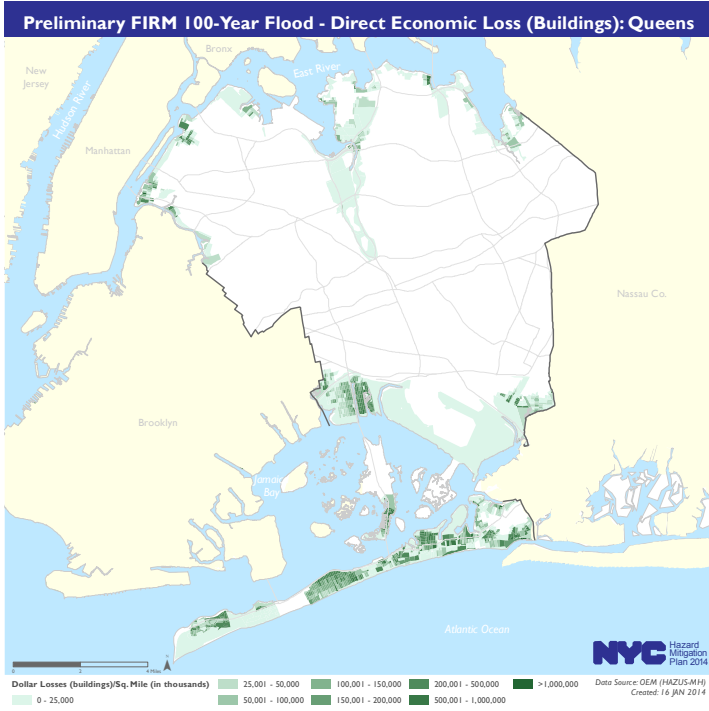
**Figure 3.11.83: HAZUS-MH Results for Economic Losses from a 100-Year Flood in Manhattan**



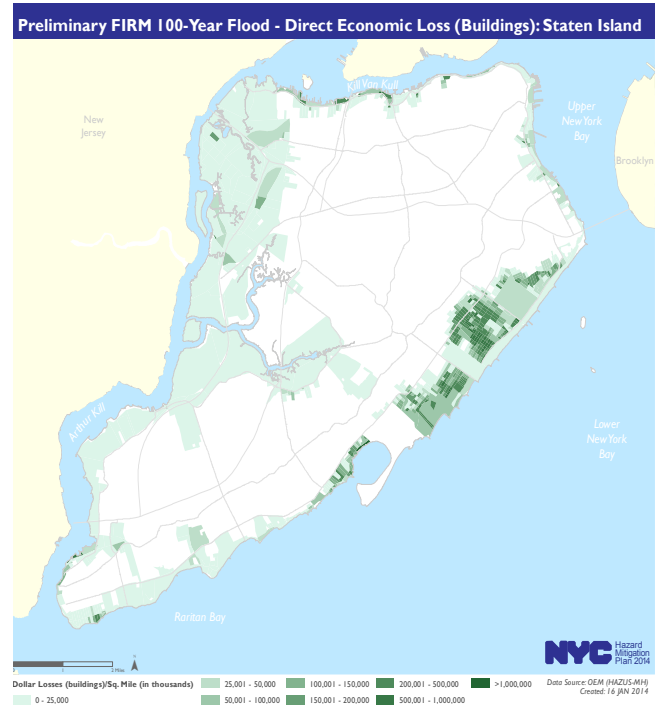
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**Figure 3.11.84: HAZUS-MH Results for Economic Losses from a 100-Year Flood in Queens**



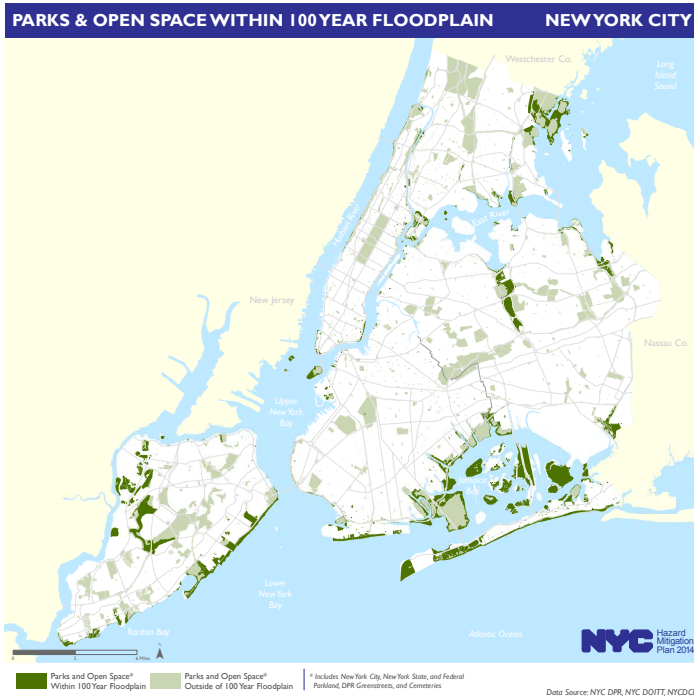
**Figure 3.11.85: HAZUS-MH Results for Economic Losses from a 100-Year Flood in Staten Island**



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**Figure 3.11.86: Parks and Open Space in the 100-year Floodplain**



**Table 3.11.61: Parks in the 100-year Floodplain**

|                        | Within 100-year Floodplain | Overall | %    |
|------------------------|----------------------------|---------|------|
| DPR Parks              | 6,893                      | 28,380  | 24.3 |
| Greenstreets           | 26                         | 174     | 15.1 |
| Schoolyard/playgrounds | 3                          | 146     | 2.3  |
| State parks            | 264                        | 752     | 34.9 |
| Federal parks          | 4,225                      | 6,513   | 64.9 |
| Citywide               | 11,172                     | 35,966  | 31.1 |

MH run of a 100-year flood in New York City. A 100-year flood affecting all five boroughs could cause more than \$12 billion in damage. More than 60% of the total damage would be to contents such as furniture, supplies, and other possessions.

### iii. Natural Environment

New York City's natural areas—its parks, trees, beaches, wetlands, and barrier islands—often act as the first line of defense against flooding. They are also among the city's most vulnerable assets to flooding hazards.

According to FEMA's Preliminary FIRMs, more than

5,800 acres of the city's parkland—almost 24% of total parkland—are within the 100-year floodplain. Some city parkland is composed of natural areas that are able to withstand and recover from most storm events without significant repair costs. These areas include wetlands, meadows, and dunes. However, other parkland contains landscaped areas and facilities such as ballfields, recreation centers, pools, plazas, amphitheaters, and bicycle and pedestrian paths. Such areas and facilities are, not surprisingly, more vulnerable to structural damage (see Figure 3.11.86 and Table 3.11.61).

Flooding from coastal storm surge is the most significant flood risk to the city's parks. This was made evident during Sandy, when 5,700 acres of New York City's park system were inundated by floodwaters, causing \$800 million in damages. The city's beaches bore the brunt of the storm's wave action, with significant impacts on beachfront infrastructure and facilities in the Rockaway Peninsula, Coney Island and adjacent areas of southern Brooklyn, and along the east and south shores of Staten Island. In addition, erosion displaced up to 3 million cubic yards of sand and in some places, beachfronts retreated by as much as 70 feet.

Heavy rainfall can also threaten the integrity of inland parks, natural areas, and preserves. Intense rain events, which produce several inches of rain in a short time period, can severely damage planted areas in parks that lack adequate drainage, often resulting in loss of vegetation or porous soils that help slow the release of water and impact on adjacent areas. The August 8, 2007 storm, which produced more than 3 inches of rain in a two-hour period, is a notable example of flooding caused by heavy rain in New York City's recent history.

Not surprisingly, climate change is likely to place additional natural assets at risk to flood damage. For instance, the city's wetlands, which play a particularly important role in buffering inland areas from storm surge impacts, are at risk of submergence from sea level rise and degradation from salt water intrusion.

According to the New York City Panel on Climate Change (NPCC), sea levels are expected to rise around New York City. By the 2020s, under high-end sea-level-rise projections, 6,600 acres (27%) of the city's parkland could lie in the 100-year floodplain, increasing

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to over 7,400 acres (or 31%) by the 2050s. Sea level rise could result in a significant loss of tidal wetlands if wetlands do not receive an adequate supply of naturally occurring sediment to keep up with rising tides.

#### iv. Future Environment

Climate change is projected to exacerbate flooding hazards in the future. The rise in sea levels will create higher storm surges that will flood larger areas. Low-lying areas of the city already subject to coastal flooding at astronomical high tides will become more vulnerable to regular flooding from daily and monthly high tides. Additionally, changes in storm activity may lead to a greater number of the most intense coastal storms. (For more information on climate projections, see *Impact of Climate Change* in section 4. *New York City's Hazard Environment*.)

#### Sea Level Rise

The NPCC projects that by mid-century, sea levels could rise as much as 2.5 feet (see Table 3.11.62), especially if the polar ice sheets melt at a more rapid rate than previously anticipated. That magnitude of sea level rise would threaten low-lying communities in New York City with regular and highly disruptive tidal flooding, and make flooding as severe as from today's 100-year storm at the Battery up to five times more likely. The NPCC also predicts that it is more likely than not (more than 50% probable) that there will be an increase in the most intense hurricanes in the North Atlantic Basin. With higher sea levels, such storms could have a more damaging impact on New York City.

#### Future Flood Maps

The City worked with the NPCC to develop a series of "future flood maps" for New York City that will help guide the city's resiliency and mitigation efforts (see Figure 3.11.87). These forward-looking maps illustrate how the 100-year floodplain could increase over the next several decades. The future flood maps are created by using a simplified "bathtub model" approach of combining the NPCC's high-end sea-level-rise projections with FEMA's June 2013 Preliminary FIRMs. Because these maps were not developed using advanced coastal modeling, the accuracy of the flood projections is limited. Although they are not suitable for evaluating risks

to individual properties, they are extremely useful for understanding the general extent of future flood risks.

The future flood maps show that with a rise in sea level of nearly a foot by the 2020s, the area that could be flooded in a 100-year storm could expand to 59 square miles (up 23% from the Preliminary FIRMs) and encompass approximately 88,000 buildings (up 31%). With more than 2.5 feet of sea level rise by the 2050s, New York City's 100-year floodplain could be 72 square miles—a staggering 24% of the city; this is an area that today contains approximately 114,000 buildings (almost twice as many as encompassed by the Preliminary FIRMs). This area currently accounts for the infrastructure responsible for 97% of the city's power generation capacity, 20% of its hospital beds, and a large share of its public housing. Over 800,000 New Yorkers, or 10% of the city's current population, now live in the 100-year floodplain projected for the 2050s—a number of flood-vulnerable residents that is greater than the total number of people living in the entire city of Boston.

Figure 3.11.87: Projected Future 100-Year Floodplain

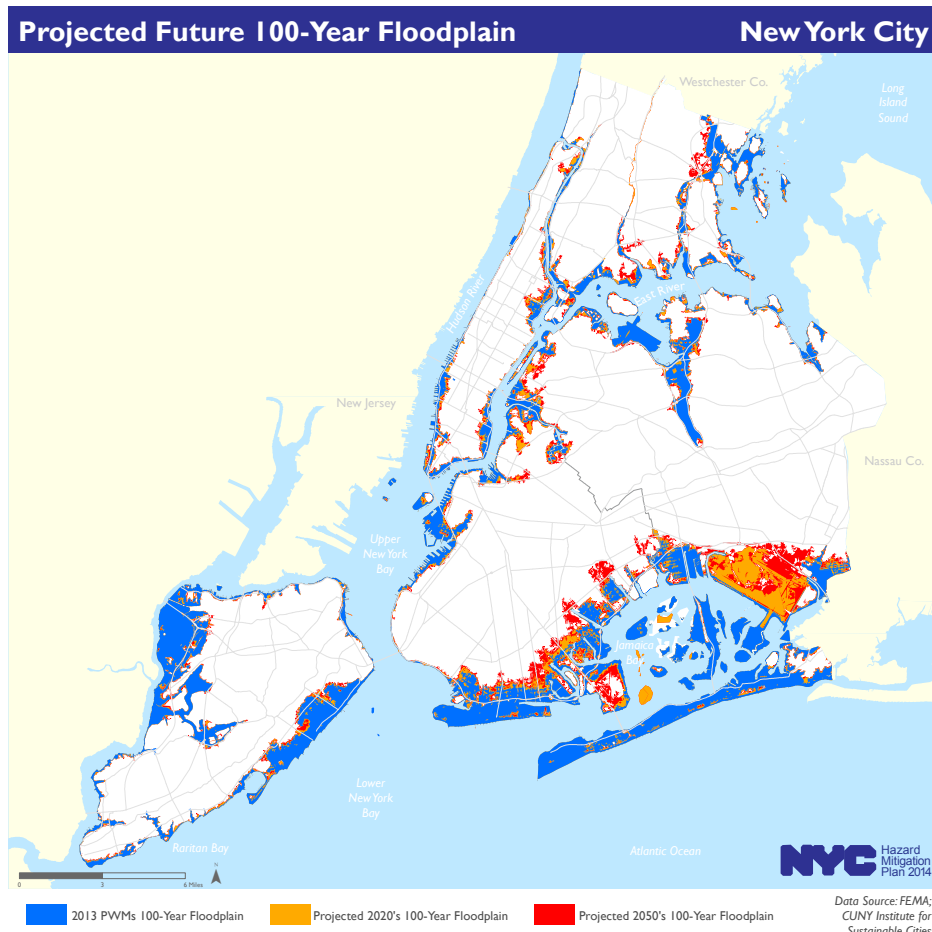


Table 3.11.62: Sea Level Rise in the 2020s and 2050s

| Sea Level Rise |          | 2020s   |   | 2050s   |   |
|----------------|----------|---|---|---|---|
|                | Baseline | Middle Range<br>(25 <sup>th</sup> -75 <sup>th</sup> percentile) | High End<br>(90 <sup>th</sup> percentile) | Middle Range<br>(25 <sup>th</sup> -75 <sup>th</sup> percentile) | High End<br>(90 <sup>th</sup> percentile) |
|                | 0        | +4 to 8 inches  | +11 inches                                | +11 to 24 inches  | +31 inches                                |



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## 12. HURRICANE SANDY RETROSPECTIVE ANALYSIS

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## 12. Hurricane Sandy Retrospective Analysis

### A. Summary

Hurricane Sandy, which made landfall on October 29, 2012, was an unprecedented storm in many respects as well as the costliest natural disaster in New York City's history. Much progress has been made to rebuild and restore the city since the storm. However, many of the hardest-hit areas are still recovering—a process that will likely continue for years. As recovery continues, the City is making plans to lessen the risk and impact of another disaster of this magnitude in the future.

### B. Storm Characteristics

#### i. Formation and Evolution

Sandy was first classified as a tropical storm in the central Caribbean on October 22, 2012, strengthening into a hurricane on October 24 before making initial landfalls in Jamaica, eastern Cuba, and the Bahamas (see Figure 3.12.88). From there, Sandy continued on a northerly path paralleling the Eastern Seaboard of the United States. As the storm tracked northward, weather forecast models came into agreement that the storm would take an unusual westward turn and make landfall in southern New Jersey. To make matters

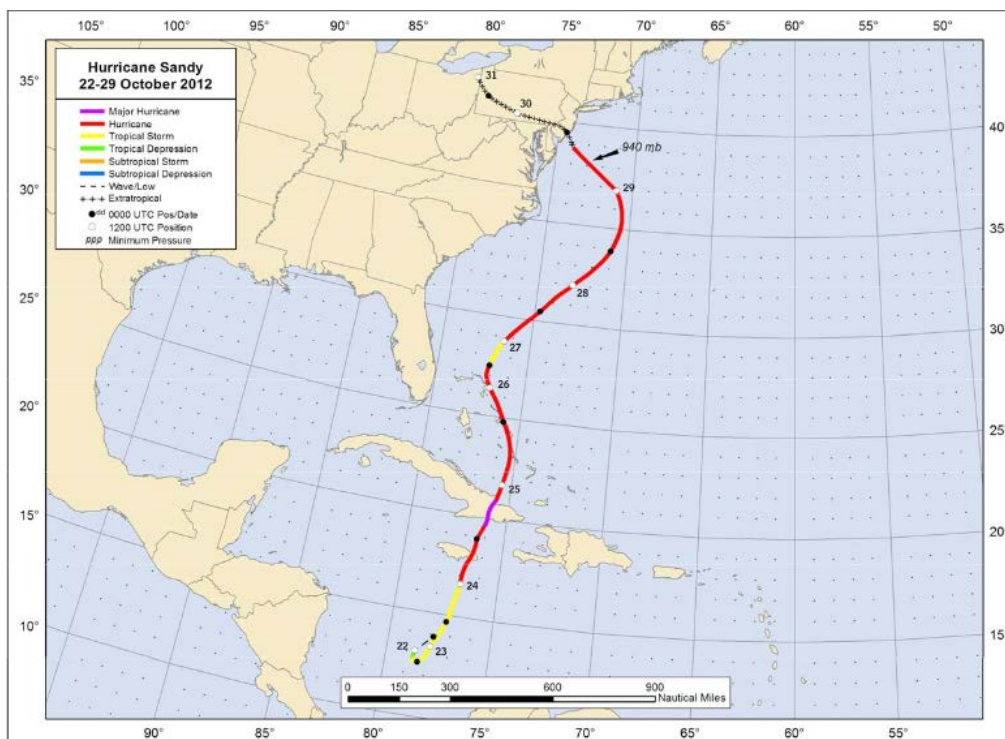
worse, Sandy was interacting with a frontal system that was moving eastward at the time, causing it to morph into an incredibly dangerous hybrid storm with both tropical and non-tropical characteristics.

#### ii. Unique Characteristics

From a meteorological standpoint, Sandy was an anomaly. For one thing, the storm was massive, stretching nearly 1,000 miles across at its peak (see Figure 3.12.89). The storm generated waves and storm surge that were larger than what would have been expected from a Category 1 storm in select locations; this is because tropical-storm-force or higher winds were spread across such a large area. Before Sandy made landfall, its wind field stretched from the Atlantic to as far west as Chicago and produced large waves on the Great Lakes.

Sandy's track was another unusual characteristic. Most storms in the western Atlantic either move east out to sea or move north-northeast, paralleling the east coast of the United States. However, a blocking high-pressure system over the northern Atlantic, combined with a pronounced southerly dip in the Jet Stream, caused this storm to make an unprecedented sharp westward turn before it made landfall.

Figure 3.12.88: Hurricane Sandy's Path (Source: NOAA).



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The same weather pattern facilitated the interaction between Sandy and the weather system moving eastward, producing a storm with an unusual combination of tropical and non-tropical characteristics. In fact, Sandy marked the first time in recorded history in which snow (experienced in parts of the interior Northeast and Mid-Atlantic) was associated with a tropical cyclone. Just prior to landfall, Sandy's minimum central pressure, another indicator of storm strength, set a record for any East Coast storm north of Cape Hatteras, North Carolina, at 940 millibars.

and New Jersey. MTA, DOT, and PANYNJ also closed bridges and tunnels as conditions warranted. Airlines cancelled all scheduled flights into and out of area airports.

At the same time, the City issued mandatory evacuation orders for Zone A (based on New York City's old evacuation zone for a worst-case scenario Category 1 storm) plus the Rockaway Peninsula and Hamilton Beach in Queens and City Island in the Bronx. The Mayor's Office, in coordination with the Office of Emergen-

**Figure 3.12.89: Satellite Image Showing Hurricane Sandy Engulfing Much of the Eastern United States and Southern Canada (Source: Phys.org).**



### C. Pre-Storm Preparations in New York City

When computer forecast models began to suggest a possible landfall in the region, New York City activated its Coastal Storm Plan (for more information, see Chapter 4: Mitigation Strategy, Section 6: Emergency Planning and Operations). Many pre-storm preparations were related to transportation. Several days before the storm, City agencies fueled vehicles and generators in anticipation of possible fuel shortages. At 7 PM on October 28 (the day before the storm), the Metropolitan Transportation Authority (MTA) began a citywide shutdown of buses, subways, and commuter rails (Metro North and Long Island Railroads). At 12 AM on October 29, the Port Authority of New York and New Jersey (PANYNJ) suspended all PATH service between New York

City Management (OEM) and the Department of Homeless Services, opened emergency shelters throughout the city. The Department of Parks & Recreation (DPR) closed all City parks. All New York City residents who were not evacuated, other than authorized government personnel and essential emergency personnel, were advised to stay home. In anticipation of power outages, utility crews were brought in from other states. Utility providers also erected temporary storm barriers around their facilities.

### D. Impacts on New York City

#### i. Landfall

On October 29, shortly after transitioning from a Cat-

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egory 1 hurricane to an extra-tropical storm, Sandy made landfall near Atlantic City, New Jersey. This was a worst-case-scenario storm track for New York City (see section 6. Coastal Storms). The storm's track, combined with its massive size and coincidence with an astronomical high tide (up to half a foot higher than normal high tide), produced a storm tide that exceeded what would typically be expected from a Category 1 hurricane in some locations. Storm surge reached record levels at various points throughout New York City, including the Battery in Lower Manhattan, which experienced a 9.4-foot storm surge (see Figure 3.12.90) and a storm tide of 14.06 feet above mean lower low water (MLLW).

In addition to the unprecedented storm surge, massive waves crashed into ocean-facing beaches. One buoy south of New York Harbor measured a wave height of 32.5 feet.

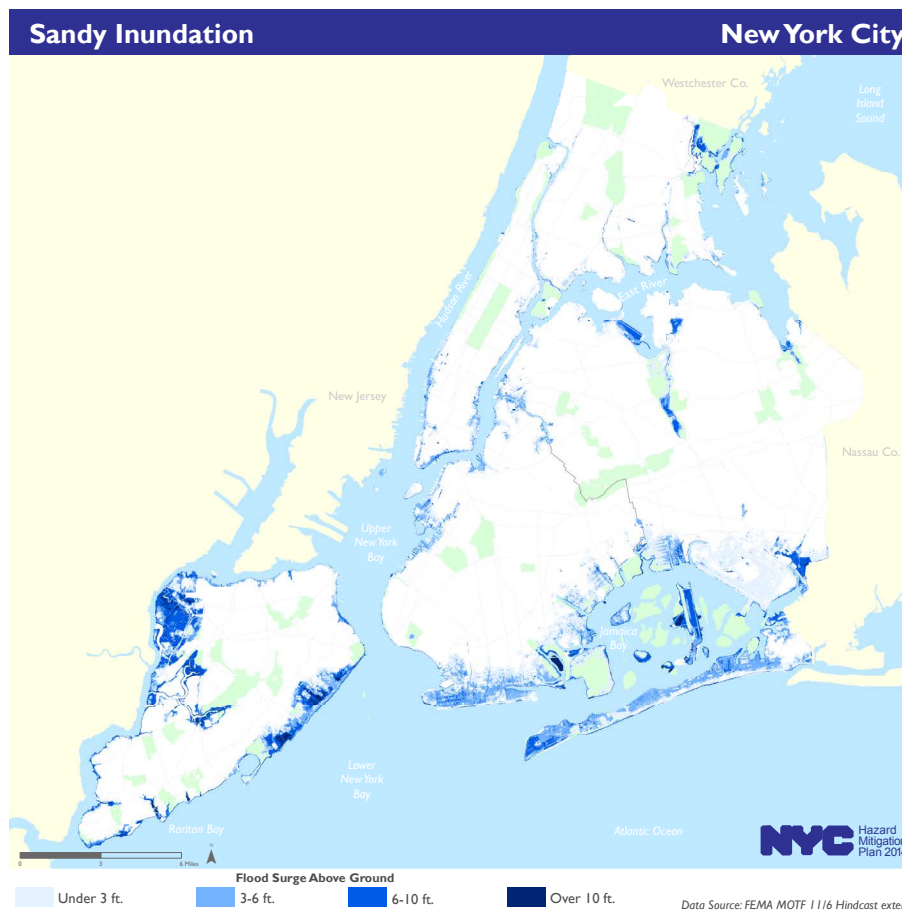
Although Sandy did not produce a significant amount

of rain in New York City (less than one inch), the majority of the Tri-State Area experienced repeated wind gusts over 60 mph for at least several hours, including at both LaGuardia and Kennedy Airports. Downed trees and power lines blocked roadways. A number of fires also resulted where saltwater came into contact with electrical wires. One massive fire in the Queens community of Breezy Point destroyed over 100 homes.

#### ii. Aftermath

When Sandy finally moved out of the area, it left significant damage in its wake. In total, the storm flooded 51 square miles of New York City—17% of the city's total land mass (see Figure 3.12.90). The most affected areas were the eastern and southern shores of Staten Island, the Brooklyn/Queens waterfront, southern Queens, southern Brooklyn, and Lower Manhattan.

Figure 3.12.90: Hurricane Sandy Inundation in New York City (Source: DCP GIS)



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#### Impacts on Social Environment

As a result of Hurricane Sandy, there were 44 deaths in New York City (the 44<sup>th</sup> death was confirmed by the New York City Office of the Chief Medical Examiner in June 2013), 23 of which were in Staten Island and the remainder of which were spread across Queens, Brooklyn, and Manhattan. The majority of these deaths were attributed to drowning in areas where storm surge rose rapidly. Nearly half of the fatalities were among adults aged 65 or older, most due to drowning.

Approximately 450,000 New York City residents were living in areas that were inundated. Approximately one-third of these residents were displaced from their homes and forced to seek temporary housing or immediate home repairs following the storm. According to [A Stronger, More Resilient New York](#) (website link provided at the end section 12) (see Post-Storm Recovery, below), 27% of households in the surge area were seniors, of which 12.1% were living alone. Also disproportionately impacted were low-income residents—New Yorkers who would have difficulty covering losses despite the availability of Federal Emergency Management Agency (FEMA) assistance. Residents in New York City Housing Authority developments were hit particularly hard, with roughly 80,000 residents in 423 buildings significantly impacted.

#### Impacts on Built Environment

Sandy caused nearly \$20 billion in damage to the city's building stock and infrastructure. Various methods have been employed to calculate the number of buildings within the inundation area, each resulting in slightly different estimates. Depending on the methodology used for calculation, there were an estimated 70,000 to 90,000 buildings within the inundation zone.

Building damage from Sandy was widespread and in many cases severe. By December 2012, DOB had tagged 800 buildings as being destroyed or structurally unsound, with tens of thousands more suffering at least minor damage. Nearly 70,000 housing units were registered with FEMA as having sustained at least some level of damage.

Overall, there were several indicators of how the storm

impacted New York City's building stock. Shoreline areas that experienced the force of waves sustained more damage to buildings than areas with still-water flooding only. Other factors related to the structural characteristics of buildings (such as height and construction type) as well as age (which defined the regulations in force when the buildings were constructed) were also important determinants. Overall, older (constructed before 1961), one-story, light-frame buildings, such as bungalows originally intended for seasonal use along the immediate ocean shoreline, suffered the most structural damage. High-rise buildings generally experienced less structural damage, but they did sustain damage to generators and electrical equipment housed in basements or otherwise insufficiently elevated. Repairing this damage was in many cases costly and disruptive.

Sandy caused significant damage to the city's critical infrastructure, disrupting services and damaging facilities essential to the well-being of the city's residents. Power distribution systems suffered a particularly heavy blow. Inundation of five Con Edison substations and four Long Island Power Authority substations, combined with damage to overhead power lines, resulted in the loss of power to nearly two million residents.

Table 3.12.63 identifies critical facilities that were inundated during Sandy, thus satisfying New York State Office of Emergency Management (NYS OEM) Requirement F2. (For more detailed information on how these critical facilities were impacted, see [A Stronger, More Resilient New York](#).)

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**Table 3.12.63: Critical Assets in Hurricane Sandy Inundation Area (Source: OEM GIS; analysis based on FEMA MOTF Hindcast data)**

| ASSET TYPE                      | IN INUNDATION AREA | NOT IN INUNDATION AREA | TOTAL        |
|---------------------------------|--------------------|------------------------|--------------|
| Airport (perimeter)*            | 2                  | 0                      | 2            |
| Nursing home (FP)               | 15                 | 158                    | 173          |
| Hospital (FP)                   | 6                  | 55                     | 61           |
| Police station (FP)             | 2                  | 75                     | 77           |
| Fire station (FP)               | 18                 | 210                    | 228          |
| EMS station (FP)                | 8                  | 71                     | 79           |
| Wastewater treatment plant (FP) | 10                 | 4                      | 14           |
| Power plant (est. FP)           | 9                  | 17                     | 26           |
| DOE school organization         | 94                 | 1,719                  | 1,813        |
| Private school                  | 30                 | 818                    | 848          |
| College                         | 7                  | 116                    | 123          |
| Ferry landing**                 | N/A                | N/A                    | 47           |
| Subway station (point)          | 31                 | 459                    | 490          |
| Rail station                    | 9                  | 33                     | 42           |
| Cultural facility (DCP)***      | 1                  | 36                     | 37           |
| Bus depot                       | 6                  | 24                     | 30           |
| Bridge****                      | 29                 | 41                     | 70           |
| Tunnel****                      | 3                  | 1                      | 4            |
| Major road (mi)****             | 235                | 652                    | 887          |
| <b>Total</b>                    | <b>515</b>         | <b>4,489</b>           | <b>5,051</b> |
| <b>Percentage</b>               | <b>10%</b>         | <b>89%</b>             | <b>100%</b>  |

Notes:

Asset counts are not based on facility field reports from the event. Hindcast data may contain inaccuracies. Unless otherwise noted, a facility point was used to do a spatial calculation; this may result in some inaccuracies in category designation. FEMA Modeling Task Force (MOTF) Hindcast data was produced using the SLOSH model. It is the best available data, but it may not reflect actual ground conditions in all areas. Assets that fall within the Hindcast extent but appear to be the result of DEM (terrain data) anomalies were excluded from the inundation area. Where possible, facility footprints were used for the analysis. When this data was not available, point locations were used. Data may not always reflect actual conditions on the ground. Asset types with "FP" indicate that the actual facility footprint was used in the calculation (for power plants, FPs were estimated).

\*Hindcast data shows inundation for both LGA and JFK airports, but field reports indicated only LGA was definitively impacted by surge.

\*\*Active commuter/commercial/recreational ferry landings only (includes Ellis and Liberty Islands). Hindcast data clipped to shoreline—cannot accurately determine impact to ferry landings.

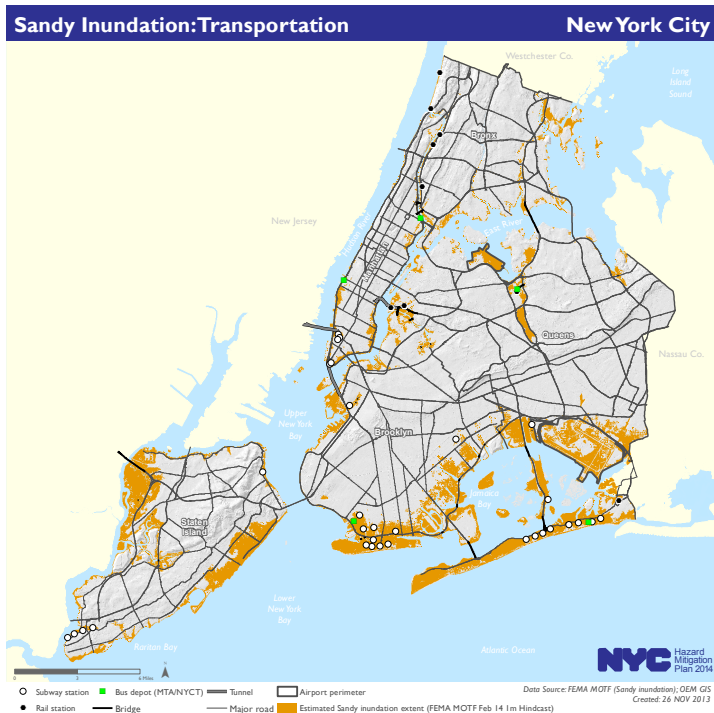
\*\*\*Determination made by OEM and DCP on which assets to include.

\*\*\*\*Estimated only. Based on visual review of bridge/tunnel segments with ortho photo. Considered not in a zone if all New York City approaches are fully clear of inundation. Major roads do not include bridge/tunnel spans.

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**Figure 3.12.91: Transportation Infrastructure Inundated during Hurricane Sandy (Source: OEM GIS).**



New York City's transportation infrastructure was severely impacted by Sandy (see Figure 3.12.91), affecting 8.5 million public transit riders and 4.2 million drivers. The MTA suffered an estimated \$5 billion in damage, half of which was attributed to the inundation of subway and commuter rail tunnels. All six East River subway tunnels connecting Brooklyn and Manhattan were knocked out of service by flooding, along with the Steinway Tunnel that carries the 7 train between Queens and Manhattan, the G train tunnel under Newtown Creek, the Long Island Railroad and Amtrak tunnels under the East River, and the PATH and Amtrak tunnels under the Hudson River. Corrosion from salt-water flooding caused severe damage to the electrical equipment at the South Ferry subway station (subway service has since been restored to the old South Ferry station, but the new station remains closed indefinitely due to damage sustained during the storm). Additionally, one subway bridge, three subway yards, and six city bus facilities were flooded.

More than 500 miles of city roads suffered significant damage. Roads were littered with trees and debris, and the Brooklyn-Battery and Queens-Midtown passenger car tunnels were inundated by storm surge. While subway service was out—it took days to restore—there

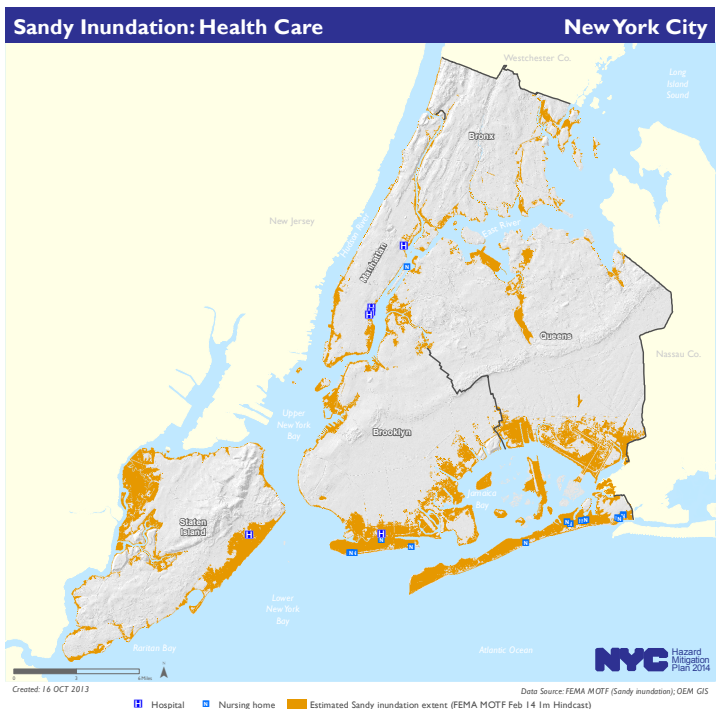
was gridlock on city roads and bridges.

Both LaGuardia and Kennedy Airports remained closed for days after the storm (although field reports indicated that only LaGuardia was definitively inundated by storm surge). Over 12,000 flights scheduled into and out of the three New York City area airports were cancelled.

Sandy also severely impacted the city's supply of liquid fuels. The storm shut down refineries for several weeks, stopped marine and pipeline deliveries for three to four days, and damaged storage terminals. For four days after the storm, the system received no new supply, and for almost a month after that, supply was limited. As a result, a number of gas stations closed, and many of the ones that remained open had significant fuel shortages.

The storm placed a significant strain on the city's healthcare system (see Figure 3.12.92). In total, six hospitals were forced to close (four in Manhattan, one in Brooklyn, and one on Staten Island), which required City and State health officials, co-located at OEM, to coordinate the evacuation of nearly 2,000 patients.

**Figure 3.12.92: Healthcare Facilities Inundated during Hurricane Sandy (Source: OEM GIS).**





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The storm also forced the closure or partial closure of 31 nursing homes and adult care facilities, from which 4,500 additional patients required evacuation. Many of these facilities were forced to close due to flood damage to backup power generators.

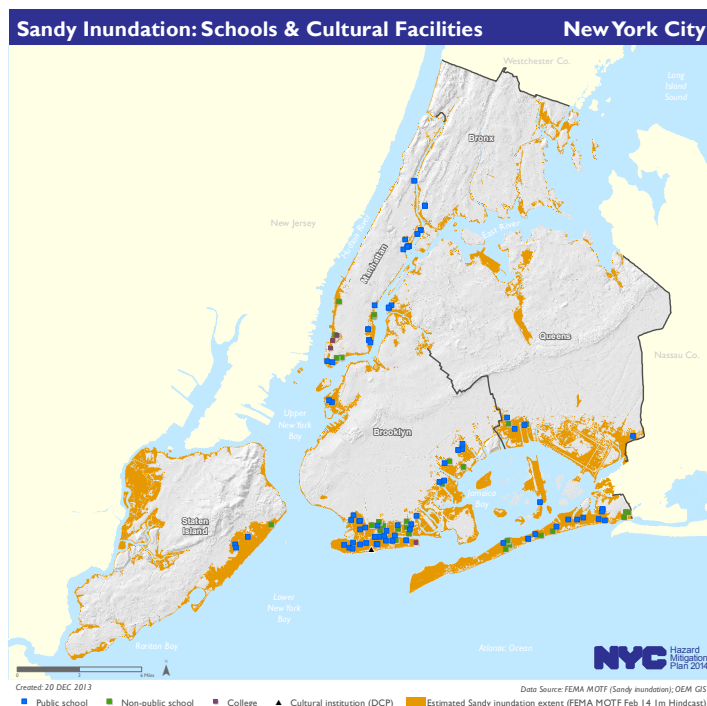
The city's telecommunications system also experienced significant outages. Short-term outages to wireless and cell service generally occurred as a direct result of power loss, while flood damage at critical facilities—in Lower Manhattan, Red Hook in Brooklyn, and the Rockaway Peninsula in Queens—disrupted landline and Internet service for up to 11 days. Flood damage to telecommunications equipment in buildings caused even longer outages in some coastal areas.

Damage to City schools resulted in over one million children being unable to attend school for at least a week. Some schools that suffered severe damage were forced to close for the remainder of the year (see Figure 3.12.93).

#### Loss Estimates

Loss estimates from Sandy were calculated using the same HAZUS-MH methodology that was used for

**Figure 3.12.93: Schools and Cultural Facilities Inundated during Hurricane Sandy (Source: OEM GIS).**



flooding (see section 3. Hazard Risk Assessment Organization and section 11. Flooding) of the Sandy storm surge inundation zone, provided by the FEMA Modeling Task Force (MOTF). This hazard boundary was used to produce a depth grid to perform a HAZUS-MH coastal flood analysis (this is not a true storm surge model as it does not account for the impacts of fast-moving surge). Over 50% of all buildings within the storm surge inundation zone were flooded (Table 3.12.64), amounting to nearly \$20 billion in total damages (Table 3.12.65).

**Table 3.12.64: Percentage of Buildings in Hurricane Sandy Inundation Zone Damaged due to Flooding, by Borough (Source: OEM GIS, FEMA)**

| Borough           | % of Buildings Damaged |
|-------------------|------------------------|
| Bronx             | 41                     |
| Kings             | 42                     |
| New York          | 39                     |
| Queens            | 54                     |
| Richmond          | 73                     |
| <b>City Total</b> | <b>53</b>              |

**Table 3.12.65: Direct Economic Losses due to Flooding from Hurricane Sandy, by Borough (Source: OEM GIS, FEMA)**

| Borough           | Capital Stock Loss (\$) | Income Loss (\$)   | Total Loss (\$)       |
|-------------------|-------------------------|--------------------|-----------------------|
| Bronx             | 405,881,000             | 2,533,000          | 408,414,000           |
| Kings             | 5,123,469,000           | 62,542,000         | 5,186,011,000         |
| New York          | 7,006,110,000           | 70,448,000         | 7,076,558,000         |
| Queens            | 5,238,726,000           | 87,869,000         | 5,326,595,000         |
| Richmond          | 1,998,276,000           | 10,594,000         | 2,008,870,000         |
| <b>City Total</b> | <b>19,772,462,000</b>   | <b>233,986,000</b> | <b>20,006,448,000</b> |

Notes: Damage estimates are calculated to the nearest \$1,000.

#### Impacts on the Natural Environment and Recreation

Sandy also had a significant impact on the natural environment, parks, and recreational facilities. When storm surge inundated wastewater treatment plants it caused 10 of the 14 plants operated by the Department of Environmental Protection (DEP) to release untreated or partially treated sewage into local waterways. Due to loss of power, 42 of the 96 pumping stations, which facilitate the movement of combined sewage through the system, were temporarily out of service. The city's stormwater and combined sewer systems were simply unable to handle the unprecedented volume of storm surge.

During Sandy, 5,700 acres of New York City's park system were inundated by floodwaters, causing \$800 million in damages. City parks and natural areas remained closed or inaccessible for days after the storm as crews worked to remove downed trees and debris.

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. The storm damaged beachfront infrastructure and facilities. On the Rockaway Peninsula, storm surge destroyed whole sections of nearly three miles of the boardwalk, scattering wood planks into neighboring communities. Meanwhile, erosion displaced approximately 3 million cubic yards of sand. In some places, beachfronts retreated by as much as 70 feet. Sandy also pushed water over bulkheads on waterfront sites, damaging these critical coastal defenses.

Storm surge inundated and damaged coastal wetland ecosystems. However, salt marshes located in Jamaica Bay and its tributary systems remained largely clear of floating debris, with much vegetation surviving.

Flooding from storm surge also affected 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.

#### E. Post-Storm Recovery

Although it will likely take years for New York City to fully recover, much progress has already been made. In the days and weeks following the storm, roads were reopened, flooded tunnels were "dewatered," power was restored, public transportation resumed, and the airports gradually returned to normal flight schedules. One week after the storm struck, many subway lines were fully or partially restored, but some elements of the system remained closed for a longer period, with repairs projected to take months or even years.

In the months following the storm, thousands of City employees and service volunteers worked tirelessly to clear 700,000 tons of debris and rebuild neighborhoods. Relief money, food, and supplies were brought in to help the hardest-hit communities. The Mayor's Office of Housing and Recovery Operations (HRO) was established to rebuild and repair homes and return displaced residents to safe and sustainable housing. The City worked with FEMA to create and implement the federal Sheltering and Temporary Essential Power (STEP) program as NYC Rapid Repairs, a free program to restore power, heat, and hot water to private homes. When the program concluded in April 2013, it had repaired approximately 11,500 residential structures representing more than 20,000 housing units. Many residents displaced by the storm have since returned to their homes.

HRO also developed loan and grant programs to help businesses clean up and reopen. By mid-March 2013, 82% of the 11,295 businesses that were inundated had reopened.

The City has made beach restoration a priority and has been working with the United States Army Corps of Engineers to restore miles of damaged and eroded beach and coastal flood risk management structures. This work has been occurring in areas including the Rockaway Peninsula, Coney Island, and the southern shore of Staten Island. Many beaches in these areas were open again during the summer of 2013.

In January 2013, President Obama signed the Disaster Relief Appropriations Act of 2013, which provides

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\$15.1 billion in Community Development Block Grant Disaster Recovery (CDBG-DR) funds to repair and restore areas affected by Sandy. New York City has received two allocations of CDBG-DR funding: \$1.77 billion from the first round and \$1.447 billion from the second round. The United States Department of Housing and Urban Development has approved the City's action plan for the first round of funding, and the City is using these funds for rebuilding and recovery-based housing programs, business programs, infrastructure, resiliency programs, and citywide administration and planning. The City is updating its action plan to incorporate the second round of CDBG-DR funding.

After Sandy, FEMA issued interim mapping and elevation products to provide New Yorkers with a better understanding of flood risks because the Flood Insurance Rate Maps (FIRMs) in effect at the time of the storm were out of date. These products included Advisory Base Flood Elevations and Preliminary Flood Insurance Rate Maps (Preliminary FIRMs). The City also revised its hurricane evacuation zones, placing a greater focus on the varying angles of approach for different storms (see section 6. Coastal Storms).

A number of resiliency initiatives have come about in the wake of the storm. The most comprehensive of these is the Special Initiative for Rebuilding and Resiliency (SIRR), initiated by Mayor Bloomberg in December 2012 to explore what happened during Sandy and how to prepare for and reduce New York City's risk from the impacts of climate change. In June 2013 SIRR released a report entitled [A Stronger, More Resilient New York](#), a comprehensive plan with actionable recommendations for rebuilding the communities impacted by Sandy and increasing the resiliency of buildings and infrastructure citywide. The report includes community rebuilding and resiliency plans for the Brooklyn-Queens waterfront, the East and South shores of Staten Island, southern Queens, southern Brooklyn, and southern Manhattan. Many of the actions in the 2014 Hazard Mitigation Plan related to coastal storms and flooding are adapted from this report.

In collaboration with SIRR, the City reconvened the New York City Panel on Climate Change (NPCC), a team

of climate science experts who make climate projections for New York City and offer recommendations for how the city can adapt to a changing climate. In 2010 the NPCC had released its first publication, *Climate Change Adaptation in New York City: Building a Risk Management Response*. In June 2013 the NPCC released its second publication, [Climate Risk Information: Observations, Climate Change Projections, and Maps](#), (website link provided at the end of section 12) coinciding with the release of *A Stronger, More Resilient New York*.

Additional city resiliency actions are included in the [Hurricane Sandy After Action](#) (website link provided at the end of section 12) report to Mayor Bloomberg, with recommendations on how the City's response capacity and performance can be strengthened in the future. The report groups its recommendations according to seven themes:

- Improved evacuation, including updated evacuation zones and better, clearer communication to help New Yorkers understand how to protect themselves from the risk of severe weather.
- Improved accessibility of all coastal storm-related information and services to make them available to all New Yorkers, including persons with disabilities or special medical needs, homebound populations, non-English speakers, and undocumented immigrants.
- Better integration of the City's data across platforms and agencies to increase situational awareness and allow more targeted, efficient response and recovery operations.
- Additional capacity to respond to large-scale building inundation and loss of power, including pre-storm identification of the equipment and skilled resources likely to be needed for building restoration and better coordination with private building owners.
- Better coordination of relief to affected areas and to vulnerable or homebound populations, including more efficient deployment of volunteers and donations to residents and business

owners.

- The development of a mid- to long-term housing plan for New Yorkers displaced by damage from coastal storms.
- Partnership with the federal and state authorities that regulate and enforce standards for private companies and utilities providing essential services to New York City residents.

#### F. Lessons Learned

Sandy brought a number of city needs to light. The analysis of the storm's impacts emphasized the necessity for updated FEMA flood zones and new hurricane evacuation zones. Sandy underlined the need to rethink how to build or rebuild in vulnerable coastal areas by promoting more flood-resistant building designs and encouraging land uses that can accommodate periodic flooding. Sandy also highlighted the need to ensure access to critical services for older adults, populations with disability, and other vulnerable communities. The importance of accurate weather and climate forecasting and warnings was another lesson to come out of the city's experience with Sandy. Along with this comes the need to improve coordination among weather experts, emergency management officials, and the general public.

The storm also prompted City officials, businesses, academics and residents to think more seriously about and move forward with strategies to protect New York City as it becomes increasingly vulnerable in the face of climate change. Prior to Sandy, New York City's vulnerability to hurricanes and climate change had been well established, but few people anticipated the devastation that such a coastal storm could bring. Moreover, although New York City had already been factoring climate change into its planning and undertaking resiliency initiatives, Sandy revealed that these efforts should be expanded and accelerated. Although a direct link between Sandy and climate change cannot be proven, sea level rise will continue to exacerbate the impacts of storm surge in the future.

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- Rosenzweig, C., *Hurricane Sandy, Lessons Learned*, Presented at ICLEI Resilient Cities Conference, Bonn, Germany, May 31, 2013, [http://resilientcities.iclei.org/fileadmin/sites/resilientcities/files/Resilient\\_Cities\\_2013/Presentations/A1\\_Rosenzweig\\_RC2013.pdf](http://resilientcities.iclei.org/fileadmin/sites/resilientcities/files/Resilient_Cities_2013/Presentations/A1_Rosenzweig_RC2013.pdf) (last accessed October 30, 2013).

## 12. HURRICANE SANDY RETROSPECTIVE ANALYSIS

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#### Website Links:

A Stronger, More Resilient New York:

<http://www.nyc.gov/html/sirr/html/report/report.shtml>

Climate Risk Information: Observations, Climate Change Projections, and Maps:

[http://www.nyc.gov/html/planyc2030/downloads/pdf/npsc\\_climate\\_risk\\_information\\_2013\\_report.pdf](http://www.nyc.gov/html/planyc2030/downloads/pdf/npsc_climate_risk_information_2013_report.pdf)

Hurricane Sandy After Action:

[http://www.nyc.gov/html/recovery/downloads/pdf/sandy\\_aar\\_5.2.13.pdf](http://www.nyc.gov/html/recovery/downloads/pdf/sandy_aar_5.2.13.pdf)



### 13. Severe Weather: Thunderstorms, Tornadoes, and Windstorms

#### A. Hazard Profile

##### i. Hazard Description

Severe thunderstorms, tornadoes, and windstorms are what are known as severe weather, and

these weather events can pose serious risks in New York City.

#### *Severe Thunderstorms*

Thunderstorms are caused by a combination of moisture, unstable air, and lift caused by cold or warm fronts moving into the area. Non-severe thunderstorms produce lightning, rain, small hail, and winds of less than 58 mph. According to the National Weather Service (NWS), the national average size of a thunderstorm is 15 miles in diameter and lasts an average of 30 minutes. Thunderstorms are normally localized events.

About 10% of thunderstorms are classified as severe. Severe thunderstorms consist of winds of 58 mph or higher, and/or large hail measuring at least 1 inch in diameter, and/or a tornado.

Hailstones are falling particles of ice. Hail develops as warm, moist air rises in the upper atmosphere and then cools. As the air cools below the freezing point, water vapor condenses into ice crystals. These ice crystals remain suspended by high-velocity updraft winds, grow larger, and eventually fall to the ground as hail, sometimes at speeds of 100 mph or greater. The size of hail is usually determined by the severity of the storm and for New York City typically ranges from 0.20 inches to 2.0 inches in diameter.

The NWS issues a Severe Thunderstorm Watch when severe thunderstorms are possible over a large area, in some cases several states. A Severe Thunderstorm Warning is issued when a severe thunderstorm is occurring or expected to occur within a matter of minutes.

Thunderstorms and hail can pose serious threats to human life and property in New York City. Severe storms

can leave broken tree limbs, downed power lines, and other debris, which may lead to power outages, transportation disruptions, and damage to buildings and vehicles.

#### *Tornadoes*

Thunderstorms can also create a favorable environment for tornadoes, which are violent rotating columns of air with winds of up to 200 miles per hour or greater (vice winds up to 300 miles per hour). These short-lived storms generally appear as funnel-shaped clouds, gray to black in color, extending toward the ground from the base of a thundercloud. Tornadoes actually begin as transparent—and it is at this time that they are especially dangerous because they cannot easily be seen; as they pick up debris and dust, they acquire their grayish coloration. Most tornadoes move southwest to northeast at an average forward speed of 30 mph, but tornadoes can move in any direction and may vary from stationary to 70 mph. Tornadoes are most frequent east of the Rocky Mountains during spring and summer between 3 PM and 9 PM. They may also accompany hurricanes (see section 6. [Coastal Storms](#)).

Tornadoes are the most violent of all atmospheric phenomena and, over a small area, the most destructive—they can uproot trees and buildings and turn harmless objects into deadly missiles in a matter of seconds. Their damage paths can exceed one mile in width and 50 miles in length. Each year there are an average of 1,200 tornadoes nationwide, causing 60 to 65 fatalities and 1,500 injuries.

#### *Windstorms*

High-winds events are often associated with other storms, such as hurricanes or nor'easters (see 6. [Coastal Storms](#)), but may occur independently. High winds can cause downed trees and power lines, flying debris, and building collapses—all of which may lead to power outages, transportation disruptions, damage to buildings and vehicles, and personal injury and death. Flying debris is the primary cause of damage during a windstorm. While a building may remain generally structurally sound, broken glass from windows can cause injuries inside and outside the building and extensive damage to building contents.

# 13. SEVERE WEATHER: THUNDERSTORMS, TORNADOES, AND WINDSTORMS

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### ii. Severity

#### Severe Thunderstorms

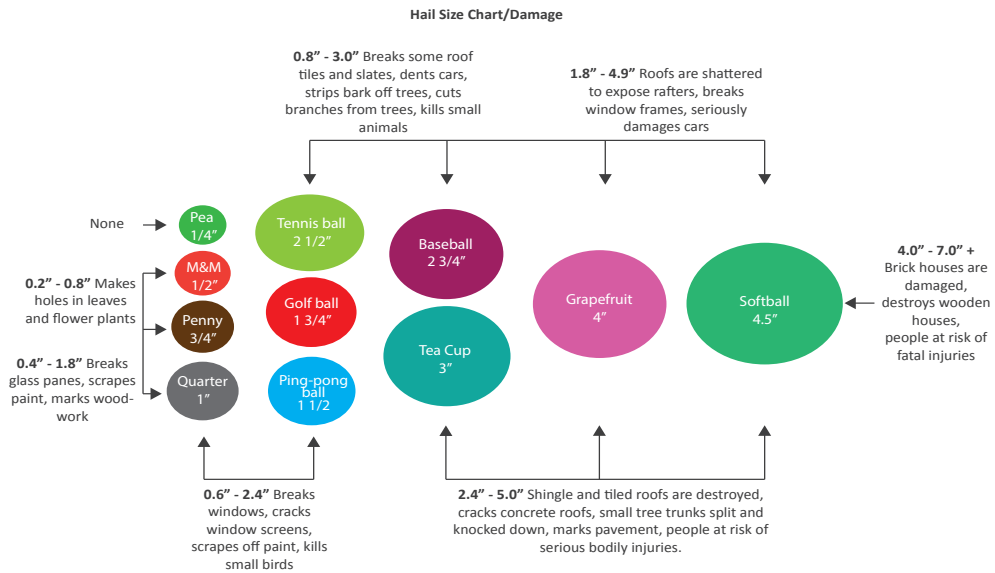
A thunderstorm is considered severe if it produces wind gusts of at least 58 mph and/or large hail of at least 1 inch in diameter. Severe thunderstorms can also produce tornadoes. Generally the size of hailstones is correlated with the severity of the thunderstorm. As

shown below in Figure 3.13.94, hailstones vary widely in scale.

#### Tornadoes

The Fujita Scale (F-Scale) used to be the standard measurement for rating the strength of a tornado. The NWS has used this scale and an analysis of damage after a tornado to infer wind speeds. On February 1, 2007, the

**Figure 3.13.94: Hail Size and Related Damages (Source: Burt, 2007)**



Source: Burt, Christopher C. *Extreme Weather: A Guide and Record Book Climate Change Edition*. W.W.Norton & Company Inc. New York (2007).

**Table 3.13.66: Comparison of Fujita (F-Scale) and Enhanced Fujita (EF-Scale) Scales**

| F - Scale | 3 -sec. gust speed (mph) | EF - Scale | 3 -sec. gust speed (mph) | TYPICAL DAMAGE   |
|-----------|--------------------------|------------|--------------------------|--|
| F0        | 45 -78                   | EF0        | 65-85                    | Light damage. Some damage to chimneys. Branches broken off trees. Shallow-rooted trees pushed over, signboards damaged.  |
| F1        | 79-117                   | EF1        | 86-109                   | Moderate damage. Peels surface off roofs. Mobile homes pushed off foundations or overturned. Moving autos blown off roads.   |
| F2        | 118-161                  | EF2        | 110-137                  | Considerable damage. Roofs torn off frame houses. Mobile homes demolished. Boxcars overturned. Large trees snapped or uprooted. Light-object missiles generated. Cars lifted off ground.                           |
| F3        | 162-209                  | EF3        | 138-167                  | Severe damage. Roofs and some walls from off well-constructed houses. Trains overturned. Most trees in forest uprooted. Heavy cars lifted off the ground and thrown.   |
| F4        | 210-261                  | EF4        | 168-199                  | Devastating damage. Well-constructed houses leveled. Structures with weak foundations blown away some distance. Cars thrown and large missiles generated.  |
| F5        | 262-317                  | EF5        | 200-234                  | Incredible damage. Strong frame houses leveled off foundations and swept away. Automobile-sized missiles fly through the air in excess of 100 meters (109 yards). Trees debarked. Incredible phenomena will occur. |



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NWS transitioned from the F-Scale to the Enhanced Fujita Scale (EF-Scale). The EF-Scale is now the standard used to determine the strength of a tornado. References to the old F-scale are needed for historical purposes (see [Historic Occurrences](#)). The EF-scale is more complex and enables surveyors to assess tornado severity with greater precision. Table 3.13.66: Comparison of Fujita (F-Scale) and Enhanced Fujita (EF-Scale) Scales compares the F-Scale and EF-Scale and shows damage

es associated with these ratings.

#### *Windstorms*

The Beaufort Wind Scale, shown below, aids in the estimation of wind speed and corresponding typical effects (see Table 3.13.67).

**Table 3.13.67: Beaufort Wind Scale (NOAA, 2013)**

| Force | Wind Speed (mph) | Name            | Damage  |
|-------|------------------|-----------------|---|
| 0     | Less than 1      | Calm            | Calm, smoke rises vertically  |
| 1     | 1 – 4            | Light Air       | Smoke drift indicates wind direction, still wind vanes  |
| 2     | 5 - 7            | Light Breeze    | Wind felt on face, leaves rustle, vanes begin to move   |
| 3     | 8 - 12           | Gentle Breeze   | Leaves and small twigs constantly moving, light flags extended  |
| 4     | 13 - 18          | Moderate Breeze | Dust, leaves, and loose paper lifted, small tree branches move  |
| 5     | 20 - 24          | Fresh Breeze    | Small trees in leaf begin to sway   |
| 6     | 25–31            | Strong breeze   | Large branches in motion; whistling in telephone wires; umbrellas used with difficulty                                      |
| 7     | 32–38            | Near gale       | Whole trees in motion; resistance felt while walking against the wind   |
| 8     | 39–46            | Gale            | Twigs break off trees; wind impedes walking   |
| 9     | 47–54            | Strong gale     | Slight structural damage to chimneys and slate roofs  |
| 10    | 55–63            | Storm           | Seldom felt inland; trees uprooted; considerable structural damage  |
| 11    | 64–72            | Violent storm   | Very rarely experienced; widespread structural damage; roofing peels off buildings; windows broken; mobile homes overturned |
| 12    | 73+              | Hurricane       | Widespread structural damage; roofs torn off homes; weak buildings and mobile homes destroyed; large trees uprooted         |

iii. Probability

Severe weather occurs often in New York City. Based on the frequency of past events, severe weather is highly probable for the future.

*Severe Thunderstorms*

While non-severe thunderstorms occur on 25 to 30 days annually across New York City, severe thunderstorms occur much less frequently, but at least a few times each year. Based on the annual frequency of past severe thunderstorms in New York City, the probability of at least one of the criteria for severe storms being met (usually winds) is high and happens multiple times on a local scale each year, whereas the recurrence interval for tornadoes and large hail is much lower.

From 1974 to 2013, there have been 49 major occurrences of severe thunderstorms and hail, and eight of these storms have been citywide events (impacting more than one borough). Although hail doesn't always occur during thunderstorms, all eight of the citywide events produced hailstones, which ranged from 0.75 inches to 1.75 inches in diameter. From 1974 to 2013, there were 40 occurrences of hail (equal or greater than 3/4 inch) in New York City.

*Tornadoes*

Although not as common as severe thunderstorms, tornadoes are still probable for the future. Over the past 40 years, 12 tornadoes have hit New York City, 11 of which were scaled F0 or F1. In the past six years, tornado activity has increased in New York City. There have been five tornadoes since 2007; in comparison to seven tornadoes over a 33 year period (1974 was the first occurrence of a tornado in NYC).

*Windstorms*

From 1974 to 2013, there have been 31 documented windstorms with gusts above 40 mph in New York City. During this same period, there have been 14 major windstorms with wind gusts ranging from 50 to 90 mph. Based on the historic occurrences, New York City experiences a high-wind event at least once a year.

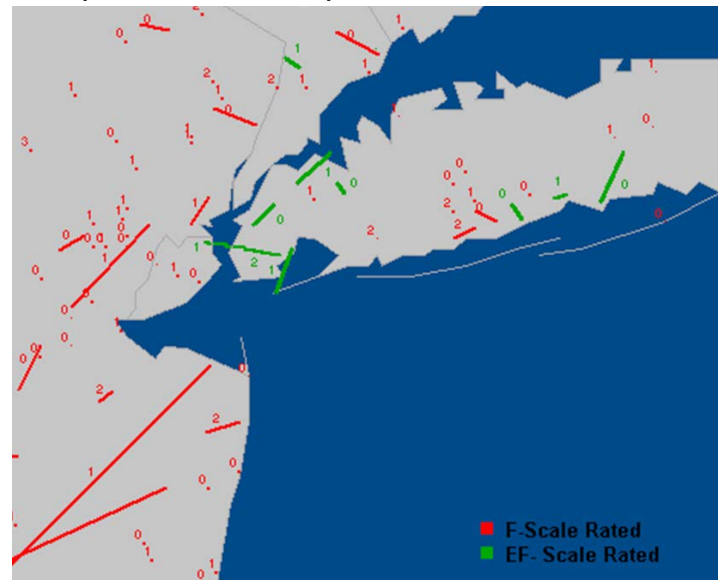
iv. Location

Based on historic events, severe weather has an equal probability of occurrence city-wide.

*Thunderstorms and Hail*

Although thunderstorms occur throughout New York City, they don't necessarily affect all five boroughs at the same time or with the same severity. Some thunderstorms are extremely localized events.

**Figure 3.13.95: Tri-State Tornado Climatology, 1950 to 2012 (Source: NOAA 2013)**



*Tornadoes*

A common misconception is that tornadoes do not occur in dense urban areas such as New York City. Since 1950, at least one tornado has occurred in 4 of the 5 boroughs (none in Manhattan). Figure 3.13.95 shows the locations of previous tornadoes in the New York City area. Scientists say that although tornadoes are rare, they are possible in any part of the city.

*Windstorms*

New York City is located in an area that is susceptible to windstorms. Accordingly, FEMA and the National Fire Protection Association's (NFPA) Model Manufactured Home Installation Standards categorize the United States into four wind zones: Zone I, Zone II, Zone

# 13. SEVERE WEATHER: THUNDERSTORMS, TORNADOES, AND WINDSTORMS

## CHAPTER 3: RISK ASSESSMENT

III, and the highest wind zone, Zone IV (see Figure 3.13.96). These wind zones portray the frequency and strength of extreme windstorms and help determine wind provisions for safe installation of manufactured homes. Figure 3.13.97 shows that New York City is located in Zone II, which means that the city is susceptible to 90-mph and 110-mph winds. Both figures also show that New York City is located in a hurricane susceptible region.

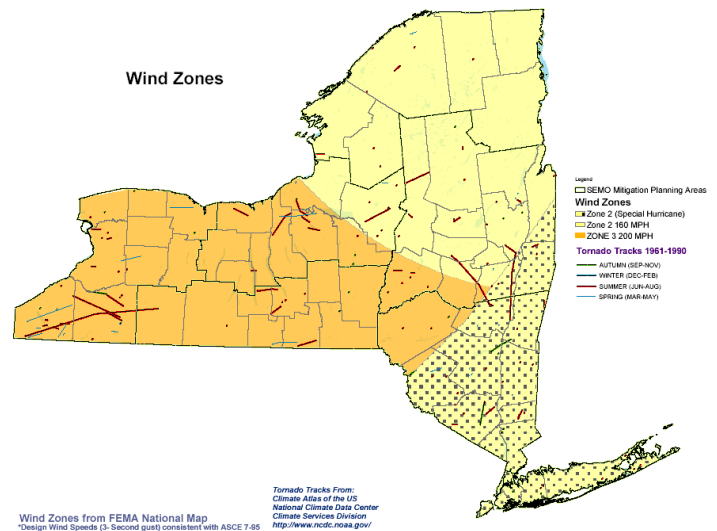
**Figure 3.13.96: Wind Zones in the United States (Source: FEMA, 2013)**



### v. Historic Occurrences

Table 3.13.68, below, describes selected severe thunderstorms, tornadoes, and high-wind events from 1974 to 2013. Due to the high frequency of severe thunderstorms, the table only features major severe thunderstorms. Of these severe weather events, there have been two presidential disaster declarations.

**Figure 3.13.97: Wind Zones in New York State (Source: FEMA, 2008)**



### 13. SEVERE WEATHER: THUNDERSTORMS, TORNADOES, AND WINDSTORMS

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**Table 3.13.68: Selected Severe Weather Events 1974 to 2013**

| Date              | Event                  | Location(s)   | Description   |
|-------------------|------------------------|---------------|---|
| September 2, 1974 | Tornado                | Bronx         | <ul style="list-style-type: none"> <li>F1 tornado</li> <li>No injuries or fatalities</li> </ul>   |
| October 5, 1985   | Tornado                | Queens        | <ul style="list-style-type: none"> <li>F1 tornado</li> <li>Runs for 2 miles; width of 50 yards</li> <li>No fatalities; 6 injuries</li> </ul>  |
| August 10, 1990   | Tornado                | Staten Island | <ul style="list-style-type: none"> <li>F0 tornado</li> <li>Runs for 2 miles; width of 17 yards</li> <li>No fatalities; 3 injuries</li> </ul>  |
| March 2, 1994     | Windstorm              | Citywide      | <ul style="list-style-type: none"> <li>High winds of 61 mph</li> </ul>  |
| October 28, 1995  | Tornado                | Staten Island | <ul style="list-style-type: none"> <li>F1 tornado</li> <li>No fatalities or injuries</li> <li>Estimated damage \$500,000</li> </ul>   |
| February 25, 1996 | Windstorm              | Citywide      | <ul style="list-style-type: none"> <li>Intensity unknown</li> <li>1 fatality in Brooklyn due to a fallen tree</li> <li>1 reported injury</li> </ul>   |
| March 19, 1996    | Windstorm              | Citywide      | <ul style="list-style-type: none"> <li>High winds of 79 mph</li> <li>No fatalities or injuries</li> </ul>   |
| October 19, 1996  | Windstorm              | Citywide      | <ul style="list-style-type: none"> <li>High winds of 92 mph</li> <li>Fallen trees cause 3 fatalities; no additional injuries</li> <li>Downed power lines and trees close Bayonne Bridge</li> <li>Roof reported to be ripped off a Bronx building</li> </ul>     |
| March 6, 1997     | Windstorm              | Citywide      | <ul style="list-style-type: none"> <li>Winds of more than 60 mph</li> <li>Knocks down trees and power lines on houses and streets</li> <li>75-foot maple tree falls on school bus carrying 10 children</li> <li>Two injuries caused by flying debris</li> </ul> |
| November 2, 1997  | Windstorm              | Citywide      | <ul style="list-style-type: none"> <li>Reported wind gusts of 40 to 46 mph</li> <li>1 fatality; 1 injury</li> </ul>   |
| November 4, 1997  | Thunderstorms and hail | Bronx         | <ul style="list-style-type: none"> <li>1-inch hailstones from a line of scattered thunderstorms</li> <li>Gusty winds and heavy rain</li> </ul>  |
| November 27, 1997 | Windstorm              | Manhattan     | <ul style="list-style-type: none"> <li>Winds average 25 to 35 mph; gusts around 50 mph</li> <li>Winds cause loss of control of parade balloon, which strikes a light pole, causing it to fall and injure 4 spectators</li> </ul>                                |
| February 4, 1998  | Windstorm              | Manhattan     | <ul style="list-style-type: none"> <li>Winds of 57 mph</li> <li>No fatalities; 1 injury reported</li> </ul>   |
| June 30, 1998     | Tornado/hail           | Bronx/Queens  | <ul style="list-style-type: none"> <li>0.75-inch hail and damaging winds from a wave of severe storms in the Bronx</li> <li>High winds in Queens down trees that strike and injure three girls</li> <li>F1 tornado in Long Island</li> </ul>                    |

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| Date               | Event                     | Location(s)                   | Description  |
|--------------------|---------------------------|-------------------------------|--|
| September 7, 1998  | Severe thunderstorms/hail | Citywide                      | <ul style="list-style-type: none"> <li>● Intense line of severe thunderstorms</li> <li>● Wind gusts of 60 to 80 mph</li> <li>● Downed trees and power lines</li> <li>● Hailstones of 1.50 inches</li> <li>● On Staten Island high winds down trees, causing a building to collapse</li> <li>● Tree falls on three people in the Bronx, resulting in 1 fatality and two injuries</li> <li>● Two injuries in Brooklyn—one caused by downed tree and one by hailstones</li> </ul> |
| March 18, 1999     | Windstorm                 | Manhattan                     | <ul style="list-style-type: none"> <li>● Winds of 40 to 47 mph</li> <li>● 15-foot metal rod tumbles 22 stories from top of 1 Times Square, injuring 3 women</li> </ul>   |
| May 18, 2000       | Severe thunderstorms/hail | Bronx/Queens/Brooklyn         | <ul style="list-style-type: none"> <li>● Line of severe thunderstorms produce damaging wind gusts</li> <li>● Large hailstones (0.75 to 1.0 inch)</li> <li>● Heavy rain and lighting</li> <li>● Downed trees in the Bronx</li> <li>● Large awning blown off building in Brooklyn</li> <li>● 1-inch hailstones in Woodside, Queens</li> </ul>  |
| December 12, 2000  | Windstorm                 | Citywide                      | <ul style="list-style-type: none"> <li>● Winds of 64 mph</li> <li>● Nor'easter</li> <li>● 1 fatality; 6 injuries</li> </ul>  |
| May 29, 2001       | Severe thunderstorms/hail | Brooklyn/Queens               | <ul style="list-style-type: none"> <li>● Scattered severe thunderstorms with high winds</li> <li>● People in 19 houses in Queens report downed trees and power lines</li> <li>● 0.75-inch hailstones reported in Brooklyn</li> </ul>   |
| August 2, 2002     | Severe thunderstorms/hail | Manhattan/Staten Island/Bronx | <ul style="list-style-type: none"> <li>● 0.75-inch hailstones in Staten Island</li> <li>● Man struck and killed by lightning in Manhattan</li> <li>● Thunderstorms in Bronx</li> <li>● High winds down power lines near Fordham University</li> </ul>  |
| September 11, 2002 | Windstorm                 | Citywide                      | <ul style="list-style-type: none"> <li>● Strongest winds measure 66 mph in Queens</li> <li>● Winds last at least 6 hours</li> <li>● 1 fatality; 4 injuries</li> <li>● Widespread power outages</li> <li>● Construction debris causes injuries</li> </ul>   |
| September 19, 2003 | Windstorm                 | Bronx                         | <ul style="list-style-type: none"> <li>● Winds of up to 46 mph</li> <li>● Hurricane Isabel</li> <li>● No fatalities; 1 injury</li> <li>● Downed trees and power lines</li> </ul>   |
| October 15, 2003   | Windstorm                 | Queens                        | <ul style="list-style-type: none"> <li>● Winds of 45 mph</li> <li>● No fatalities or injuries reported</li> <li>● Downed trees and power lines reported</li> <li>● Property damage estimated at a least \$100,000</li> </ul>   |
| October 27, 2003   | Tornado                   | Staten Island                 | <ul style="list-style-type: none"> <li>● F0 tornado</li> <li>● No fatalities or injuries</li> </ul>  |

### 13. SEVERE WEATHER: THUNDERSTORMS, TORNADOES, AND WINDSTORMS

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| Date              | Event                     | Location(s)                             | Description  |
|-------------------|---------------------------|---|--|
| November 13, 2003 | Windstorm                 | Citywide                                | <ul style="list-style-type: none"> <li>Winds of 64 mph</li> <li>1 fatality; no injuries reported</li> </ul>  |
| August 11, 2004   | Severe thunderstorms/hail | Bronx                                   | <ul style="list-style-type: none"> <li>Severe thunderstorms produce flash flooding</li> <li>Wind damage and 1-inch hailstones</li> </ul>   |
| December 1, 2004  | Windstorm                 | Brooklyn                                | <ul style="list-style-type: none"> <li>Winds of 70 mph</li> <li>No fatalities or injuries reported</li> </ul>  |
| December 23, 2004 | Windstorm                 | Queens                                  | <ul style="list-style-type: none"> <li>Winds of 47 mph</li> <li>1 fatality caused by tree crushing traveling car; no injuries</li> </ul>   |
| March 8, 2005     | Windstorm                 | Queens                                  | <ul style="list-style-type: none"> <li>Winds of 58 mph</li> <li>No fatalities or injuries reported</li> </ul>  |
| April 2, 2005     | Windstorm                 | Queens                                  | <ul style="list-style-type: none"> <li>Winds of 58 mph</li> <li>No fatalities or injuries reported</li> </ul>  |
| October 16, 2005  | Windstorm                 | Citywide                                | <ul style="list-style-type: none"> <li>Winds of 36 mph</li> <li>No fatalities or injuries reported</li> <li>Trees downed</li> <li>Windows in a high-rise office building in Manhattan blow out</li> <li>\$17,000 in property damage</li> </ul> |
| October 25, 2005  | Windstorm                 | Citywide                                | <ul style="list-style-type: none"> <li>Winds of 48 mph</li> <li>No fatalities or injuries reported</li> <li>Downed trees reported</li> <li>Property damage of \$35,000 reported</li> </ul>   |
| November 24, 2005 | Windstorm                 | Citywide                                | <ul style="list-style-type: none"> <li>Winds of 40 mph</li> <li>Parade balloon strikes a lamppost causing a 30-pound light to fall into the crowd</li> <li>Two injuries reported</li> <li>No damage costs reported</li> </ul>                  |
| January 15, 2006  | Windstorm                 | Queens                                  | <ul style="list-style-type: none"> <li>High winds of 63 mph</li> <li>No fatalities; 1 injury reported</li> </ul>   |
| January 18, 2006  | Windstorm                 | Bronx, Manhattan, Staten Island, Queens | <ul style="list-style-type: none"> <li>Winds of 68 mph</li> <li>No fatalities or injuries reported</li> </ul>  |
| February 17, 2006 | Windstorm                 | Brooklyn, Queens, Staten Island         | <ul style="list-style-type: none"> <li>Winds of 61 mph</li> <li>No fatalities or injuries reported</li> </ul>  |
| October 20, 2006  | Windstorm                 | Staten Island                           | <ul style="list-style-type: none"> <li>Winds of 58 mph</li> <li>No fatalities or injuries reported</li> </ul>  |
| January 20, 2007  | Windstorm                 | Citywide                                | <ul style="list-style-type: none"> <li>Winds of 47 mph</li> <li>Flying construction debris results in 1 injury</li> </ul>  |

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| Date              | Event                     | Location(s)                  | Description   |
|-------------------|---------------------------|------------------------------|---|
| August 8, 2007    | Tornado                   | Brooklyn                     | <ul style="list-style-type: none"> <li>• EF2 tornado</li> <li>• Discontinuous path</li> <li>• 16 homes have moderate to severe roof damage</li> <li>• Tornado tears roof off a car dealership</li> <li>• Downed trees reported</li> <li>• Event accompanied by severe flooding</li> <li>• Federally declared disaster (DR-1724) with more than \$5.1 million given in Individual and Household Program (IHP) funding from the Federal Emergency Management Agency (FEMA)</li> <li>• More than 3,700 residents file claims at Disaster Assistance Service Centers</li> </ul> |
| March 8, 2008     | Windstorm                 | Manhattan/<br>Bronx/Brooklyn | <ul style="list-style-type: none"> <li>• Damaging winds cross over Lower Hudson Valley and New York City</li> <li>• Scaffold collapses in Manhattan</li> <li>• Downed power lines in the Bronx</li> <li>• Downed tree in Brooklyn</li> </ul>  |
| June 10, 2008     | Windstorm                 | Citywide                     | <ul style="list-style-type: none"> <li>• Wind gusts of 80 mph</li> <li>• Causes widespread downed trees</li> </ul>  |
| June 22, 2008     | Severe thunderstorms/hail | Bronx                        | <ul style="list-style-type: none"> <li>• Severe thunderstorms cross over Lower Hudson Valley</li> <li>• 0.75-inch hailstones reported along Pelham Parkway</li> <li>• Flash flooding</li> </ul>   |
| August 11, 2008   | Severe thunderstorms/hail | Citywide                     | <ul style="list-style-type: none"> <li>• 1.75-inch hailstones in the Bronx accumulate up to one inch</li> <li>• Hailstones damage cars, flower and vegetable gardens</li> <li>• Downed tree limb on Cross Island Parkway in Queens</li> </ul>   |
| August 15, 2008   | Windstorm                 | Bronx                        | <ul style="list-style-type: none"> <li>• Wind gusts of 70 mph</li> </ul>  |
| February 12, 2009 | Windstorm                 | Citywide                     | <ul style="list-style-type: none"> <li>• Wind gusts of 50 to 60 mph</li> <li>• One fatality in Staten Island</li> <li>• One injury caused by a fallen tree in Brooklyn</li> </ul>   |
| July 29, 2009     | Severe thunderstorms/hail | Citywide                     | <ul style="list-style-type: none"> <li>• 0.75-inch hailstones in Staten Island</li> <li>• 70-mph wind gusts in Queens</li> <li>• Flash flooding forces some road closures in the Bronx</li> </ul>   |
| August 18, 2009   | Severe thunderstorms/hail | Citywide                     | <ul style="list-style-type: none"> <li>• 0.75-inch hailstones in Bronx</li> <li>• 80-mph wind gusts in Manhattan/Bronx</li> <li>• OEM reports a few hundred trees down in Central Park</li> <li>• Downed trees hit cars in Manhattan</li> <li>• Fewer than 100 trees down in Queens, but some fallen trees damage cars</li> </ul>   |

### 13. SEVERE WEATHER: THUNDERSTORMS, TORNADOES, AND WINDSTORMS

#### CHAPTER 3: RISK ASSESSMENT

| Date               | Event                     | Location(s)     | Description   |
|--------------------|---------------------------|-----------------|---|
| June 24, 2010      | Severe thunderstorms/hail | Citywide        | <ul style="list-style-type: none"> <li>• 1.75-inch hailstones fall on Throgs Neck Bridge</li> <li>• One car damaged in Queens</li> <li>• Downed trees, utility poles, street lamps, and one chimney collapse in northeastern Queens</li> <li>• Wind gusts of 54 mph at La Guardia Airport</li> <li>• Downed trees in Bronx</li> </ul>   |
| July 25, 2010      | Tornado                   | Bronx           | <ul style="list-style-type: none"> <li>• EF1 tornado touches down in the Bronx</li> <li>• Large tree damages car</li> <li>• Seven injuries</li> <li>• \$150,000 in damage</li> </ul>  |
| September 16, 2010 | 2 Tornadoes               | Brooklyn/Queens | <ul style="list-style-type: none"> <li>• EFO tornado in Park Slope, Brooklyn, and EF1 tornado in Flushing, Queens</li> <li>• Park Slope tornado causes significant tree damage and estimated \$8.5 million in damage</li> <li>• Queens tornado causes one fatality; severe damage to residential buildings; estimated \$17.2 million in damage</li> <li>• Federally declared disaster (DR-1943) with \$17.9 million total for Public Assistance (PA): \$11.4 million for emergency work and \$6.5 million for permanent work</li> </ul> |
| October 1, 2010    | Windstorm                 | Brooklyn/Queens | <ul style="list-style-type: none"> <li>• 60-mph wind gusts</li> </ul>   |
| August 1, 2011     | Severe thunderstorms/hail | Queens          | <ul style="list-style-type: none"> <li>• Severe thunderstorms produce lime-size hailstones in Glen Oaks</li> <li>• 2.75-inch hailstones reported in Bayside, causing damage to cars</li> </ul>  |
| August 28, 2011    | Tornado                   | Queens          | <ul style="list-style-type: none"> <li>• Hurricane Irene produces two confirmed tornadoes: one EFO in Cunningham Park and one on Long Island</li> </ul>   |
| July 26, 2012      | Severe weather            | Citywide        | <ul style="list-style-type: none"> <li>• Warm front triggers multiple severe thunderstorms</li> <li>• One fatality: lightning strikes the steeple of a Brooklyn church that collapses, striking and killing a pedestrian</li> </ul>   |
| August 15, 2012    | Severe weather            | Citywide        | <ul style="list-style-type: none"> <li>• Multiple rounds of severe thunderstorms</li> <li>• Downed trees in Brooklyn damage cars</li> <li>• 1-inch hailstones in Queens</li> <li>• Downed power lines and power outages in Queens</li> </ul>  |
| September 8, 2012  | Tornado                   | Brooklyn/Queens | <ul style="list-style-type: none"> <li>• EFO tornado in Queens and EF1 tornado in Brooklyn</li> <li>• Tornado in Queens causes estimated damages of \$20,000</li> <li>• Tornado in Brooklyn causes structural damage to several homes and estimated damages of \$250,000</li> </ul>   |



#### B. Vulnerability Assessment

##### i. Social Environment

The City closely monitors severe weather, but thunderstorms, tornados, and windstorms can occur with little or no warning, increasing risk to the population by compromising public safety. People who are caught outdoors during severe weather are vulnerable to injury and death. Hailstones, which can fall at speeds faster than 100 mph, can strike and injure people.

Data on death and injuries from severe weather confirm the risks of these events. In New York City from 1996 to 2012, nine confirmed deaths and 69 injuries have occurred during the 263 severe weather events and lightning strikes. During a thunderstorm in August 2004, two individuals were killed after stepping out of their car into a flooded intersection electrified by a downed power line in New York City.

Large, older trees can fall on people and property, causing injury or death. At least 11 people have been killed by downed trees in New York City during a severe weather event:

- February 25, 1996 – 1 fatality during high-wind event
- October 19, 1996 – 3 fatalities during high-wind event
- March 6, 1997 – 4 fatalities during high-wind event
- September 7, 1998 – 1 fatality during severe thunderstorm/hail event
- December 23, 2004 – 1 fatality during high-wind event
- September 16, 2010 – 1 fatality during tornado

##### ii. Built Environment

Hail can cause severe damage to buildings, cars, and trains. According to the NWS, hail causes more than \$1 billion in crop and property damage nationally each year. In addition, NWS also estimates that lightning costs more than \$1 billion in insured losses each year.

High winds pose a serious threat to buildings and infrastructure. Due to New York City's dense urban environment, flying debris can severely damage structures. Areas with tall buildings—such as Midtown Manhattan, the Financial District, and Downtown Brooklyn—are at a greater risk because of increased wind pressures at greater heights. While these structures can withstand strong winds, glass windows pose a potentially fatal threat if broken.

Construction sites are also especially vulnerable to high winds. Tools and construction materials, cranes, scaffolding, and other building appurtenances may loosen in high winds.

Structural vulnerability to wind is related to the building's construction type and age. Wood structures and manufactured homes are more susceptible to wind damage, while steel and concrete buildings are more resistant to it. Less than 0.1% of the city's buildings are manufactured housing, and 54% are wooden structures. Ninety-three percent of Staten Island's structures are made of wood, increasing that borough's vulnerability to windstorms and tornadoes.

The 2008 New York City Construction Code addresses high winds in a dense, high-rise environment. The Construction Code establishes wind-exposure categories to set design requirements for new buildings. These requirements account for location, surroundings, and occupancy to ensure buildings can withstand extreme winds. For example, buildings along the coastline are subject to higher wind loads, as are buildings that are more than 300 feet tall.

It is not possible to estimate potential losses to specific structures from severe weather. However, historically tornadoes have caused up to \$7.2 million in IHP funding from FEMA. (For more information on the structural vulnerability of the city's built environment, see New York City's Hazard Environment.)

#### iii. Natural Environment

Severe weather can negatively affect the natural environment. For example, severe thunderstorms, tornadoes, and windstorms can destroy historic trees and damage the aesthetic value of parks and open space. The secondary impacts from severe weather on the natural environment include lightning-induced fires and hazardous material leaks and spills.

#### iv. Future Environment

Predicting the impact of severe weather on the future environment is complex and varies by the type of weather event. Some of the impacts of climate change are warmer weather and moister air, which could create an environment favorable for severe thunderstorms. However, these same conditions have been shown to reduce the wind shear necessary for tornadoes to get a full lift. At this point it is unclear how the long-term effects of climate change will impact the strength and occurrence of tornadoes.

### 13. SEVERE WEATHER: THUNDERSTORMS, TORNADOES, AND WINDSTORMS

#### CHAPTER 3: RISK ASSESSMENT

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14. Wild Fires

A. Hazard Profile

i. Hazard Description



While New York City does not experience the devastating wildfires that often rage through the western United States, wildfires do occur many times a year in the city. Certain areas of the city face a significant risk from this hazard.

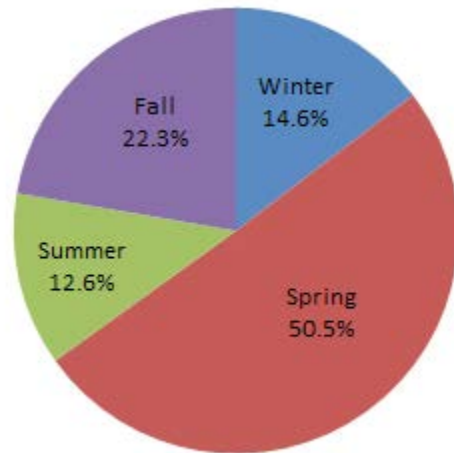
Wildfires, also referred to as wildland fires or brushfires, are uncontrolled fires that are ignited in woodland, brush, or grassland areas with minimal development. When wildfires burn out of control and begin to threaten buildings or other manmade structures, they are referred to as wildland-urban interface (WUI) fires. The WUI is the area, or zone, where structures and other human developments come into contact with undeveloped areas or vegetative fuels.

For wildfires to ignite, grow, and sustain themselves, they require optimal weather conditions, a fuel source, and an ignition source. Optimal weather conditions include lack of precipitation, high temperatures, and low relative humidity (which allow vegetation and brush to burn more easily) and high winds (which cause the fire to spread). During periods of unusually dry weather or sustained drought, dry leaves, brush, and grass accumulate, forming a hazardous source of fuel. Tall perennial grasses called phragmites, typically found in temperate wetland areas, significantly contribute to the risk of wildfires. The combination of high fuel loads and WUI development create a dangerous scenario when weather conditions are favorable. Once the right combination of fuel and weather is in place, all that is required is an ignition source. Ignition sources may be natural, such as lightning, but are more commonly the result of human activities. Dropped cigarette butts, campfires, or intentional "prescribed" fires that burn out of control can all lead to wildfires.

A recent New York City Fire Department (FDNY) analysis of wildfires within the Gateway National Recreation Area (which includes parts of the Rockaway Peninsula,

southeastern Brooklyn, and Jamaica Bay) indicates that the New York City area has a bimodal fire season; that is, during a given year there is an increase in brushfires during two separate periods: one during spring and one during fall. Although wildfires may occur during any time of year, conditions are most conducive for the start of brushfires during these periods due to low relative humidity and strong winds. Most wildfires (65.1%) occur during the first six months of the year, with 14.6% occurring in winter and 50.5% in spring. The occurrence of fires drops to 12.6% in summer but rises again to 22.3% in fall (see Figure 3.14.98). FDNY has defined the spring fire season as March 17 through April 30 and the fall fire season as October 15 through November 30; during these periods, the FDNY's brushfire units are staffed daily.

Figure 3.14.98: Annual Distribution of Wildfires in New York City based on FDNY Temporal Analysis at Gateway National Recreation Area (Source: FDNY)



ii. Severity

The severity of wildfires is dependent on weather conditions (precipitation, temperature, humidity, and winds) and the type and amount of fuel available. If favorable weather conditions persist for a significant period, more fuel will accumulate and any fires that are sparked will be more severe.

The flammability of fuel is determined by moisture content, chemical makeup, and density of fuel par-

ticles. Typically, fuel sources containing oils or resins that promote combustion and have low moisture content (partially determined by the weather) are most likely to burn easily, quickly, and intensely. Fuel particles also need to be close enough together so that they will ignite each other, but not so close as to prevent air circulation.

There are three recognized levels of intensity and patterns of wildfire spread. At the lowest level are ground fires, which are sustained by glowing combustion and primarily burn organic matter and leaves in the soil. At the next level are surface fires, which burn leaf litter, fallen branches, and other fuels at ground level. The hottest and most dangerous fires are crown fires, which can reach significant heights and burn the top layer of foliage on trees, known as the canopy or crown. Crown fires are also the most difficult type of wildfire to contain.

When fires begin to threaten the built environment, they are classified according to the alarm assignment system. Alarm assignments start at one and increase with fire severity; the more significant the fire, the higher the alarm assignment number. There is technically no maximum alarm assignment, although fires are rarely classified above five alarm.

**iii. Probability**

Wildfires occur many times a year throughout New York City, although the frequency and recurrence interval vary depending on the exact location. Based on historic occurrences, it is probable that New York City will continue to experience wildfires.

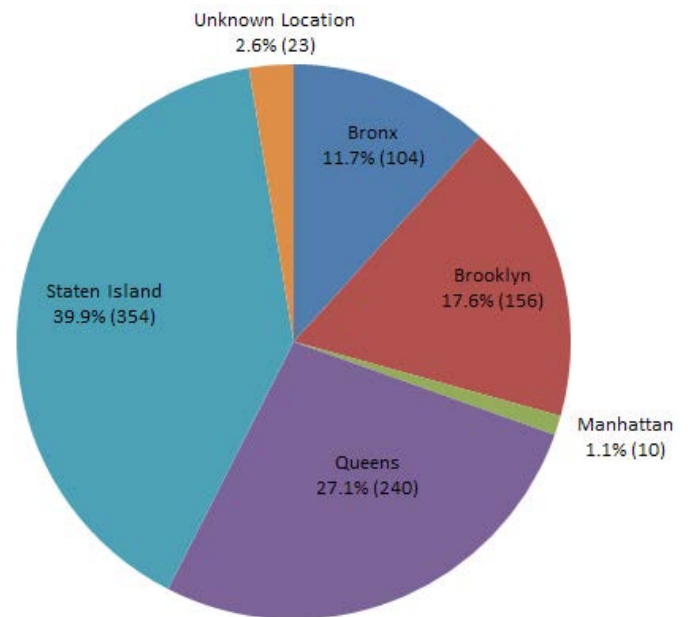
**iv. Location**

Certain areas of New York City face a greater risk of wildfires than other areas. Staten Island is the most vulnerable of the five boroughs (particularly along the eastern shore), although parts of southern Queens and Brooklyn around the wetlands of Jamaica Bay are also prone to wildfires. These areas contain the highest concentration of phragmites in the city, and the grasses become highly flammable during optimal weather conditions. In addition, Staten Island has the highest

percentage of wooded area in the city as well as the largest WUI zone.

Most wildfires that occur in New York City are small fires and do not affect built structures. Wildfires that are considered two-alarm or higher, i.e. "all-hands," are more serious. Between 1996 and 2013, New York City experienced 887 such fires (an average of almost 50 per year). Of these, 354 were in Staten Island (an average of almost 20 per year), 240 were in Queens (an average of about 13 per year), 156 were in Brooklyn (an average of about 9 per year), 104 were in the Bronx (an average of about 6 per year), 10 were in Manhattan (an average of one fire every 1.8 years), and 23 were in unknown locations. Figure 3.14.99 shows the percentage of serious wildfires by borough between 1996 and 2013.

**Figure 3.14.99: Serious wildfires in New York City by Borough 1996 to 2013 (Source: FDNY)**



In 2012, the New York City Department of Parks & Recreation (DPR), in collaboration with the New York City Department of Environmental Protection (DEP), FDNY, the New York State Department of Environmental Conservation (NYS DEC), and the United States National Park Service (NPS), developed a Community Wildfire Protection Plan (CWPP) for Staten Island in order to manage the significant threat of wildfires along the

## 14. WILD FIRES

### CHAPTER 3: RISK ASSESSMENT

eastern shore of the borough. The goal was to establish recommendations and priorities to help vulnerable communities protect residents, homes, infrastructure, and the natural environment from the impacts of wildfires. The Staten Island CWPP encompasses the area of Staten Island bounded to the north and east by Lower New York Bay, to the south by the southern boundary of Great Kills Park, and to the west by Maryland Avenue and Hylan Boulevard (see Figure 3.14.100). This area includes the communities of Oakwood Beach, Midland Beach, South Beach, Old Town, Grasmere, Arrochar, and Shore Acres. The population of this area is 51,200 residents.

#### v. Historic Occurrences

Table 3.14.69 lists select significant wildfires in New York City between 2008 and 2012.

**Figure 3.14.100: Area covered by Staten Island Community Wildfire Protection Plan (Source: Staten Island CWPP, 2012)**



**Table 3.14.69: Select Significant Wildfires in New York City 2008 to 2012**

| Date               | Location        | Description  |
|--------------------|-----------------|--|
| July 8, 2008       | Staten Island   | <ul style="list-style-type: none"> <li>Wildfire near Hopkins Avenue and Hylan Blvd.</li> </ul>   |
| September 15, 2008 | Staten Island   | <ul style="list-style-type: none"> <li>Two large wildfires burn over 40 acres</li> </ul>   |
| March 23, 2009     | Staten Island   | <ul style="list-style-type: none"> <li>Wildfire near Richard Avenue and Hylan Blvd.</li> </ul>   |
| March 24, 2009     | Staten Island   | <ul style="list-style-type: none"> <li>2-alarm wildfire near 2900 Veterans Rd.</li> </ul>  |
| March 25, 2009     | Bronx           | <ul style="list-style-type: none"> <li>Wildfire breaks out just north of NYPD shooting range at Rodman's Neck</li> <li>No injuries reported</li> <li>Operations not interrupted</li> </ul> |
| April 4, 2009      | Brooklyn        | <ul style="list-style-type: none"> <li>2-alarm wildfire near 77-75 Flatbush Ave.</li> </ul>  |
| April 12, 2009     | Staten Island   | <ul style="list-style-type: none"> <li>Large wildfire near Kissam Avenue spreads to three adjacent structures</li> </ul>   |
| April 16, 2009     | Queens          | <ul style="list-style-type: none"> <li>Wildfire in Howard Beach area</li> </ul>  |
| January 12, 2010   | Queens/Brooklyn | <ul style="list-style-type: none"> <li>2-alarm wildfire in Gateway National Park</li> </ul>  |
| June 30, 2010      | Queens          | <ul style="list-style-type: none"> <li>Wildfire in Howard Beach area</li> </ul>  |
| July 18, 2010      | Queens          | <ul style="list-style-type: none"> <li>Wildfire near 165th Avenue and 83rd Street, in Howard Beach area</li> </ul>   |
| September 8, 2010  | Staten Island   | <ul style="list-style-type: none"> <li>Wildfire near Woodrow Road and Alexander Avenue</li> </ul>  |
| September 9, 2010  | Staten Island   | <ul style="list-style-type: none"> <li>Wildfire in Great Kills Park</li> </ul>   |
| October 16, 2010   | Staten Island   | <ul style="list-style-type: none"> <li>Wildfire near Great Kills Park</li> </ul>   |
| October 23, 2010   | Staten Island   | <ul style="list-style-type: none"> <li>Large wildfire near Forest Hill Road and Richmond Avenue</li> </ul>   |
| November 12, 2010  | Staten Island   | <ul style="list-style-type: none"> <li>5-alarm, 100-acre wildfire near Kissam Avenue and Mill Road spreads to nearby garage and delays traffic</li> </ul>                                  |
| December 9, 2010   | Staten Island   | <ul style="list-style-type: none"> <li>Large wildfire near Richmond Hill Road and Old Mill Road</li> </ul>   |
| March 28, 2011     | Staten Island   | <ul style="list-style-type: none"> <li>Wildfire in Siedenbug Park</li> </ul>   |
| April 9, 2012      | Staten Island   | <ul style="list-style-type: none"> <li>Wildfires break out across Staten Island, including in Great Kills Park and a 5-alarm fire above former Fresh Kills landfill</li> </ul>             |

## B. Vulnerability Assessment

### i. Social Environment

In developed parts of New York City, wildfires tend to present a greater risk to firefighters and first responders than to residents or their property. When wildfires do threaten populated areas, residents may be at risk, especially those who choose not to evacuate. The situation may be particularly dangerous in the case of fires that spread quickly or unpredictably, which can result in little or no advanced warning or evacuations. Secondary health effects may result from smoke inhalation and poor air quality in the vicinity of fires. Populations that may be particularly vulnerable include the elderly, residents with pre-existing respiratory conditions, and, in the event of an evacuation, people with mobility impairments (for more information on vulnerable populations, see Risk Assessment Section 4: New York City's Hazard Environment).

### ii. Built Environment

When wildfires reach the WUI, they have the potential to cause significant damage to the built environment. In New York City, particularly on Staten Island, there are many areas where the built environment is directly adjacent to open areas with minimal or no natural buffers. This puts many homes and critical facilities at risk. In addition, these fires are often more difficult to contain than normal building fires due to their size, abundant natural fuel sources, and weather conditions. Buildings constructed of wood and other combustible materials are particularly at risk, especially if they have wooden exteriors. Utilities, transportation, and telecommunications infrastructure are also vulnerable to the effects of wildfires, which may in turn lead to service disruptions.

The Staten Island CWPP area is primarily comprised of residential homes, light commercial zones, open space, and manufacturing areas. The area contains 13 schools, 11 daycare facilities, 12 historical sites, one hospital, and one psychiatric facility.

The Consolidated Edison Company (Con Ed) has substantial utility distribution infrastructure in the CWPP area, but only some of it is vulnerable to wildfire dam-

age. There are four electric substations in the CWPP, but only one is near enough to a fire-prone area to be at any risk. Con Ed's distribution of electricity, however, is almost exclusively via wooden street poles and overhead power lines, making that system vulnerable, especially in areas where phragmites grow.

One of DEP's wastewater treatment plants, located in the southwest portion of the Oakwood Beach watershed, is also at risk from wildfire.

### iii. Natural Environment

Depending on the type and severity of the wildfire, the impacts of fire on the natural environment may be either positive or negative. For certain ecosystems, fires are a necessary part of the ecological cycle and promote the overall health and longevity of these environments. Benefits of fires include insect pest control, removal of invasive species, addition of nutrients for trees and other types of vegetation, and removal of undergrowth that may prevent the growth of native species. Certain types of vegetation are also dependent on periodic fires for survival. Additionally, burned trees may provide homes for certain species of birds and mammals and a base from which new plants can grow.

Although low-intensity fires may be beneficial to the environment, high-intensity fires can be devastating. In addition to burning large stands of trees, these fires cause soil destruction and the removal of debris needed to protect seedlings. In extreme cases, wildfires may destroy entire habitats and threaten numerous species.

Since certain ecosystems require periodic low-intensity fires to sustain themselves, a dangerous situation may arise if those types of fires are too infrequent. In these cases, fuel can accumulate to dangerous levels and result in devastating fires. Periodic intentional burning (also known as "prescribed" or "controlled" fires) is a tactic often used to reduce the amount of fuel available for large fires and to promote healthy ecosystem function.

#### iv. Future Environment

Wildfires are a frequent occurrence in certain areas of the city and this will likely continue into the future. Since wildfires are largely dependent on weather conditions, climate change may affect the frequency of wildfires in the future. However, there is still much uncertainty as to what effect climate change will have and how significant it would be. Other factors which may play a role in determining future vulnerability are the rate of future development within fire-prone areas and the presence of buffers between urban infrastructure and wooded areas.



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15. Winter Storms

A. Hazard Profile

i. Hazard Description

New York City winters usher in heavy snow and ice. Heavy snow generally means snowfall accumulating to four inches or more in depth in 12 hours or less, or snowfall accumulating to six inches or more in depth in 24 hours or less. According to the National Climatic Data Center, the city averages 26.7 inches of snowfall annually. While snow and ice are the defining features of New York City's winter storms, wind gusts and frigid temperatures (see Section 10. **Extreme Temperatures**) can also accompany these weather events.

The primary types of wintry precipitation are snow, sleet and freezing rain. Snow is precipitation in the form of ice crystals, mainly of intricately branched, hexagonal form and often agglomerated into snowflakes, formed directly from the freezing of the water vapor in the air. Sleet is defined as pellets of ice composed of frozen or mostly frozen raindrops or refrozen partially melted snowflakes. Freezing rain is precipitation that falls as rain, but freezes on contact with the surface, forming a glaze of ice. All types of wintry precipitation contribute to hazardous travel conditions, although freezing rain is the most treacherous.

There are different types of winter storms. The storms that can affect New York City are described in Figure 3.15.101 and below:

- **Snow showers** are brief, intense periods of snowfall resulting in accumulations of one inch or less.
- A **blizzard** is a severe snowstorm with winds of 35 miles per hour (mph) or greater and snow and blowing snow, reducing visibility to less than 1/4 mile for three hours or longer.
- A **snowsquall** has moderate to heavy snowfall accompanied by strong, gusty winds and, sometimes, lightning.

- **Thundersnow events** are accompanied by thunder and lightning.
- **Ice storms** occur when freezing rain results in dangerous accumulations of ice, usually 1/4 inch or greater.

Figure 3.15.101: Winter Weather Definitions

|              |  |
|--------------|--|
| Snow         | Precipitation in the form of ice crystals that form directly from the freezing of water vapor in the air.  |
| Snow Showers | Snow that falls at varying intensities for brief periods with accumulations of one inch or less.   |
| Blizzard     | The following conditions prevail for at least three hours:<br>- Sustained winds or frequent gusts to 35 miles an hour or greater.<br>-Blowing snow which may reduce visibility to a 1/4 of a mile. |
| Snow Squalls | An intense, but brief period of moderate to heavy snowfall, accompanied by strong, gusty surface winds and possibly lightning. Snow accumulation may be significant.                               |
| Thundersnow  | A snowstorm that includes thunder and lightning. Thundersnow can occur when there is relatively strong instability and abundant moisture such as above a warm front.                               |
| Ice Storms   | Freezing rain which can accumulate to a quarter of an inch or greater.   |

The impacts of winter storms can be significant, with snow and ice compromising public safety and health and the functioning of infrastructure and services. Ice storms can have a greater impact on New York City than heavy snowfall because these storms develop quickly and have a greater chance of downing overhead power and telecommunications lines, resulting in loss of power and communication ability. Accumulations of ice make walking and driving extremely dangerous. In addition, ice accumulations can make roads impassable and affect rail beds and the mass transit system. Winter storms in general can be especially hazardous for people who work outdoors, those who are homeless, those without adequate home heat, and at-risk populations such as seniors and children.

**ii. Severity**

The severity of a winter storm depends on several factors including temperature, wind speed, type of precipitation, and rate of deposition. The time of year a storm hits also affects its severity. For example, a storm that occurs during the early winter months, when trees still have leaves, may result in more downed trees and power lines because the leaves hold the accumulation of snow and ice.

The severity of a winter storm can be classified by meteorological measurements and societal impacts. The Northeast Snowfall Impact Scale (NESIS), (see Figure 3.15.102) characterizes and ranks high-impact Northeast snowstorms—those with large areas of snowfall accumulations of 10 inches and greater—and was developed because of the transportation and economic impacts Northeast snowstorms can have on the rest of the country.

**Figure 3.15.102: Northeast Snowfall Impact Scale (NESIS)**

| CATEGORY | DESCRIPTION |
|----------|-------------|
| 1        | Notable     |
| 2        | Significant |
| 3        | Major       |
| 4        | Crippling   |
| 5        | Extreme     |

The NESIS index differs from other meteorological indices in that it uses population information in addition to meteorological measurements to give an indication of a storm's societal impact. NESIS scores are a function of the area affected by the snowstorm, the amount of snow, and the number of people living in the path of the storm. The snowfall and population information are combined in an equation that calculates a NESIS score, which varies from around one for smaller storms to over 10 for extreme storms, with largest NESIS values resulting from storms producing heavy snowfall over large areas that include major metropolitan centers. The raw score is then converted into one of the five NESIS categories: Notable, Significant, Major, Crippling, and Extreme.

Since 1798, New York City has experienced 19 snowstorms with snowfall totaling 16 inches or greater. According to NESIS, of these 19 storms, one was Extreme, five were Crippling, five were Major, three were Significant, and one was Notable. The remaining 12 historical snowstorms did not qualify for a NESIS rank.

**iii. Probability**

Winter storms are frequent occurrences in New York City. Based on historical frequency, it is probable that New York City will experience a winter storm with 16 inches or more of snow approximately once every nine years. Thundersnow events are rare in New York City—there have been only two reported events—and less likely to occur in the winter months than they are during months of warmer weather.

**iv. Location**

All areas of New York City are susceptible to winter storms. However, during these events, snowfall totals can vary widely across the city. For example, during the winter storm on December 26 and 27, 2010, snowfall ranged from 13 inches in Queens to 29 inches in Staten Island (see Table 3.15.70).

**Table 3.15.70: Inches of Measured Snowfall December 26 and 27, 2010 (Source: National Weather Service)**

| Great Kills | Central Park | LaGuardia Airport | Kennedy Airport |
|-------------|--------------|-------------------|-----------------|
| 29.0        | 20.0         | 13.0              | 15.6            |

**v. Historic Occurrences**

Table 3.15.71, below, identifies major winter storms in New York City from 1798 to 2013. Between 1953 and 2013 there have been three presidential disaster declarations for winter snowstorms and blizzards in New York City.

## 15. WINTER STORMS

### CHAPTER 3: RISK ASSESSMENT

**Table 3.15.71: Selected Major Winter Storms in New York City 1798 to 2013**

| Date                    | Name                        | Total (inches) | NESIS | Comments  |
|-------------------------|-----------------------------|----------------|-------|---|
| November 19 to 21, 1798 | The Long Storm              | ~18            | N/A   | <ul style="list-style-type: none"> <li>Snow from Maryland to Maine</li> </ul>   |
| January 26 to 28, 1805  | N/A                         | ~24            | N/A   | <ul style="list-style-type: none"> <li>48 hours of continuous snow</li> </ul>   |
| January 14 to 16, 1831  | The Great Snow-storm        | ~15            | N/A   | <ul style="list-style-type: none"> <li>Rivals the "Storm of the Century" of 1993 for expansiveness of coverage</li> </ul>   |
| January 26 to 28, 1836  | The Big Snow                | ~15            | N/A   | <ul style="list-style-type: none"> <li>Interior sections see widespread 30- to 40-inch tallies</li> </ul>   |
| March 12 to 14, 1888    | The Blizzard of '88         | 21             | 4     | <ul style="list-style-type: none"> <li>Extreme blizzard conditions leave behind more than 50 inches of snow in some areas of Connecticut and the Hudson Valley</li> </ul>   |
| March 16 to 18, 1892    | St. Patrick's Day Snowstorm | 15.4           | N/A   | <ul style="list-style-type: none"> <li>Largest snowstorm on record for many areas of the South</li> </ul>   |
| February 17 to 18, 1893 | N/A                         | 17.8           | N/A   | <ul style="list-style-type: none"> <li>Follows a warm spell when temperatures reached as high as 54°F</li> </ul>  |
| February 25 to 27, 1894 | N/A                         | 15.2           | N/A   | <ul style="list-style-type: none"> <li>Before the storm, temperatures start out around 0°F before rising to just above freezing</li> </ul>                                  |
| February 12 to 13, 1899 | The Blizzard of 1899        | 16             | 4     | <ul style="list-style-type: none"> <li>Temperatures in the single digits for most of the storm</li> </ul>   |
| February 4 to 7, 1920   | N/A                         | 17.5           | N/A   | <ul style="list-style-type: none"> <li>Parts of Westchester receive more than 20 inches of snow</li> </ul>  |
| January 22 to 24, 1935  | N/A                         | 17.5           | N/A   | <ul style="list-style-type: none"> <li>Snow from Gulf Coast to Maine</li> </ul>   |
| March 7 to 8, 1941      | N/A                         | 18.1           | N/A   | <ul style="list-style-type: none"> <li>Quick drop-off of snow toward the coast with parts of New Jersey and Eastern Suffolk reporting less than 10 inches</li> </ul>        |
| December 26 to 27, 1947 | Big Snow                    | 26.4           | 2     | <ul style="list-style-type: none"> <li>Worst blizzard since 1888 and record-holder until 2006</li> </ul>  |
| December 19 to 20, 1948 | N/A                         | 16             | N/A   | <ul style="list-style-type: none"> <li>20-hour duration</li> <li>Widespread totals of 12 to 18 inches across the metropolitan area</li> </ul>                               |
| December 11 to 12, 1960 | N/A                         | 15.2           | 3     | <ul style="list-style-type: none"> <li>20.4 inches of snow recorded at Newark, NJ</li> <li>17 inches at the Battery, NYC</li> </ul>   |
| February 3 to 4, 1961   | N/A                         | 17.4           | 4     | <ul style="list-style-type: none"> <li>Storm follows prolonged cold period (16 days of temperatures in the teens and 20s)</li> <li>JFK Airport records 24 inches</li> </ul> |
| February 6 to 7, 1967   | N/A                         | 15.2           | 2     | <ul style="list-style-type: none"> <li>Blizzard conditions produce totals of more than 20 inches of snow in parts of New Jersey</li> </ul>                                  |
| February 9 to 10, 1969  | Lindsay Storm               | 15.3           | 2     | <ul style="list-style-type: none"> <li>Mayor John Lindsay receives criticism after sections of New York City remained unplowed for a week</li> </ul>                        |

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### CHAPTER 3: RISK ASSESSMENT

| Date                    | Name                         | Total (inches) | NESIS | Comments  |
|-------------------------|------------------------------|----------------|-------|---|
| February 5 to 7, 1978   | Blizzard of '78              | 17.7           | 3     | <ul style="list-style-type: none"> <li>• Long Island and New England hardest hit</li> <li>• Near hurricane-strength winds</li> <li>• Thundersnow reported</li> <li>• 36-hour storm duration</li> </ul>  |
| February 19, 1979       | President's Day Snowstorm I  | 12.2           | N/A   | <ul style="list-style-type: none"> <li>• Fast-moving snowstorm brings 12.2 inches of snow to the city</li> <li>• Heaviest snowfall ranged from 18.7 to 20 inches in Washington, D.C. and Baltimore, MD</li> </ul>   |
| February 11 to 12, 1983 | Megalopolitan Snowstorm      | 17.6           | 4     | <ul style="list-style-type: none"> <li>• Occurs during one of the strongest El Niños of the 20th century</li> </ul>   |
| March 12 to 14, 1993    | Storm of the Century         | 12.2           | N/A   | <ul style="list-style-type: none"> <li>• Tremendous snowfall leaves 13 inches of snow in Birmingham, AL, and 36 inches in Syracuse, NY</li> <li>• Dozens of tornadoes reported in the South</li> <li>• Storm ranks as one of the most deadly and costly weather events in the 20<sup>th</sup> century</li> </ul>  |
| January 7 to 8, 1996    | Blizzard of 1996             | 20.2           | 5     | <ul style="list-style-type: none"> <li>• Snow accumulation of more than 30 inches across portions of New Jersey</li> <li>• New York City schools closed for the first time since Blizzard of '78</li> <li>• Federally declared disaster (DR-1083), with \$21.3 million in eligible damages for all affected counties</li> </ul>   |
| February 16 to 17, 2003 | Presidents' Day Snowstorm II | 19.8           | 4     | <ul style="list-style-type: none"> <li>• 25.6 inches of snow recorded at JFK Airport</li> <li>• Federally declared disaster (EM-3184), with \$33.7 million in Public Assistance (PA) funds authorized for New York City and 17 counties</li> </ul>  |
| February 11 to 12, 2006 | Blizzard of 2006             | 26.9           | 3     | <ul style="list-style-type: none"> <li>• Largest snowstorm in New York City history</li> <li>• Thundersnow reported</li> </ul>  |
| December 26 to 27, 2010 | Blizzard of 2010             | 20             | 3     | <ul style="list-style-type: none"> <li>• New York Airports close</li> <li>• Public transportation severely hampered</li> <li>• Delayed snow removal</li> <li>• 8,000 customers lose power in New York City</li> <li>• Federally declared disaster (DR-1957), with \$37.7 million in PA funds made available for New York City (\$30.6 million in Emergency Work and \$7.4 Million in Permanent Work)</li> </ul> |
| February 25 to 26, 2010 | N/A                          | 20.9           | 3     | <ul style="list-style-type: none"> <li>• Extensive damages and power outages from wet snow North of the New York City</li> <li>• 3<sup>rd</sup> major Eastern snowstorm in February</li> <li>• Fallen tree causes 1 fatality</li> <li>• Causes major flight delays at New York City airports</li> </ul>   |
| January 26 to 27, 2011  | N/A                          | 19             | 1     | <ul style="list-style-type: none"> <li>• Snowfall rates of over 3 inches per hour</li> <li>• New York City public schools close</li> </ul>  |

According to the National Weather Service (NWS), the five snowstorms with the greatest snowfall in New York City were:

- (1) 26.9 inches on February 11 to 12, 2006
- (2) 26.4 inches on December 26 to 27, 1947
- (3) 21 inches on March 12 to 14, 1888
- (4) 20.9 inches on February 25 to 26, 2010
- (5) 20 inches on December 26 to 27, 2010

### B. Vulnerability Assessment

#### i. Social Environment

A major winter storm affects the health, safety, and daily routine of New Yorkers and causes significant economic losses for businesses and City government.

The public's risk from winter storms varies by population group. Among the people most at risk are laborers or individuals who spend time outdoors, and the homeless. Also at greater risk are seniors, children, persons in poor physical health, and those without adequate heat in their homes. The ability to tolerate colder weather is contingent on age. Older individuals have decreased thermoregulatory ability and also have difficulty compensating for sudden temperature change. At the other end of the age scale, children lose body heat much faster than adults. In addition, underweight individuals lose body heat at a faster rate than those with greater body weights.

Public health concerns during winter storms include frostbite, hypothermia, exacerbation of pre-existing respiratory and cardiovascular conditions, and carbon monoxide poisoning (due to poorly ventilated gas ranges and kerosene space heaters or, in the case of power outages, generators or grills used indoors). Health risks may also include slips and other injuries related to icy, snowy streets; back injuries from strenuous shoveling; and electrocution from contact with a downed power line.

Accumulations of snow and ice can affect public safety in other ways. The collapse of building roofs and the

downing off trees and power lines can put people at risk. When heavy snow and ice disrupt the city's infrastructure and services, commuters and travelers can be stranded, the flow of supplies can be impeded, and emergency and medical services can be impaired. The greatest danger during winter storms in New York City is the risk of automobile accidents. Even small accumulations of ice on roadways can be extremely dangerous to motorists and pedestrians.

During and after winter storms, the loss of business and the challenge of snow removal and repairs can have a severe economic impact on New York City. Commercial and financial businesses may see revenue and productivity losses, although this is usually short-term. Government services may also be affected. A large snowstorm will significantly increase costs to City agencies. The Department of Sanitation (DSNY), Department of Transportation (DOT), and Department of Parks & Recreation (DPR) will incur additional costs related to snow and ice removal and pothole repair.

There are no standard loss estimation models or methodologies for winter storms. Potential losses from winter storms are, in most cases, indirect and therefore difficult to quantify. In May 1994, the New York City Office of the Comptroller conducted a study of the fiscal and economic impact of the winter of 1993 to 94. The study revealed that the winter's unseasonably cold and snowy weather cost the City about \$50 million more than a normal winter (\$76 million when adjusted for inflation to 2008 dollars). Of this, \$35.7 million was from additional costs to City agencies (DSNY, DOT, and DPR) and snow-related claims against the City. The other \$14.7 million was from lost City revenues, such as parking meters and towing fees, and lost savings from the City's energy plan.

More recently, the blizzard on December 26 and 27 of 2010 is estimated to have cost the City of New York over \$68 million. The Metropolitan Transportation Authority lost \$30 million due to overtime expenses and lost ridership revenue. Furthermore, holiday and weekend pay for workers called in to operate buses, subways, railroads, and crossings totaled \$14 million. Total costs related to the storm were reported to exceed \$38.8 million, which was the entire City's snow

budget for the year. A majority of the costs were due to overtime pay for DSNY workers.

#### ii. Built Environment

Winter storms can affect both buildings and infrastructure. Accumulations of snow and ice can cause roofs to collapse and knock down trees and power lines.

Structural damage or building collapses because of snow are very rare in New York City. However, buildings with flat rooftops may be at greater risk than other buildings. This is because snow can more easily accumulate on flat roofs and cause damage, even to the point of jeopardizing the building's structural soundness. As the snow melts, it can collect in depressed or recessed areas of a flat roof—a condition commonly called "ponding"—because the water cannot easily travel off the surface. This additional weight, or load, can lead to leaks, roof damage, or even building collapse.

Chapter 16 of the New York City Building Code governs the structural design of buildings and provides minimum design loads, load combinations, and procedures for determining snow loads. The Department of Buildings bases snow loads on New York City regional climate value for ground snow load and incorporates thermal factors for heated and unheated buildings. There are also provisions for snowdrifts caused by parapets and adjacent buildings.

Ice storms can also have a significant impact on infrastructure and transportation. Ice can disrupt communication and power for days while utility companies repair damage. In addition, ice accumulations can affect rail beds and the public transit switch system. Bridges and overpasses are particularly dangerous because they freeze before other surfaces. Fire hydrants could also be snowed in, compromising the ability of the Fire Department of New York to suppress fires.

#### iii. Natural Environment

Heavy accumulations of ice can bring down trees. In addition, when snow and ice melts, it creates runoff

that flows into the city's sewer system. The increased volume of runoff combined with sanitary waste may exceed the capacity of the City's wastewater treatment plants. When the plants cannot handle the excess volume, untreated wastewater is discharged into local waterways (see section 18. [Infrastructure Failures](#)).

#### iv. Future Environment

According to the New York City Panel on Climate Change, climate change projections indicate that in the future snowfall will decline in frequency and the length of snow seasons will likely decrease. Nevertheless, the intensity of snowfall per storm is highly uncertain, and it is unknown whether the frequency and intensity of ice storms and freezing rain will change.

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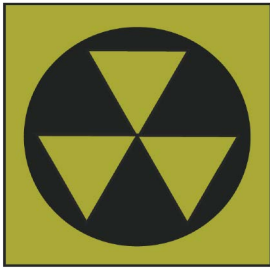


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## 16. Chemical, Biological, Radiological, and Nuclear (CBRN)

### A. Hazard Profile

#### i. Hazard Description

A hazardous materials (HAZMAT) incident is a

situation in which harmful substances are released into the environment. These types of releases are often classified as chemical, biological, radiological, or nuclear—hence the abbreviation CBRN.

The cause of a release may be either accidental or intentional. Accidental incidents may result from human error, tainted food products, technological failure, or a natural disaster and may include spills, leaks, airborne releases, or seepage into uncontained areas. Asbestos released during building demolition or collapse is one example of this kind of incident; oil spills or raw sewage releases are others. A significant number of spills and leaks also result from accidents which occur during the transportation of hazardous materials to and from storage facilities or manufacturing plants. Intentional releases of hazardous materials include criminal acts such as purposeful dumping by industries to avoid regulatory requirements or terrorist acts that target a specific location, possibly involving the use of a dispersal device or explosive. Whether accidental or intentional, the impacts of a CBRN event can be significant.

#### *Chemical*

A chemical is generally considered hazardous if it exhibits toxicity, reactivity, corrosivity, or flammability. The chemical properties of these substances are such that they can react with and cause damage to living cells and tissue. Exposure pathways include inhalation, skin contact, ingestion, and injection. Commercially or industrially used hazardous chemicals (also known as Toxic Industrial Chemicals, or TICs) that may be released accidentally include petroleum substances (such as oil, gasoline, and liquid natural gas) and those with industrial applications (such as chlorine and pesticides).

Chemical weapons are often classified according to their effect on the body, based on the primary organ system affected by exposure. Nerve agents (e.g., sarin, VX, and VR) enter the body through the skin or lungs and affect the nervous system. Blood gases or systemic agents (e.g., hydrogen cyanide) enter the bloodstream either directly or indirectly and are transported throughout the body. Respiratory agents (e.g., chlorine, phosgene) are inhaled and can cause damage to the lungs. Blister agents (e.g., mustard gas, lewisite) damage the skin, and if they are absorbed they may also affect other parts of the body. Depending on the severity of exposure, impacts may include temporary illness or injury, permanent medical conditions, or death.

#### *Biological*

Biological hazards include disease-causing microorganisms and pathogens, such as bacteria and viruses. The distinguishing characteristic of these substances is their ability to multiply within a host and cause an infection. Some bacteria and viruses can be spread, or transmitted, from one individual to another. Infections typically occur as a result of airborne exposure, skin contact, or ingestion. In general, exposure to bacteria and viruses may occur through inhalation (as is the case with airborne *B. anthracis* spores, which cause anthrax), ingestion of contaminated food or water (the case with *E. coli*, which causes gastrointestinal infection), contact with infected individuals, or contact with contaminated surfaces (which may be harboring, for example, viruses that cause influenza). Ricin, a toxin found in castor beans, is also classified as a biological agent with the potential for use in an intentional attack.

#### *Radiological*

Radiological hazards involve exposure to harmful doses of radiation. According to the Centers for Disease Control (CDC), "external" radiation occurs when radioactive material in the form of dust, powder, or liquid comes into contact with a person's skin, hair, or clothing. "Internal" contamination occurs when people swallow or inhale radioactive materials. Sources of accidental radiation exposure include underground seep-

age of naturally occurring radioactive materials (such as radon gas) into homes and leakage from facilities storing radioactive waste (such as spent fuel rods from nuclear power plants).

Intentional releases may come from radiological dispersal devices (RDDs), such as dirty bombs, which trigger small-scale explosions that release radiation. They may also come from radiological exposure devices (REDs), which are not explosive and typically involve the use of a hidden radioactive source designed to unknowingly expose people to radiation.

The health effects of radiation depend on many factors, including the type of radiation, exposure pathway, concentration and amount of exposure, and duration of exposure. Large exposures delivered over a short period may cause acute radiation sickness and, in some cases, death. Lower exposures to radiation over time (e.g., over a working lifetime) increase the probability of developing chronic health problems, cancer, or having children with genetic defects, especially if the cumulative dose is significant.

#### *Nuclear*

Nuclear incidents are those that involve the release of large amounts of energy in the form of intense light, heat, pressure, and radiation. With a nuclear event, radiation exposure typically occurs on a larger scale than with radiological incidents.

Nuclear incidents may result from the detonation of a nuclear device or from an accidental or intentional release at a nuclear reactor site. Such incidents have the potential to cause catastrophic loss of life and direct damage to structures. In addition, an incident could significantly disrupt civil services and infrastructure.

While the nuclear devices that terrorist organizations may be able to fabricate under special circumstances are relatively small, in extreme circumstances they may still have the potential to cause mass casualties.

#### **ii. Severity**

A CBRN incident becomes a citywide emergency when it poses a threat to human safety and welfare or to the environment. However, acute exposures to hazardous

materials are often difficult to evaluate because people may experience a wide range of adverse health effects, the severity of which varies with intensity and duration of exposure. In a typical population, there is also significant variation in response among individuals. Furthermore, for many substances there is not enough available data on toxic responses in humans to allow for an accurate assessment of health impacts. Thus, the severity of the hazard will depend on the type and amount of material released, the location of the release relative to human populations, and the characteristics of the exposed population.

#### *Chemical*

For chemical hazards, severity is commonly measured using the National Fire Protection Association (NFPA) 704M rating system. This system uses numbers and primary colors on a label to define the basic hazards of a specific material (see Figure 3.16.103). The system represents the risk posed by a particular substance, using a diamond with four colors: blue for health, red for flammability, yellow for reactivity, and white for special hazards. These categories are ranked on a scale from 0 (no hazard) to 4 (extreme hazard).

#### *Biological*

The severity of a biological hazard will depend on the type, location, and amount of the release, as well as the size, density, and characteristics of the population affected. Virulence is the relative severity of the disease caused by a microorganism (the ratio of clinical cases to the number of infected hosts). Different strains of the same microorganism may cause different diseases with varying levels of severity.

#### *Radiological*

For radiological hazards, severity is dependent on a number of factors, including the size of the dose, the type of radiation emitted, duration of exposure, the ability of the radiation to harm human tissue, and the organs affected. Exposure to single, short-duration, high doses of radiation (a dose is the amount of energy absorbed by the body) can cause acute health effects, while relatively low doses over extended periods can accumulate in the body and cause chronic health im-

Figure 3.16.103: NFPA 704M Rating System for Chemical Hazards (Source: Compliance Signs).

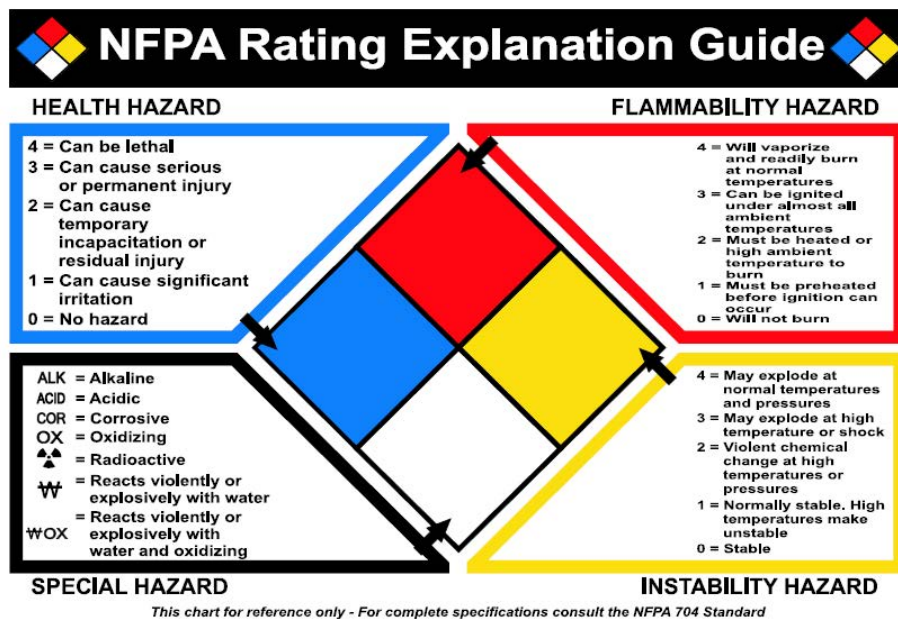


Table 3.16.72: Symptoms of Radiation Exposure (Source: Next Big Future).

|  |          |
|--|----------|
| Chest X-ray  | 0.1 mSv  |
| Average background exposure in one year  | 3 mSv    |
| Abdominal X-ray  | 4 mSv    |
| Living on the Colorado Plateau for one year  | 4.5 mSv  |
| Typical yearly dose for a uranium miner  | 5-10 mSv |
| Full-body CT scan  | 10 mSv   |
| Lowest dose for any statistical risk of cancer   | 50 mSv   |
| Mild radiation sickness (headache, risk of infection)  | 0.5-1 Sv |
| Light radiation poisoning (mild to moderate nausea, fatigue, 10% risk of death after 30 days)                      | 1-2 Sv   |
| Severe radiation poisoning (vomiting, hair loss, permanent sterility, 35% risk of death after 30 days)             | 2-3 Sv   |
| Severe radiation poisoning (bleeding in mouth and under skin, 50% risk of death after 30 days)                     | 3-4 Sv   |
| Acute radiation poisoning (60% fatality risk after 30 days)  | 4-6 Sv   |
| Acute radiation poisoning (bone marrow destroyed, nearly 100% fatality after 14 days)                              | 6-10 Sv  |
| Acute radiation poisoning (symptoms appear within 30 minutes, massive diarrhea, internal bleeding, delirium, coma) | 10-50 Sv |
| Coma in seconds or minutes, death within hours   | 50-80 Sv |
| Instant death*   | >80 Sv   |

pacts. The unit of measurement for absorbed dose is the rad (radiation absorbed dose).

However, since certain types of radiation are more dangerous than others, the absorbed dose must be multiplied by a "quality factor" to produce a "dose equivalent" that reflects the type of radiation to which an individual is exposed. The units of measurement for dose equivalent are the rem (roentgen equivalent man), Sv (Sievert), and mSv (milliSievert), with one Sv equivalent to 100 rem and 1,000 mSv. Doses greater than 100 rem/1 Sv/1,000 mSv received over a short period are likely to cause acute radiation syndrome, leading to possible death within weeks. Table 3.16.72. describes some symptoms of radiation exposure from different levels of dose equivalent.

*Nuclear*

The severity of a nuclear hazard will depend on the type, location, and amount of the release, as well as the size, density, and characteristics of the population affected.

**iii. Probability**

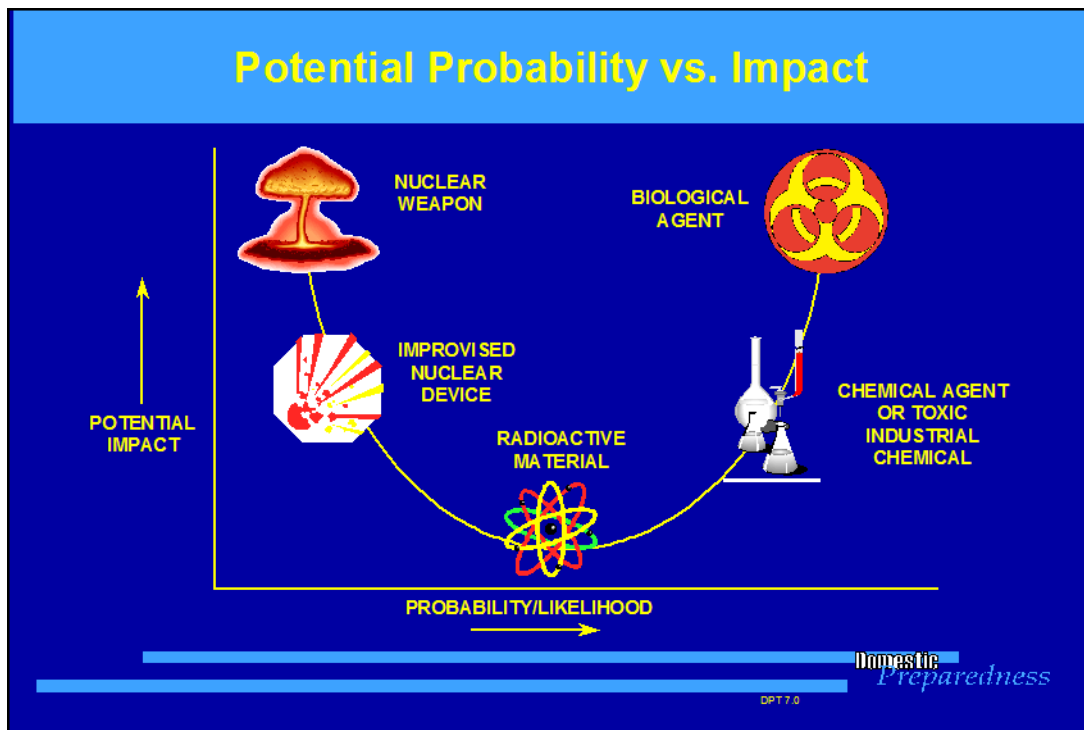
Since CBRN releases are generally not predictable, it is difficult to calculate the probability or recurrence intervals for specific events. The probability of an event will be higher near facilities that are not routinely maintained or inspected, at potential targets for an intentional attack, and at ports or other facilities where high volumes of hazardous materials are moved on a frequent basis.

Broader categories of releases can be considered on a more general continuum. Figure 3.16.104 is an unclassified and commonly used reference chart for the probability of CBRN events.

**iv. Location**

Locations vulnerable to CBRN releases vary according to the type of release and whether the incident is accidental or intentional.

Figure 3.16.104: Probability vs. Impact from Different Categories of CBRN Releases.



*Chemical*

The most at-risk locations for accidental chemical releases include neighborhoods and recreational or natural areas near chemical plants, industrial facilities/storage sites, warehouses, fuel stations, and brownfields/Superfund sites (such as Newtown Creek in Brooklyn/Queens and Gowanus Canal in Brooklyn). Common household chemicals (such as cleaning solutions) or materials present in most buildings (such as heating oil) may also pose a risk to human health. The most likely targets for intentional releases are densely populated and crowded areas (such as tourist attractions, public transportation facilities, and entertainment venues) and critical facilities (water supply reservoirs and distribution systems, power plants, ports, and hospitals). Financial centers and government offices are also potential targets for an intentional release.

*Biological*

Accidental biological incidents may occur anywhere in the city, although the risk of spread will be highest in the most densely populated areas. These outbreaks could potentially start from, for example, restaurants or food markets selling tainted food, or from a combined sewer overflow (CSO) outfall that exposes the public to raw sewage. The most vulnerable locations for intentional biological attacks are the same as for chemical attacks.

*Radiological*

Accidental radiological incidents are most likely to occur near facilities storing radioactive materials or waste, and in buildings built above or near natural sources of radiation, such as radon gas. The most likely targets for an intentional radiological attack are the same as for chemical and biological attacks.

*Nuclear*

While there are no nuclear power facilities within New York City, a leak at a nearby facility (whether accidental or intentional) could potentially expose New York City residents to harmful radiation. Likely targets for an intentional nuclear detonation are the same as for chemical, biological, and radiological attacks.

**v. Historic Occurrences**

Although data on CBRN releases is limited, certain types of events (such as CSOs/raw sewage releases and oil spills) are relatively common occurrences, especially during heavy precipitation and flooding. Table 3.16.73 includes examples of significant known CBRN releases in recent decades (details vary based on amount of information available).

## 16. CHEMICAL, BIOLOGICAL, RADIOLOGICAL, AND NUCLEAR (CBRN)

### CHAPTER 3: RISK ASSESSMENT

**Table 3.16.73: Selected CBRN Releases in New York City 1973 to 2013**

| Date               | Event/Substance  | Location      | Description   |
|--------------------|--|---------------|---|
| February 10, 1973  | Liquefied natural gas explosion                                | Staten Island | <ul style="list-style-type: none"> <li>40 workers killed in an explosion while cleaning an empty LNG tank in Bloomsfield, Staten Island</li> </ul>  |
| November 15, 1979  | Oil spill  | Brooklyn      | <ul style="list-style-type: none"> <li>Oil refinery tank explosion in Greenpoint, Brooklyn, releases 17 to 30 million gallons of oil into Newtown Creek</li> <li>Spill area covers up to 100 acres</li> <li>Newtown Creek designated a Superfund site in 2010</li> <li>No direct fatalities or health effects linked to spill</li> </ul>  |
| August 7, 1980     | Liquefied petroleum gas  | Manhattan     | <ul style="list-style-type: none"> <li>A truck carrying 9,000 gallons of liquefied petroleum gas leaks on the George Washington Bridge traveling from New Jersey to New York City</li> <li>Bridge cleared for 8 hours out of fear of an explosion, creating massive traffic jam</li> </ul>  |
| September 2, 1986  | Cyanide (intentional)  | Manhattan     | <ul style="list-style-type: none"> <li>21 injured when cyanide is released in Metropolitan Opera</li> </ul>   |
| August 24, 1989    | Asbestos   | Manhattan     | <ul style="list-style-type: none"> <li>Steam pipe explosion results in evacuation of Gramercy Park area in Manhattan after discovery of "extremely high" levels of asbestos</li> </ul>  |
| September 18, 2001 | Anthrax (intentional)  | Manhattan     | <ul style="list-style-type: none"> <li>Letters sent to various media offices in New York City contain anthrax spores</li> <li>Part of larger coordinated attack that also infects people in other cities and states</li> <li>5 people killed, 17 others infected (not all in New York City)</li> </ul>  |
| December 3, 2004   | Chlorine   | Bronx         | <ul style="list-style-type: none"> <li>An SUV collides with a tractor-trailer carrying barrels of chlorine on the Cross Bronx Expressway, causing chlorine to leak onto the roadway</li> <li>3 firefighters and 2 police officers are exposed to high levels of chlorine and treated at the hospital</li> </ul>   |
| July 18, 2007      | Asbestos   | Manhattan     | <ul style="list-style-type: none"> <li>Steam pipe explosion with asbestos found in the debris</li> </ul>  |
| August 15, 2010    | Hydrogen peroxide  | Manhattan     | <ul style="list-style-type: none"> <li>Spill in a high-rise building due to machine malfunctioning releases about 30 gallons hydrogen peroxide</li> </ul>   |
| July 20, 2011      | Raw sewage   | Citywide      | <ul style="list-style-type: none"> <li>Four-alarm fire at North River Wastewater Treatment Plant on the Hudson River and 135<sup>th</sup> Street in Manhattan</li> <li>15 to 20 million gallons of raw sewage released into Hudson River</li> <li>Forced closure of 3 beaches in Staten Island and 1 beach in Brooklyn due to high levels of harmful bacteria in the water</li> <li>DEP treats water with chlorine to reduce concentration of bacteria</li> </ul> |
| October 29, 2012   | Release of various hazardous substances during Hurricane Sandy | Citywide      | <ul style="list-style-type: none"> <li>10 of 14 DEP wastewater treatment plants are damaged or lose power, releasing approximately 560 million gallons of untreated sewage mixed with stormwater into local waterways</li> <li>Floodwaters contain numerous other toxic substances such as oil, household chemicals, pesticides, and industrial pollutants</li> </ul>   |
| October 22, 2013   | Oil spill  | Manhattan     | <ul style="list-style-type: none"> <li>Approximately 50 gallons of home heating oil spill into the street at West 36<sup>th</sup> Street and 7<sup>th</sup> Avenue in Manhattan</li> <li>3 people are contaminated and treated on-scene</li> </ul>  |

#### B. Vulnerability Assessment

##### i. Social Environment

CBRN incidents could potentially compromise the safety and health of any person who resides in, works in, or visits New York City. Specific impacts will vary according to the type of material released, the geographic area affected, and the demographics of the population within that geographic area. Additional impacts may stem from long-term isolation of affected areas. Human fear or panic may also cause mental health impacts or disruptions to society, even if the real danger is not particularly severe.

To evaluate the existence and/or magnitude of health problems resulting from exposure to a hazardous substance, health risk assessments are utilized. There are generally four steps in the health risk assessment: health problem identification, toxicology (dose response), exposure assessment, and health-risk characterization. Health problem identification is the process of determining whether human exposure to a hazardous substance could cause adverse health impacts. Toxicology is the process of characterizing the relationship between the dose received and the adverse health effect in exposed populations; it also involves estimating the incidence of effects as a function of exposure and considers factors such as intensity of exposure, age, sex, and lifestyle. Exposure assessment is the process of measuring or estimating the intensity, frequency, and duration of exposure to a substance currently in the environment, or to a hypothetical release of a substance into the environment. The main purpose of exposure assessment is to determine the concentration of hazardous materials over time and space in each environmental media where people may be exposed. The final stage of a health-risk assessment is risk characterization, which involves estimating the incidence of health effects under various conditions of exposure described in the exposure assessment. The risk characterization combines the exposure and dose-response assessments.

##### *Chemical*

Populations who live or work near sites that contain hazardous materials or potential terrorist targets are at elevated risk of exposure to chemical hazards.

##### *Biological*

Densely populated residential areas, crowded business districts, and tourist attractions are at increased risk from biological hazards due to closer human contact and the potential for increased rates of transmission. The elderly, young children, persons with mobility impairments, and individuals with pre-existing medical conditions or weakened immune systems are at a heightened risk if exposed (for more information on vulnerable populations, see Section 3.4: New York City's Hazard Environment).

##### *Radiological*

The entire population is potentially at risk from radiological hazards, but the elderly, young children, the immobile, and those with pre-existing medical conditions are especially vulnerable. The elderly, young children, and those with pre-existing medical conditions are more likely to have a lower threshold dose of radiation to experience health issues.

##### *Nuclear*

Nuclear incidents could potentially impact any person who resides in, works in, or visits New York City.

##### ii. Built Environment

Although the most significant impacts of CBRN releases are on the human population and the natural environment, some materials may cause damage to the built environment. Impacts will depend on the type of material released and the specific buildings, equipment, or infrastructure exposed.

##### *Chemical*

Corrosive chemicals have the potential to damage building materials and infrastructure. Sensitive equipment and electronics may also be vulnerable to damage or explosions if they come into contact with re-



active chemicals. Water distribution and filtration systems and air ventilation systems may be damaged or destroyed if contaminated with certain substances.

#### *Biological*

Biological hazards are an inherent danger to living organisms but generally do not pose a significant threat to the built environment.

#### *Radiological*

The most significant impacts of a radiological release to the built environment would come from the explosion of an RDD and not from the radiation itself. However, radioactive contamination of certain structures may necessitate demolition to prevent exposure of occupants.

#### *Nuclear*

The entire built environment could suffer severe damage from a nuclear blast or detonation. The extent of damage would depend on the magnitude and location of the blast.

### **iii. Natural Environment**

The impacts of CBRN releases on the natural environment will depend on the type of material released, the magnitude of the release, the location of the release relative to critical natural resources or habitats, and the existence of pathways which would allow substances to spread throughout the environment. Exposure may occur via contact with contaminants in the water supply or ambient air. The remediation of the natural environment after a release poses unique challenges and could be lengthy and costly.

#### *Chemical*

Certain chemicals may be toxic to many species of plants and animals. Even if the only exposure is to species that are low on the food chain, these chemicals could indirectly impact other species because the concentration of the chemicals increases due to bioaccumulation. This may ultimately result in the loss of critical natural resources and ecosystems and negatively impact the human food supply. Depending on the type

and size of the release, permanent damage or destruction of critical ecosystems may occur.

#### *Biological*

Biological releases could also be devastating to plants and animals. Since different microorganisms and pathogens affect different hosts, the severity of impacts will depend on the type of material released. A significant release has the potential to cause wide-ranging impacts on a scale similar to what might occur from a significant chemical release.

#### *Radiological*

Exposure to significant doses of radiation damages cells and living tissues in plants and animals. Overall risks may include genetic defects, mutations, and death. If the absorbed dose of radiation is relatively low, it may not have significant impacts on the plants and animals directly exposed, but could accumulate in the food chain and ultimately contaminate the human food supply.

The disposal of radiological waste from environmental cleanup is a particular concern. There are only a few designated radiological waste depositories in the United States, and radiological waste can persist in the environment for hundreds or thousands of years.

#### *Nuclear*

Nuclear releases pose the same threats to the natural environment as radiological releases do, with the additional risk of damage resulting from a nuclear blast.

### **iv. Future Environment**

The threat of CBRN releases in the future will depend on a number of factors that are currently uncertain.

#### *Chemical*

Increased or decreased reliance on products containing certain types of chemicals could affect the risk of exposure. Shifts in the market or industrial trends may also change the number or distribution of facilities where hazardous chemicals are stored. New or emerging chemicals may have toxicological effects and

pose challenges to preventing and controlling exposure. New technologies, such as safer storage, could decrease the likelihood of a release.

#### *Biological*

Shifts in population density and distribution may affect the number of people impacted and the transmission rate for biological hazards. Medical advances in antibiotics and vaccines could also decrease the risk of exposure to certain types of diseases. However, these changes also have the potential to promote genetic mutations in microorganisms and pathogens, which could cause deadly new resistant strains of diseases.

#### *Radiological*

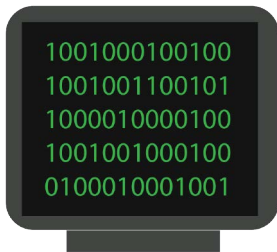
The future risk of radiological releases will depend on changes in the need for these types of materials for usage in industrial processes or power generation. New technologies, such as increased or improved radiation screening and the development of alternatives for the storage of radioactive waste will also play a role in determining future vulnerability.

#### *Nuclear*

The future risk of accidental nuclear releases will depend, at least in part, on trends in power generation. New technologies could potentially make nuclear facilities either safer or obsolete. Technological advances could also result in the development of more sophisticated nuclear explosives. The threat from such devices would depend on the availability of this technology and the pursuit of political aims through intentional harmful acts. However, advances in security may also go a long way in preventing intentional attacks.

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## 17. Cyber Threats

### A. Hazard Profile

#### i. Hazard Description

The broad reach of cyberspace has done much to improve communication, innovation, and access to information. However, the largely open and unregulated nature of the Internet also leaves New York City vulnerable to cyber threats. These threats—whether a deliberate attack on an information system resulting in a data breach or the spread of a crippling virus, the threat of such an attack, or the accidental exposure of private information—can be extremely damaging. The growing dependence on digital interconnectivity means that even a small incident at a targeted location may have widespread, harmful consequences.

A cyber attack is a crime both intentional and malicious in nature. An attack compromises the digital infrastructure of a person or organization, often for financial or terror-related reasons. Such attacks vary in nature and are perpetrated using digital mediums or, sometimes, social engineering, which targets human operators—as opposed to computers—as a primary vulnerability of a digital system. Generally, attacks last minutes to days, but large-scale events—and their impacts—can last much longer.

Cyber attacks differ by motive, attack type and vector, and perpetrator profile.

Motives for cyber attacks can vary tremendously, ranging from the pursuit of financial gain—the primary motivation for what is commonly referred to as "cyber crimes"—to political or social aims. Hacktivism is the act of hacking, or breaking into a computer system, for a political or social purpose. It is the most common motivation for incidents affecting New York City, based on historical occurrences. Cyber espionage is the act of obtaining secrets without permission of the holder of the information, using methods on the Internet, networks, or individual computers.

Cyber attacks can also be grouped by attack type and

vector, or technique. As shown in Table 3.17.74, below, there are six attack types, each of which is carried out through specific vectors.

**Table 3.17.74: Major Types of Cyber Attacks and Attack Vectors (Source: New York City Draft Cyber Incidents Response Protocol)**

| Attack Type            | Attack Vectors                       | Description of Attack  |
|------------------------|--------------------------------------|--|
| Spoofing               | Phishing                             | A person or program successfully masquerades as another by falsifying data and thereby gaining an illegitimate advantage   |
| Tampering              | Defacement                           | Modification of data. Example: modification of website content or appearance leading to propagation of misinformation  |
| Repudiation            | Internal manipulation                | Challenging authenticity. Example: account compromise or unauthorized access to information technology—data, emails, or network—leading to loss of data integrity                  |
| Information Disclosure | Data leak                            | The unintentional or intentional release of secure information—possibly private or confidential data—to an untrusted environment   |
| Denial of service      | Distributed denial of service (DDoS) | An overwhelming number of false requests intended to prevent any legitimate service from functioning properly  |
| Elevation of Privilege | Malicious code                       | Exploitation of a bug or design flaw—sometimes in an operating system, software application, database, or website—which allows a user to gain higher levels of access to resources |

Cyber attacks may be carried out by a variety of perpetrators. As shown in Table 3.17.75, perpetrators can be categorized as "external" actors (i.e. from outside the victim organization), "internal" actors (from within the victim organization), and "partner" actors (a third party sharing a business relationship with the victim). Most attacks are perpetrated by external actors. Ac-

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### CHAPTER 3: RISK ASSESSMENT

According to the Verizon 2013 Data Breach Investigation Report (DBIR), 92% of cyber attacks in the country in 2012 were perpetrated by external actors, 14% were perpetrated by internal actors, and only 1% was the result of partner interaction (see Figure 3.17.105).

#### ii. Severity

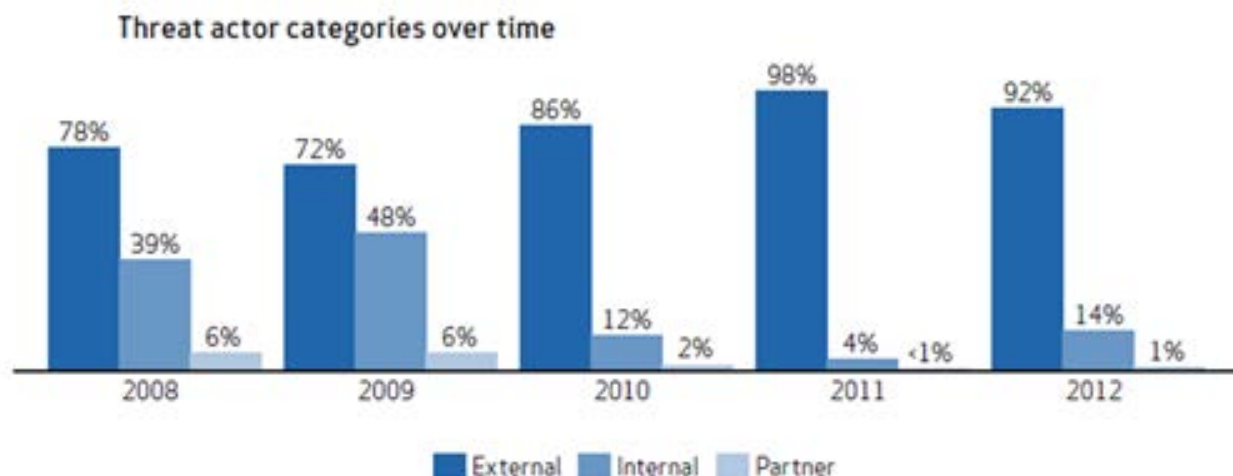
There is currently no official index for measuring the severity of a cyber attack. However, the Gibson Index, an open-source ranking system created in February 2013, is widely used in cyber threat analysis. The Gibson Index ranges from 0 to 7, as shown below, with 7 being the most severe class of attack.

- 0 – Little or no disruption
- 1 – Some small real-world consequences
- 2 – Clear malicious intent, resulting in longer outages
- 3 – Minor financial damages and moderate privacy implications
- 4 – Major financial damages and privacy implications
- 5 – Systematic, coordinated, broad penetration of a multitude of networks
- 6 – Attacks that manifest themselves in real-world, targeted, intentional damage
- 7 – Mass casualties from intentional, targeted efforts

**Table 3.17.75: Perpetrator Categories for Cyber Attacks (Source: Verizon Wireless DBIR, 2013)**

| Category | Category Description  | Description of Attack  |
|----------|---|--|
| External | Outside the victim organization                             | Attacks—which can be perpetrated by subgroups including organized crime, state-affiliated entities, unaffiliated individuals, activists, and former employees—can take any number of forms |
| Internal | Inside the victim organization                              | These attacks have usually been malicious, for the purposes of financial gain, though some were the result of breaches due to careless or accidental data exposure                         |
| Partner  | Third party sharing a business relationship with the victim | The least common of the three perpetrator categories and often unintentional. Example: a courier losing a device containing sensitive data   |

**Figure 3.17.105: Threat Actor Categories 2008 to 2012 (Source: Verizon Wireless DBIR, 2013)**



**iii. Probability**

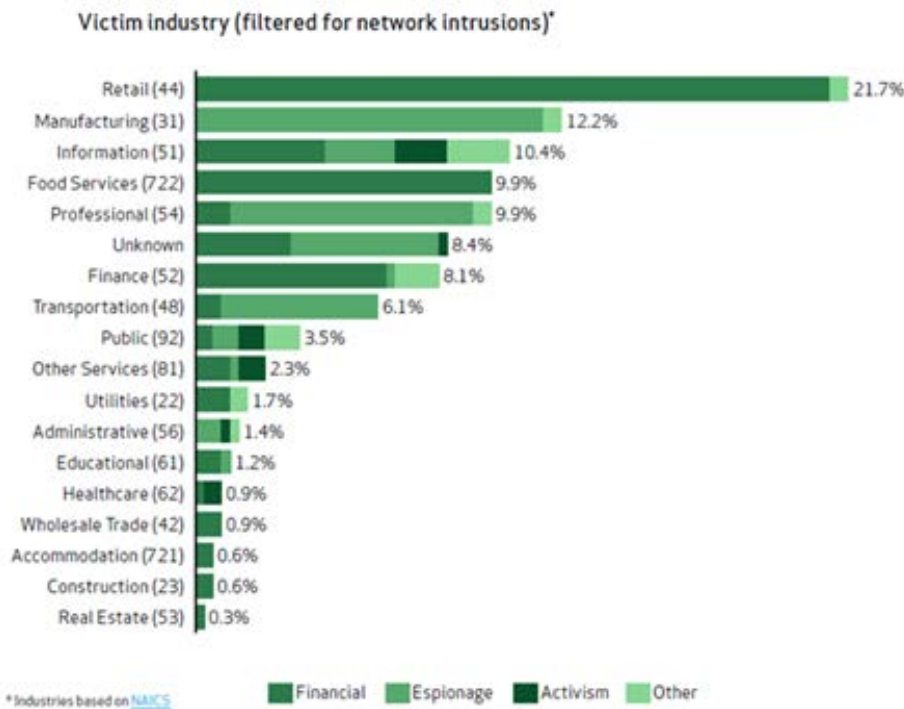
The probability of a cyber attack that will affect New York City is difficult to calculate due to the unpredictability of human behavior and the fact that the technology field continues to evolve quickly. While perpetrators of cyber attacks are becoming more sophisticated, companies and other users of digital technology are also getting smarter and learning to add layers of protection to systems and data.

nerable.

However, there are specific possible target sectors that might result in citywide effects. These include:

- Financial centers
- Government buildings
- Media outlets
- Transportation authorities

**Figure 3.17.106: Victims of Cyber Attacks by Industry in 2012 (Source: Verizon DBIR, 2013)**



- Power/utilities companies
- Telecommunications networks

**iv. Location**

Cyber threats differ from other hazards in that vulnerability to this hazard is unrelated to geographic location. The Internet is accessible remotely from all over the world. Attacks that affect New York City can originate from anywhere—including far outside the city—adding an additional layer of complexity to protecting the city. The targets of cyber attacks can be very large corporations, governments, or even individuals—in fact, anything that is digitally connected is technically vul-

Figure 3.17.106, below, shows the breakdown of victim industries for cyber attacks across the country in 2012, taken from the Verizon DBIR.

**v. Historic Occurrences**

There have been significant cyber attacks in New York City over the last few years, as indicated in Table 3.17.76, below.

**Table 3.17.76: Significant Cyber Incidents Affecting New York City 2010 to 2013**

| Date               | Category               | Description   |
|--------------------|------------------------|---|
| December 8, 2010   | Denial of service      | <ul style="list-style-type: none"> <li>Denial of service for Visa, MasterCard, and Paypal</li> </ul>  |
| May 10, 2011       | Information disclosure | <ul style="list-style-type: none"> <li>Data breach for 360,000 Citibank customers</li> <li>Cost of the breach was around \$22 million, with the hackers making \$2.7 million</li> </ul>   |
| September 13, 2012 | Denial of service      | <ul style="list-style-type: none"> <li>New York Times hacked</li> </ul>   |
| April 23, 2013     | Tampering              | <ul style="list-style-type: none"> <li>AP Twitter feed hacked</li> <li>A false message about explosions in the White House injuring President Obama is tweeted</li> <li>Attack causes Dow Jones industrial average to fall 128 points</li> <li>The White House is forced to reassure reporters that the president was all right and the report was false</li> </ul>   |
| August 15, 2013    | Denial of service      | <ul style="list-style-type: none"> <li>CNN.com hacked by Syrian Electronic Army</li> <li>Deemed malicious external attack</li> </ul>  |
| August 15, 2013    | Denial of service      | <ul style="list-style-type: none"> <li>Syrian Electronic Army attack on the Washington Post website through a third-party service provided by a company called Outbrain</li> </ul>  |
| August 27, 2013    | Denial of service      | <ul style="list-style-type: none"> <li>Attack on New York Times and Twitter</li> <li>New York Times website was unavailable to readers due to an attack on the company's domain name registrar—an incident considered more sophisticated than previous incidents</li> <li>New York Times website was inaccessible for over 10 hours</li> <li>Attack credited to Syrian Electronic Army</li> <li>Deemed malicious external attack</li> </ul> |

**B. Vulnerability Assessment****i. Social Environment**

Cyber attacks can affect the population of New York City in a number of ways. Stolen personal information may destroy the financial standing of individuals. Additionally, cyber incidents can have a damaging effect on public trust in systems that are traditionally considered stable and secure. Cyber attacks may create fear and erode the public trust needed for private and public services to run successfully.

Cyber attacks can also have extensive economic impacts. Companies and government services can lose large sums of unrecoverable revenue from site downtime and possible compromise of sensitive confidential data. Cyber incidents could result in the theft or modification of important data—including personal, agency, or corporate information—and the sabotage of critical processes, including the provision of basic services by government or private-sector entities.

**ii. Built Environment**

A cyber incident can have far-ranging effects on buildings and public and private infrastructure systems. Cyber attacks can cause physical damage if real assets or the end consumers are affected by service disruption. This might occur if cyber attacks target industries related to utilities, life support, transportation, human services, and telecommunications. In many cases, attacks on these systems initially will not be detected, and it may be some time before it is known that system impairment or failure is the result of a cyber event.

**iii. Natural Environment**

While effects of cyber threats on the natural environment would be unlikely, they are conceivable. As with the built environment, the effects on the natural environment may come from a system failure that, for example, allows a release of hazardous materials or improper disposal of waste.

**iv. Future Environment**

Vulnerability to cyber attacks may change significantly

in the future. As technology evolves, more and more functions that were once grounded in the physical world go online, from building security to healthcare record-keeping. Security measures, too, will continue to improve, but, at the same time, cyber threat capabilities may also become increasingly sophisticated. The attack vectors, however, may stay the same. Cyber threats in various forms remain a genuine threat, and emphasis should be placed on preventative security measures.



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**18. Infrastructure Failures**

**A. Hazard Profile**

**i. Hazard Description**

New York City—like other older urban centers across the country—has aging public infrastructure systems. At the same

time that these systems are experiencing age-related deterioration, they are also facing increasing strain from population growth. Endogenous hazards (such as construction or maintenance flaws) and exogenous hazards (natural hazards) may also increase the risk of failure.

Effective maintenance is critical to reducing potential risks, and all agencies and utility providers make investments to maintain their built assets. However, failures are still possible, and the inter-connectedness of New York City's infrastructure networks means that failure in one system can result in failure in others.

New York City's large infrastructure systems are described in Section 4. [New York City's Hazard Environment](#). This section zeroes in on the potential for failure in four of those systems: energy, telecommunication, transportation, and water systems. These systems are deemed critical infrastructure sectors under the authority of the Homeland Security Presidential Directive 7 (HSPD-7). They are crucial to the public safety, health, and well-being of New York City.

**Energy Systems**

Due to the inter-dependencies of the energy, telecommunication, transportation, and water systems, a failure in the energy system will most likely impact the remaining systems' ability to function. The loss of electrical, gas, or steam service can be due to equipment failure, natural hazards, or accident.

*Electricity Systems*

Power disruptions or outages can occur as a result of problems in the generation and/or distribution systems. Generation capacity can be strained during

high-heat events in the summer, when residents and businesses have air conditioners turned on and power usage is at its peak. Power outages are most common at these times. Electric generation plants are also vulnerable to flooding from coastal storms. A majority of the plants are located in the 100-year floodplain.

As for the city's electrical distribution system—which consists of a combination of overhead utility lines and underground networks—it is subject to failure from a variety of causes. Overhead utility lines are vulnerable to high winds and ice storms. High winds can knock down trees, which can sever power lines, and ice accumulations can weigh down lines to the point that they break. However, overhead lines can typically be restored faster than underground networks because the damage can be easily located, accessed, isolated, and repaired. The underground electrical network, on the other hand, can be subject to failure from flooding, resulting in power disruption or outage. This is especially true for underground transformers and cables as well as area substations (responsible for reducing voltage for distribution) located in the flood zone. Underground networks take two to three times longer to restore than overhead lines. This is usually due to the time needed for crews to safely access underground manholes or transformers, find the location of the fault, electrically ground equipment for safety, and make repairs to wires and other power equipment. Whatever the cause of failure, the loss of power can affect the functioning of other networks in the city.

*Natural Gas*

An indoor or outdoor leak in the natural gas distribution system can be caused by weather, equipment failures, or human error (such as when a leak is caused by building contractors). Since natural gas has no odor, transmission line operators add an odorant to the gas. As a result, when members of the public smell natural gas, they are able to report the odor to first responders. Another indication of a gas leak is pressure loss. Repairs to leaks will often require closing valves or opening trenches to access underground pipes.

*Steam*

Within the steam system, pipes require periodic repair

and maintenance due to the age of the pipes and extreme service conditions, which include high temperatures and high pressure. Steam mains are maintained by utility providers, which address leaks immediately.

Emergencies in the steam system can develop when water surrounds steam pipes and the main must be turned off until the water condition is alleviated. Steam pipe explosions are rare, but when they do happen they can be catastrophic and severely impact human life and street infrastructure. Explosions can be a result of a phenomenon called "water hammer," whereby rapid cooling of the main creates excessive condensation that is not removed effectively from the steam pipe. Pooling condensate is picked up by flowing steam and driven—with great force—into pipe fittings.

#### Telecommunication Systems

The telecommunication system is vulnerable to weather events including flooding, coastal storms, high winds, and extreme heat. Since electricity is used to power telecommunications, the system is also subject to power failures. Finally, telecommunication failures can also occur as a result of congestion (call volumes and internet usage) overloading the communications system during a crisis or disaster.

Although critical facilities have back-up batteries and fuel-powered generators, these systems are vulnerable to flooding if located in the building basements. For example, Verizon's central office had generators and electrical switchgear located at or below grade that were inundated with salt water during Hurricane Sandy. The flooding caused power failures that led to a loss of phone service over a wide swath of Lower Manhattan.

Critical facilities are also vulnerable to extreme heat events. These facilities contain computer-controlled digital and fiber optic equipment that is sensitive to dust, temperature, and humidity. Although these facilities are equipped with ventilation and cooling systems, a long-lasting heat event may threaten the power grid and shorten the lifespan of electronic telecommunications equipment.

The cabling that is essential to telecommunications—

located both above and below ground—can be subject to failure. Overhead cabling is subject to failure due to high winds, tornadoes, and ice storms, and underground cables could be destroyed by earthquakes and flooding. The oldest cabling in the telecommunications system is lead-encased copper, which is in poor condition due to its age. Some of these cables have leaks, compromising the pressurized air system designed to keep water from inundating the copper wiring.

Cell sites in the city, often placed on the rooftop of private buildings, are at risk of power failure. These cell sites have only a four- to eight-hour backup life. Before power can be restored to the cell site on a building, it must first be restored to the individual building.

Although federal, state, and city agencies are involved in the regulation of the telecommunications industry, no single governmental entity has the full responsibility for the entire system nor has the jurisdiction to require that service is available in emergencies.

#### Transportation Systems

New York City's transportation system—comprised of large, interconnected rail, roadway, and water transportation networks—is subject to failure for a variety of reasons.

##### *Rail Networks*

Freight, commuter, and subway lines may fail due to weakening joints, erosion, and unstable rails that can cause train-car collisions and derailment. Subway breakdowns, while not frequent, can occur as a result of aging machinery.

Rail transportation's underground and above-ground rails are also vulnerable to weather-related events. Underground rails are vulnerable to flooding from coastal storms and heavy precipitation, whereas above-ground rails are subject to high winds that can cause subway or rail cars to tip or derail. Extreme temperatures can also affect railroad tracks, causing the steel to shrink during extreme cold and buckle during extreme heat, which could cause train derailments.

The functioning of rail lines may also be disrupted by

power failures, since rail networks depend on electricity. For example, in October 2013, a power failure caused by the loss of a feeder cable on the New Haven line of the Metro-North Railroad affected commuter service from Grand Central Station in Manhattan to Stamford, Connecticut, for 12 days causing major delays for daily commuters.

#### *Roadway Network*

Within the roadway network, bridges, tunnels, and roads are vulnerable to deterioration from use and climate and thus require regular maintenance.

While New York City has continued to make major investments in maintaining its bridges, many bridges are over 100 years old and may suffer age-related deterioration. Bridge components are subject to cracking, rusting, ground subsidence, and corrosion caused by exposure to water, vibration, ozone, dust, dirt, chemicals in salt products, and gasoline. For these reasons, New York State law mandates that vehicular bridges be inspected every two years. When deterioration is identified during inspections, repairs may necessitate bridge closures, which disrupt traffic patterns.

Tunnels are also susceptible to major damage and deterioration caused by weather events. DOT, the Metropolitan Transportation Authority (MTA), and the Port Authority of New York and New Jersey (PANYNJ) regularly inspect tunnels to identify any structural vulnerability. However, water can seep into tunnels as a result of groundwater penetration or broken water mains. Tunnel systems are also vulnerable to rain and coastal flooding. For example, multiple rail and vehicular tunnels were inundated during Hurricane Sandy in 2012.

While at-grade roadways are generally less likely to fail than bridges and tunnels, subsurface conditions (such as a sinkhole or collapsed sewer) can undermine streets. Retaining walls, many of which were built in the early 1900s, are critical to the structural integrity of the roadway network. In 2005, the collapse of a retaining wall in Washington Heights buried a portion of the Henry Hudson Parkway in rubble, causing major disruptions to traffic.

#### *Maritime Transportation*

Proper maintenance of maritime assets is important to ensure that water transportation can continue to play its increasingly important role in New York City. In addition to regular maintenance of the vessels themselves, there are over 50 piers, slips, docks, and ferry terminals in New York City that must be regularly maintained to ensure the safe docking of ferry boats and unloading of passengers. Major coastal storms and ferry accidents can cause damage to these structures and result in large pieces of debris in the waterways, posing a navigational hazard. Additionally, many piers have mechanical ramps that rely on electricity to function, and shipping container terminals cannot operate without power. Power outages have a major impact on passenger ferry and shipping operations.

Water-borne transportation has become a key tool in emergency management. New York Harbor provides alternative options for evacuating residents during major emergencies and for moving people safely when other modes of transportation experience shutdowns, such as during power outages. After the 9/11 attacks, ferries safely evacuated hundreds of thousands of people from Lower Manhattan and were used in the following days for transportation of emergency personnel, vehicles, and equipment to and from Ground Zero. Therefore, properly maintained piers, landings and vessels are imperative for both the economic development of New York City and redundancy in transportation systems to support emergency evacuations.

#### **Water Systems**

##### *Water Supply*

New York City is vulnerable to infrastructure failures in the water supply system, which includes upstate reservoirs, dams, and aqueducts, along with water tunnels and distribution mains in the city itself. Water system or dam failures north of the city could cause a water shortage. Redundancy is built into the system to minimize impacts and occurrences of failures, including leaks, cracks, or collapse, and the system is monitored. Nevertheless, around 30% of the distribution system was built before 1930. Given the system's extent, size, and age, parts of it may be subject to failure.

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The Delaware Aqueduct, which runs 300 to 2,400 feet below surface and conveys, on average, 50% of the city's water from upstate sources, has confirmed leaks in two areas and leaks up to an estimated 36 million gallons per day. While the leaks are a cause of concern, the situation in the tunnel and amount of water loss is stable. In the opinion of the professional engineering firm retained by the New York City Department of Environmental Protection (DEP) to investigate the status of the tunnel, there is very little immediate risk of failure of the tunnel. Since 2002, the City has invested \$186 million to investigate the leak in the Branch Tunnel of the Delaware Aqueduct and to develop the City's long-term plan, *Water for the Future*, to repair the leak and ensure reliable water.

Within the city, Water Tunnel 1, built in 1917, and Water Tunnel 2, completed in 1936, have been in continuous service since they were activated. So that the tunnels can be inspected and rehabilitated, if needed, the City has been constructing Water Tunnel 3 in stages; a portion of the tunnel was opened in 2013. The tunnel is projected to be completed by 2020.

Water main breaks is another type of infrastructure failure. These breaks are due to a combination of factors including temperature—breaks are more likely to occur in the colder months—and the material from which the water main is made. Although water main breaks may occur, they rarely cause severe damage to the city's water distribution system. Moreover, breaks have declined in recent years. In 2012, there were almost 350 breaks in the City's network of approximately 6,800 miles of water mains, down from a high of 632 breaks in 2003. As of October 2013, there were fewer than six breaks per 100 miles of pipe, well below the accepted industry standard.

Concerns have arisen about the effect the New York Harbor deepening project will have on one or both of the existing siphons that serve as a backup water supply for Tunnel 2, which provides potable water to Staten Island via Brooklyn. In preparation for the deepening project, both siphons will be replaced by one 72-inch siphon positioned approximately 50 feet deeper than the existing siphons. This replacement project is designed to ensure uninterrupted water service to

Staten Island by adding a redundancy of 5 million gallons per day of water supply under normal conditions.

#### *Wastewater Treatment*

New York City's wastewater treatment system—which includes 14 wastewater treatment plants that treat 1.3 billion gallons of wastewater daily before releasing it into the local waterways—is crucial to the city's functioning. However, although the City makes regular capital investments in its wastewater treatment infrastructure, the system is vulnerable to failure from weather-related events. This is partly due to the fact that wastewater treatment plants are located on the waterfront and are thus vulnerable to flooding and coastal storms. It is also due to the fact that New York City has a combined sewer system that collects both stormwater and sanitary waste together. Although DEP currently invests in "green" infrastructure and Bluebelt projects to help absorb stormwater before it can enter the sewer system, wastewater treatment facilities may not be able to handle the combined volume of sewage and stormwater during periods of heavy rains or snow, flooding, or coastal storms. As a result, combined sewer overflows (CSOs) may be released into the local waterways.

In addition, wastewater treatment facilities depend on power to function. In the event of a power failure, they may lose the ability to treat wastewater and may release CSOs.

#### **ii. Severity** **Energy Systems**

The severity of an energy disruption depends on the cause, location, duration, and time of year. It can range from a localized event to a city-wide power outage. Although New York City's power system is much more reliable than the national average, impacts from a failure of the city's grid system can be significant. During the Northeast Blackout of 2003, the New York City Fire Department (FDNY) rescued more than 800 people trapped in elevators, and the subway system was halted, stranding 400,000 passengers traveling on 400 subway trains who were eventually evacuated by the MTA. In the absence of back-up power for the city's traffic signals, traffic disruptions, city tunnel closures,

and congestion occurred.

The severity or extent of a power failure depends to a large extent on the electrical distribution system affected. For instance, while overhead utility lines are less reliable and are vulnerable to weather like high winds and ice storms, they can typically be restored faster than underground networks, which are vulnerable to coastal flooding, can take two to three times longer to restore. Crews need to safely access underground manholes or transformers, find the location of the fault, electrically ground equipment for safety, and make repairs to wires and other power equipment — repairs that can be complicated by traffic, pedestrians, and proximity of the public and vehicular obstructions.

The severity of a power outage can be characterized by the duration of the outage, and a longer outage can have a more severe impact. During the Queens blackout in 2006, 174,000 residents were without power for nine days. Four days after Hurricane Sandy hit, Con Edison was able to restore power to most customers in Manhattan; however, some customers were without power for two or more weeks. The Long Island Power Authority (now Public Service Electric & Gas Company, or PSEG) took an average of 14 days to restore electric service, with some customers experiencing much longer outages.

#### Telecommunication Systems

The severity of a telecommunications failure depends on the cause, location, and duration of the disruption. Similar to failures of the energy system, the severity's scale can range from a localized disruption in service to a citywide failure. Since telecommunications services are dependent on the city's power grid, major energy disruptions can result in citywide disruptions in telecommunication systems.

#### Transportation Systems

The severity of infrastructure failures for New York City's transportation system largely depends on the size and criticality of affected networks, their location, the number of people directly impacted, and the secondary impacts to essential services and the economy. A failure's severity can range from a localized occurrence to a system-wide incident. Because New York

City residents heavily rely on subways and rail transportation, system-wide failures can be quite severe, disrupting daily operations and/or posing life safety concerns.

#### Water Systems

The severity of water distribution and treatment failures is largely dependent on the location of the failure, the number of people impacted, the duration of the disruption, and impacts to essential services. The severity of a water system failure can range from a localized event, such as a water main break, to a system-wide incident, such as a dam failure impacting the distribution of water to all of New York City. Since the water system provides more than one billion gallons of water each day to more than 8.2 million New York City residents and many others, a system-wide incident would be quite severe.

#### iii. Probability

#### Energy Systems

Based on the age and extent of New York City's energy distribution system combined with future population growth, it is probable that energy disruptions will occur in the future. More frequent occurrences of weather-related events (extreme temperatures, severe weather, coastal storms, and flooding) increase the chances of failures. In addition, human error or damage during equipment operation, maintenance, or construction—none of which is easy to predict—may increase the risk of failures.

Historically, power outages are more likely to occur during extreme heat events in the summer, when peak load is at or above 11,000 megawatts (MW) per day. The record peak load of 13,322 MW was reached July 19, 2013.

#### Telecommunication Systems

If telecommunications companies do not invest in mitigation strategies—such as hardening facilities, switching to fiber cables, and elevating electrical equipment—infrastructure failures will continue to occur in the future. Due to the absence of a single entity overseeing telecommunication systems, mitigation regulations are not required or enforced, increasing the

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probability of future communication failures.

#### Transportation Systems

Due to the extent of New York City's transportation system and the age of certain of its components, combined with future population growth, it is probable that transportation failures will occur in the future. In addition, more frequent occurrences of extreme weather events (earthquakes, periods of extreme temperatures, coastal storms, and flooding) may increase the likelihood of failures. Operational errors and design flaws may also increase the risk of failures. However, significant investments in repair and maintenance lower the likelihood that elements of the transportation system may fail.

#### Water Systems

Based on the extent of New York City's water distribution and treatment system combined with future population growth, it is likely that water distribution and treatment failures will occur in the future. In addition, more frequent occurrences of extreme weather events (coastal storms, flooding, and severe weather) increase the threat of failures.

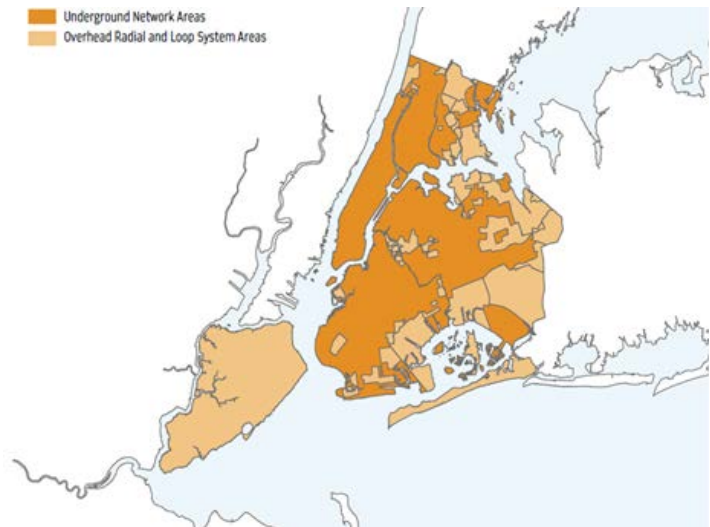
#### iv. Location

#### Energy Systems

Although energy disruptions can occur anywhere in New York City, some areas are more vulnerable to power outages than others, depending on the cause. A significant portion of New York City's energy system is located in the 100-year floodplain and thus is more vulnerable to flooding during a coastal storm: 88% of the city's steam, 53% of electric generation, 37% of transmission substation, and 12% of large distribution substation capacity are located in the flood zone. Therefore, coastal areas are more susceptible to power outages during a coastal storm.

Areas that are serviced by overhead power lines are more vulnerable to outages during an ice storm or high-wind event. Such areas include Staten Island, southeast Queens, southeast Brooklyn, and areas of the Bronx (see Figure 3.18.107).

**Figure 3.18.107: Electricity Distribution System Types**  
(Source: SIRR, 2013)



#### Telecommunication Systems

Although New York City's telecommunications system is generally reliable, a large volume of traffic is routed through a small number of colocation facilities in Lower Manhattan, increasing vulnerability. In addition, 13% of critical telecommunications facilities are located in the 100-year floodplain. Areas in the city that are serviced by overhead utility cables—including parts of the Bronx, Brooklyn, Queens, and Staten Island—are more vulnerable to power disruptions caused by high winds, ice storms, and tornadoes that could result in telecommunications disruptions.

#### Transportation Systems

Transportation infrastructure is dispersed throughout the city. Major bridges that could be vulnerable to infrastructure failures include the George Washington, Goethels, Outerbridge Crossing, Verrazano-Narrows, Robert F. Kennedy (formerly Triborough), Hell Gate, Brooklyn, Manhattan, Williamsburg, and Ed Koch-Queensboro Bridges. The major underwater vehicular tunnels that could be vulnerable to infrastructure failures are the Holland, Lincoln, Queens Mid-town, and Hugh L. Carey (formerly the Brooklyn Battery) Tunnels.

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#### Water Supply and Wastewater Treatment

The various components of the City's water supply systems are located both in the City and north of the City. The Catskill/Delaware watersheds are located northwest of the city, and the Croton Watershed is north of the city in Westchester and Putnam Counties. Although the reservoirs, aqueducts, and dams are located outside the city's boundaries, a system failure could have city-wide impacts. To lessen this risk, DEP has built redundancies into the system; these redundancies minimize impacts and occurrences of leaks, cracks, or collapse.

Within the city, wastewater treatment plants are located along the waterfront at relatively low elevations. Due to their location, they can be vulnerable to flooding and loss of electrical power during coastal storms. For example, during Hurricane Sandy, 10 of DEP's 14 wastewater treatment plants were damaged or lost power due to flooding, and they released untreated or partially treated wastewater into local waterways.

#### V. Historic Occurrences

Table 3.18.77, below, identifies major infrastructure failures from 1928 to 2013.

**Table 3.18.77: Selected Infrastructure Failures in New York City 1928 to 2013**

| Date              | Infrastructure Sector | Location  | Description  |
|-------------------|-----------------------|-----------|--|
| August 24, 1928   | Transportation        | Manhattan | <ul style="list-style-type: none"> <li>Subway train derails in Times Square</li> <li>16 fatalities</li> <li>100 injuries</li> </ul>  |
| August 31, 1959   | Energy                | Manhattan | <ul style="list-style-type: none"> <li>Power outage for a 500-block radius around Central Park during an extreme heat event</li> <li>500,000 people lose power for nearly 13 hours</li> </ul>  |
| November 9, 1965  | Energy                | Citywide  | <ul style="list-style-type: none"> <li>Several Northeastern states and parts of Canada experience blackouts</li> <li>800,000 subway riders are stranded</li> <li>Major traffic disruptions</li> <li>Planes unable to land</li> </ul>   |
| December 29, 1969 | Transportation        | Bronx     | <ul style="list-style-type: none"> <li>Southbound IRT train derails near 180<sup>th</sup> Street</li> <li>48 injuries</li> </ul>   |
| May 18, 1973      | Transportation        | Manhattan | <ul style="list-style-type: none"> <li>Northbound No. 5 Lexington Avenue Express train derails south of Grand Central</li> <li>First eight cars of the 10-car train derail</li> </ul>  |
| August 28, 1973   | Transportation        | Queens    | <ul style="list-style-type: none"> <li>20-foot chunk of concrete ceiling duct in Steinway Tunnel hits subway cars</li> <li>One fatality</li> <li>18 injuries</li> <li>Passengers trapped in 115-degree heat and heavy smoke</li> </ul> |
| July 13, 1977     | Energy                | Citywide  | <ul style="list-style-type: none"> <li>A series of lighting strikes initiates a 25-hour blackout</li> <li>Leads to widespread looting</li> <li>Estimated \$300 million in damage</li> </ul>  |



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| Date              | Infrastructure Sector | Location               | Description   |
|-------------------|-----------------------|------------------------|---|
| August 19, 1989   | Energy (steam)        | Manhattan              | <ul style="list-style-type: none"> <li>• Explosion near Gramercy Park</li> <li>• Two steam workers and one resident killed</li> <li>• 200 residents evacuated from their building due to the release of asbestos</li> </ul>   |
| December 29, 1989 | Energy (Natural Gas)  | Bronx                  | <ul style="list-style-type: none"> <li>• Natural gas main in South Bronx explodes, producing a tower of flames nearly 12 stories high</li> <li>• Explosion is caused by a backhoe truck striking a 26-inch underground main outside a Con Edison distribution plant</li> <li>• Two fatalities (one Con Edison utility worker)</li> <li>• Forces a shutdown of power and subway service in Bronx and areas of Manhattan</li> </ul> |
| August 28, 1991   | Transportation        | Manhattan              | <ul style="list-style-type: none"> <li>• Southbound No. 4 train derailed going over a switch north of Union Square</li> <li>• Five fatalities</li> <li>• 200 injuries</li> <li>• Service disrupted for 6 days</li> <li>• Considered the worst subway accident in 63 years</li> </ul>  |
| February 2, 1993  | Telecommunications    | Manhattan              | <ul style="list-style-type: none"> <li>• A bomb planted by terrorists explodes in the World Trade Center (WTC) underground garage, killing 6 and injuring over 1,000</li> <li>• Breakdown of communications at WTC because of insufficient capacity in FDNY's radio network</li> </ul>  |
| June 5, 1995      | Transportation        | Manhattan/<br>Brooklyn | <ul style="list-style-type: none"> <li>• Manhattan-bound M train on the Williamsburg Bridge is hit from behind by a J train</li> <li>• One fatality</li> <li>• 50 injuries</li> <li>• Spacing of signals and poor performance of train brakes contribute to the crash</li> </ul>  |
| August 13, 1996   | Transportation        | Brooklyn               | <ul style="list-style-type: none"> <li>• Brooklyn-bound D train derailed while pulling out of DeKalb Avenue station</li> <li>• Caused by track work in the area</li> </ul>  |
| August 31, 2000   | Energy (steam)        | Manhattan              | <ul style="list-style-type: none"> <li>• Steam pipe explosion near Washington Square Park near New York University Bobst Library</li> <li>• Explosion scatters debris</li> <li>• Releases asbestos in the air</li> </ul>  |
| June 21, 2000     | Transportation        | Brooklyn               | <ul style="list-style-type: none"> <li>• Southbound B train derailed at Dekalb Avenue</li> <li>• First three cars of train derail</li> <li>• 70 injuries</li> <li>• 70 feet of track need to be replaced</li> </ul>   |

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| Date               | Infrastructure Sector                    | Location  | Description   |
|--------------------|--|-----------|---|
| September 11, 2001 | Transportation/energy/telecommunications | Citywide  | <ul style="list-style-type: none"> <li>• Terrorist attacks on the WTC cause major damage to infrastructure and disruptions to critical services</li> <li>• Bridges and tunnels close</li> <li>• Tracks and stations under the WTC shut down after first attack</li> <li>• Trains running to Lower Manhattan lose power and have to be evacuated</li> <li>• Two substations lose power</li> <li>• Portions of Con Edison's infrastructure in Lower Manhattan are destroyed</li> <li>• Broadcast capabilities are disrupted because 1 WTC housed many television and radio broadcast antennas</li> <li>• Nearly 3,000 fatalities</li> </ul> |
| August 15, 2003    | Energy/transportation/telecommunications | Citywide  | <ul style="list-style-type: none"> <li>• Power surge causes power outages in some Northeastern states and parts of Canada</li> <li>• Subway riders are evacuated from tunnels</li> <li>• Airports suffer major disruptions</li> </ul>   |
| May 13, 2005       | Transportation                           | Manhattan | <ul style="list-style-type: none"> <li>• A 75-foot-high stone retaining wall built in 1908 collapses onto Henry Hudson Parkway</li> <li>• Wall in need of reinforcement</li> </ul>  |
| July 18, 2006      | Energy                                   | Queens    | <ul style="list-style-type: none"> <li>• Major power outages in Astoria, Long Island City, Sunnyside, and Woodside during extreme heat event</li> <li>• 174,000 people lose power</li> <li>• Power is disrupted at LaGuardia Airport</li> <li>• Subway lines in Queens lose power</li> </ul>  |
| July 18, 2007      | Energy (steam)                           | Manhattan | <ul style="list-style-type: none"> <li>• Steam pipe explosion occurs at 41<sup>st</sup> Street and Lexington</li> <li>• Shakes nearby office buildings</li> <li>• 40-story-high shower of mud and debris</li> <li>• One fatality</li> <li>• 45 injuries</li> </ul>  |
| February 13, 2009  | Transportation                           | Manhattan | <ul style="list-style-type: none"> <li>• Coney Island-bound D train derailed at 81<sup>st</sup> Street station</li> <li>• Two subway cars derail</li> <li>• Broken rail may have contributed to the accident</li> </ul>   |
| August 7, 2009     | Water systems                            | Manhattan | <ul style="list-style-type: none"> <li>• Water main break floods several building basements</li> <li>• Buildings are evacuated</li> <li>• Some streets are closed</li> </ul>  |
| September 29, 2009 | Water systems/transportation             | Manhattan | <ul style="list-style-type: none"> <li>• Water main break causes street collapse</li> <li>• Forces evacuation of residents</li> </ul>   |
| July 8, 2010       | Energy/transportation                    | Manhattan | <ul style="list-style-type: none"> <li>• Power outage in an Amtrak tunnel at Penn Station</li> <li>• Causes delays for Amtrak and NJ Transit</li> </ul>   |

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| Date                      | Infrastructure Sector              | Location        | Description   |
|---------------------------|------------------------------------|-----------------|---|
| July 10, 2010             | Water systems/transportation       | Manhattan       | <ul style="list-style-type: none"> <li>Water main break near Union Square</li> <li>Causes major street damage and transportation disruptions</li> </ul>   |
| August 7, 2010            | Water systems/transportation       | Manhattan       | <ul style="list-style-type: none"> <li>Water main break on East 59<sup>th</sup> Street</li> <li>Disrupts water service for several hours</li> <li>Causes transportation disruptions</li> </ul>  |
| July 27 to August 1, 2011 | Water systems/energy (natural gas) | Bronx           | <ul style="list-style-type: none"> <li>108-year-old water main breaks in the Bronx</li> <li>Results in a flood nearly a foot and a half deep on Jerome Avenue near 177<sup>th</sup> Street</li> <li>Creates a 40-by-46 foot crater on Jerome Avenue</li> <li>Damages two nearby gas mains due to water infiltration</li> <li>Con Edison shuts down service to 500 customers</li> <li>Disrupts vehicular traffic and subway/bus service</li> </ul> |
| August 12, 2011           | Water/energy (natural gas)         | Manhattan       | <ul style="list-style-type: none"> <li>Water main break floods St. Nicholas Avenue and West 152nd Street in Washington Heights</li> <li>Creates large sinkhole</li> <li>Gas main is also damaged due to water infiltration</li> <li>Disrupts gas and water service for days</li> <li>Disrupts subway service</li> </ul>   |
| July 25, 2012             | Energy                             | Citywide        | <ul style="list-style-type: none"> <li>Storm knocks out power to approximately 4,800 people</li> </ul>  |
| September 18, 2012        | Energy                             | Citywide        | <ul style="list-style-type: none"> <li>Approximately 4,500 people lose power in storm</li> </ul>  |
| October 29, 2012          | All sectors                        | Citywide        | <ul style="list-style-type: none"> <li>Hurricane Sandy floods tunnels and causes the suspension of rail service</li> <li>Increases combined sewer overflows</li> <li>Storm knocks out power to more than 2 million New York City residents</li> <li>Telecommunication networks are disrupted</li> <li>44 fatalities</li> </ul>  |
| November 8, 2012          | Energy                             | Citywide        | <ul style="list-style-type: none"> <li>Nor'easter cuts off power to approximately 5,500 customers</li> </ul>  |
| July 18, 2013             | Transportation                     | Bronx/Manhattan | <ul style="list-style-type: none"> <li>CSX train hauling trash derailed onto Metro North Hudson Line tracks</li> <li>Causes widespread transportation disruptions to and from the city</li> </ul>   |
| September 25, 2013        | Transportation/energy              | Manhattan       | <ul style="list-style-type: none"> <li>Feeder cable fails on the Metro North New Haven line</li> <li>Disrupts service between Stamford, Connecticut, and Grand Central Terminal in Manhattan for 12 days</li> </ul>   |
| December 1, 2013          | Transportation                     | Bronx           | <ul style="list-style-type: none"> <li>Metro North train traveling from Poughkeepsie to Grand Central Terminal derailed in the Bronx</li> <li>Four fatalities and more than 60 injuries</li> </ul>  |

**B. Vulnerability Assessment****i. Social Environment**

Infrastructure failures can impact the population by disrupting essential services. Depending on the type and severity of the incident, it may also cause severe injuries and fatalities.

**Energy Systems***Electricity*

Since electricity is essential to daily life, a power outage can be life-threatening and cause major economic losses. Energy failures can impact vulnerable populations, healthcare facilities, public health, public safety, and the economy.

People most at risk during an electricity failure include seniors, the homebound, young children, individuals with disabilities, those who require power-dependent medical equipment, and people who are dependent on medicines that must be refrigerated. A power outage during hot or cold weather may place people at risk of illness or death due to lack of air conditioning or heat.

People who live in high-rise buildings may be at greater risk during power failures. For example, electric pumps are needed to provide water to upper floors in buildings over six stories. In the event of a power outage, tenants in high-rise buildings may lose water and suffer from dehydration. In addition, elevators in these buildings may cease to function, making evacuation more difficult. Chronically ill or homebound people who live on upper floors of high-rise apartments are especially vulnerable.

Residents of older New York City Housing Authority (NYCHA) developments may be at particular risk. These developments typically consist of high-rise buildings that are more sensitive to power outages and power voltage reductions. Since the population of NYCHA housing is predominantly low-income, outages in these buildings would disproportionately affect low-income New Yorkers. During Hurricane Sandy, approximately 80,000 NYCHA residents in 423 buildings lost power, heat, and/or hot water.

Since power outages impair the operations of health-

care facilities, residents of those facilities can be at greater risk. Loss of power at healthcare facilities may compromise medications that need appropriate temperature control. Disruptions to steam distribution can also be problematic for hospitals that rely on steam to sterilize equipment. During the August 2003 Northeast Blackout, four out of 75 New York City hospitals lost power despite having back-up power generators. Nine years later, during Hurricane Sandy, five healthcare facilities voluntarily evacuated prior to the storm due to concerns of flooding; three additional hospitals evacuated during or after the storm due to the failure of electrical and mechanical systems. In addition, 61 nursing homes and adult care facilities were located in areas impacted by power outages (some due to internal equipment problems) and/or flooding. Approximately half of these facilities were able to continue operating at first, but within a week of the storm, 26 had to shut down and five were partially evacuated.

Power outages can threaten public health. During outages, people who use backup generators, charcoal grills, gas stoves, ovens, and grills indoors improperly for cooking or heating are at risk of carbon monoxide poisoning. Power outages that occur during winter months may prompt people to use equipment inappropriately to generate heat. New York City requires carbon monoxide alarms with battery backup in residences. However, immigrant populations with limited English proficiency may not be aware of this safety requirement and therefore may be at greater risk.

If electricity disruptions affect water and food supplies, the population may be adversely affected. Lack of water for flushing toilets and washing hands compromises sanitation and increases the risk of the spread of communicable disease. According to an independent academic study on the impact of power outages on public health, food-borne illnesses may result from consuming food spoiled due to lack of refrigeration. In August 2003, when the Northeast Blackout occurred, 70% of emergency department visits were for diarrheal syndrome, which was above the normal daily average, and worker absenteeism increased by 29% due to gastrointestinal illness.

The study also found that mortality rates increased during energy failure events. In August 2003, an in-

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crease in both accidental and natural deaths resulted in 90 excess deaths. Researchers theorize that some of the deaths can be attributed to the added physical demands on vulnerable people due to non-functioning elevators, A/C units, and subways; the closure of stores and pharmacies that cut people off from needed supplies and medicines; and exposure to air pollution and warmer temperatures.

In addition, outages may result in civil disturbances impacting public safety. The blackout of 1977, occurring at a time of socioeconomic instability in the city, saw significant looting, disorderly conduct, vandalism, and arson in many areas.

Power disruptions also impact the economy. For example, financial markets and the service industry would all be affected, resulting in lost revenue for the city. Furthermore, electricity failures that cause transportation disruptions may prevent people from going to work, resulting in lost productivity.

#### *Steam*

Steam pipe explosions can cause injuries and fatalities as well as impact air quality. Since asbestos was used to insulate steam pipes when they were constructed in the late 1800s, explosions can release asbestos into the air. This happened during the 1989 steam pipe explosion in Gramercy Park, prompting a vacate order for 200 residents who lived near the site of the explosion. This same explosion also killed two Con Edison employees and a neighborhood resident. In 2007, a steam pipe explosion produced a 40-story-high cloud of flying mud and debris, resulting in one death and 45 injuries. This explosion also caused interruptions in telephone and Internet services, and businesses in the area of the explosion were said to have suffered financial losses of \$30 million.

#### **Telecommunication Systems**

Telecommunications disruptions are damaging to preparedness, response, and relief efforts. These disruptions can be detrimental for the general public and particularly for vulnerable populations during or after an emergency. They could cause failures in emergency messaging and communication to the general public and vulnerable groups, disrupting the ability to send a

text message to a family member or make a 911 call. For example, people harmed or trapped in their homes after a hazard event would have difficulties contacting local emergency services (FDNY or NYPD). This would also cause a breakdown in communication between friends and family networks. It also hinders the ability of first responders to charge equipment, utilize computer networks, and operate communication devices.

During the 9/11 attacks, congestion in the telecommunications system led to breakdowns in response ability. For example, the radio system used by the New York City Emergency Medical Service was damaged due to increased demand on the communications system.

Telecommunication failures can create a flow of misinformation both into and out of the impacted area. It is usually easier to communicate out from a disaster than to reach someone located within an affected area. If people who are located in a disaster area are cut off from communications, they will be less informed. During these occurrences, rumors and false warnings could lead to widespread panic.

#### **Transportation Systems**

Transportation infrastructure failures can have primary and secondary impacts on the population, depending on the severity of the incident. Bridge, roadway, and retaining wall collapses and tunnel leaks may cause injuries and fatalities. The secondary impacts of these failures include transportation disruptions, which would affect people's access to work, education, goods, and services. Low-wage workers are often hardest hit during mass-transit disruptions because a majority of these workers rely on public transportation to get to work. Furthermore, hourly workers lack job security, can easily be replaced, and are less likely to recover from the loss of wages during the disruption.

#### **Water Systems**

Water infrastructure failures affect the population by disrupting water distribution and increasing risks to public health. For example, failures in the distribution system for drinking water could have severe impacts for city residents, particularly vulnerable populations such as the very young, the elderly, or those with compromised immune systems. Since water is needed for

flushing toilets, bathing, and washing hands, water shortages could increase the risk of communicable diseases (see Section 8. Drought). Water infiltration into basements from water main breaks might also cause mold issues. In addition, emergency responders such as members of the FDNY may be hampered in their ability to suppress fires due to water shortages.

The public may also be exposed to contaminated water during a flood or coastal storm if wastewater treatment plants cannot handle the influx of sanitary and stormwater and the system discharges CSOs directly into the local waterways.

### **ii. Built Environment**

#### **Energy, Telecommunication, Transportation, and Water Systems**

Infrastructure failures can impact the built environment in a myriad of ways. Due to the interdependencies of the transportation, water systems, energy, and communications system, impacts on the built environment can reverberate across all sectors. Steam pipe explosions and water main breaks can destroy streets impacting transportation on roadways and disruption in water and energy services. These explosions can also compromise the structural stability of surrounding buildings. For instance, the steam pipe explosion in 2007 inflicted severe damage on the streets and caused several buildings to shake. Natural gas leaks can cause explosions in homes and in major natural gas distribution plants.

### **iii. Natural Environment**

#### **Energy, Telecommunication, Transportation, and Water Systems**

Infrastructure failures may destroy the natural landscape or cause air, land, or water contamination. For example, the release of asbestos during a steam pipe explosion can contaminate the air. Infrastructure failures can cause fires that damage the natural environment. Systems that filter water or air may be interrupted.

Power outages can increase the risk of sewage dis-

charges to surface waters around the city. During the 2003 Northeast Blackout, backup generators at some sewage treatment plants failed, causing the release of untreated sewage into surrounding waters. During Sandy, 10 of DEP's 14 wastewater treatment plants were damaged or lost power. Three of the facilities were non-operational: Coney Island (two hours), North River (seven hours), and Rockaway (three days). As a result, approximately 560 million gallons of untreated sewage mixed with stormwater and seawater and another approximately 800 million gallons of partially treated and disinfected wastewater were released into local waterways.

### **iv. Future Environment**

#### **Energy, Telecommunication, Transportation, and Water Systems**

The impact of infrastructure failures in the future environment will be influenced by aging infrastructure systems, population growth, and climate change. If the city does not continue to invest in new infrastructure or maintain and repair existing infrastructure, failures will continue to occur. Furthermore, as the population grows, the demands on aging transportation, water, energy, and telecommunications infrastructure will increase, amplifying the impacts of failures.

Climate change and sea level rise increase risks. More intense and more frequent coastal storms and floods heighten the probability of more power outages. According to the New York City Panel on Climate Change, in the future more frequent and intense heat waves will likely occur. This will increase the electricity demand, straining electric generation and distribution equipment. Population growth combined with these more frequent and intense weather-related events will place the city at greater risk of infrastructure failures.

Currently much of the city's energy generation, transmission, and distribution infrastructure is in the 100-year floodplain. With sea level rise, flood zones are expected to expand, further compromising the ability of these parts of the system to function. Sea level rise can also pose issues for wastewater treatment plants because they are located along the waterfront at low

elevations.

Although critical telecommunications facilities are generally located farther inland, 13% of these sites are in the 100-year floodplain, according to the Preliminary Flood Insurance Rate Maps (see section 11. [Flooding](#)). Due to climate change and sea level rise, it is projected that by the 2020s the number of facilities in the floodplain will grow to 18% of the total, and by the 2050s it is expected to grow to 24%. Moreover, by the 2050s it is expected that 31 inches of projected sea level rise will occur, increasing the risk of flooding to these facilities.

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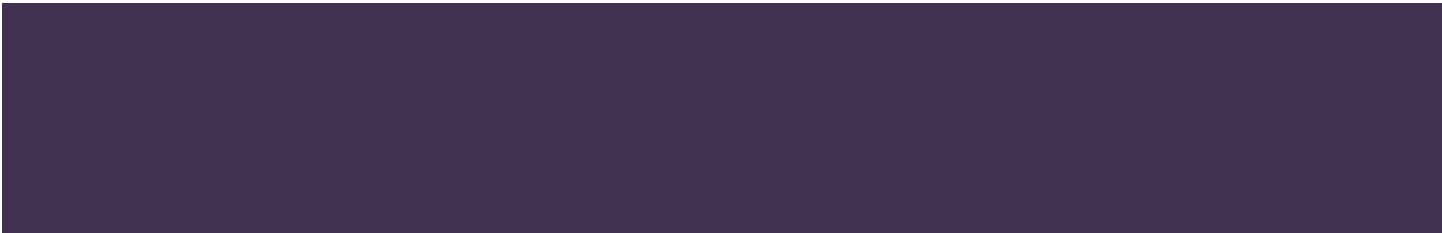
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# CHAPTER 4: MITIGATION STRATEGY



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## 1. Introduction

This chapter presents New York City's Mitigation Strategy, a comprehensive effort to reduce or eliminate potential losses from the 13 hazards described in the Risk Assessment chapter. This Mitigation Strategy includes "existing" and "potential" mitigation actions that will minimize the effects of a hazard event on New York City's population, economy, property, building stock, and infrastructure. It is the result of a coordinated effort by 41 New York City agencies and partners to develop and implement a broad range of inventive and effective ways to mitigate hazards.

New York City's Mitigation Strategy was developed consistent with the process and steps outlined in the Federal Emergency Management Agency (FEMA) [Local Mitigation Plan Review Guide](#) (2011) (website link provided at the end of Chapter 4). This chapter's presentation of the Mitigation Strategy satisfies the following FEMA requirements:

- **FEMA 44 CFR Requirement §201.6(c)(3):** [The plan *shall* include the following:] A mitigation strategy that provides the jurisdiction's blueprint for reducing the potential losses identified in the risk assessment, based on existing authorities, policies, programs, and resources, and its ability to expand on and improve these existing tools.
- **FEMA 44 CFR Requirement §201.6(c)(3)(i):** [The hazard mitigation strategy *shall* include a] description of mitigation goals to reduce or avoid long-term vulnerabilities to the identified hazards.
- **FEMA 44 CFR Requirement §201.6(c)(3)(ii):** [The hazard mitigation strategy *shall* include a] section that identifies and analyzes a comprehensive range of specific mitigation actions and projects being considered to reduce the effects of each hazard, with particular emphasis on new and existing buildings and infrastructure. All plans approved by FEMA after October 1,

2008, must also address the jurisdiction's participation in the NFIP, and continued compliance with NFIP requirements, as appropriate.

- **FEMA 44 CFR Requirement: §201.6(c)(3)(iii):** [The hazard mitigation strategy *shall* include an] action plan, describing how the action identified in paragraph (c)(3)(ii) of this section will be prioritized, implemented, and administered by the local jurisdiction. Prioritization shall include a special emphasis on the extent to which benefits are maximized according to a cost benefit review of the proposed projects and their associated costs.
- **FEMA 44 CFR Requirement: §201.6(c)(4)(ii):** [The plan *shall* include a] process by which local governments incorporate the requirements of the mitigation plan into other planning mechanisms such as comprehensive or capital improvements, when appropriate.

The following New York State Division of Homeland Security and Emergency Services (DHSES) [Hazard Mitigation Planning Standards](#) (2012) (website link provided at the end of Chapter 4) are also addressed in this chapter:

- **NYS Requirement §F2:** Plans developed with State OEM-administered funds *must* document that proposed (or already implemented) projects will protect facilities to a 500-year flood event or the actual worst-damage scenario, whichever is greater.
- **NYS Requirement §F3:** Plans developed with State OEM-administered funds *must* identify potential sites (for the placement of temporary housing units to house residents displaced by disaster; sites within the community suitable for relocation of houses out of the floodplain, or building new houses once properties in the floodplain are razed) and any pre-disaster actions required to make them viable, and in-

clude a letter from the floodplain administrator listing any actions required to ensure conformance with the NYS Uniform Fire Prevention and Building Code, the applicable local floodplain law, etc.

- **NYS Requirement §F4:** Plans developed with State OEM-administered funds *must* identify evacuation routes and shelters (or refer back to such components in an existing valid plan), any pre-disaster actions required to make them viable, evidence of coordination with adjoining communities, and a project lead/point of contact and timetable for implementing new items or revisions.
- **NYS Requirement §F5:** Plans developed with State OEM-administered funds *must* develop a format to describe the projects identified in individual communities; its communities' already-completed projects; and include a list of viable funding sources which must incorporate active web links to the appropriate agency page.

## 2. Developing Goals and Objectives

The first step in developing a hazard mitigation strategy for New York City was to establish goals and objectives. Mitigation goals are general guidelines about what New York City wants to achieve in preventing losses from hazards. Objectives are specific, measurable strategies or implementation steps to achieve those goals. Developing clear goals and objectives helped reinforce New York City's overall purpose for undertaking mitigation planning.

To begin the process, the Planning Team reviewed the goals and objectives from the 2009 New York City Hazard Mitigation Plan. Incorporating input and suggestions from the Mitigation Planning Council Steering Committee (MPCSC), the Planning Team revised and refined the goals and objectives, producing the final five goals and 28 objectives shown in Table 4.1, below. These goals and objectives provide the necessary framework to develop a mitigation strategy. New York City will re-evaluate its goals and objectives during each plan maintenance cycle to ensure they continue to represent New York City's hazard mitigation priorities.



## DEVELOPING GOALS AND OBJECTIVES

### CHAPTER 4: Mitigation Strategy

**Table 4.1: Hazard Mitigation Goals and Objectives**

| <b>Goal 1: Protect public health and safety</b> |  |
|---|--|
| Objective 1.1                                   | Identify and reduce the impacts of hazards on vulnerable populations   |
| Objective 1.2                                   | Improve and promote systems that provide early warning and emergency communications  |
| Objective 1.3                                   | Strengthen state and local building and health code enforcement  |
| Objective 1.4                                   | Train emergency responders   |
| Objective 1.5                                   | Reduce public health risk from natural and non-natural hazards   |
| Objective 1.6                                   | Improve community engagement and outreach by organizations and agencies that provide services to vulnerable/special needs populations  |
| <b>Goal 2: Preserve property</b>                |  |
| Objective 2.1                                   | Implement mitigation programs that protect critical facilities and services and promote reliability of lifeline systems to minimize impacts from hazards, maintain operations, and expedite recovery from an emergency   |
| Objective 2.2                                   | Consider known hazards when identifying a site for new facilities and systems  |
| Objective 2.3                                   | Create redundancies for critical networks such as water, sewer, digital data, power, and communications  |
| Objective 2.4                                   | Adopt and enforce public policies to minimize negative impacts of development and enhance safe construction in high-hazard areas   |
| Objective 2.5                                   | Integrate new hazard and risk information into building codes and land use planning mechanisms   |
| Objective 2.6                                   | Educate public officials, developers, realtors, contractors, building owners, and the general public about hazard risks and building requirements  |
| Objective 2.7                                   | Promote appropriate mitigation actions for all public and privately owned property within the City's jurisdiction including, but not limited to, residential units, commercial structures, educational institutions, health-care facilities, cultural facilities, and infrastructure systems |
| Objective 2.8                                   | Incorporate effective mitigation strategies into capital improvement projects within the city  |
| Objective 2.9                                   | Promote post-disaster mitigation as part of restoration and recovery   |
| Objective 2.10                                  | Encourage the development and incorporation of innovative technological solutions without compromising neighborhood or building character  |
| <b>Goal 3: Promote a sustainable economy</b>    |  |
| Objective 3.1                                   | Form partnerships to leverage and share resources  |
| Objective 3.2                                   | Develop feasible plans to continue critical business operations post-disaster  |
| Objective 3.3                                   | Partner with the private sector, including small businesses, to promote structural and non-structural hazard mitigation as part of standard business practices   |
| Objective 3.4                                   | Educate businesses about citywide contingency planning, targeting small businesses and those businesses located in high-risk areas   |

## DEVELOPING GOALS AND OBJECTIVES

### CHAPTER 4: Mitigation Strategy

|  |  |
|--|--|
| Objective 3.5  | Partner with the private sector to promote employee/employer education about disaster preparedness at work and at home                                 |
| <b>Goal 4: Sustain a healthy environment</b>               |  |
| Objective 4.1  | Advance understanding of the relationship between climate change and natural hazards   |
| Objective 4.2  | Increase social resiliency by improving knowledge about climate-related hazards and promoting adaptive mitigation strategies                           |
| Objective 4.3  | Develop hazard mitigation policies that protect the environment  |
| Objective 4.4  | Promote climate change adaptation strategies that protect against long-term effects on the environment   |
| <b>Goal 5: Encourage public preparedness for disasters</b> |  |
| Objective 5.1  | Improve public outreach and access to hazard information, data, and maps to enhance understanding of natural hazards and the risks they pose           |
| Objective 5.2  | Improve hazard information, including databases and maps, by using the latest available data and scientific analysis about hazards and vulnerabilities |
| Objective 5.3  | Improve public knowledge of hazards and protective measures so individuals are able to appropriately respond during hazard events                      |

### 3. Identification and Analysis of Mitigation Actions

The mitigation actions described in this chapter are the result of a careful identification and analysis process.

#### A. Identification of Mitigation Actions

Mitigation Planning Council (MPC) members identified existing and potential mitigation actions for their respective agencies and organizations that meet the following criteria:

- Reduce or eliminate the risk to human life and property from at least one of the 13 hazards identified in the Risk Assessment chapter
- Fall under one or more of the six FEMA mitigation action categories
- Achieve one or more of the five hazard mitigation goals and 28 objectives

Of the 41 MPC members, 38 submitted initial, preliminary mitigation actions to the Office of Emergency Management (OEM) for inclusion in the Mitigation Strategy. The Mayor's Office for Housing and Recovery (HRO) and the Regional Plan Association (RPA) submitted capabilities (see Table 4.22) and provided guidance throughout the planning process but did not submit mitigation actions; nor did the New York City Office of Management and Budget (OMB), though OMB is involved in the process of determining and overseeing funding for projects submitted by other MPC members. The Planning Team held one-on-one meetings with each MPC member to discuss its proposed mitigation actions in detail and suggest potential changes and additions. The MPC members then submitted final lists of actions to OEM, which resulted in a total of 662 mitigation actions (330 existing and 332 potential) that met the criteria above.

#### i. Mitigation Action Categories

FEMA sets six broad categories for organizing mitigation actions. The Planning Team slightly modified these categories to align more with New York City's built environment. For example, the FEMA category Natural Resource Protection was changed to Coastal/Natural Resource Protection and the FEMA category Structural Projects was changed to Infrastructure Projects. These categories allow mitigation actions to be compared

and provide a standardized method for eliminating unsuitable actions. All mitigation actions identified in New York City's HMP fall within one of the following mitigation action categories, described below:

1. **Prevention and Policy:** Government, administrative, or regulatory actions and processes that influence the way land and buildings are developed and built. These actions also include public activities that reduce hazard losses. Examples of this category include building and construction code revisions, zoning regulation changes, and hazard computer modeling.
2. **Property Protection:** Actions that involve the modification of existing buildings or structures to protect them from a hazard, or removal from the hazard area. Examples: seismic retrofits, roadway elevations, and flood-proofing.
3. **Education and Awareness:** Actions to inform and educate citizens, elected officials, businesses, and property owners about the hazards they face and protective measures they can take to best prepare for or respond to hazards. Examples: programs that target Severe Repetitive Loss properties and vulnerable populations.
4. **Coastal/Natural Resource Protection:** Actions that, in addition to minimizing hazard losses, also preserve or restore the functions of natural or coastal systems. Examples: projects that create open space, greenbelts, Bluebelts, or wetlands.
5. **Emergency Services:** Actions that protect people and property, or increase the capacity of emergency response during and immediately following a disaster event. Examples: enhancements that provide advanced warning and redundant communications.
6. **Infrastructure Projects:** Actions that involve the engineering of infrastructure systems to be more resistant to the impacts of hazards. Examples: projects that control floodwater, reconstruct dams and seawalls, and construct green roofs.

ii. Mitigation Action Summary

Table 4.2 summarizes New York City's mitigation actions by hazard, mitigation action category, and goals/objectives addressed.

Table 4.2: Mitigation Actions Summary Tabulation

| Category   | Existing   | Potential  | Total      |
|--|------------|------------|------------|
| Number of Mitigation Actions                             | 330        | 332        | <b>662</b> |
| <b>Mitigation Actions by Hazard Addressed*</b>           |            |            |            |
| CBRN releases  | 5          | 7          | 12         |
| Coastal erosion  | 2          | 3          | 5          |
| Coastal storms   | 18         | 32         | 50         |
| Cyber threats  | 1          | 2          | 3          |
| Disease outbreaks  | 4          | 1          | 5          |
| Drought  | 8          | 4          | 12         |
| Earthquakes  | 7          | 9          | 16         |
| Extreme temperatures                                     | 13         | 5          | 18         |
| Flooding   | 103        | 75         | 178        |
| Infrastructure failures                                  | 6          | 20         | 26         |
| Severe weather   | 1          | 5          | 6          |
| Wildfires**  | 0          | 0          | 0          |
| Winter storms  | 2          | 2          | 4          |
| Multi-hazard   | 160        | 167        | 327        |
| <b>Total</b>   | <b>330</b> | <b>332</b> | <b>662</b> |
| <b>Mitigation Actions by Category</b>                    |            |            |            |
| Prevention and policy                                    | 118        | 56         | 174        |
| Property protection                                      | 79         | 89         | 168        |
| Public education and awareness                           | 32         | 29         | 61         |
| Coastal/natural resource protection                      | 19         | 10         | 29         |
| Emergency services                                       | 48         | 91         | 139        |
| Infrastructure projects                                  | 34         | 57         | 91         |
| <b>Total</b>   | <b>330</b> | <b>332</b> | <b>662</b> |
| <b>Mitigation Actions by Goal/Objective Addressed***</b> |            |            |            |
| 1.1  | 54         | 94         | 148        |
| 1.2  | 13         | 11         | 24         |
| 1.3  | 18         | 3          | 21         |
| 1.4  | 3          | 3          | 6          |
| 1.5  | 26         | 19         | 45         |
| 1.6  | 9          | 16         | 25         |
| 2.1  | 160        | 228        | 388        |
| 2.2  | 17         | 39         | 56         |
| 2.3  | 112        | 77         | 189        |
| 2.4  | 20         | 16         | 36         |

## IDENTIFICATION AND ANALYSIS OF MITIGATION ACTIONS

### CHAPTER 4: Mitigation Strategy

| Category     | Existing   | Potential  | Total       |
|--------------|------------|------------|-------------|
| 2.5          | 48         | 30         | 78          |
| 2.6          | 5          | 15         | 20          |
| 2.7          | 92         | 123        | 215         |
| 2.8          | 36         | 50         | 86          |
| 2.9          | 15         | 18         | 33          |
| 2.10         | 19         | 30         | 49          |
| 3.1          | 29         | 7          | 36          |
| 3.2          | 3          | 8          | 11          |
| 3.3          | 1          | 25         | 26          |
| 3.4          | 2          | 13         | 15          |
| 3.5          | 1          | 10         | 11          |
| 4.1          | 4          | 4          | 8           |
| 4.2          | 9          | 0          | 9           |
| 4.3          | 54         | 26         | 80          |
| 4.4          | 14         | 20         | 34          |
| 5.1          | 10         | 28         | 38          |
| 5.2          | 21         | 33         | 54          |
| 5.3          | 20         | 18         | 38          |
| <b>Total</b> | <b>815</b> | <b>964</b> | <b>1779</b> |

#### Notes:

\*Since many actions address multiple hazards but are listed here only in connection with a single hazard, actions for each hazard may appear to be underrepresented.

\*\*Although wildfires are not individually addressed by any actions, they are addressed by the multi-hazard actions.

\*\*\*Many mitigation actions address more than one goal and/or objective.

Once existing and potential mitigation actions were identified, they were organized into two separate tables. For both of these tables, projects are assigned an index reference. This reference consists of an abbreviation of the primary hazard addressed (see Table 4.3) followed by a number based on the order in which the action appears in the table.

## IDENTIFICATION AND ANALYSIS OF MITIGATION ACTIONS

### CHAPTER 4: Mitigation Strategy

#### iii. Existing Mitigation Actions

New York City has programs, plans, projects, and policies currently under way to mitigate hazards. These "existing" mitigation actions are either already being implemented or have already been approved and appropriated the necessary funding for implementation. By assessing what the city is currently doing to mitigate hazards, the Planning Team was able to determine how the city might expand or improve upon its hazard mitigation efforts.

Table 4.4 and Table 4.5 describe the types of information detailed in the Existing Hazard Mitigation Actions table (Table 4.6). Each mitigation action is assigned an index value to indicate the hazard addressed and whether it is an existing ("E") or potential ("P") action. The hazards are placed in alphabetical order. Within each hazard, actions are listed according to the alphabetical order of the lead agencies associated with the actions. For example, the mitigation action with the index F.E.1 is the first existing mitigation action that addresses flooding: it is being implemented by Con Ed, the first MPC agency in alphabetical order.

Not included in the Existing Hazard Mitigation Actions table are actions that were listed as "existing" in the 2009 Hazard Mitigation Plan which were either aban-

doned or never implemented. These actions are no longer considered "existing" and appear in a separate table in Appendix B.

**Table 4.3: Hazard Abbreviations for Mitigation Action Tables**

|                       | Hazard                  | Abbreviation |
|-----------------------|-------------------------|--------------|
| <b>Hazards</b>        | CBRN releases           | CB           |
|                       | Coastal erosion         | CE           |
|                       | Coastal storms          | CS           |
|                       | Cyber threats           | CY           |
|                       | Disease outbreaks       | DO           |
|                       | Drought                 | D            |
|                       | Earthquake              | EQ           |
|                       | Extreme temperatures    | ET           |
|                       | Flooding                | F            |
|                       | Infrastructure failures | IF           |
|                       | Multi-hazard*           | MH           |
|                       | Severe weather          | SW           |
| <b>Project Status</b> | Existing                | E            |
|                       | Potential               | P            |

Notes: \*Includes existing or potential actions addressing wildfires.

**Table 4.4: Implementation Key**

| Column Header                        | Description  |
|--------------------------------------|--|
| <b>Action Category</b>               | The FEMA mitigation action category (Prevention, Property Protection, Education and Awareness, Coastal/Natural Resource Protection, Emergency Services, and Infrastructure Projects) |
| <b>Mitigation Action Description</b> | Title and description of the action  |
| <b>Lead</b>                          | The agency that has primary jurisdiction over the mitigation action and the primary point of contact for the mitigation action   |
| <b>Support</b>                       | Supporting entities that will assist in the implementation, funding, or maintenance of the mitigation action   |
| <b>Timeline</b>                      | Estimation of when the project will begin and approximately how long it will take to complete; "ongoing" refers to actions that are either under way or have no definitive end date. |
| <b>Cost Estimate</b>                 | Estimated costs associated with implementing a mitigation action. TBD indicates that the cost has not yet been determined or is currently unknown.                                   |
| <b>Possible Funding Source(s)</b>    | Possible sources of funding including capital funding, grants, and bonds   |
| <b>2009 Action Progress Status</b>   | N/A or blank: New<br>No Change: Action has not changed since the 2009<br>Other text indicates a status update since the 2009 HMP   |
| <b>Goals and Objectives</b>          | Hazard mitigation goals and objectives addressed by the mitigation action  |

**Table 4.5: Funding Sources and Cost Abbreviations**

| Funding Source | Definition  |
|----------------|---|
| AOTPS          | Administrative Other-Than-Personal-Services   |
| CDBG           | Community Development Block Grant   |
| CDBG-DR        | Community Development Block Grant — Disaster Recovery Assistance  |
| CDC PHEP       | CDC Public Health Emergency   |
| CMAQ           | Congestion Mitigation and Air Quality Improvement Program   |
| CTL            | City Tax Levy   |
| FEMA PA        | FEMA Public Assistance  |
| FHWA           | Federal Highway Administration  |
| FTA            | Federal Transportation Administration   |
| FTA-ER         | Federal Transportation Administration — Emergency Relief Program  |
| GIGP           | Green Infrastructure Grant Program  |
| HMGP           | Hazard Mitigation Grant Program   |
| 406            | FEMA grant for repair, restoration, and replacement of facilities damaged due to a presidentially declared natural disaster |
| NYS DHCR       | NYS Division of Housing and Community Renewal   |
| NYS REDC       | NYS Regional Economic Development Council   |
| PDM-C          | FEMA Pre-Disaster Mitigation Competitive Grant Program  |
| RCPGP          | Regional Catastrophic Preparedness Grant Program  |
| SSBG           | Sandy Social Services Block Grant (SSBG) Funding  |
| TAP            | Transportation Alternatives Program   |
| TEP            | Transportation Enhancement Program  |
| TSGP           | Transit Security Grant Program  |
| UASI           | U.S. Department of Homeland Security Urban Area Security Initiative   |
| USDA EWPP      | U.S. Department of Agriculture Emergency Watershed Protection Program   |
| \$ K/M/B       | Thousand/million/billion dollars  |

## IDENTIFICATION AND ANALYSIS OF MITIGATION ACTIONS

### CHAPTER 4: MITIGATION STRATEGY

Table 4.6: Existing Hazard Mitigation Actions

| Index  | Action Category       | Mitigation Action Description   | Lead | Support    | Timeline  | Cost Estimate  | Funding Source(s)         | 2009 Progress Status | Goals and Objectives |
|--------|-----------------------|---|------|------------|---|--|---------------------------|----------------------|----------------------|
| CBRN   |                       |   |      |            |   |  |                           |                      |                      |
| CB.E.1 | Education & Awareness | <b>Pro-bono environmental services:</b> Provide expert services through the NYC Brownfield Partnership.   | OER  | N/A        | In place 1 year                                       | No cost  | Staff time                | N/A                  | 4.3                  |
| CB.E.2 | Prevention & Policy   | <b>NYC Brownfield Cleanup Program:</b> Clean up contaminated properties throughout New York City. Includes installation of vapor mitigation systems, protection of building inhabitants in the event of hazardous materials release; installation of cover systems, providing containment in the event of hazardous materials releases/spills; and groundwater remediation. This will improve groundwater quality for potential use during drought. | OER  | N/A        | In place since January 2011                           | No cost  | Staff time                | N/A                  | 1.1, 2.3, 4.3        |
| CB.E.3 | Property Protection   | <b>NYC Brownfield Incentive Grant (BIG) program:</b> Provide financial assistance to property owners seeking to investigate and clean up contaminated properties.   | OER  | EDC, USEPA | In place 1 year                                       | \$200 K for petroleum assessment and \$1.4 M in cleanup loans and grants | EPA                       | N/A                  | 4.3                  |
| CB.E.4 | Education & Awareness | <b>"Cleaning Up New York City" community education video series:</b> Educate the public about environmental investigation, cleanup, and community protection and engagement during the cleanup process.   | OER  | N/A        | In place 18 months                                    | \$40 K   | Rockefeller Brothers Fund | N/A                  | 4.3, 5.1             |
| CB.E.5 | Education & Awareness | <b>NYC Green Property Certification:</b> Increase public understanding and awareness of cleanup sites by recognizing that cleanup properties are the "safest places in NYC to live and work."   | OER  | EDC        | In place 2 years; funding in place through March 2014 | \$10 K/year  | Rockefeller Brothers Fund | N/A                  | 4.3, 5.1             |



## IDENTIFICATION AND ANALYSIS OF MITIGATION ACTIONS

### CHAPTER 4: MITIGATION STRATEGY

| Index                  | Action Category                               | Mitigation Action Description  | Lead | Support          | Timeline  | Cost Estimate | Funding Source(s)         | 2009 Progress Status           | Goals and Objectives        |
|------------------------|---|--|------|------------------|---|---------------|---------------------------|--------------------------------|-----------------------------|
| <b>COASTAL EROSION</b> |   |  |      |                  |   |               |                           |                                |                             |
| CE.E.1                 | Coastal/<br>Natural<br>Resource<br>Protection | <b>Protection of Rikers Island north shoreline:</b> Rebuild and mitigate the north shoreline. This northerly exposure to the East River is the most vulnerable to erosion.   | DOC  | N/A              | Design began January 2013; construction to be completed by December 2016                        | \$25 M        | City capital budget, FEMA | Project design is 60% complete | 1.1,<br>2.1,<br>2.7         |
| CE.E.2                 | Property<br>Protection                        | <b>Rikers Island north shore administrative modular units:</b> Relocate modular units currently located in a low-lying area on the north shore, which was affected by Hurricane Sandy. Due to proximity to shoreline and temporary nature of construction, Rikers Island trailers are vulnerable to extreme weather events.  | DOC  | N/A              | This project must be implemented in conjunction with the rehabilitation of the north shoreline. | \$19 M        | City capital budget, FEMA | No change                      | 1.1,<br>2.1,<br>2.2,<br>2.7 |
| <b>COASTAL STORMS</b>  |   |  |      |                  |   |               |                           |                                |                             |
| CS.E.1                 | Education &<br>Awareness                      | <b>Urban Waterfront Adaptive Strategies report:</b> Provide a systematic assessment of the coastal flood hazards that face New York City, a thorough survey of coastal protection and adaptation strategies that may be suitable for different shoreline and neighborhood types, and a framework for evaluating coastal protection alternatives. The report is intended to serve as a resource for planners, policymakers, and communities within New York City, the region, and elsewhere in the coastal United States. | DCP  | DPR, DEP,<br>DOB | 2013  | TBD           | TBD                       | N/A                            | 2.7,<br>4.2,<br>4.4         |

## IDENTIFICATION AND ANALYSIS OF MITIGATION ACTIONS

### CHAPTER 4: MITIGATION STRATEGY

| Index  | Action Category        | Mitigation Action Description   | Lead                      | Support   | Timeline                                  | Cost Estimate | Funding Source(s)                                  | 2009 Progress Status | Goals and Objectives |
|--------|------------------------|---|---------------------------|---|---|---------------|--|----------------------|----------------------|
| CS.E.2 | Infrastructure Project | <b>Drainage improvements:</b> Expand use of green infrastructure (street trees, Greenstreets, right-of-way bioswales, etc.), in concert with DDC, DEP, and DPR partners, within the public right-of-way to capture and detain stormwater, thereby reducing loads on sewage treatment plants and consequent combined sewer overflows.  | DOT                       | DDC, DPR, DEP                                   | Ongoing                                   | \$700-750 M   | HMGP, TEP,TAP, City capital budget, Expense budget | Ongoing              | 2.1, 2.3, 2.10, 4.3  |
| CS.E.3 | Property Protection    | <b>Far Rockaway multi-family design competition:</b> Launch competition to enhance resiliency of planned Arverne East project.  | HPD                       | N/A   | Estimated date of completion October 2013 | \$80 K        | Grants   | N/A                  | 2.5, 2.6             |
| CS.E.4 | Property Protection    | <b>Build It Back:</b> Work with private property owners (of small homes and multi-family housing) to secure funds to address storm damage and allow for resiliency upgrades including system and material enhancements or replacements.   | HPD,HRO                   | HRO for 1-4 units, HPD for multi-family housing | 4 years                                   | \$160 M       | Grants   | N/A                  | 1.1, 2.9, 3.1        |
| CS.E.5 | Emergency Services     | <b>Backup generator at Governors Island:</b> Install a standby emergency generator at the Governors Island ventilation building for the Hugh L. Carey Tunnel to provide capacity for pumps and other equipment in case of power outage.   | MTA (Bridges and Tunnels) | N/A   | 1-2 years                                 | \$3 M         | HMGP, seeking 406                                  | N/A                  | 2.3                  |
| CS.E.6 | Infrastructure Project | <b>Mitigation of Hugh L. Carey and Queens Midtown Tunnels:</b> Install flood gates, tunnel plugs, and water-filled barriers; extend plaza retaining walls; protect vulnerable ingress locations and building openings; harden generators with flooding protection; and perform other associated mitigation work. At minimum, ABFE + 1 foot + additional elevation needed to account for wave action (additional study will be needed to complete design). | MTA (Bridges and Tunnels) | N/A   | 2-3 years                                 | \$50 M        | Seeking 406  | N/A                  | 2.1, 2.7, 2.8        |

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| Index   | Action Category        | Mitigation Action Description  | Lead        | Support | Timeline                | Cost Estimate | Funding Source(s)  | 2009 Progress Status | Goals and Objectives |
|---------|------------------------|--|-------------|---------|-------------------------|---------------|--|----------------------|----------------------|
| CS.E.7  | Property Protection    | <b>Harlem River lift bridge:</b> Replace facility houses and circuit break houses at higher elevations to protect from flooding. (Design under way through Sandy ER Program with construction to follow.)  | MTA (MNR)   | N/A     | 2.5 years               | \$5 -10 M     | Sandy Emergency Relief Program-Restoration, MTA Capital budget | N/A                  | 2.1, 2.7             |
| CS.E.8  | Property Protection    | <b>Hudson Line substations (including Riverdale location):</b> Replace and raise substations damaged by Hurricane Sandy to protect from flooding. (Design under way through Sandy ER Program with construction to follow.)   | MTA (MNR)   | N/A     | 2.75 years              | \$40 M        | Sandy Emergency Relief Program-Restoration                     | N/A                  | 2.1, 2.3, 2.7, 2.9   |
| CS.E.9  | Property Protection    | <b>Power and C&amp;S infrastructure improvements:</b> Replace critical power and C&S components damaged by Sandy and protect as feasible. (Preliminary design to be awarded through Sandy ER program with design-build to follow.)                                   | MTA (MNR)   | N/A     | Complete within 5 years | \$237 M       | Sandy Emergency Relief Program-Restoration                     | N/A                  | 2.1, 2.3, 2.7, 2.9   |
| CS.E.10 | Property Protection    | <b>Flood mitigation at MJ Quill, Castleton, Yukon, Casey Stengel, Ulmer Park depots:</b> Relocate equipment to higher levels; install backflow preventers and high-capacity permanent pumps; reinforce/harden openings/entrances and other water-penetration points. | MTA (Buses) | N/A     | TBD                     | TBD           | TBD  | N/A                  | 2.1, 2.7             |
| CS.E.11 | Property Protection    | <b>Flood mitigation at Far Rockaway depot:</b> Relocate equipment to higher elevation; install backflow preventers (10 feet above BFE).  | MTA (Buses) | N/A     | TBD                     | TBD           | TBD  | N/A                  | 2.1, 2.7             |
| CS.E.12 | Infrastructure Project | <b>NYC Clean Soil Bank:</b> Launch full operation of the soil bank for use in elevating grades or creating natural barriers to mitigate impacts of storm surge or sea level rise. This action saves city \$5 M per year; 2% credit of savings to OER to hire staff.  | OER         | Many    | Ongoing                 | \$125 K/year  | Staff time   | N/A                  | 4.3                  |

## IDENTIFICATION AND ANALYSIS OF MITIGATION ACTIONS

### CHAPTER 4: MITIGATION STRATEGY

| Index   | Action Category        | Mitigation Action Description   | Lead          | Support   | Timeline  | Cost Estimate | Funding Source(s)  | 2009 Progress Status | Goals and Objectives |
|---------|------------------------|---|---------------|---|-----------|---------------|--|----------------------|----------------------|
| CS.E.13 | Prevention & Policy    | <b>NYS 2100 Commission:</b> Support the goals of the Commission to protect New York State, consumers, and businesses.   | OLTPS         | N/A   | TBD       | No cost       | TBD  | N/A                  | 3.3, 5.3             |
| CS.E.14 | Prevention & Policy    | <b>Overhead utility lines:</b> Work with utilities and the PSC to harden vulnerable lines against winds.  | OLTPS         | Con Ed, PSC   | TBD       | No cost       | TBD  | N/A                  | 2.1, 2.3, 2.7, 3.1   |
| CS.E.15 | Education & Awareness  | <b>Annual Hurricane Tabletop Exercise:</b> Challenge the agencies to respond to various hurricane scenarios. Response includes restoration, logistics, and communications.  | PSEG          | NYS OEM, Nassau County OEM, Suffolk County OEM, NYC OEM | Annual    | \$25 K        | PSEG   | N/A                  | 1.4                  |
| CS.E.16 | Infrastructure Project | <b>Oakwood Beach (SI) levee and tidegate:</b> Repair the levee and tidegate.  | USACE, NYSDEC | DEP   | 2 months  | \$500 K       | USACE Operations & Maintenance   | N/A                  | 2.7, 2.9             |
| CS.E.17 | Infrastructure Project | <b>Plumb Beach groins and breakwater:</b> Complete work to protect Belt Parkway.  | USACE         | DPR   | 3 months  | \$6 M         | USACE General Investigations study and General Construction funds, City capital budget         | N/A                  | 2.7                  |
| CS.E.18 | Infrastructure Project | <b>Study of South Shore of SI with recommendation for wall and levees:</b> Complete Phase 1 (Ft. Wadsworth to Oakwood Beach) final draft report scheduled for spring 2014. Phase 2 (Great Kills Harbor to Tottenville) is in initial phase. | USACE         | DPR   | 3-6 years | \$300 M       | USACE General Investigations study and General Construction funds, NYSDEC, City capital budget | N/A                  | 2.7, 5.2             |

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| Index                    | Action Category       | Mitigation Action Description   | Lead  | Support  | Timeline  | Cost Estimate                  | Funding Source(s)                                     | 2009 Progress Status | Goals and Objectives |
|--------------------------|-----------------------|---|-------|--|---|--------------------------------|---|----------------------|----------------------|
| <b>CYBER THREATS</b>     |                       |   |       |  |   |                                |   |                      |                      |
| C.E.1                    | Property Protection   | <b>Protection of City's data, systems and services from cyber attack:</b> Install appliances for advanced bandwidth management.   | DoITT | N/A  | 2 years   | \$4.4 M                        | UASI  | N/A                  | 2.1, 2.3             |
| <b>DISEASE OUTBREAKS</b> |                       |   |       |  |   |                                |   |                      |                      |
| DO.E.1                   | Education & Awareness | <b>CUNY stakeholder outreach:</b> Conduct university-wide hazard mitigation and awareness regarding mass prophylaxis initiatives (scope: all 24 CUNY campuses with a population of 450,000+ students). Publish and disseminate information to university stakeholder populations.   | CUNY  | CUNY, DOHMH, New York City Medical Reserve Corps (NYC MRC) | Ongoing, with an annual awareness campaign to university stakeholders | Nominal cost                   | CUNY Central Office (CO) and campus operating budgets | N/A                  | 1.5, 5.1, 5.3        |
| DO.E.2                   | Prevention & Policy   | <b>Maven Electronic Disease Surveillance and Outbreak Management:</b> Install pre-configured surveillance, case management, and electronic workflow software system that supports over 80 reportable conditions including vaccine-preventable diseases, communicable diseases, STDs, and TB. Maven allows for follow-up care and management of cases and contacts, enables outbreak detection and management, and designs architecture for a flexible workflow case management. | DOHMH | DOHMH  | Ongoing need  | Approximately \$800 K per year | UASI, seeking additional funding sources              | N/A                  | 1.1, 1.2, 1.5        |

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| Index          | Action Category     | Mitigation Action Description   | Lead  | Support   | Timeline     | Cost Estimate    | Funding Source(s)                        | 2009 Progress Status | Goals and Objectives |
|----------------|---------------------|---|-------|---|--------------|------------------|--|----------------------|----------------------|
| DO.E.3         | Prevention & Policy | <b>StarLIMS:</b> Invest in state-of-the-art Laboratory Information Management System (LIMS) essential to maintaining and strengthening DOHMH's ability to rapidly perform the laboratory testing required to detect and manage disease outbreaks of significant public health concern. This investment will provide the labs the ability to test for new emerging diseases, provide for OCME integration (electronic interface with the Chief Medical Examiner), and allow more tests to be performed during a biological or terrorist event where mass casualties may occur. | DOHMH | N/A   | Ongoing need | \$500 K per year | UASI, seeking additional funding sources | N/A                  | 1.2, 1.5             |
| DO.E.4         | Emergency Services  | <b>Pandemic plan:</b> Provide guidance in the event of a pandemic outbreak in PSEG's service territory. This plan addresses prevention, response, and recovery due to a pandemic outbreak.  | PSEG  | NYS OEM, Nassau County OEM, Suffolk County OEM, NYC OEM | As required  | TBD              | PSEG, TBD                                | N/A                  | 5.3                  |
| <b>DROUGHT</b> |                     |   |       |   |              |                  |  |                      |                      |
| D.E.1          | Prevention & Policy | <b>Hands-free sensors in restroom sinks:</b> Install during renovations to 55 City-owned buildings.   | DCAS  | N/A   | Ongoing      | \$2 M            | City capital budget                      | No change            | 2.3, 2.10, 4.3       |
| D.E.2          | Prevention & Policy | <b>Low water-use toilets and flush sensors:</b> Install during renovations to 55 City-owned buildings.  | DCAS  | N/A   | Ongoing      | \$2 M            | City capital budget                      | No change            | 2.3, 2.10, 4.3       |

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| Index | Action Category        | Mitigation Action Description  | Lead | Support                           | Timeline  | Cost Estimate  | Funding Source(s)                            | 2009 Progress Status | Goals and Objectives |
|-------|------------------------|--|------|-----------------------------------|---|--|--|----------------------|----------------------|
| D.E.3 | Infrastructure Project | <b>Croton filtration facility:</b> Activate new filtration facility for Croton system. Historically, 10% of the city's average daily water demand has been provided by the Croton system, although in times of drought it may supply significantly more water. The Croton system has been offline since 2008 while the City constructs a water treatment plant to filter the Croton Reservoir. The new filtration facility will allow the system to resume its supply of water to New York City. | DEP  | DPR                               | Plant activation in 2014  | \$145 M  | City capital budget                          | N/A                  | 2.2, 2.3             |
| D.E.4 | Prevention & Policy    | <b>Water Demand Management Plan and water shortage rules:</b> Adopt new plan to conserve water citywide and the rules to impose use restrictions during drought and emergencies.   | DEP  | FDNY, DOE, CUNY, NYCHA, DPR, DCAS | Water shortage rules will be in place by end of 2014. Plan implemented by 2021. | \$146 M  | City capital budget, Agency operating budget | N/A                  | 2.1, 2.3, 4.3        |
| D.E.5 | Prevention & Policy    | <b>Hydrant locking program:</b> Fit critical fire hydrants in the city with locks to limit water usage during a drought.   | DEP  | FDNY                              | Ongoing   | Included in regular agency operations/maintenance (o/m) budget | Agency operating budget                      | No change            | 2.1, 2.3, 2.7, 2.8   |
| D.E.6 | Infrastructure Project | <b>179th Street pumping station rehabilitation:</b> Provide additional redundancy for water supply operations by allowing DEP to move water between the Croton and Catskill/Delaware systems to supplement the local distribution system.  | DEP  | N/A                               | 2023  | \$12 M   | City capital budget                          | No change            | 2.3                  |

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| Index             | Action Category        | Mitigation Action Description  | Lead | Support | Timeline  | Cost Estimate                             | Funding Source(s)        | 2009 Progress Status                 | Goals and Objectives     |
|-------------------|------------------------|--|------|---------|---|---|--------------------------|--------------------------------------|--------------------------|
| D.E.7             | Prevention & Policy    | <b>Gouverneur Healthcare Services facility water conservation:</b> Replace existing water fixtures with new code-compliant low-water-use fixtures.   | HHC  | DASNY   | 4 years   | \$680 K                                   | General obligation bonds | This phase of the project is ongoing | 1.1, 2.1, 2.3, 2.5, 2.8  |
| D.E.8             | Prevention & Policy    | <b>Construction Code revision:</b> Allow the use of waterless urinals as part of an approved water conservation plan.  | DOB  | N/A     | In effect since July 2009   | TBD                                       | Staff Time               | Implemented                          | 1.3, 2.3, 2.5, 2.10, 4.3 |
| <b>EARTHQUAKE</b> |                        |  |      |         |   |   |                          |                                      |                          |
| EQ.E.1            | Property Protection    | <b>Wastewater treatment plant facility seismic retrofit:</b> Retrofit wastewater treatment facilities and methane gas storage systems to withstand seismic activity. Design facilities to meet current building codes (most of the facilities were designed and constructed prior to current seismic standards). | DEP  | N/A     | Ongoing   | Included in regular agency capital budget | City capital budget      | No change                            | 2.4, 2.5, 2.8, 4.3       |
| EQ.E.2            | Infrastructure Project | <b>City Tunnel 3:</b> Construct a seismically resistant and redundant third water tunnel. City Tunnels 1 and 2 currently distribute water to all five boroughs of New York City. These tunnels are nearly 90 and 70 years old, respectively, and have never been taken out of service.                           | DEP  | DDC     | Manhattan section of Phase 2 completed in 2013, Brooklyn and Queens section to be completed in 2023 | \$389 M                                   | City capital budget      | No change                            | 2.3, 2.5                 |
| EQ.E.3            | Prevention & Policy    | <b>Construction Code revision:</b> Require that new critical facilities, such as fire stations and hospitals, be designed with redundant structural systems. (The current code has no such requirement.)   | DOB  | N/A     | In effect since July 2009   | TBD                                       | Staff Time               | Implemented                          | 1.3, 2.1, 2.3, 2.5, 2.7  |



## IDENTIFICATION AND ANALYSIS OF MITIGATION ACTIONS

### CHAPTER 4: MITIGATION STRATEGY

| Index                       | Action Category     | Mitigation Action Description  | Lead                      | Support | Timeline                  | Cost Estimate | Funding Source(s)               | 2009 Progress Status   | Goals and Objectives    |
|-----------------------------|---------------------|--|---------------------------|---------|---------------------------|---------------|---------------------------------|--|-------------------------|
| EQ.E.4                      | Prevention & Policy | <b>Construction Code revision:</b> Update seismic engineering requirements to current national standards. Take into account soil and foundation underpinning. Require seismic detailing and inspections to ensure compliance. This will make new buildings both stronger and more flexible in an earthquake. | DOB                       | N/A     | In effect since July 2009 | TBD           | Staff Time                      | Implemented  | 1.3, 2.1, 2.5, 2.7      |
| EQ.E.5                      | Prevention & Policy | <b>Gouverneur Healthcare Services upgrade:</b> Retrofit existing building to meet new seismic codes.   | HHC                       | DASNY   | Completed                 | \$500 K       | General obligation bonds        | This phase of the project is implemented                               | 1.1, 2.1, 2.5, 2.7      |
| EQ.E.6                      | Property Protection | <b>Ground stabilization:</b> Densify soil beneath the new Patient Pavilion building at Harlem Hospital to reduce the impact of seismic activity.   | HHC                       | DASNY   | Completed                 | 8.5 M         | General obligation bonds        | implemented  | 1.1, 2.1, 2.4, 2.5, 2.7 |
| EQ.E.7                      | Property Protection | <b>Seismic studies and retrofit:</b> Identify and incorporate seismic requirements in bridge and tunnel restoration projects.  | MTA (Bridges and Tunnels) | N/A     | ongoing                   | TBD           | TBD                             | These studies are being done for each facility under various projects. | 2.5, 2.7, 2.9           |
| <b>EXTREME TEMPERATURES</b> |                     |  |                           |         |                           |               |                                 |  |                         |
| ET.E.1                      | Prevention & Policy | <b>Power conservation:</b> Install energy-saving light fixtures in 55 City-owned buildings.  | DCAS                      | N/A     | 5 years                   | \$10 M        | City capital and expense budget | No change  | 2.3, 2.10, 4.3          |
| ET.E.2                      | Prevention & Policy | <b>Peak load management program:</b> Conserve power during summer peak demand hours, usually noon to 6:00 PM, on days designated by NYPA.  | DCAS                      | DDC     | FY 13-22                  | TBD           | Expense budget                  | No change  | 2.1, 2.3, 4.3           |

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|--------|---|--|------|-------------|---------------------------|---------------|---------------------|---|----------------------|
| ET.E.3 | Coastal/<br>Natural Resource Protection | <b>Wastewater treatment tanks upgrade:</b> Increase blower output and maintain diffuser efficiency. During periods of extreme heat, increased levels of dissolved oxygen are necessary for safe and balanced wastewater treatment. The blower sends dissolved oxygen to the tank, and the diffuser distributes it throughout the tank. | DEP  | N/A         | 2023                      | \$25 M        | City capital budget | No change   | 2.1,<br>2.3,<br>2.8  |
| ET.E.4 | Education & Awareness                   | <b>Code Blue and Code Red extended outreach:</b> Coordinate personnel to increase efforts to keep New York City's street homeless population safe during extreme cold and heat events.   | DHS  | DOHMH, NYPD | Ongoing                   | \$120 K       | CTL                 | Implemented:<br>Added Code Red outreach for extreme heat events | 1.1,<br>1.6          |
| ET.E.5 | Prevention & Policy                     | <b>Construction Code revision:</b> Encourage more "cool roofs" installations.  | DOB  | N/A         | In effect since July 2009 | TBD           | Staff time          | N/A   | 1.3,<br>2.5,<br>4.3  |
| ET.E.6 | Prevention & Policy                     | <b>Construction Code revision:</b> Require roof coverings or setbacks with a slope less than a 25% be white or a color rated by EnergyStar as highly reflective. This color shall cover at least 75% of the area of the roof or setback surface to better reflect heat.  | DOB  | N/A         | In effect since July 2009 | N/A           | Staff Time          | Implemented   | 1.3,<br>2.5          |
| ET.E.7 | Prevention & Policy                     | <b>AC Improvements:</b> Install additional and/or upgrade existing AC in various facilities to accommodate different classifications pursuant to requirements imposed under Benjamin litigation.   | DOC  | N/A         | TBD                       | \$20 M        | City capital budget | N/A   | 1.1,<br>1.5,<br>2.5  |
| ET.E.8 | Education & Awareness                   | <b>AC Availability:</b> Secure funding to make air conditioners available to qualified seniors and people with disabilities.   | HRA  | OEM         | 2 Years                   | TBD           | NYS DHCR            | Lead agency changed from DFTA to HRA.                           | 1.1,<br>1.5,<br>1.6  |

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| ET.E.9  | Property Protection | <b>Protection of engines from heat-related damage:</b> Protect engines and prepare for response to heat-related incidents including increased switch, bridge, signal, catenary (MNR only), and track circuit failures, as well as heat kinks.  | MTA (LIRR)  | N/A         | TBD      | TBD           | TBD                        | Ongoing   | 2.1, 2.7             |
| ET.E.10 | Property Protection | <b>Protection of system from heat-related damage:</b> Protect engines, increase pantograph inspections, and prepare for response to heat related incidents including increased switch, bridge, signal, catenary and track circuit failures, as well as heat kinks.   | MTA (MNR)   | N/A         | Complete | TBD           | TBD                        | Implemented                                     | 2.1, 2.3, 2.7        |
| ET.E.11 | Prevention & Policy | <b>Summer operations manual:</b> Write guide on how to perform pre-trip bus inspections to confirm windows and hatches are closed and the air conditioning system is working properly. Provide bus operators with summer uniforms and information about heat stress.   | MTA (Buses) | OEM         | TBD      | TBD           | MTA Buses operating budget | No change                                       | 2.1, 5.2             |
| ET.E.12 | Emergency Services  | <b>Communications Redundant System:</b> Develop communications system with surge protection to allow uninterrupted operation during potential power surges due to rolling black-outs or electrical storms. Additional redundancies include steam generator back-up and "failsoft" computer based protection. | MTA (Buses) | N/A         | TBD      | TBD           | TBD                        | No change                                       | 2.3                  |
| ET.E.13 | Prevention & Policy | <b>Infrastructure protection:</b> Advocate for Con Ed to implement recommendations from the City's report on the northwest Queens power outages. Power outages of this magnitude are often caused by extreme heat events.  | OLTPS       | Con Ed, PSC | 8 years  | TBD           | TBD                        | Completed, recommendations compiled in a report | 2.1, 2.3, 3.2        |

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| <b>FLOODING</b> |                        |  |        |          |          |               |                         |                      |                              |
| F.E.1           | Prevention & Policy    | <b>Mapping of flooding vulnerability data:</b> Evaluate latest flooding information available post-Sandy to potentially update infrastructure maps to more accurately define flooding vulnerability of company assets.   | Con Ed | N/A      | Ongoing  | TBD           | Agency operating budget | No change            | 2.5,<br>2.9,<br>5.2          |
| F.E.2           | Education & Awareness  | <b>Designing for Flood Risk report:</b> Identify key principles to guide the design of new buildings in flood zones to promote construction that can not only withstand coastal flood events, but also supports the vibrancy of the public realm. Recognizing the distinct character and needs of higher-density urban environments, such as New York City, the report provides recommendations for how regulations and individual project design can incorporate resilient design principles. | DCP    | DOB      | 2013     | TBD           | TBD                     | N/A                  | 2.2,<br>2.4,<br>2.5,<br>2.6  |
| F.E.3           | Infrastructure Project | <b>High-level storm sewers:</b> Supplement existing combined sewers with high-level storm sewers in certain areas near the water's edge. High-level storm sewers are able to capture 50% of rainfall before it enters combined sewers, reducing street flooding and combined sewer overflows.  | DEP    | DDC, DOT | Ongoing  | \$255 M       | City capital budget     | No change            | 2.3,<br>2.8,<br>2.10,<br>4.3 |
| F.E.4           | Infrastructure Project | <b>Stormwater sewers in areas of Queens with limited drainage systems:</b> Continue to build out the storm sewer systems in Queens locations in conjunction with DOT street improvements and other community infrastructure projects, including in areas with street flooding.   | DEP    | DOT, DDC | Ongoing  | \$148 M       | City capital budget     | N/A                  | 2.3,<br>2.8,<br>4.3          |

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|-------|---|--|------|---------------------|--|---|------------------------------|----------------------|-------------------------------------|
| F.E.5 | Coastal/<br>Natural<br>Resource<br>Protection | <b>Watershed Protection Program:</b> Acquire land strategically in the watershed and continue stream, farm, and forestry programs.   | DEP  | NYS DEC,<br>NYS DOH | Ongoing.<br>programs<br>are regu-<br>lated under<br>2007-2017<br>Filtration<br>Avoidance<br>Determina-<br>tion | \$286 M   | City capital<br>budget       | N/A                  | 4.3                                 |
| F.E.6 | Property<br>Protection                        | <b>Valve installation/plumbing improvements through enhanced outreach and education:</b> Encourage appropriate installation of check valves and other property protection systems to mitigate flooding risk.   | DEP  | DOB                 | Ongoing  | Funded by<br>property<br>owners                     | TBD                          | No change            | 2.1,<br>2.3,<br>2.7,<br>2.8,<br>5.3 |
| F.E.7 | Property<br>Protection                        | <b>Drainage improvement plan and design:</b> Identify inland flood- and coastal flood-prone areas and determine appropriate improvements to drainage services and levels of stormwater management.   | DEP  | N/A                 | Ongoing  | Included<br>in regular<br>agency<br>o/m bud-<br>get | Agency operat-<br>ing budget | N/A                  | 2.2                                 |
| F.E.8 | Infrastruc-<br>ture Project                   | <b>Sewer infrastructure upgrade:</b> Make regulator improvements for sewer outfalls around East River, Westchester Creek, Hutchinson Creek, Flushing Bay, and Newtown Creek. Improved regulators will control releases from the sewer system during storms, reduce street flooding, and prevent sewer backups.                     | DEP  | N/A                 | Project<br>funded<br>through<br>2015   | \$94 M  | City capital<br>budget       | N/A                  | 2.1,<br>2.3,<br>2.7,<br>2.8,<br>4.3 |
| F.E.9 | Emergency<br>Services                         | <b>Drainage system maintenance and pre-storm inspections:</b> Perform regular maintenance and repair of sewers and catch basins citywide. Perform pre-storm inspections of Bluebelt facilities and targeted areas of the city with potential for flooding to facilitate proper function during normal operations and storm events. | DEP  | DPR, DOT            | Ongoing<br>operation   | Included<br>in regular<br>agency<br>o/m bud-<br>get | Agency operat-<br>ing budget | N/A                  | 2.1,<br>2.3,<br>4.3                 |

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|--------|------------------------|---|------|---------|---|---------------------------------------|-------------------------|---|----------------------|
| F.E.10 | Prevention & Policy    | <b>Dam inspection program:</b> Implement New York City dam inspection program on both monthly and yearly cycles to facilitate appropriate maintenance and attain state of good repair.  | DEP  | N/A     | Ongoing   | Included in regular agency o/m budget | Agency operating budget | No change   | 2.4                  |
| F.E.11 | Prevention & Policy    | <b>Property and infrastructure protection:</b> Prepare large area drainage plans for the following locations that lack a fully built system or require upgrades: southeast Queens, Rockaway Peninsula, Coney Island, and White-stone. These plans will examine and optimize how storm and floodwater is managed in these areas. | DEP  | N/A     | Ongoing   | Included in regular agency o/m budget | Agency operating budget | No change   | 2.2, 2.5             |
| F.E.12 | Education & Awareness  | <b>Stormwater/flooding public outreach and education:</b> Develop school curricula and public outreach materials to educate the public about flooding and stormwater.   | DEP  | N/A     | Ongoing   | Included in regular agency o/m budget | Agency operating budget | No change   | 2.6, 5.1, 5.3        |
| F.E.13 | Infrastructure Project | <b>Sewage pumps upgrade:</b> Replace main sewage pumps with higher-head units to overcome hydraulic resistance created by a flooding event.   | DEP  | N/A     | 2018  | \$26 M                                | City capital budget     | No change   | 2.1, 2.3, 2.7, 2.8   |
| F.E.14 | Prevention & Policy    | <b>Construction code revision:</b> Clarify current flooding regulations and adopt the latest national standards.  | DOB  | N/A     | Mayoral adoption Dec. 2013/<br>law effective Oct. 1, 2014 | TBD                                   | Staff time              | Mayoral adoption Dec. 2013/<br>law effective Oct. 1, 2014 | 2.4, 2.5             |

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| F.E.15 | Prevention & Policy | <b>Construction Code Revision:</b> Require new critical facilities located in flood zones be raised higher than currently required.  | DOB  | N/A            | In effect since July 2009 | TBD           | Staff Time        | Implemented          | 1.3, 2.1, 2.5, 2.7   |
| F.E.16 | Property Protection | <b>Facility protection:</b> Execute flood-elimination capital projects at 20 sites that need long-term solutions for recurring flood damage due to groundwater infiltration.   | DOE  | DOE-SCA        | 1 year                    | TBD           | FEMA              | No change            | 2.1, 2.8             |
| F.E.17 | Property Protection | <b>Protection of NYCDOT facilities from flood impacts:</b> Reconstruct bulkhead at Harper Street facilities; elevate mechanical equipment in flood-prone areas whenever possible; use mold-resistant building materials whenever possible at sites in flood zones; improve stormwater management through measures such as containment systems and green infrastructure (Some individual projects are completed, others are ongoing). | DOT  | DDC, DEP, DCAS | TBD                       | TBD           | TBD               | N/A                  | 2.1, 2.7             |
| F.E.18 | Property Protection | <b>Protection of DOT tunnels in Lower Manhattan (Battery Park Underpass + West Side Underpass) from flooding:</b> Install permanent structures to mitigate against future flooding of the tunnels and damage to its electrical and mechanical systems.   | DOT  | MTA            | 5 years                   | \$7 M         | FHWA              | N/A                  | 2.1, 2.7             |

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| F.E.19 | Coastal/<br>Natural<br>Resource<br>Protection | <b>Wetland or upland habitat restoration:</b> Improve ability of land to absorb and retain water. Prevent flooding and release of silt and dirt into sewers and habitat.        | DPR  | N/A                   | 5 years                                | \$100 K for upland/<br>\$1 M for wetland | HMGP, other grants          | No change                                      | 4.3                  |
| F.E.20 | Prevention<br>& Policy                        | <b>Wetlands protection:</b> Assess vulnerability of existing wetlands and identify additional policies to protect them.   | DPR  | NPS, EDC,<br>DCP, EPA | 8 years                                | TBD                                      | TBD                         | No change                                      | 4.3                  |
| F.E.21 | Emergency<br>Services                         | <b>Sandbagging of all fuel fill ports and man-ways:</b> Prevent water intrusion, thereby ensuring fuel viability for continuity of operations.                                  | DSNY | N/A                   | Duration of<br>emergency/<br>immediate | Staff time                               | TBD                         | N/A  | 2.1,<br>2.3          |
| F.E.22 | Emergency<br>Services                         | <b>Roof drains and gutters:</b> Have garage personnel do inspections and take action to clear roof drains and gutters to ensure facilities are protected from water intrusion.  | DSNY | N/A                   | Duration of<br>emergency/<br>immediate | Staff time                               | TBD                         | N/A  | 2.1,<br>2.7          |
| F.E.23 | Coastal/<br>Natural<br>Resource<br>Protection | <b>Wetlands restoration:</b> Include wetlands restoration as part of waterfront development projects to comply with aesthetic permitting or stormwater management requirements. | EDC  | NYSDEC                | TBD                                    | TBD                                      | NYSDEC, City capital budget | No change                                      | 4.3,<br>4.4          |
| F.E.24 | Coastal/<br>Natural<br>Resource<br>Protection | <b>Flushing Airport wetlands restoration:</b> Implement Flushing Airport Wetlands Mitigation Project in College Point, Queens.  | EDC  | NYSDEC                | TBD                                    | \$6 M                                    | NYSDEC, City capital budget | Currently in design and under review by NYSDEC | 4.3,<br>4.4          |



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| F.E.25 | Property Protection    | <b>Facility protection:</b> Install special waterproofing membrane in the basement of the Gouverneur Healthcare facility to prevent groundwater from entering the building's basement.   | HHC                       | DASNY   | 4 years                    | \$425 K       | General Obligation Bonds                      | This phase of the project is implemented | 1.1, 2.1, 2.7        |
| F.E.26 | Property Protection    | <b>Flood-resistant construction and materials for HPD-assisted projects:</b> Revise construction specifics for substantial rehabilitation and new construction projects.   | HPD                       | N/A     | Estimated completion: 2014 | \$20 K        | CTL   | N/A                                      | 2.4, 2.5             |
| F.E.27 | Property Protection    | <b>Portable generators:</b> Maintain an inventory of portable generators for facility staff to use to operate tradesman tools.   | HRA                       | N/A     | Generators now in storage  | \$6 K         | City capital budget                           | N/A                                      | 1.1, 2.1, 2.3        |
| F.E.28 | Property Protection    | <b>Marine Parkway Bridge protection:</b> Perform substructure and underwater work to prevent damage from flooding, including scour.  | MTA (Bridges and Tunnels) | N/A     | 2 years                    | \$14 M        | City capital budget, applying for 406         | In procurement phase of construction     | 2.1, 2.7, 2.8        |
| F.E.29 | Infrastructure Project | <b>Perimeter protection/drainage improvements and flood barriers for West Side Yard and East River tunnels:</b> Implement improvements for flood protection at these critical facilities.  | MTA (LIRR)                | Amtrak  | TBD                        | \$58.3 M      | Potential FTA Local Priority Resiliency Funds | N/A                                      | 2.1, 2.7, 2.8        |
| F.E.30 | Property Protection    | <b>LIRR critical facilities protection:</b> Define flood elevation criteria required to standardize ongoing and future flood-protection projects throughout the network. Revise LIRR design standards, which would influence future construction projects. | MTA (LIRR)                | N/A     | TBD                        | TBD           | TBD   | N/A                                      | 2.1, 2.5, 2.7        |

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| F.E.31 | Infrastructure Project | <b>Electrification of Tracks 7 and 8 in Long Island City Yard:</b> Allow LIRR to divert more trains to Hunterspoint Avenue station when there is a service disruption at Penn Station/East River tunnels. This allows Manhattan-bound LIRR customers access to Hunterspoint Avenue to connect with #7 subway to Manhattan. Project also restores damaged assets and improves drainage in the yard. | MTA (LIRR)  | N/A              | TBD                    | \$33.8 M      | FTA Pro-Rated Recovery / Local Priority Resiliency | N/A                  | 2.3, 2.9             |
| F.E.32 | Infrastructure Project | <b>Portal floodgates for the East River tunnels:</b> Install flood barriers in lieu of extensive tunneling dewatering improvements.  | MTA (LIRR)  | N/A              | TBD                    | TBD           | TBD  | N/A                  | 2.1, 2.7             |
| F.E.33 | Infrastructure Project | <b>Drainage mitigation in LIRR track system:</b> Design and install stormwater pump stations to relieve major flood-prone areas.   | MTA (LIRR)  | N/A              | Ongoing                | TBD           | MTA capital budget, LIRR operating budget          | Ongoing              | 2.1, 2.3, 2.8        |
| F.E.34 | Prevention & Policy    | <b>Track drainage on the Harlem Line:</b> Install drainage improvements at the Mott Haven Interlocking, located near 149th and 159th Streets in the Bronx, to improve drainage and reduce impact of flooding in this area.   | MTA (MNR)   | N/A              | Completion – 18 months | \$9 M         | MTA capital budget                                 | N/A                  | 2.1, 2.7, 2.8        |
| F.E.35 | Property Protection    | <b>Baisley Park depot drainage improvement:</b> Implement corrective actions to mitigate repetitive flooding caused by moderate to heavy rain.   | MTA (Buses) | DEP, FTA, NYSDEC | 2 years                | \$8 M         | MTA capital budget                                 | No change            | 2.1, 2.7, 2.8        |

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| F.E.36 | Prevention & Policy    | <b>Dewatering of oil-water separators at East New York, Castleton, Michael J. Quill, and Grand Avenue depots:</b> Provide additional capacity for incoming rainwater. Drain 200,000-gallon stormwater retention tank to accept incoming rainwater. (This tank is normally full and used for bus washing.) | MTA (Buses)       | N/A                | Ongoing  | TBD           | TBD                           | No change   | 2.1                  |
| F.E.37 | Infrastructure Project | <b>JFK depot drainage improvement:</b> Include on-site stormwater management improvements at new parking facilities to decrease flow to DEP treatment facilities during high-volume precipitation events.   | MTA (Buses)       | DEP, FTA, NYSDEC   | 2 years  | \$3.234 M     | MTA capital budget            | No change   | 2.1, 2.8             |
| F.E.38 | Prevention & Policy    | <b>NYCT Hurricane Plan:</b> Perform pre-storm flood mitigation actions in pre-identified flood-prone areas. Actions include checking drains, vents, and installed pumps as well as deploying covers and sandbags to pre-identified sites to cover vents and protect subway entrances.                     | MTA (NYCT-Subway) | NJT, PATH (PANYNJ) | Ongoing  | TBD           | TBD                           | Hurricane plan developed and is used as needed and updated periodically | 2.1, 2.7             |
| F.E.39 | Prevention & Policy    | <b>Flood plan:</b> Finalize plan, including mapping of critical areas, mitigation plan, and contingency plan.   | MTA (NYCT-Subway) | DEP                | Ongoing  | TBD           | NYCT- Subway operating budget | Implemented   | 5.2                  |
| F.E.40 | Prevention & Policy    | <b>DEP/NYCT station inspection and cleaning program:</b> Implement program featuring cleaning of catch basins, sewers, and siphons at locations in flood-prone areas.   | MTA (NYCT-Subway) | DEP                | Ongoing  | TBD           | NYCT- Subway operating budget | Ongoing   | 2.1, 2.8             |

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| F.E.41 | Property Protection | <b>Stormwater drainage improvement:</b> Raise vent grating and subway entrances at five locations: (1) Broadway-7th Avenue Line: 77th to 96th Street; (2) Broadway-7th Avenue Line: Chambers Street; (3) 8th Avenue Line: 34th Street; (4) Hill Avenue Line; and (5) Broadway Line.   | MTA (NYCT-Subway) | DEP     | Ongoing   | TBD                            | NYCT operating budget, MTA capital budget | Partially implemented, with balance not currently funded | 2.1, 2.7, 2.8        |
| F.E.42 | Property Protection | <b>Station mitigation:</b> Seal system openings from floodwaters through closure/hardening of stairs, elevators, vents, emergency exits, and manholes. Enhance emergency communication within stations.   | MTA (NYCT-Subway) | MTA/FTA | 2-6 years | \$184 M currently allocated    | FTA-Sandy grants                          | N/A  | 2.1, 2.7             |
| F.E.43 | Property Protection | <b>Line equipment mitigation:</b> Make improvements to pumping system including discharge lines, upsizing of pumps, power redundancy for pumps, mobile pump equipment and generators, and emergency equipment deployment. Harden subway equipment in flood-prone areas including hardening of fans, communication/Electrical Distribution Room (EDR)/relay rooms, subway equipment, and power supply equipment. | MTA (NYCT-Subway) | MTA/FTA | 2-6 years | \$800 M currently allocated    | FTA-Sandy grants                          | N/A  | 2.1, 2.7, 2.8        |
| F.E.44 | Property Protection | <b>Subway structures mitigation:</b> Internally seal tunnels and station complexes through inflatable bladders, pre-engineering, and site mobilization for temporary structures to prevent flood damage along vulnerable service lines.   | MTA (NYCT-Subway) | MTA/FTA | 2-6 years | \$1.8934 B currently allocated | FTA-Sandy grants                          | N/A  | 2.1, 2.7             |

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| F.E.45 | Property Protection | <b>Subway signals and communications mitigation:</b> Make system improvements for subway service flexibility, including major and minor interlocking enhancements for short-turn terminal operations, additional interlocking reconfigurations, power redundancy improvements in underwater tubes, feeder redundancy and/or power storage for critical operations, passenger capacity enhancements at interim terminal stations and stations affected by reduced service levels, and new passenger transfer facilities. Add and enhance communications systems and technologies for improved coordination of emergency response and customer information. | MTA (NYCT-Subway) | MTA/FTA | 2-6 years | \$850 M currently allocated   | FTA-Sandy grants  | N/A                  | 2.1, 2.3, 2.7        |
| F.E.46 | Property Protection | <b>Traction power mitigation:</b> Harden power cables and ducts to provide grid resiliency for critical locations.  | MTA (NYCT-Subway) | MTA/FTA | 2-6 years | \$300 M currently allocated   | FTA-Sandy grants  | N/A                  | 2.1, 2.3, 2.7        |
| F.E.47 | Property Protection | <b>Subway car shops and yards mitigation:</b> Perform flood mitigation at yard complexes, including protection of perimeters and portals.   | MTA (NYCT-Subway) | MTA/FTA | 2-6 years | \$325 M currently allocated   | FTA-Sandy grants  | N/A                  | 2.1, 2.7             |
| F.E.48 | Property Protection | <b>Flood mitigation at varied facilities:</b> Perform mitigation at police, revenue control, and administrative facilities, including backup power and employee emergency reporting flexibility.  | MTA (NYCT-Subway) | MTA/FTA | 2-6 years | \$137.7 M currently allocated | FTA-Sandy grants  | N/A                  | 2.1, 2.3, 2.7        |

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| F.E.49 | Property Protection | <b>Staten Island Railway flood mitigation:</b> Protect critical stations, facilities, and tunnels from flood damage.   | MTA (NYCT-Subway) | MTA/FTA      | 2-6 years | \$100 M currently allocated | FTA-Sandy grants                          | N/A   | 2.1, 2.7             |
| F.E.50 | Property Protection | <b>Incremental standards mitigation:</b> Continue upgrade of design standards to improve resilience to seismic activity, wind, and fire events, and apply to new and existing facilities as capital work is performed. | MTA (NYCT-Subway) | NYCT         | Ongoing   | TBD                         | Core and future capital programs          | N/A   | 2.1, 2.5, 2.7, 2.8   |
| F.E.51 | Property Protection | <b>Stormwater drainage improvement:</b> Install 34 check valves at all direct connections to the City's combined sewer/storm drainage system to prevent backflow into the NYCT drainage system.                        | MTA (NYCT-Subway) | DEP          | 3 years   | TBD                         | NYCT operating budget, MTA capital budget | Implemented   | 2.1, 2.3, 2.7        |
| F.E.52 | Property Protection | <b>Flood mitigation and backup power for OCME Forensic Biology Laboratory:</b> Install emergency generator and transfer switches and elevate petroleum bulk storage.   | OCME              | Con Ed, FDNY | Unknown   | 2.35 M                      | Capital                                   | N/A   | 2.1, 2.3, 2.7        |
| F.E.53 | Property Protection | <b>Flood mitigation and backup power for OCME main office (Manhattan Morgue) at 520 First Ave.:</b> Install emergency generator and transfer switches, elevate petroleum bulk storage, and install flood barriers.     | OCME              | DDC          | Unknown   | \$6.263 M                   | City capital budget                       | N/A   | 2.1, 2.3, 2.7        |
| F.E.54 | Property Protection | <b>Critical facility relocation:</b> Relocate OEM supply warehouse to higher elevation, out of the 100-year floodplain and coastal storm surge zone.   | OEM               | N/A          | 1 month   | \$20 K                      | Agency operating budget                   | Complete. Relocated to 930 Flushing Avenue in Brooklyn. | 2.1, 2.2, 2.3        |

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| F.E.55 | Prevention & Policy    | <b>FEMA 100-year floodplain maps for New York City:</b> Update maps reflecting current weather conditions and topography/bathymetry. | OLTPS | DOB, DCP, EDC, OEM | 8 years  | TBD           | TBD                       | Ongoing              | 5.2                  |
| F.E.56 | Prevention & Policy    | <b>Flood resiliency for buildings in the 100-year floodplain:</b> Improve regulations for new and substantially improved buildings.  | OLTPS | DOB, DCP           | TBD      | No cost       | TBD                       | N/A                  | 2.2, 2.4, 2.5        |
| F.E.57 | Prevention & Policy    | <b>FEMA flood mapping:</b> Work with FEMA to improve the flood-mapping process.  | OLTPS | DOB                | TBD      | No cost       | TBD                       | N/A                  | 3.1, 5.2             |
| F.E.58 | Education & Awareness  | <b>Communication of flood risks:</b> Work with FEMA to improve the communication of current risks.                                   | OLTPS | N/A                | TBD      | \$1 M         | CDBG, HMGP                | N/A                  | 3.1, 5.3             |
| F.E.59 | Prevention & Policy    | <b>Future flood mapping:</b> Explore improved approaches for mapping future flood risks, incorporating sea level rise.               | OLTPS | N/A                | TBD      | No cost       | TBD                       | N/A                  | 4.1, 5.2             |
| F.E.60 | Infrastructure Project | <b>Flood protection in Coney Island:</b> Install armor stone shoreline protection (revetments).                                      | OLTPS | N/A                | TBD      | \$32 M        | CDBG                      | N/A                  | 2.1, 2.5             |
| F.E.61 | Infrastructure Project | <b>Bulkhead improvements:</b> Raise bulkheads in low-lying neighborhoods across the city to minimize inland tidal flooding.          | OLTPS | N/A                | TBD      | \$80 M        | CDBG, City capital budget | N/A                  | 2.1, 2.5             |
| F.E.62 | Infrastructure Project | <b>Hospital Row flood protection:</b> Install an integrated flood protection system.   | OLTPS | N/A                | TBD      | \$60.3 M      | CDBG                      | N/A                  | 1.1, 2.1             |

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| F.E.63 | Prevention & Policy | <b>Comprehensive flood protection study of New York Harbor:</b> Continue to work with the USACE to complete its study.   | OLTPS | N/A     | TBD      | No cost       | TBD   | N/A                  | 5.2                  |
| F.E.64 | Prevention & Policy | <b>USACE comprehensive study:</b> Identify a lead entity for overseeing the collaboration on the study and the implementation of coastal flood protection projects.  | OLTPS | N/A     | TBD      | No cost       | TBD   | N/A                  | 5.2                  |
| F.E.65 | Prevention & Policy | <b>Flood protection project standards:</b> Call on and work with the USACE and FEMA to collaborate more closely on standards.  | OLTPS | N/A     | TBD      | No cost       | TBD   | N/A                  | 2.1, 2.4, 2.5        |
| F.E.66 | Prevention & Policy | <b>Enclosed hazardous substances mitigation:</b> Develop a catalog of best practices for storing hazardous substances in the 100-year floodplain.  | OLTPS | OER     | TBD      | No cost       | TBD   | N/A                  | 1.1, 4.3             |
| F.E.67 | Prevention & Policy | <b>New hospitals:</b> Amend Construction Codes to require a higher level of protection and critical systems redundancy for any new hospital built within the 500-year floodplain.  | OLTPS | N/A     | TBD      | No cost       | TBD   | N/A                  | 1.1, 1.3, 2.5        |
| F.E.68 | Property Protection | <b>Existing hospitals in the 500-year floodplain:</b> Require the retrofitting of hospitals in the 500-year floodplain to meet a subset of the amended Construction Code standards.  | OLTPS | N/A     | 2030     | \$785 M       | FEMA PA, CDBG, HMGP, VA Hospital (partially funded) | N/A                  | 1.1, 1.3, 2.4, 2.5   |
| F.E.69 | Prevention & Policy | <b>New nursing homes and adult care facilities:</b> Amend Construction Codes to require that new facilities be constructed with additional resiliency for emergency power systems, which are essential to allow patients and staff to shelter in place safely during a disaster. | OLTPS | N/A     | TBD      | No cost       | TBD   | N/A                  | 1.1, 1.3, 2.5        |



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| F.E.70 | Property Protection | <b>Existing nursing homes in the 100-year floodplain:</b> Require the retrofitting of existing adult care facilities in the 100-year floodplain to meet standards for the protection of electrical equipment, emergency power systems, and domestic water pumps (if applicable) retroactively pursuant to changes in the Construction Codes. | OLTPS | N/A      | 2030     | \$91 M        | FEMA PA/406 (partially funded) | N/A                  | 1.1, 1.3, 2.4, 2.5   |
| F.E.71 | Property Protection | <b>Existing adult care facilities in the 100-year floodplain:</b> Require existing adult care facilities 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 Construction Codes.                           | OLTPS | N/A      | 2030     | \$1 M         | FEMA PA                        | N/A                  | 1.1, 1.3, 2.4, 2.5   |
| F.E.72 | Prevention & Policy | <b>Affordability issues related to reform of the NFIP:</b> Support federal efforts to address NFIP affordability issues.   | OLTPS | DCP      | TBD      | \$1.1 M       | CDBG                           | N/A                  | 2.4                  |
| F.E.73 | Property Protection | <b>Flood protection standards and certifications:</b> Develop FEMA-endorsed standards and certifications for existing urban buildings.   | OLTPS | DOB, DCP | TBD      | No cost       | TBD                            | N/A                  | 2.4                  |
| F.E.74 | Property Protection | <b>Mixed-use buildings as a building category:</b> Call on FEMA to recognize such buildings as a distinct building category in relation to flood insurance.  | OLTPS | DOB, DCP | TBD      | No cost       | TBD                            | N/A                  | 2.5                  |

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| F.E.75 | Property Protection    | <b>Mitigation credits:</b> Call on FEMA to develop mitigation credits for resiliency measures.   | OLTPS | DOB, DCP | TBD      | No cost       | TBD               | N/A                  | 2.7                  |
| F.E.76 | Prevention & Policy    | <b>Higher deductibles for residential policyholders:</b> Call on FEMA to allow flood insurance policyholders to select higher deductibles.         | OLTPS | DOB, DCP | TBD      | No cost       | TBD               | N/A                  | 2.4                  |
| F.E.77 | Prevention & Policy    | <b>Flood insurance policy awareness:</b> Call on New York State to improve flood insurance policyholder awareness at the point of sale or renewal. | OLTPS | N/A      | TBD      | No cost       | TBD               | N/A                  | 2.4, 5.3             |
| F.E.78 | Education & Awareness  | <b>Flood insurance engagement campaign:</b> Launch an engagement campaign targeting insurers.  | OLTPS | N/A      | TBD      | No cost       | TBD               | N/A                  | 2.4, 5.3             |
| F.E.79 | Infrastructure Project | <b>Dunes on the Rockaway Peninsula:</b> Complete short-term dune improvements.   | OLTPS | N/A      | TBD      | \$9 M         | FEMA              | N/A                  | 2.7, 2.9             |
| F.E.80 | Infrastructure Project | <b>Sea Gate oceanfront protections:</b> Call on and work with the USACE to study additional protections in Sea Gate.                               | OLTPS | N/A      | TBD      | No cost       | TBD               | N/A                  | 2.2, 2.7             |
| F.E.81 | Prevention & Policy    | <b>Coney Island/Brighton Beach nourishment:</b> Continue to work with the USACE to study strengthening the beach nourishment.                      | OLTPS | DPR      | TBD      | No cost       | TBD               | N/A                  | 2.2, 2.7             |
| F.E.82 | Prevention & Policy    | <b>Manhattan Beach oceanfront protections:</b> Call on and work with the USACE to study protections for the Manhattan Beach oceanfront.            | OLTPS | N/A      | TBD      | No cost       | TBD               | N/A                  | 2.2, 2.7             |

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| F.E.83 | Prevention & Policy    | <b>Study of mitigation of inundation risks through Rockaway Inlet:</b> Call for USACE to develop an implementation plan to mitigate inundation risks through Rockaway Inlet in southern Brooklyn and south Queens, exploring a surge barrier and alternative measures. | OLTPS | DEP            | TBD      | No cost       | TBD               | N/A                  | 2.2,<br>2.7                 |
| F.E.84 | Prevention & Policy    | <b>CUNY study and pilot of new technologies for high-rise buildings:</b> Support CUNY launch of study and pilot.   | OLTPS | N/A            | TBD      | No cost       | TBD               | N/A                  | 2.1                         |
| F.E.85 | Prevention & Policy    | <b>Resiliency of private cogeneration facilities:</b> Study options to ensure resiliency of such facilities.   | OLTPS | N/A            | TBD      | No cost       | TBD               | N/A                  | 2.1,<br>2.3,<br>2.7         |
| F.E.86 | Infrastructure Project | <b>Reinforcement of Belt Parkway edge protections:</b> Call for the USACE to develop an implementation plan for the reinforcement of existing Belt Parkway edge protections.   | OLTPS | DOT, DPR       | TBD      | No cost       | TBD               | N/A                  | 2.1,<br>2.7                 |
| F.E.87 | Prevention & Policy    | <b>Flood protection standards for telecommunications equipment:</b> Develop standards for placement of telecommunications equipment in buildings.  | OLTPS | N/A            | TBD      | No cost       | TBD               | N/A                  | 2.1,<br>2.3                 |
| F.E.88 | Prevention & Policy    | <b>Hardening power generators against flooding:</b> Work with power suppliers and regulators to harden key power generators.   | OLTPS | Con Ed,<br>PSC | TBD      | No cost       | TBD               | N/A                  | 2.1,<br>2.3,<br>2.7,<br>3.1 |
| F.E.89 | Prevention & Policy    | <b>Hardening electric transmission and distribution infrastructure:</b> Work with utilities and the PSC to harden key infrastructure against flooding.   | OLTPS | Con Ed,<br>PSC | TBD      | No cost       | TBD               | N/A                  | 2.1,<br>2.3,<br>2.7,<br>3.1 |

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| F.E.90 | Prevention & Policy | <b>Hardening the natural gas system against flooding:</b> Work with utilities, regulators, and gas pipeline operators to harden the natural gas system.   | OLTPS             | Con Ed, PSC             | TBD      | No cost       | TBD                              | N/A                             | 2.1, 2.3, 2.7, 3.1   |
| F.E.91 | Prevention & Policy | <b>Hardening steam plants against flooding:</b> Work with plant operators and the PSC to harden steam plants.   | OLTPS             | Con Ed, PSC             | TBD      | No cost       | TBD                              | N/A                             | 2.1, 2.3, 2.7, 3.1   |
| F.E.92 | Prevention & Policy | <b>Water quality protection:</b> Form interagency best-management practices (BMP) task force. Encourage addition of stormwater BMPs to New York City projects. Currently, stormwater BMPs are included to the extent allowed by the project's budget. Additionally, task force will pilot innovative stormwater BMPs. | OLTPS             | DEP, DOB, DOT, DPR, EDC | 8 years  | TBD           | TBD                              | Completed; resulted in a report | 2.3, 4.3             |
| F.E.93 | Property Protection | <b>Drainage improvements for Pump House # 4 and # 6 at LaGuardia Airport:</b> Upgrade pumps and electrical power supply, and modify structural walks and platform decks.  | PANYNJ (Aviation) | PANYNJ                  | 3 years  | \$7.5 M       | PANYNJ capital budget, HMGP, 406 | N/A                             | 2.1, 2.7             |
| F.E.94 | Property Protection | <b>Backflow preventers at PANYNJ-controlled buildings at JFK Airport:</b> Install backflow prevention devices and water meter upgrades in accordance with the New York State sanitary code and City regulations. Perform water meter upgrades as required.  | PANYNJ (Aviation) | NYC DEP, NYS DEC        | 6 years  | \$19.203 M    | PANYNJ capital budget, HMGP      | No change                       | 2.1, 2.3             |
| F.E.95 | Property Protection | <b>Drainage improvement at JFK Airport:</b> Install synthetic material at two locations at the intersection of runways 4L and 31L to increase permeable surfaces and enhance stormwater runoff capacity.  | PANYNJ (Aviation) | FAA                     | 8 years  | \$29.998 M    | PANYNJ capital budget            | No change                       | 2.1, 2.3             |
| F.E.96 | Property Protection | <b>Drainage improvement at JFK Airport:</b> Retrofit and/or rebuild stormwater outfalls, including replacing terminating section of concrete triple box culvert, to enhance drainage capacity.  | PANYNJ (Aviation) | DEP, NYS-DEC            | 5 years  | \$8.434 M     | PANYNJ capital budget, HMGP      | No change                       | 2.1, 2.3             |

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| F.E.97  | Property Protection | <b>Facility upgrade at JFK Airport:</b> Redesign and retrofit runways 13R-31L, including raising existing grade, modifying existing drainage, and installing new lighting and concrete pavement.                           | PANYNJ (Aviation) | FAA     | 4 years                  | \$218.063 M                            | PANYNJ capital budget            | No change            | 2.1, 2.3             |
| F.E.98  | Property Protection | <b>Storm drainage rehabilitation at LaGuardia Airport, Phase III:</b> Upgrade existing storm drainage pipe system by replacing pipe or installing an inner lining system to eliminate leaks in the stormwater pipe system. | PANYNJ (Aviation) | PANYNJ  | 8 years                  | \$12 M                                 | PANYNJ capital budget, HMGP      | No change            | 2.1, 2.3             |
| F.E.99  | Property Protection | <b>World Trade Center resiliency improvements:</b> Make mitigation improvements to the WTC site, including flood panels and site-wide ejector pumping, to enhance the existing surcharged storm drain system.              | PANYNJ(WTC)       | PANYNJ  | 5 years                  | \$100 M                                | PANYNJ capital budget, HMGP, 406 | N/A                  | 2.1, 2.3             |
| F.E.100 | Property Protection | <b>Temporary flood mitigation measures:</b> Protect substations/equipment flooded during Sandy from future floods until permanent measures are completed.  | PSEG              | N/A     | Completed September 2013 | \$ 850 K for NYC substation protection | 406, CDBG, PSEG                  | N/A                  | 2.1, 2.3, 2.7        |
| F.E.101 | Property Protection | <b>Flood study of Long Island floodplain:</b> Perform study and develop mitigation strategies based on findings.   | PSEG              | NYPA    | Completed December 2013  | \$125 K prorated for NYC substations   | 406, CDBG, PSEG                  | N/A                  | 5.2                  |
| F.E.102 | Property Protection | <b>Flood sensors:</b> Install information-based sensors to aid transmission operations during a flood event.   | PSEG              | N/A     | Completed September 2013 | \$ 120 K for NYC substation detection  | FEMA, CDBG, PSEG                 | N/A                  | 2.3, 2.10, 5.2       |

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| F.E.103                       | Property Protection | <b>Emergency generators for contingency support to flood-damaged substations:</b> Install mobile generators and secure additional capacity to ensure customers in the Rockaways do not experience long power outages should flood-damaged substation equipment fail before it can be replaced.  | PSEG  | N/A     | May 2013 start, December 2014 completion                              | \$3.5 M       | 406, PSEG                                 | N/A                  | 2.3                           |
| <b>INFRASTRUCTURE FAILURE</b> |                     |   |       |         |   |               |   |                      |                               |
| IF.E.1                        | Emergency Services  | <b>Cogeneration equipment at North River Wastewater Treatment Plant:</b> Install cogeneration equipment while hardening electrical assets. Using methane generated by the wastewater treatment process, cogeneration will produce electric power to keep wastewater treatment processes at North River online during power outages or peak summer load periods, when Con Ed may request that the facility reduce its power usage. | DEP   | N/A     | Design complete by 2015; construction timeline pending specifications | \$212 M       | City capital budget                       | N/A                  | 2.1, 2.3, 2.7, 2.8, 2.10, 4.3 |
| IF.E.2                        | Prevention & Policy | <b>Citywide VOIP:</b> Allow users to move to a different location with minimal reconfiguration and have regular phone numbers restored within hours if a City office building becomes inaccessible due to severe impact to both the PBX and Centrex lines.  | DoITT | N/A     | TBD   | \$10 M        | TBD                                       | N/A                  | 2.1, 2.3                      |
| IF.E.3                        | Prevention & Policy | <b>Smart utility location:</b> Explore the feasibility of consolidating utilities within the public right-of-way (e.g. into multi-utility corridors consistently located within the roadway cross-section) to protect them from hazard events and speed response and recovery times.  | DOT   | DDC     | 1 year (consultant study)   | \$500 K       | HMGP, City capital budget, expense budget | N/A                  | 2.1, 2.3                      |

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| IF.E.4              | Prevention & Policy                 | <b>Fuel infrastructure hardening:</b> Call on the federal government to convene a regional working group to develop a fuel infrastructure hardening strategy.  | OLTPS  | N/A     | TBD  | No cost                    | TBD                     | N/A                  | 2.1, 2.7             |
| IF.E.5              | Prevention & Policy                 | <b>Post-emergency restoration for fuel infrastructure:</b> Develop a reporting framework for fuel infrastructure operators to support restoration.   | OLTPS  | N/A     | TBD  | No cost                    | TBD                     | N/A                  | 2.9                  |
| IF.E.6              | Property Protection                 | <b>Breezy Point storm damage restoration:</b> Rebuild power-distribution infrastructure throughout the fire-damaged section of Breezy Point in the Rockaway Peninsula (~ 150 homes)  | PSEG   | N/A     | September 2013 start, November 2013 completion | \$630 K                    | Insurance, FEMA, PSEG   | Implemented          | 2.1, 2.3, 2.9        |
| <b>MULTI-HAZARD</b> |                                     |  |        |         |  |                            |                         |                      |                      |
| MH.E.1              | Emergency Services                  | <b>Improved weather forecasting:</b> Develop and enhance high-resolution weather forecasting technology to forecast weather-caused damage at a micro-geographic level. Utilize various weather parameters (such as rain, wind speed and direction, and temperature) to assist in advance warning capabilities.                 | Con Ed | N/A     | Ongoing  | Approximately \$200 K/year | Agency operating budget | No change            | 1.2, 4.2, 5.2        |
| MH.E.2              | Coastal/Natural Resource Protection | <b>Vegetation Management Program:</b> Continue performing vegetation management to ensure infrastructure, as well as the public, is secure during and after a natural hazard event. Proper pruning and thinning of the tree canopy is important to minimize damage during hurricanes and wind events and cleanup after storms. | Con Ed | N/A     | Ongoing  | Approximately \$5 M/year   | Agency operating budget | No change            | 2.1, 4.3             |
| MH.E.3              | Emergency Services                  | <b>Improved Con Ed communications:</b> Continue to provide and enhance communications on forecasted impact to Con Ed's system and updates on outages to customers, community leaders, and regulators. This includes notifications to customers on life-support equipment.  | Con Ed | N/A     | Ongoing  | TBD                        | Agency operating budget | N/A                  | 1.1, 1.2, 5.3        |

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| MH.E.4 | Prevention & Policy   | <b>Load-reduction programs:</b> Continue contingency and peak shaving demand response programs to mitigate constraint during times of high demand and electric infrastructure failure.   | Con Ed | N/A                            | Ongoing  | TBD           | Agency operating budget  | N/A                  | 2.1                  |
| MH.E.5 | Prevention & Policy   | <b>Con Ed cyber security:</b> Continue ensuring network and data integrity by implementing security measures; limiting access; maintaining traditional fire walls; deploying additional IPS/web and database monitoring technologies; segmenting the network; monitoring cyber attacks; and sharing information with local, state, and federal agencies. | Con Ed | N/A                            | Ongoing  | N/A           | Agency operating budget  | N/A                  | 2.1, 2.3             |
| MH.E.6 | Education & Awareness | <b>CUNY stakeholder outreach:</b> Conduct CUNY university-wide "all-hazards" mitigation training and awareness initiatives (scope: all 24 CUNY campuses with a population of 450,000+ students). Publish and disseminate information to university stakeholder populations.  | CUNY   | CUNY, OEM, FEMA, DHS           | Ongoing, with an annual awareness campaign to university stakeholders                | Nominal cost  | CUNY Central Office (CO) and campus operating budgets, CUNY internal CO and campus staff time, outside agency staff time, where applicable | N/A                  | 5.1, 5.3             |
| MH.E.7 | Emergency Services    | <b>Protection of City's fuel supply:</b> Procure additional mobile fueling trucks, generators, light towers, forklifts, and water pumps to permit the City to harden its own fuel supply infrastructure and put in place emergency fueling operations immediately following a disruption in the supply chain. Light towers have been delivered.          | DCAS   | NYPD, OEM, DSNY, DOT, DPR, DEP | Fuel trucks, forklifts, generators and water pumps are in the specification process. | \$25.8 M      | City capital budget and FY14 expense budget  | N/A                  | 2.1, 2.3, 2.9        |
| MH.E.8 | Emergency Services    | <b>Resiliency of food supply:</b> Expand current pilots to backstop DCAS food procurement to strengthen resiliency and redundancy in case of future climate hazards. DCAS will work so that its supplier contracts for DOC, DYFJ, and HRA (food pantries and soup kitchens) have backstops in place by the end of 2013.                                  | DCAS   | DOC, ACS, HRA                  | Sysco contract available for use currently   | N/A           | Operating/emergency expense funds  | N/A                  | 1.1, 2.1, 2.3        |



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| MH.E.9  | Emergency Services  | <b>City fueling during emergencies:</b> Harden municipal fueling stations and enhance mobile fueling capability to support City government and critical fleets. DCAS is increasing its mobile fueling fleet, negotiating with fuel suppliers and the NY National Guard to enhance emergency fueling operations, and negotiating with the NYPD to prioritize fueling of City vehicles at select retail fueling locations. A new Fuel Operations Playbook was finalized and submitted to the City Council by OEM as required by law. | DCAS | NYPD, OEM, OLTPS, DSNY, DOT, DPR, DEP | Ongoing                                    | \$8.75 M (included in budget for MH.E.7) | DCAS capital budget | N/A  | 2.1                  |
| MH.E.10 | Emergency Services  | <b>Inter-agency fueling:</b> Support inter-agency fueling city-wide through fuel-management system. DCAS is currently implementing the EJ Ward fuel-tracking system citywide. Agencies will have the ability to fuel at other agency locations and track fuel reserves electronically.   | DCAS | N/A                                   | Technology will be rolled out over FY 2014 | \$6.75 M                                 | DCAS capital budget | N/A  | 2.1, 3.1             |
| MH.E.11 | Emergency Services  | <b>Fuel rationing:</b> Develop and maintain a fuel-rationing plan and package of regulatory waivers and modifications that would be put in place immediately after a mayoral declaration of a liquid fuels shortage by the mayor.  | DCAS | OLTPS, OEM                            | Complete                                   | TBD                                      | TBD                 | Implemented and included in emergency fueling operations playbook          | 2.1, 2.3             |
| MH.E.12 | Prevention & Policy | <b>Green zoning regulations:</b> Remove impediments to the construction and retrofit of green buildings and promote sustainable and resilient stormwater management through green and blue roofs, the use of permeable pavement, residential streetscape preservation, yard and open space enhancements, and green standards for parking lots. Additionally, regulations allow greater flexibility for location of boilers and cogeneration facilities on rooftops, increasing a building's resiliency during a disaster.          | DCP  | DOB                                   | 2011                                       | TBD                                      | TBD                 | Implemented; City Council adopted Zone Green Text Amendment April 30, 2012 | 2.3, 4.3             |

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| MH.E.13 | Prevention & Policy | <b>Open Industrial Uses Study:</b> Promote a more sustainable and resilient working waterfront by assessing cost-effective, pollution-prevention controls for unenclosed industrial facilities. The study also recommends stronger safeguards for open activities and the storage of hazardous and non-hazardous materials along the waterfront and in flood zones.  | DCP  | EDC, DEP, DSNY, OLTPS, OER, DOB | 2013                                    | TBD           | TBD               | N/A                  | 2.4, 4.3             |
| MH.E.14 | Prevention & Policy | <b>Parking lot stormwater management:</b> Promote the greening of new and expanded commercial parking lots of more than 18 spaces, or 6,000 square feet, by requiring landscaping, perimeter screening, street tree planting, minimum percentage of planting in front yards, and maneuverability standards based on the lot size. In keeping with PlaNYC sustainability goals, the new regulations, approved in 2007, will assist in effectively managing stormwater runoff, cooling the air, reducing the heat island effect, improving vehicular circulation, and enhancing the public realm by visually improving unsightly expanses of pavement. | DCP  | DPR, DEP                        | 2008                                    | TBD           | TBD               | Implemented          | 2.3, 4.3, 4.4        |
| MH.E.15 | Prevention & Policy | <b>Hazard mitigation planning and zoning:</b> Examine ways to incorporate hazard mitigation goals into City-sponsored rezoning initiatives. A number of rezonings with waterfront and floodplain components have been adopted, including Greenpoint/Williamsburg, Coney Island, and Hunter's Point. These rezonings incorporate goals established in the Waterfront Revitalization Program (WRP), increase open space along the waterfront, and encourage flood resilient construction in new development.   | DCP  | N/A                             | WRP - 2002 and 2012 revisions, HMP 2009 | TBD           | TBD               | Implemented          | 2.2, 2.7, 4.3        |

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| MH.E.16 | Coastal/<br>Natural<br>Resource<br>Protection | <b>Waterfront open space:</b> Promote the preservation and development of waterfront open space. Pursuant to Policy 8 of the Waterfront Revitalization Program (WRP), the development of public open space along the waterfront is promoted through public and private initiatives. This effort increases biodiversity and natural assets while supporting flood resiliency efforts by mitigating the impact of sea level rise, erosion, subsidence, and other flood risks.  | DCP  | DPR, DEP | 2002                                | TBD           | TBD               | Implemented          | 2.2,<br>4.3          |
| MH.E.17 | Prevention<br>& Policy                        | <b>Waterfront Revitalization Program consistency:</b> Review discretionary projects for consistency with the City's Waterfront Revitalization Program (WRP). Policy 6 of the WRP establishes a goal of "minimizing loss of life, structures and natural resources caused by flooding and [coastal] erosion," and impacts decisions regarding all discretionary review of development on the waterfront and in the 100-year floodplain. Policy 5 protects water quality in coastal areas by ensuring wetlands and natural areas, which are critical buffers against flood hazards, receive sufficient quantities of water to sustain or improve their functioning. The WRP revisions proactively advance resiliency by incorporating climate change and emergency preparedness considerations into its Coastal Zone Management Program. | DCP  | N/A      | WRP - 2002<br>and 2012<br>revisions | TBD           | TBD               | Implemented          | 2.1,<br>2.2,<br>4.3  |
| MH.E.18 | Prevention<br>& Policy                        | <b>Front yard planning requirements:</b> Prevent excessive paving of front yards. Require a minimum percentage of all front yards be landscaped, prohibit steeply pitched driveways in front yards, and encourage rear-yard garages to maximize planting area in the front yard. This package of regulations mitigates stormwater run-off, reduces surrounding temperatures, and enhances the attractiveness of neighborhood streets while furthering PlaNYC sustainability goals.   | DCP  | DPR, DEP | 2008                                | TBD           | TBD               | Implemented          | 2.3,<br>4.3,<br>4.4  |

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| MH.E.19 | Coastal/<br>Natural<br>Resource<br>Protection | <b>Street tree requirements:</b> Require planting of one street tree for every 25 feet of street frontage of the zoning lot for new developments, major enlargements, and certain use conversions. Each lot is subject to a minimum of one street tree. This zoning resolution establishes requirements for sidewalk planting strips in lower-density residential districts. These zoning regulations, adopted into law on April 30, 2008, support PlaNYC goals for increased street tree canopy, air quality improvement, and stormwater management. They also help reduce the urban heat island effect.  | DCP  | DPR, DEP | 2008                       | TBD           | TBD  | Implemented                               | 2.3,<br>4.3,<br>4.4                  |
| MH.E.20 | Prevention<br>& Policy                        | <b>Waterfront planning and zoning:</b> Prepare comprehensive waterfront plan to establish citywide and site-specific guidelines for regulating development at the water's edge. In 2012, DCP proposed a set of revisions that advances sustainability and climate resilience planning along the waterfronts, making New York City one of the first major cities in the U.S. to incorporate climate change considerations into its Coastal Zone Management Program. The revisions will also promote a range of ecological objectives and strategies, facilitate interagency review of permitting to preserve and enhance maritime infrastructure, and support a sustainable working waterfront. | DCP  | DPR, DEP | 1992, 2009,<br>and 2012    | TBD           | TBD  | Implemented;<br>2012 revisions<br>pending | 2.2,<br>4.3                          |
| MH.E.21 | Coastal/<br>Natural<br>Resource<br>Protection | <b>Green infrastructure:</b> Construct green infrastructure to capture the first inch of runoff in 10% of impervious surfaces citywide in areas within the combined sewer system by 2030. Green infrastructure is constructed primarily to reduce combined sewer overflows but can also mitigate flooding and the urban heat island effect.  | DEP  | DPR, DOT | Ongoing<br>through<br>2030 | \$1.026 B     | City capital<br>budget, private<br>developers,<br>HMGP | N/A                                       | 2.7,<br>2.8,<br>2.10,<br>4.3,<br>4.4 |

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| MH.E.22 | Coastal/<br>Natural<br>Resource<br>Protection | <b>Bluebelts:</b> Implement and accelerate Bluebelt drainage program to preserve and enhance natural areas such as streams, ponds, and other wetlands.  | DEP  | DPR     | Ongoing                                | \$360 M       | City capital budget, HMGP, EWPP | Action F.E.15 from 2009 HMP is folded into this action | 2.3, 2.8, 2.10, 4.3  |
| MH.E.23 | Infrastructure Project                        | <b>Interconnection between the Catskill and Delaware Aqueducts:</b> Construct the Shaft 4 connection, a new engineered connection between the Catskill and Delaware Aqueducts at the Delaware Aqueduct's Shaft 4 location, where the two aqueducts cross. This connection will allow DEP to divert Delaware system water into the Catskill Aqueduct, thereby allowing DEP to reduce the flow of water from Ashokan Reservoir when turbidity is elevated while still maintaining sufficient flow to provide service to outside communities and meet overall demand. This increases operational flexibility, reduces turbidity levels entering Kensico, and improves water quality for outside communities. | DEP  | N/A     | Project complete in 2015               | \$21 M        | City capital budget             | N/A  | 1.5, 2.3, 4.3        |
| MH.E.24 | Property Protection                           | <b>Bridge reconstruction and stabilization:</b> Reconstruct and stabilize DEP-owned bridges and culverts located in the Croton, Catskill, and Delaware watersheds. Adhere to NYSDOT bridge safety standards to meet 50-year storm event design standards and withstand seismic loading.   | DEP  | N/A     | Ongoing project scheduled through 2022 | \$233 M       | City capital budget             | N/A  | 2.4, 2.5, 2.7, 2.8   |

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| MH.E.25 | Infrastructure Project | <b>Dam reconstruction:</b> Reconstruct seven high-hazard dams to safely pass the probable maximum flood criteria in accordance with NYS dam safety guidelines and withstand seismic loading based on NYSDEC seismic guidance. The following dams are being reconstructed: Gilboa Dam (impounding Schoharie Reservoir), Olivebridge Dam (impounding Ashokan Reservoir), New Croton Dam (impounding New Croton Reservoir), Cannonsville Dam (impounding Cannonsville Reservoir), Merriman Dam (impounding Rondout Reservoir), Downsville Dam (impounding Pepacton Reservoir) and Neversink Dam (impounding Neversink Reservoir). | DEP  | N/A     | Ongoing project scheduled through 2023 | \$352 M                               | City capital budget     | No change            | 2.4, 2.5, 2.7, 2.8   |
| MH.E.26 | Infrastructure Project | <b>Drainage improvements:</b> Develop plan for drainage enhancements based on flooding and sewer backup issues.  | DEP  | N/A     | Ongoing                                | Included in regular agency o/m budget | Agency operating budget | No change            | 2.1, 2.3, 2.8, 4.3   |
| MH.E.27 | Emergency Services     | <b>Mapping and analysis enhancement:</b> Continue to leverage GIS data with modeling capabilities to provide information on areas experiencing issues, faster diagnostics of issues, and alternative analysis to weigh benefits of potential mitigation actions.   | DEP  | N/A     | Ongoing                                | Included in regular agency o/m budget | Agency operating budget | No change            | 2.10, 5.2            |
| MH.E.28 | Property Protection    | <b>Facility and infrastructure protection:</b> Reconstruct and harden sludge-vessel docks and piping to ensure continuity of treatment and protection of marine fleet assets.  | DEP  | N/A     | 2023                                   | \$20 M                                | City capital budget     | No change            | 2.1, 2.7             |
| MH.E.29 | Education & Awareness  | <b>Public education on emergency preparedness and hazard mitigation actions:</b> Develop and conduct educational forums or seminars.   | DFTA | OEM     | 2 years                                | \$10 K                                | TBD                     | No change            | 1.1, 1.6, 5.3        |

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| MH.E.30 | Education & Awareness | <b>Public outreach to seniors:</b> Increase enrollment in Carrier Alert program to prepare seniors to meet the challenges of disasters.   | DFTA | Alzheimer's Foundation, HRA, MOPD, NYPD, USPS | 2 years  | TBD           | Agency operating budget | No change               | 1.1, 1.6, 5.3        |
| MH.E.31 | Education & Awareness | <b>Emergency planning and hazard mitigation literature:</b> Reach 45,000 clients with literature in multiple languages.   | DFTA | OEM, DOHMH                                    | 2 years  | \$15 K        | TBD                     | N/A                     | 1.1, 1.6, 5.3        |
| MH.E.32 | Emergency Services    | <b>Communications equipment:</b> Purchase/obtain (through DoITT) 600 radios to provide redundant 800 MHz communications to support agency and citywide communications. Develop pre-event radio operations training program. | DHS  | OEM, HHC, DOHMH                               | Ongoing  | \$600 K       | TBD                     | No change               | 1.1, 1.2, 2.3        |
| MH.E.33 | Emergency Services    | <b>Park Slope Armory garage facility improvements:</b> Centralize emergency supply storage and logistics hub to support agency and citywide emergency operations.   | DHS  | N/A   | Ongoing  | \$250 K       | TBD                     | N/A                     | 1.1, 2.1             |
| MH.E.34 | Prevention & Policy   | <b>Existing building code revision:</b> Develop a building code that will promote the inclusion of natural hazard mitigation measures into existing building design and retrofit projects.                                  | DOB  | N/A   | TBD      | \$475 K       | Agency operating budget | No change               | 2.5                  |
| MH.E.35 | Prevention & Policy   | <b>Interagency coordination:</b> Participate in regular interagency coordination with OEM to discuss natural hazard mitigation.   | DOB  | OEM   | Ongoing  | Staff time    | Agency operating budget | No change               | 3.1                  |
| MH.E.36 | Prevention & Policy   | <b>DOB staff development:</b> Participate in natural hazard mitigation code and standards development by sending staff to national events and training sessions that focus on seismic, wind, and flood codes.               | DOB  | N/A   | Ongoing  | \$25 K        | Agency operating budget | Implemented and ongoing | 2.6                  |
| MH.E.37 | Prevention & Policy   | <b>DOB training:</b> Send staff to national training sessions and seminars on hazards and mitigation practices.   | DOB  | N/A   | Ongoing  | \$25 K        | Agency operating budget | Implemented and ongoing | 2.6                  |

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| MH.E.38 | Prevention & Policy | <b>Construction Code revision:</b> Develop Construction Code amendments to reduce energy demand and reliance on fossil fuels as part of PlaNYC. These amendments will apply to existing and new buildings and in some cases may result in energy reductions beyond the requirements of the Energy Conservation Construction Code of New York State. Review literature on how climate change will impact New York City, and review provisions developed by other jurisdictions to mitigate the anticipated effects of climate change. | DOB  | OLTPS   | 2 years                   | \$5.8 M       | Agency operating budget | Implemented and ongoing | 2.5, 4.1, 4.3        |
| MH.E.39 | Emergency Services  | <b>Advanced warning system:</b> Provide advanced warning of wind and other weather hazards to registered construction superintendents, site safety managers, and the media. This system will allow construction sites to take mitigating steps prior to the onset of hazardous weather.  | DOB  | N/A     | Completed and in effect   | TBD           | Staff Time              | Implemented             | 1.2, 1.3             |
| MH.E.40 | Prevention & Policy | <b>Construction Code revision:</b> Enhance connectivity requirements for structural components. These changes will increase the structural integrity of new buildings, allowing them to better withstand an unanticipated event.   | DOB  | N/A     | In effect since July 2009 | TBD           | Staff Time              | Implemented             | 1.3, 2.5             |
| MH.E.41 | Prevention & Policy | <b>Construction Code revision:</b> Introduce "importance factors" into the design of new critical facilities, power generating facilities, water treatment plants, and buildings where 300 people or more congregate in one area. Importance factors increase the design seismic, snow, and wind loads of a structure to prevent catastrophic collapse.  | DOB  | N/A     | In effect since July 2009 | TBD           | Staff Time              | Implemented             | 1.3, 2.5, 2.7        |
| MH.E.42 | Prevention & Policy | <b>Construction Code revision:</b> Provide fee rebates to encourage construction of sustainable buildings.   | DOB  | N/A     | Completed and in effect   | TBD           | Staff Time              | Implemented             | 1.3, 2.5             |
| MH.E.43 | Prevention & Policy | <b>Construction Code revision:</b> Require overflow drains to protect roof structures if primary roof drains fail. The structural load of accumulated rainwater will be accounted for in roof design.  | DOB  | N/A     | In effect since July 2009 | TBD           | Staff Time              | Implemented             | 1.3, 2.5             |



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| MH.E.44 | Emergency Services  | <b>Cogeneration plant:</b> Install cogeneration plant to reduce reliance on Con Ed power while complying with the GreenNYC Plan for DOB.   | DOC   | N/A      | Completion by December 2014 | \$125 M   | City capital budget             | Project construction 60% complete. Planned construction completion December 2014 | 1.1, 2.3, 2.10, 4.3  |
| MH.E.45 | Property Protection | <b>Emergency power upgrades and replacements:</b> Install emergency generator ports to allow immediate portable generator installation. Purchase 10 900KW portable generators.   | DOC   | N/A      | TBD                         | \$15 M  | City capital budget             | N/A  | 1.1, 2.3, 2.7        |
| MH.E.46 | Emergency Services  | <b>Redundant communications:</b> Establish a redundant emergency communications system.  | DOE   | OEM      | 2 years                     | \$5 M   | FEMA                            | No change  | 2.3                  |
| MH.E.47 | Emergency Services  | <b>NYC Community Air Survey (NYCCAS):</b> Collect integrated air quality data in response to emergencies and environmental hazards including combustion emissions, structural fires or brush fires, demolition and debris removal from storm damaged areas, and extensive use of temporary generators and boilers following widespread utility disruption. Use real-time ambient fine particulate matter (PM2.5) monitors to enhance agency preparedness capabilities. | DOHMH | DPR, DEP | Since 2008                  | \$200 K/year for staffing, equipment maintenance, and data communications | Staff time, grants              | N/A  | 1.5, 5.2             |
| MH.E.48 | Emergency Services  | <b>Citywide health and safety program for large-scale emergencies:</b> Coordinate the development of an Incident Health & Safety Plan using the Citywide Health & Safety Plan (CHASP) as a model. The new plan would provide multi-agency health and safety guidance during large-scale emergencies. Program also provides training and symposia for City agencies to build capacity and disaster preparedness.  | DOHMH | N/A      | Ongoing                     | TBD   | Agency operating budget, grants | N/A  | 1.1, 1.2, 1.5        |

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| MH.E.49 | Emergency Services    | <b>Environmental emergency preparedness:</b> Develop risk characterization and communication; training for multi-agency biological incident environmental sampling teams and guidance for emergency response staff; guidance and plans for biological and radiological remediation for agencies and other stakeholders including building owners, employers, and the public.  | DOHMH | N/A   | Ongoing      | TBD                          | Agency operating budget, grants   | N/A                  | 1.1, 1.2, 1.4, 1.5   |
| MH.E.50 | Prevention & Policy   | <b>Real-time surveillance of health outcomes:</b> Utilize data about health-related behaviors that are already stored in an electronic format for syndromic surveillance, i.e., recognizing diseases based on signs and symptoms.   | DOHMH | FDNY, 59 of 61 NYC hospital emergency departments, OCME   | Ongoing need | Approximately \$2 M per year | Currently funded by CDC PHEP and Epi and Lab capacity grants. Long-term funding sources are needed. | Ongoing              | 1.1, 1.5             |
| MH.E.51 | Emergency Services    | <b>Public health information for healthcare providers:</b> Disseminate information, checklists, and specific guidance and provide timely and accurate health alerts, advisories, and updates to healthcare providers and agencies that provide services to vulnerable populations on extreme weather events and other environmental hazards like pollen, air pollution, and vector-borne disease. Use the Health Alert Network, Dialogic NXT Communications System, and blast fax to assist them in preparing themselves to protect their clients during extreme events and improve messaging coordination. | DOHMH | DFTA, OEM, HRA, organizations in the Health Alert Network | Ongoing      | TBD                          | Agency operating budget, staff time   | No change            | 1.1, 1.2, 1.5, 1.6   |
| MH.E.52 | Education & Awareness | <b>Public health risk communication for the general public:</b> Raise public awareness on how to reduce or prevent illness and mortality from extreme weather events and other environmental hazards including air pollution and environmental exposures (such as carbon monoxide releases, mold, toxic spills, and other toxic releases). Use 311, nyc.gov, printed materials, media, and public forums and presentations.   | DOHMH | NWS, OEM, DFTA, HRA                                       | Ongoing      | TBD                          | Agency operating budget, staff time   | No change            | 1.5, 5.3             |

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| MH.E.53 | Emergency Services    | <b>Interagency field and environmental data gathering and exchange:</b> Facilitate environmental data capture, exchange, and storage among government agencies using web-based data systems. Interagency data exchange supports timely identification and characterization of potential hazards and provides a means to mitigate impacts of natural disasters and emergencies.  | DOHMH | OEM, FDNY, DEP                    | Ongoing                                  | TBD                                     | Staff time, grants | No change            | 1.5, 3.1, 5.2        |
| MH.E.54 | Education & Awareness | <b>Interagency environmental data workshop:</b> Host annual conference to improve interagency coordination, promote best practices, and introduce emerging tools for data sharing, risk analysis, and vulnerability assessment.   | DOHMH | OEM                               | Ongoing                                  | TBD                                     | Staff time, grants | No change            | 1.5, 3.1, 5.2        |
| MH.E.55 | Prevention & Policy   | <b>Health Code revisions:</b> Examine the New York City Health Code to identify what elements can be revised to bolster natural hazard mitigation and improve public safety and health during extreme weather events.   | DOHMH | N/A                               | Ongoing                                  | TBD                                     | Staff time         | No change            | 1.1, 1.3, 1.5        |
| MH.E.56 | Prevention & Policy   | <b>Climate change and public health assessment:</b> Assess health risks of climate-related events, conduct vulnerability assessments, implement enhanced surveillance systems for climate-sensitive conditions, and promote climate-health strategies and interventions.  | DOHMH | N/A                               | 3-year program, just renewed for 3 years | \$173 K-\$250 K/year (not fully funded) | Grants             | N/A                  | 1.1, 1.5, 4.2        |
| MH.E.57 | Education & Awareness | <b>Climate and health community resilience:</b> Conduct workshops and disseminate public health information and educational tools through community stakeholders, professional associations, faith-based coalitions, and agencies that provide services to vulnerable populations (children, seniors, inmates, the homeless, and the mentally ill). Workshops provide targeted instruction on how to reduce illness and mortality impacts of extreme weather on affected populations. | DOHMH | DFTA, OEM, HRA, external partners | 3-year program, just renewed for 3 years | \$173 K-\$250 K/year (not fully funded) | Grants             | N/A                  | 1.1, 1.5, 1.6, 4.2   |

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| MH.E.58 | Education & Awareness  | <b>Environmental health tracking portal:</b> Facilitate environmental data dissemination to the public using web-based data systems. Data dissemination supports community preparedness, public education, and characterization of potential environmental hazards.  | DOHMH | OLTPS    | 3-year program currently on its third year | \$753 K       | Grants, staff time   | N/A                  | 1.1, 1.5, 5.1        |
| MH.E.59 | Emergency Services     | <b>Environmental monitoring information telemetry system:</b> Implement wireless transmission of handheld and vehicle-mounted environmental monitoring data from field to office. Identification and characterization of radiological environmental hazards, including air emissions data, provides a means to mitigate public health impacts. | DOHMH | N/A      | Ongoing                                    | TBD           | Grants   | N/A                  | 1.1, 1.5, 5.2        |
| MH.E.60 | Education & Awareness  | <b>Assessing and communicating risks from drinking and recreational waters:</b> Issue public advisories on health hazards from flooding/storm impacts to water supply and public waters/beaches, using 311, nyc.gov, printed materials and media.  | DOHMH | DEP, DPR | Ongoing                                    | TBD           | Agency operating budget  | N/A                  | 1.1, 1.2, 1.5, 5.3   |
| MH.E.61 | Education & Awareness  | <b>Public education on mental health:</b> Conduct a "Mental Health First Aid" education program to introduce the public to risk factors and warning signs of mental health problems, build understanding of their impact, and review common treatments to increase individual and community resilience.  | DOHMH | N/A      | Immediately and ongoing                    | \$150 K       | TBD  | N/A                  | 1.1, 1.5             |
| MH.E.62 | Emergency Services     | <b>Mental health system IT record redundancy:</b> Convert paper records to electronic formats to prevent damage and loss in the event of a disaster and facilitate remote accessibility of client records. Include off-site backup capacity.   | DOHMH | N/A      | One year to implement                      | \$6 M         | One-time expense to initiate project, followed by capital allocation | N/A                  | 1.1, 1.5, 2.1        |
| MH.E.63 | Infrastructure Project | <b>Public safety land-mobile radio communications at the World Trade Center:</b> Protect and enhance the reliability and resilience of communications infrastructure by installing redundant radio antenna and related equipment at the World Trade Center.  | DoITT | N/A      | 18 months                                  | \$1.8 M       | FEMA grant   | N/A                  | 2.3                  |

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| MH.E.64 | Emergency Services  | <b>311 upgrade:</b> Support future high-call-volume events including re-architecture of the 311 platform, provide production environment for call center-specific version of applications, and implement cloud-based mapping.   | DoITT | N/A     | 18 months | \$29.3 M      | TBD                  | N/A   | 2.1, 2.3, 2.8        |
| MH.E.65 | Emergency Services  | <b>311 alternate site:</b> Build out an operating environment in a hardened facility to insure that 311 operations can relocate to an alternate site should primary facility be impacted.   | DoITT | N/A     | 12 months | \$13 M        | TBD                  | N/A   | 2.1, 2.3             |
| MH.E.66 | Prevention & Policy | <b>Hardening the optical backbone:</b> Implement new omni-directional optical technology to enable DoITT to remotely switch the light and route traffic around failed fiber path. Citynet, the City's dedicated optical fiber backbone, is already undergoing a significant upgrade to increase its capacity and resiliency. While the network has the ability to dynamically switch the IP at the ethernet layer, it does not have ability to remotely switch the light through multiple fiber paths during emergencies. | DoITT | N/A     | 6 months  | \$17 M        | TBD                  | N/A   | 2.1, 2.3, 2.8        |
| MH.E.67 | Prevention & Policy | <b>Internet/DMZ management:</b> Sustain advanced bandwidth management devices to regulate appropriate usage of ISP links during emergencies.  | DoITT | N/A     | TBD       | \$1.55 M      | TBD                  | N/A   | 2.1, 2.3             |
| MH.E.68 | Property Protection | <b>Protection of New York City bridges from hazards:</b> Implement measures including seismic retrofits, structural hardening, inspections, and retrofits to protect moveable bridge machinery.   | DOT   | N/A     | 10 years  | \$1 B         | Federal, city, state | Construction under way on Brooklyn, Manhattan, and Williamsburg Bridges | 2.1, 2.7, 2.8        |

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| MH.E.69 | Prevention & Policy    | <b>Toolbox of climate resiliency features for ROW capital projects:</b> Develop a toolbox of hazard-resilient design treatments that can be incorporated into right-of-way (ROW) capital projects (streets, bulkheads/seawalls, retaining walls) and a selection process/methodology for applying the most appropriate and cost-effective treatments to particular locations based on the hazards those locations face. | DOT  | DDC     | 1 year (consultant study)  | \$1 M               | HMGP, City capital budget, Expense budget | Ongoing              | 2.8, 2.10, 5.2       |
| MH.E.70 | Property Protection    | <b>Climate resiliency features in future capital projects:</b> Apply the toolbox of hazard-resilient design treatments developed in MH.E.69 to an initial set of existing capital projects in high-risk areas. As these treatments are refined and their effectiveness and cost-effectiveness are demonstrated, apply them in a standardized way to all right-of-way capital projects going forward.                    | DOT  | DDC     | 2 years (design, construction)   | \$20 M per year     | HMGP, TEP/TAP grants, City capital budget | Ongoing              | 2.8                  |
| MH.E.71 | Infrastructure Project | <b>Resiliency in DOT planning:</b> Integrate resiliency in planning and project development.  | DOT  | N/A     | 1 year (in-house study) plus ongoing (1 new staff person focused on infrastructure resiliency) | \$150 K per year    | HMGP, Expense budget                      | N/A                  | 2.7                  |
| MH.E.72 | Property Protection    | <b>Protection of ferry terminals:</b> Protect terminals from flooding and storm damage.   | DOT  | N/A     | 6 years  | \$200 M             | FTA Emergency Relief                      | N/A                  | 2.1, 2.7             |
| MH.E.73 | Infrastructure Project | <b>Ferry use during emergencies:</b> Deploy the Staten Island Ferry's Austen Class vessels on the East River Ferry route during transportation disruptions.   | DOT  | N/A     | As necessary   | \$100 K/week/vessel | Expense budget                            | N/A                  | 2.1                  |
| MH.E.74 | Property Protection    | <b>Traffic signal equipment:</b> Elevate equipment in flood zones.  | DOT  | N/A     | 3 years  | \$3 M               | HMGP, FHWA                                | N/A                  | 2.1, 2.7             |

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| MH.E.75 | Prevention & Policy                 | <b>Emergency traffic management:</b> Plan for measures including HOV restrictions, temporary transit services, special bike/pedestrian routes, and emergency public information protocols. Conduct resiliency planning exercises.  | DOT  | PD, MTA    | Ongoing  | \$10 M        | HMGP              | N/A                  | 2.1                  |
| MH.E.76 | Infrastructure Project              | <b>Pedestrian and bicycle facilities:</b> Plan for and install new facilities to improve connectivity to key transportation hubs.  | DOT  | DDC        | Ongoing  | \$10 M        | CMAQ, FHWA        | N/A                  | 2.1, 4.3             |
| MH.E.77 | Prevention & Policy                 | <b>Bus priority strategies:</b> Expand Select Bus Service and other bus priority strategies.   | DOT  | MTA, DDC   | Ongoing  | \$20 M        | CMAQ, FTA         | N/A                  | 2.1                  |
| MH.E.78 | Prevention & Policy                 | <b>Green Streets program:</b> Transform unused road space into open (green) space to reduce volume of stormwater runoff by absorbing or storing water and reduce the impact of extreme heat events. The goal of this project is to add 40 Green Streets totaling 75 acres of open space with a storage capacity of four million gallons of stormwater. | DPR  | DOT        | 8 years  | \$15 M        | Private donors    | No change            | 1.5, 2.1, 4.3        |
| MH.E.79 | Prevention & Policy                 | <b>Street trees:</b> Fill every available street tree opportunity in New York City, thus improving drainage across the city and reducing the effects of extreme temperatures. The goal is to raise the street stocking level from 74% to 100%.   | DPR  | DOT, DOB   | 8 years  | \$246.9 M     | TBD               | No change            | 1.5, 2.1, 4.3        |
| MH.E.80 | Property Protection                 | <b>Conversion of asphalt fields to natural or synthetic turf fields:</b> Convert 24 fields from asphalt to natural or synthetic turf with new drainage systems. Both scenarios would result in improved drainage and possible reduction of the urban heat island effect in large park areas.   | DPR  | HHC, DOHMH | 8 years  | \$42.1 M      | TBD               | No change            | 2.1, 4.3             |
| MH.E.81 | Coastal/Natural Resource Protection | <b>Reforestation:</b> Reforest 2,000 acres of parkland.  | DPR  | NPS        | 10 years | \$118 M       | TBD               | No change            | 4.3                  |

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| MH.E.82 | Coastal/<br>Natural<br>Resource<br>Protection | <b>Tree pruning:</b> Implement a 5-year program to prune or remove old and overgrown trees. This program is designed to reduce the impact of severe weather including tornadoes, windstorms, and coastal storms. | DPR  | N/A                                     | 5 years                                | \$5 M   | TBD               | No change            | 2.1,<br>4.3                  |
| MH.E.83 | Coastal/<br>Natural<br>Resource<br>Protection | <b>Wetlands protection:</b> Assess the vulnerability of existing wetlands and identify additional policies to protect them.  | DPR  | DEP,<br>OLTPS,<br>NPS, EDC,<br>DCP, EPA | 8 years                                | TBD   | TBD               | No change            | 4.3                          |
| MH.E.84 | Coastal/<br>Natural<br>Resource<br>Protection | <b>Tree planting:</b> Partner with stakeholders to help plant one million trees by 2017. Trees reduce temperatures, absorb additional stormwater, and decrease flooding.   | DPR  | OLTPS,<br>DOT, DOB,<br>NPS              | 9 years                                | TBD   | TBD               | No change            | 1.5,<br>2.1,<br>4.3          |
| MH.E.85 | Emergency<br>Services                         | <b>Emergency power generators:</b> Provide five large and 60 small emergency power generators to facilities during a hazard event.   | DSNY | N/A                                     | Duration of<br>emergency/<br>immediate | Fuel/<br>equip-<br>ment cost<br>only/ab-<br>sorbed by<br>agency | TBD               | No change            | 2.3                          |
| MH.E.86 | Property<br>Protection                        | <b>Green roofs:</b> Install green roofs on facilities where appropriate to reduce the volume of stormwater runoff by absorbing or storing water and help reduce the urban heat island effect.                    | EDC  | DEP                                     | TBD                                    | TBD   | TBD               | No change            | 2.8,<br>2.10,<br>4.3,<br>4.4 |
| MH.E.87 | Emergency<br>Services                         | <b>EDC emergency power generators:</b> Provide emergency power generators to facilities during a natural hazard event.   | EDC  | N/A                                     | Ongoing                                | TBD   | EDC, OEM          | No change            | 2.3                          |



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| MH.E.88 | Infrastructure Project | <b>Expansion of ferry landings available for regular and emergency use.</b> Design and procure two new ferry landing barges that are outfitted with the required equipment for providing basic ferry service, including self-contained generators. 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. Deploy four new permanent ferry landings at strategic locations selected based on the results of the ongoing Citywide Ferry 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. | EDC  | DOT           | 5 years   | \$15 M        | FTA               | N/A  | 2.1, 2.2             |
| MH.E.89 | Prevention & Policy    | <b>Infrastructure upgrade:</b> Provide technical assistance to inform the design and installation of passenger ferry landings. EDC has experience with regard to the mooring, anchoring, and stabilization mechanisms available for ferry landings that are able to withstand the effects of various natural hazard events.  | EDC  | DOT           | 24 Months | \$30 M        | EDC, DOT, grants  | Implemented with plans for additional ferry landings | 2.1, 2.7             |
| MH.E.90 | Property Protection    | <b>Infrastructure upgrade:</b> Upgrade Arthur Kill lift bridge including possible construction of new bulkheads/pier.  | EDC  | N/A           | 36 months | \$7.7 M       | EDC               | Implemented  | 2.1, 2.7             |
| MH.E.91 | Property Protection    | <b>Critical infrastructure relocation:</b> Relocate passenger ferry barge at World Financial Center to Hunters Point. Provide for stable landing at Hunters Point, allowing for transportation system redundancy.  | EDC  | DOT           | TBD       | \$300 K       | EDC               | Implemented  | 2.1, 2.3, 2.7        |
| MH.E.92 | Emergency Services     | <b>Backup water main system:</b> Develop system to transmit fire suppression water throughout the city if existing infrastructure is disrupted due to a drought or earthquake.   | FDNY | DEP, DDC, OEM | TBD       | TBD           | TBD               | Ongoing  | 2.3, 2.7             |
| MH.E.93 | Emergency Services     | <b>Power redundancy at FDNY facilities:</b> Install backup electrical power generators in all FDNY facilities.   | FDNY | OEM, DDC      | TBD       | TBD           | Capital budget    | Ongoing  | 2.3                  |

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| MH.E.94  | Emergency Services                  | <b>Water supply redundancy:</b> Increase water drafting capabilities citywide. Drafting, which entails the suction of water from a body of water to a fire apparatus, can decrease the demand on the water supply system and provide redundant fire suppression water in the event of a drought or earthquake-induced water supply disruption. | FDNY       | DEP, U.S. EPA                                | TBD                | TBD           | Grants                   | Ongoing                              | 2.3                  |
| MH.E.95  | Property Protection                 | <b>Enterprise Asset Management System:</b> Develop and implement the system for equipment tracking and digital inventorying.   | FDNY       | N/A  | First quarter 2014 | TBD           | TBD                      | N/A                                  | 2.1                  |
| MH.E.96  | Emergency Services                  | <b>Continuity of Operations Plan (COOP):</b> Create, distribute, and implement a COOP plan to ensure continuity of all FDNY operations in the event of a disaster.   | FDNY       | OEM  | TBD                | \$810 K       | Grants                   | N/A                                  | 2.1, 2.3             |
| MH.E.97  | Emergency Services                  | <b>Emergency action plans:</b> Require non-fire emergency plans for office buildings.  | FDNY       | N/A  | TBD                | \$1.4 M       | Grants                   | N/A                                  | 2.1, 2.5             |
| MH.E.98  | Emergency Services                  | <b>IT disaster recovery:</b> Create, distribute, and implement a recovery plan to ensure continuity of IT operations in the event of a disaster.   | FDNY       | DOITT  | TBD                | \$2.4 M       | Grants                   | N/A                                  | 2.1, 2.3             |
| MH.E.99  | Emergency Services                  | <b>Redundant emergency generators:</b> Install generators for Group 2, 3, and 4 general hospitals, D&TC centers, and nursing facilities.   | HHC        | Dormitory Authority of the State of New York | 5 years            | \$90 M        | General obligation bonds | Ongoing                              | 1.1, 2.1, 2.3        |
| MH.E.100 | Education & Awareness               | <b>Flooding technical assistance to owners of landmarked structures:</b> Provide technical assistance to owners of locally landmarked structures affected by flooding and other hazards.   | LPC        | DOB, DOT                                     | Ongoing            | TBD           | LPC expense budget       | Implemented (scope has been revised) | 2.9                  |
| MH.E.101 | Coastal/Natural Resource Protection | <b>LIRR tree pruning:</b> Reduce probability of downed trees or limbs due to tornadoes, windstorms, and coastal storms along active rail lines through preventive tree pruning.  | MTA (LIRR) | N/A  | Ongoing            | TBD           | LIRR operating budget    | Ongoing                              | 2.1                  |

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| MH.E.102 | Coastal/<br>Natural Resource Protection | <b>MNR tree pruning:</b> Reduce probability of downed trees or limbs due to tornadoes, windstorms, and coastal storms along active rail lines through preventive tree pruning.   | MTA (MNR) | N/A     | Immediate, 2-year contract | \$1.6 M       | MTA capital budget, MNR operating budget, Sandy Emergency Relief Program - Resiliency | Ongoing              | 2.1                  |
| MH.E.103 | Infrastructure Project                  | <b>Harlem River lift bridge:</b> Develop threat scenario report, threat vulnerability and risk assessment, and prioritized list of security projects. This single point of failure for all MNR traffic into/out of the CBD is vulnerable to a broad spectrum of threats.   | MTA (MNR) | N/A     | Completion May 2014        | \$2.6 M       | 2011 TSGP   | N/A                  | 5.2                  |
| MH.E.104 | Emergency Services                      | <b>Operations/communications redundancy:</b> Use secondary facility at North White Plains to create redundancy for the Operations Control Center, allowing for continued operational capability for the railroad.  | MTA (MNR) | N/A     | TBD                        | \$25-30 M     | TBD   | N/A                  | 2.3                  |
| MH.E.105 | Prevention & Policy                     | <b>Summer operations manual:</b> Develop manual which describes summer preparation activities including carrying bottled water on rolling stock, continued maintenance of HVAC systems, development and implementation of Rules and Procedures for stranded train events, continued training of train crews and employees.   | MTA (MNR) | N/A     | Complete                   | TBD           | TBD   | Implemented          | 1.4, 2.1             |
| MH.E.106 | Prevention & Policy                     | <b>Storm surge/flooding mapping/design guidelines/standards:</b> Conduct study which will provide planning tool to aid the response to future storms by identifying and cataloging key infrastructure and right of way vulnerabilities. Study will provide guidelines for a recommended minimum design elevation for new construction projects and a suggested method to analyze risk to help guide implementation of new standard/guidelines. | MTA (MNR) | N/A     | Complete                   | \$150 K       | TBD   | Implemented          | 2.2, 2.4, 2.5        |
| MH.E.107 | Emergency Services                      | <b>MNR advance warning:</b> Monitor forecasts of wind speed to issue speed restrictions or operations/construction procedures prior to major wind impact. Implemented through the Coastal Storm Plan and Operating Plan.   | MTA (MNR) | N/A     | Complete                   | TBD           | TBD   | Implemented          | 1.2, 2.1             |

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| MH.E.108 | Emergency Services  | <b>Contingency planning for substitute bus service:</b> Purchase mobile emergency command center vehicles, fuel tank trucks, and mobile and fixed equipment for bus operations including electronic variable message signs, pumps, portable generators, and portable tower lights.   | MTA (Buses) | N/A     | TBD      | TBD           | TBD                 | N/A                  | 2.1, 2.3                 |
| MH.E.109 | Emergency Services  | <b>Bus command center and radio system:</b> Replace obsolete facility and system with state-of-the-art command center and radio communication system.  | MTA (Buses) | N/A     | TBD      | TBD           | TBD                 | N/A                  | 2.1                      |
| MH.E.110 | Emergency Services  | <b>Contingency bus fleet:</b> Establish fleet of approximately 50 buses to support emergencies.  | MTA (Buses) | N/A     | TBD      | TBD           | TBD                 | N/A                  | 2.1                      |
| MH.E.111 | Property Protection | <b>Emergency generators:</b> Install at depots at JFK and LaGuardia Airports and Baisley Park to provide electrical power backup.  | MTA (Buses) | N/A     | TBD      | TBD           | TBD                 | N/A                  | 2.3                      |
| MH.E.112 | Property Protection | <b>NYCHA emergency action plan:</b> Revise plan including lessons learned from Sandy. Include necessary NYCHA operational actions required 7 days, 72 hours, 48 hours, and 24 hours prior to a forecasted weather event and within the first 24 hours following the event.   | NYCHA       | TBD     | TBD      | TBD           | TBD                 | N/A                  | 1.1, 2.1, 5.2            |
| MH.E.113 | Property Protection | <b>Protective roofing:</b> Install new flashing and four-ply torch-applied modified bitumen roofing with high-reflective coating over polyisocyanurate tapered insulation in 46 developments (524 buildings) citywide. This project, which will involve removal of existing roofing and insulation and asbestos abatement, will increase storm resiliency and reduce the impacts of extreme heat events. | NYCHA       | DOE-SCA | 1 year   | \$126 M       | City Capital budget | No change            | 1.1, 2.5, 2.7, 2.8, 2.10 |
| MH.E.114 | Property Protection | <b>Window protection:</b> Install new shatter-resistant operable windows and frames and repair lintels and sills in nine developments (62 buildings) citywide. Remove existing windows and conduct asbestos abatement.   | NYCHA       | DOE-SCA | 2 years  | \$143 M       | City Capital budget | No change            | 1.1, 2.5, 2.7, 2.8, 2.10 |

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| MH.E.115 | Property Protection   | <b>Copping:</b> Remove all loose and damaged brick, stucco, and copping to reduce flying debris during wind storms, coastal storms, and tornadoes. Install new brick and copping in 34 developments (313 buildings) citywide.   | NYCHA | N/A                  | 2 years  | \$237 M       | City Capital budget | No change  | 1.1, 2.5, 2.7, 2.8      |
| MH.E.116 | Emergency Services    | <b>Continuity of Operations (COOP):</b> Ensure City agencies can provide essential services to the public during emergencies while maintaining internal critical functions. Develop plans that build contingencies around essential services, mitigate the impact of disruptions to services, and enhance the ability to provide CIMS operations, social services, and government operations.   | OEM   | DoITT                | Ongoing  | \$1.5 M       | UASI                | Ongoing  | 2.1, 2.3                |
| MH.E.117 | Emergency Services    | <b>Advance warning system integration:</b> Integrate Notify NYC and NY-ALERT advance warning and emergency capabilities. When fully operable, this system will provide advance warning to New York City residents prior to hazard events. The public is able to enroll in Notify NYC and receive messages via e-mail, phone calls, and text message, or by subscribing to the RSS feed. Messages are also sent via Twitter and Twitter Alert. Depending on the severity of the emergency, Wireless Emergency Alerts and Emergency Alert System can be activated to broaden the audience that receives the notification. | OEM   | DoITT, FEMA, NYS OEM | Ongoing  | \$2 M         | UASI, CTL           | Ongoing (scope is expanding to include additional alert mechanisms including Blackberry Messenger, Instant Messenger, and TTY/TDD) | 1.1, 1.2                |
| MH.E.118 | Education & Awareness | <b>Incident-based distribution project:</b> Implement program to track and study areas impacted by natural disasters using OEM Watch Command data and Geographic Information Systems technology. Target affected areas for post-disaster outreach and Ready New York materials. Encourage property owners to incorporate mitigation measures during recovery.   | OEM   | N/A                  | Ongoing  | \$25 K        | UASI                | By 2013, the program regularly sends several thousand guides each month.   | 1.1, 2.9, 5.1, 5.2, 5.3 |

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| MH.E.119 | Education & Awareness | <b>Insurance Working Group:</b> Work with the insurance industry to provide information on insurance-related mitigation measures.   | OEM  | NYS Insurance Department   | Ongoing  | Agency Staff Time | UASI              | OEM's Public/Private and Legal units held several meetings with representatives of the insurance industry. | 3.1, 3.5             |
| MH.E.120 | Education & Awareness | <b>Public education through Ready New York guides:</b> Promote Ready New York guides as a tool to educate New Yorkers about natural hazards. This program offers all-hazards guides; hazard-specific guides for hurricanes, floods, and heat; and guides geared specifically for seniors and people with disabilities, children, and businesses. Guides contain information on how to mitigate, prepare for, and respond to an emergency and are offered in up to 14 languages as well as audio tapes and braille. In 2012 and 2013 OEM mailed over 2.2 million hurricane guides to households that lie in the city's hurricane evacuation zones. | OEM  | DOE, DEP, Mayor's Office, SBS, DFTA, Mayor's Office for People with Disabilities | Ongoing  | \$2.4 M           | UASI              | By 2013 the program has sent out several thousand guides each month.                                       | 1.1, 5.1, 5.3        |

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| MH.E.121 | Education & Awareness | <b>Public outreach through Ready New York program:</b> Provide public outreach throughout the city by presenting and tabling at community and private-sector events. Encourage communities to understand the impact of hazards so they may better mitigate, prepare, and respond to hazards.  | OEM  | N/A                              | Ongoing  | 75 K          | UASI                    | During hurricane/coastal storm season, mailings of around 1,500 guides target elected officials, non-profits, senior centers, houses of worship, and schools. In 2013, OEM mailed the updated hurricane guide to 1.4 million households and businesses in the city's hurricane evacuation zones. | 1.1, 5.1, 5.3        |
| MH.E.122 | Emergency Services    | <b>Regulatory actions on liquid fuel shortages:</b> Develop a package of city, state, and federal regulatory actions to address shortages during emergencies.   | OEM  | DCAS                             | Ongoing  | TBD           | Agency operating budget | N/A  | 2.3                  |
| MH.E.123 | Education & Awareness | <b>Urban Post-Disaster Housing Prototype Program:</b> Develop tools and public education programs that build capability to supply post-disaster housing that meets the unique needs of urban areas. Create an option for interim housing that will provide more suitable living spaces for New Yorkers displaced by disaster than existing federal interim housing solutions. | OEM  | DDC                              | 1 year   | \$100 K       | FEMA, CTL, RCPGP        | N/A  | 1.1, 1.6             |
| MH.E.124 | Prevention & Policy   | <b>Urban Post-Disaster Housing prototype:</b> Evaluate phases of implementation of rapidly deployable solution that provides proof-of-concept for providing interim housing at the speed and scale NYC may need.  | OEM  | FEMA, US-ACE, DOB, DEP, DOT, MTA | 1 year   | \$1.6 M       | FEMA, CTL, RCPGP        | N/A  | 1.6, 2.10            |

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| MH.E.125 | Prevention & Policy    | <b>Performance specifications for Urban Post-Disaster Housing:</b> Mitigate population loss after disaster by providing NYC with operational details for procuring manufactured housing that has stringent requirements for safety, environmental quality, durability, and universal design. | OEM   | FEM, HUD, USACE, DDC, DOB, DEP, DOT, private sector | 4 years               | \$150 K       | FEMA, CTL, RCPGP  | N/A                  | 1.1, 2.5, 2.10       |
| MH.E.126 | Education & Awareness  | <b>Ready New York Mobile App:</b> Develop \Mobile iPhone and Android application for the City's Ready New York preparedness program to help New Yorkers prepare for emergencies, build emergency plans, and utilize during emergencies.  | OEM   | DOHMH   | 1 year                | \$50 K        | CDC PHEP          | N/A                  | 1.5, 5.1, 5.3        |
| MH.E.127 | Prevention & Policy    | <b>Brownfield climate change resiliency:</b> Launch audits and improve storm preparedness of brownfields.  | OER   | OLTPS   | In place for 2 months | \$40 K        | OMB               | N/A                  | 4.3                  |
| MH.E.128 | Prevention & Policy    | <b>Building Code amendments:</b> Amend the Building Code to address the impacts of climate change.   | OLTPS | DOB   | 8 years               | TBD           | TBD               | Ongoing              | 2.5, 4.4             |
| MH.E.129 | Prevention & Policy    | <b>Coordination on local climate change projections:</b> Call on the state and federal governments to coordinate with the City on local climate change projections.  | OLTPS | N/A   | TBD                   | No cost       | TBD               | N/A                  | 3.1, 4.1             |
| MH.E.130 | Prevention & Policy    | <b>Local climate change projection improvements:</b> Continue to refine projections to inform decision-making.   | OLTPS | N/A   | TBD                   | No cost       | TBD               | N/A                  | 4.1, 4.2             |
| MH.E.131 | Prevention & Policy    | <b>Food distribution system:</b> Study the system to identify vulnerabilities.   | OLTPS | N/A   | TBD                   | \$3 M         | CDBG              | N/A                  | 1.1, 2.3             |
| MH.E.132 | Education & Awareness  | <b>Preparedness guidelines for retailers:</b> Call on New York State to issue retailer preparedness guidelines for extreme weather events.   | OLTPS | N/A   | TBD                   | No cost       | TBD               | N/A                  | 3.1, 3.4             |
| MH.E.133 | Infrastructure Project | <b>Pipeline booster stations:</b> Work with Buckeye and New York State to safely build pipeline booster stations in New York City to increase supply of liquid fuel and withstand extreme weather events.  | OLTPS | N/A   | TBD                   | No cost       | TBD               | N/A                  | 2.1, 2.3, 2.7        |
| MH.E.134 | Prevention & Policy    | <b>Hardening gas stations:</b> Work with New York State to provide incentives for hardening of gas stations to withstand extreme weather events.   | OLTPS | N/A   | TBD                   | No cost       | TBD               | N/A                  | 2.1, 2.3, 2.7        |



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| Index    | Action Category     | Mitigation Action Description  | Lead  | Support     | Timeline | Cost Estimate | Funding Source(s) | 2009 Progress Status | Goals and Objectives |
|----------|---------------------|--|-------|-------------|----------|---------------|-------------------|----------------------|----------------------|
| MH.E.135 | Prevention & Policy | <b>Transportation fuel reserve:</b> Explore the creation of a fuel reserve to temporarily supply the private market during disruptions.  | OLTPS | N/A         | TBD      | No cost       | TBD               | N/A                  | 2.3                  |
| MH.E.136 | Prevention & Policy | <b>Fuel availability during disruptions:</b> Call on New York State to modify price gouging laws and allow flexibility of gas station supply contracts to increase fuel availability during disruptions. | OLTPS | N/A         | TBD      | No cost       | TBD               | N/A                  | 2.3                  |
| MH.E.137 | Prevention & Policy | <b>Strategies to address climate change threats:</b> Call on non-City agencies to implement strategies to address climate change threats.  | OLTPS | N/A         | TBD      | No cost       | TBD               | N/A                  | 3.1, 4.2, 4.4        |
| MH.E.138 | Prevention & Policy | <b>Utility system upgrade plan:</b> Work with utilities and regulators to develop a cost-effective system upgrade plan to address climate risks.   | OLTPS | Con Ed, PSC | TBD      | No cost       | TBD               | N/A                  | 3.1, 4.2, 4.4        |
| MH.E.139 | Prevention & Policy | <b>Utility system design and equipment:</b> Work with utilities and regulators to reflect climate risks in design and equipment standards.   | OLTPS | Con Ed, PSC | TBD      | No cost       | TBD               | N/A                  | 3.1, 4.2, 4.4        |
| MH.E.140 | Prevention & Policy | <b>Performance metrics for climate risk response:</b> Work with utilities and regulators to establish performance metrics for climate risk response.   | OLTPS | Con Ed, PSC | TBD      | No cost       | TBD               | N/A                  | 3.1, 4.2, 4.4        |
| MH.E.141 | Prevention & Policy | <b>New York City power supply:</b> Work with industry partners, New York State, and regulators to strengthen the city's power supply.  | OLTPS | N/A         | TBD      | No cost       | TBD               | N/A                  | 2.1, 2.3, 2.7, 3.1   |
| MH.E.142 | Prevention & Policy | <b>Plant capability:</b> Require more in-city plants to be able to restart quickly in the event of blackout.   | OLTPS | N/A         | TBD      | No cost       | TBD               | N/A                  | 2.3                  |
| MH.E.143 | Prevention & Policy | <b>Resiliency plan for the electric distribution system:</b> Work with Con Ed and the PSC to develop a long-term resiliency plan.  | OLTPS | Con Ed, PSC | TBD      | No cost       | TBD               | N/A                  | 2.1, 2.3, 2.7, 3.1   |
| MH.E.144 | Prevention & Policy | <b>Minimizing electric outages:</b> Work with utilities and regulators to minimize outages in areas not directly affected by climate impacts.  | OLTPS | Con Ed, PSC | TBD      | No cost       | TBD               | N/A                  | 2.1, 2.3, 3.1        |

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|----------|---------------------|---|-------------------|-------------------|----------|---------------|-----------------------|----------------------|----------------------|
| MH.E.145 | Prevention & Policy | <b>Smart grid technology:</b> Work with utilities and regulators to implement smart grid technology to assess system conditions in real time.   | OLTPS             | Con Ed, PSC       | TBD      | No cost       | TBD                   | N/A                  | 2.3, 2.10, 3.1       |
| MH.E.146 | Prevention & Policy | <b>Utility service restoration for critical customers:</b> Work with utilities and regulators to speed service restoration for critical customers via system configuration.   | OLTPS             | Con Ed, PSC       | TBD      | No cost       | TBD                   | N/A                  | 2.3, 3.1             |
| MH.E.147 | Prevention & Policy | <b>Utility service restoration for mobile substations:</b> Work with utilities and regulators to speed service restoration via pre-connections.   | OLTPS             | Con Ed, PSC       | TBD      | No cost       | TBD                   | N/A                  | 2.3, 3.1             |
| MH.E.148 | Prevention & Policy | <b>Natural gas supply:</b> Work with pipeline operators to expand and diversify supply.   | OLTPS             | N/A               | TBD      | No cost       | TBD                   | N/A                  | 2.3, 3.1             |
| MH.E.149 | Prevention & Policy | <b>Gas transmission and distribution system:</b> Work with utilities and regulators to strengthen the in-city system.   | OLTPS             | Con Ed, PSC       | TBD      | No cost       | TBD                   | N/A                  | 2.3, 3.1             |
| MH.E.150 | Prevention & Policy | <b>Utility demand response programs:</b> Work with utilities and regulators to expand such programs citywide.   | OLTPS             | Con Ed, PSC, DCAS | TBD      | No cost       | TBD                   | N/A                  | 2.3, 3.1             |
| MH.E.151 | Prevention & Policy | <b>Building energy efficiency:</b> Work with government and private sector partners to expand building energy efficiency.   | OLTPS             | DOB               | TBD      | No cost       | TBD                   | N/A                  | 3.1, 4.3, 4.4        |
| MH.E.152 | Prevention & Policy | <b>Electric vehicles:</b> Incorporate resiliency into the design of City electric vehicle initiatives and pilot storage technologies.   | OLTPS             | Con Ed, PSC       | TBD      | No cost       | TBD                   | N/A                  | 2.1                  |
| MH.E.153 | Emergency Services  | <b>Emergency notification system at JFK Airport:</b> Install advanced automated early warning and emergency notification system in the Green and Blue quadrants of the central terminal area. System includes variable message signs along main access roads. | PANYNJ (Aviation) | DOT               | 5 years  | \$18.033 M    | PANYNJ capital budget | No change            | 1.2                  |

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|----------|-----------------------|---|------|---|--|---|--------------------------------------|----------------------|----------------------|
| MH.E.154 | Education & Awareness | <b>Annual NYC/LI Emergency Management Conference:</b> Provide emergency management professionals with an opportunity to explore and discuss concerns, issues, and initiatives for effective emergency preparedness and planning.  | PSEG | NYS OEM, Nassau County OEM, Suffolk County OEM, NYC OEM   | May 2013                                 | \$25 K  | PSEG and other sponsors of the event | N/A                  | 5.3                  |
| MH.E.155 | Property Protection   | <b>NYC Substation Reconfigurations to Minimize Disruption of Service:</b> Installation of storm hardened equipment and bypasses to allow maximum flexibility for options to bypass station if needed.   | PSEG | N/A   | February 2013 start, May 2013 completion | \$ 1.75 M (Far Rockaway, Arverne, Rockaway Beach, and Neponsit) | 406, CDBG, PSEG                      | Implemented          | 2.1, 2.3             |
| MH.E.156 | Property Protection   | <b>Equipment integrity:</b> Inspect 17 pad-mounted distribution switchgear located in PSEG's NYC territory within flood zones and make necessary fixes. Mitigation measures include installation of new labels, repositioning of barriers as necessary, removal and replacement of fuses, fuse holders, and lubrication of door latching mechanisms. This will also include preparation of inspection form depicting load break switch (LBS), load break fuse (LBF), and fuse size for newly installed fuses. | PSEG | N/A   | May 2013 completion                      | \$40 K  | Insurance, FEMA, PSEG                | Implemented          | 2.1, 2.3, 2.7        |
| MH.E.157 | Education & Awareness | <b>Emergency response unit:</b> Support team of business counselors that assist businesses in recovering and reopening in the wake of a disaster or emergency. Team can provide information on mitigation practices.  | SBS  | OEM, other city, state, and federal partners as necessary | Ongoing                                  | TBD   | Agency operating budget              | No change            | 3.2, 3.4             |

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|-----------------------|-------------------------------------|---|-------------------|--|---------------------------|------------------|--------------------------------|--|-------------------------|
| MH.E.158              | Emergency Services                  | <b>SBS Continuity of Operations Plan (COOP):</b> Maintain plan to ensure critical agency functions and services are available after a hazard.   | SBS               | OEM and other City partners as necessary | Ongoing                   | TBD              | Agency operating budget        | N/A  | 2.3, 3.2                |
| MH.E.159              | Coastal/Natural Resource Protection | <b>Emergency restoration of the Rockaway shoreline:</b> Restore to pre-Sandy conditions and to originally authorized beach profile. Mitigation of long-term impacts will require periodic beach maintenance.              | USACE, NYSDEC     | DPR                                      | 4 months                  | \$26 M           | USACE Operations & Maintenance | N/A  | 2.7, 2.9                |
| MH.E.160              | Coastal/Natural Resource Protection | <b>Emergency restoration of Coney Island shoreline:</b> Restore to pre-Sandy conditions and to originally authorized beach profile. Mitigation of long-term impacts will require periodic beach maintenance.              | USACE, NYSDEC     | DPR                                      | 5 months                  | \$7 M            | USACE Operations & Maintenance | N/A  | 2.7, 2.9                |
| <b>SEVERE WEATHER</b> |                                     |   |                   |  |                           |                  |                                |  |                         |
| SW.E.1                | Property Protection                 | <b>Building retrofit:</b> Replace windows at Coney Island Hospital to withstand hurricane-force wind.   | HHC               | TBD                                      | 2 years                   | \$2 M            | TBD                            | Implemented  | 1.1, 1.3, 2.1, 2.5, 2.7 |
| <b>WINTER STORMS</b>  |                                     |   |                   |  |                           |                  |                                |  |                         |
| WS.E.1                | Prevention & Policy                 | <b>Construction Code revision:</b> Apply the latest national standards for the determination of snow load, snow drift loads, and sliding snow loads.  | DOB               | N/A                                      | In effect since July 2009 | TBD              | Staff time                     | Implemented  | 2.5                     |
| WS.E.2                | Property Protection                 | <b>Infrastructure and equipment protection for subway trains:</b> Store trains underground when forecast calls for temperatures 10 degrees below zero, ice storms, icing conditions, or greater than five inches of snow. | MTA (NYCT-Subway) | N/A                                      | Ongoing                   | \$220 K/per year | NYCT Subway operating budget   | Winter operations plan implemented, used as needed, and updated periodically | 2.1, 2.7                |

**iv. Potential Mitigation Actions**

What this chapter refers to as “potential” mitigation actions are programs, plans, projects, or policies that New York City proposes to implement to help reduce or eliminate the risk to human life and property from hazards. The Planning Team, Steering Committee, and MPC membership identified, analyzed, and prioritized potential actions. Table 4.7 provides descriptions of the types of information detailed in the Potential Hazard Mitigation Actions table (Table 4.8). Table 4.8 will guide New York City in the implementation and administration of the actions. This table also serves to coordinate agencies to avoid duplicating or conflicting efforts.

Each mitigation action is assigned an index value to indicate the hazard addressed and its alphabetized placement by agency in the list. For example, the mitigation action with the index EQ.P.8 is the eighth potential mitigation action that addresses earthquakes. The Planning Team prioritized these actions by using a FEMA (STAPLEE) evaluation tool in addition to looking at other criteria. For more information about the prioritization process, see Prioritization section.

The following table of potential actions is for planning purposes only and creates no obligation on the part of agencies to implement the actions listed. Potential actions may be undertaken or completed should appropriate funding become available. Prioritization of potential actions is required under FEMA grant guidelines; it will not be used to determine eligibility for funding or implementation of potential projects in the future.

All potential mitigation actions will adhere to local building codes and zoning regulations. Select critical facilities must meet additional flood protection requirements based on these regulations. Where applicable and available, potential mitigation actions describe protection measures to a 500-year flood event.

**Table 4.7: Implementation Key for Potential Hazard Mitigation Actions**

| Column Header                        | Description  |
|--------------------------------------|--|
| <b>Action Category</b>               | The FEMA mitigation action category (Prevention, Property Protection, Education and Awareness, Coastal/Natural Resource Protection, Emergency Services, and Infrastructure Projects) |
| <b>Mitigation Action Description</b> | Title and description of the action  |
| <b>Lead</b>                          | The agency that has primary jurisdiction over the mitigation action and the primary point of contact for the mitigation action   |
| <b>Support</b>                       | Supporting entities that will assist in the implementation, funding, or maintenance of the mitigation action   |
| <b>Timeline</b>                      | Estimation of when the project will begin and approximately how long it will take to complete; "ongoing" refers to actions that are either under way or have no definitive end date  |
| <b>Cost Estimate</b>                 | Estimated costs associated with implementing a mitigation action   |
| <b>Possible Funding Source(s)</b>    | Possible sources of funding including capital funding, grants, and bonds. TBD indicates that the cost has not yet been determined or is currently unknown                            |
| <b>2009 Action Progress Status</b>   | N/A or Blank: New<br>No Change: Action has not changed since the 2009<br>Other text indicates a status update on the action since the 2009 HMP                                       |
| <b>Goals and Objectives</b>          | Hazard mitigation goals and objectives addressed by the mitigation action  |
| <b>Priority</b>                      | Results of the mitigation action prioritization  |

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**Table 4.8: Potential Hazard Mitigation Actions**

| Index       | Action Category                      | Mitigation Action Description   | Lead      | Support             | Timeline   | Cost Estimate | Possible Funding Sources       | 2009 Progress Status                                  | Goals and Objectives | Prioritization |
|-------------|--------------------------------------|---|-----------|---------------------|--|---------------|--------------------------------|---|----------------------|----------------|
| <b>CBRN</b> |                                      |   |           |                     |  |               |                                |   |                      |                |
| CB.P.1      | Property Protection                  | <b>Construction Code revision:</b> Adopt improved fire protection standard and emergency egress standard for buildings over 420 feet from recent International Building Code.   | DOB       | N/A                 | Mayoral adoption Dec. 2013/ law effective Oct. 1, 2014 | TBD           | Staff time                     | Mayoral adoption Dec. 2013/law effective Oct. 1, 2014 | 2.5, 2.7, 1.5        | High           |
| CB.P.2      | Infrastructure Project               | <b>Harlem River lift bridge:</b> Design and build security and hardening measures including fencing, lighting, access control and Closed Circuit Television (CCTV), structural hardening, stand-off measures, alternate alignment plans, alternate operations plans, and consequence management plans for this single point of failure for all MNR traffic into/out of the central business district. | MTA (MNR) | N/A                 | 10-15 years  | \$35 M        | TSGP, MTA capital budget       | N/A   | 2.1, 2.2, 2.3        | Medium         |
| CB.P.3      | Prevention & Policy                  | <b>NYCHA fresh water supply:</b> Outfit all 334 NYCHA developments with oversized water storage tanks so that in the event of a water-contamination event, the buildings can be shut off from the city supply while fresh water is provided to residents for an extended period.  | NYCHA     | TBD                 | TBD  | TBD           | TBD                            | N/A   | 1.1, 2.1, 2.3        | Medium         |
| CB.P.4      | Coastal/ Natural Resource Protection | <b>Brownfield cleanup in the 100-year floodplain:</b> Establish bonus cleanup grant for projects in flood zones to accelerate cleanup to prevent release of pollutants during floods.   | OER       | OMB, NYSEDC, EDC    | 3 months pending funding                               | \$150 K/ year | Agency budget allocation, REDC | N/A   | 2.1, 2.4             | High           |
| CB.P.5      | Prevention & Policy                  | <b>Environmental research:</b> Update SPEED, the City's online environmental research engine.   | OER       | DoITT               | 3 months   | \$200 K       | CDBG                           | N/A   | 5.1, 5.2, 5.3        | High           |
| CB.P.6      | Education & Awareness                | <b>BrownfieldWORKS!:</b> Support placement of green job trainees on brownfield cleanup sites throughout New York City.  | OER       | Law Department, OMB | 3 months pending funding                               | \$100 K/ year | Agency budget allocation       | N/A   | 2.1, 2.4             | Medium         |

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| Index           | Action Category                         | Mitigation Action Description  | Lead       | Support    | Timeline                        | Cost Estimate                             | Possible Funding Sources | 2009 Progress Status | Goals and Objectives | Prioritization |
|-----------------|---|--|------------|------------|---------------------------------|---|--------------------------|----------------------|----------------------|----------------|
| CB.P.7          | Education & Awareness                   | <b>Environmental Project Information Center (EPIC):</b> Develop this online public environmental communication portal and cleanup project tracking database for developers, industry, and community to speed projects while also hosting a public document repository, information-sharing portal, bulletin boards, dialogue centers, and other community resources. | OER        | DoITT, EDC | Expected completion summer 2014 | \$400K                                    | NYS DOS and CDBG         | N/A                  | 5.1, 5.2, 5.3        | High           |
| COASTAL EROSION |   |  |            |            |                                 |   |                          |                      |                      |                |
| CE.P.1          | Coastal/<br>Natural Resource Protection | <b>Protection of Rikers Island east, west, and south shorelines:</b> Rebuild and mitigate shorelines.  | DOC        | N/A        | FY17-21                         | \$38 M                                    | City capital budget      | No change            | 1.1, 2.1, 2.7        | Medium         |
| CE.P.2          | Coastal/<br>Natural Resource Protection | <b>Beach restoration:</b> Conduct repairs to DPR beaches and infrastructure damaged in recent nor'easters. Beaches and roadways have been subject to severe erosion from these storms.   | DPR        | TBD        | TBD                             | \$10 M total (\$4.5 M for Rockaway Beach) | TBD                      | No change            | 2.1, 2.7, 4.3        | Medium         |
| CE.P.3          | Coastal/<br>Natural Resource Protection | <b>Renourishment of Orchard Beach, Bronx:</b> Periodically renourish Orchard Beach to prevent greater erosion and protect infrastructure. (USACE classifies this project as "Recreational" and not for flood damage reduction.)  | USACE, DPR | NYSDEC     | 3 years                         | \$1 M                                     | USACE                    | No change            | 4.1, 4.3, 4.4        | Medium         |
| COASTAL STORMS  |   |  |            |            |                                 |   |                          |                      |                      |                |
| CS.P.1          | Prevention & Policy                     | <b>Flooding prevention:</b> Avoid occupying space near or in SLOSH zones A and B, even if the HRA-General Support Services program can accept the space from DCAS.   | DCAS       | HRA        | TBD                             | TBD                                       | Agency lease budget      | Ongoing              | 2.1, 2.2             | Medium         |



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| Index  | Action Category        | Mitigation Action Description  | Lead | Support  | Timeline | Cost Estimate | Possible Funding Sources           | 2009 Progress Status | Goals and Objectives    | Prioritization |
|--------|------------------------|--|------|----------|----------|---------------|------------------------------------|----------------------|-------------------------|----------------|
| CS.P.2 | Prevention & Policy    | <b>Resilient neighborhoods planning studies:</b> Identify and address vulnerabilities specific to communities in flood zones, as designated by new federal flood maps, and those neighborhoods severely affected by Hurricane Sandy. Goals include: reducing risk from natural hazards such as flooding and coastal storms, fostering economically and socially vibrant communities that are able to adapt to changing conditions, coordinating land use planning with rebuilding activities and infrastructure investment, and including a robust stakeholder-engagement process. | DCP  | N/A      | N/A      | N/A           | N/A                                | N/A                  | 1.1, 1.6, 2.4, 2.5, 3.3 | High           |
| CS.P.3 | Prevention & Policy    | <b>DCP planning support and technical assistance for Sandy disaster recovery:</b> Support a variety of rebuilding and resilience activities with data analysis and mapping, coastal resilience planning, legal and technical support, community outreach and coordination, demographic analysis, tracking of housing permit activity, NYCHA resilience and replacement housing, and open space and Bluebelt planning.  | DCP  | N/A      | N/A      | N/A           | N/A                                | N/A                  | 2.1, 2.5, 5.2           | Medium         |
| CS.P.4 | Emergency Services     | <b>Emergency contracts:</b> Have contracts (tree removal, sidewalk and roadway repair, etc.) ready in advance to reduce response times when hazards occur.   | DDC  | OMB, DOT | TBD      | TBD           | TBD                                | N/A                  | 2.1                     | Medium         |
| CS.P.5 | Infrastructure Project | <b>Hardening pumping stations:</b> Retrofit pumping stations for resiliency including raising or flood-proofing critical equipment, constructing barriers, and installing backup power supplies. Preliminary estimates indicate that there are currently 58 at-risk pumping stations.  | DEP  | N/A      | Ongoing  | \$128 M       | City capital budget, HMGP, FEMA PA | N/A                  | 2.1, 2.7, 2.8           | Medium         |

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| Index   | Action Category                         | Mitigation Action Description   | Lead | Support | Timeline   | Cost Estimate | Possible Funding Sources           | 2009 Progress Status | Goals and Objectives | Prioritization |
|---------|---|---|------|---------|--|---------------|------------------------------------|----------------------|----------------------|----------------|
| CS.P.6  | Infrastructure Project                  | <b>Hardening wastewater treatment plants:</b> Protect critical facilities by raising or flood-proofing assets that are critical to the treatment process, constructing barriers, improving waterfront infrastructure, or implementing redundancy measures to avoid failure of critical treatment systems. | DEP  | N/A     | Ongoing  | \$190 M       | City Capital budget, HMGP, FEMA PA | N/A                  | 2.1, 2.2, 2.7, 2.8   | High           |
| CS.P.7  | Infrastructure Project                  | <b>Alternatives for Rockaway Wastewater Treatment Plant:</b> Consider conversion to a pumping station, which would be less expensive to protect, and potential transfer of treatment to a less vulnerable wastewater treatment facility elsewhere in the city.  | DEP  | N/A     | Initiate feasibility study in 2014   | \$150 M       | City capital budget                | N/A                  | 2.1, 2.2, 2.7, 2.8   | Medium         |
| CS.P.8  | Property Protection                     | <b>Vernon C. Bain Center (VCBC) mooring system and site access improvement:</b> Build marine vessel mooring above the FEMA 500-year flood advisory elevation of 15.36 feet. Currently VCBC mooring arm is designed at maximum 10.3 feet.  | DOC  | N/A     | TBD  | \$18.45 M     | City capital budget, HMGP          | No change            | 1.1, 2.1, 2.7        | High           |
| CS.P.9  | Property Protection                     | <b>Division I, II and III storehouse:</b> Build a replacement for this main warehouse, which is condemned, beyond asset design life, and does not adequately support storage space for up to four weeks of isolated operation.  | DOC  | N/A     | This is a long-term project and will not be implemented in the near future (FY17-21) | \$25 M        | City capital budget                | N/A                  | 2.1                  | Medium         |
| CS.P.10 | Coastal/<br>Natural Resource Protection | <b>Sunset Cove Parks sustainable shoreline at Broad Channel, Jamaica Bay:</b> Create a sustainable shoreline, floodwater capture area, and berm for local storm surge protection in Broad Channel.  | DPR  | N/A     | 2 years  | \$6.02 M      | HMGP                               | N/A                  | 2.8, 4.3, 4.4        | High           |

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|---------|-----------------------|---|------|---------|----------|---------------|--------------------------|----------------------|--------------------------|----------------|
| CS.P.11 | Property Protection   | <b>FDNY storehouse improvement:</b> Expand and create additional storehouses that would assist in ensuring continuity of basic agency operations as well as response operations.  | FDNY | DCAS    | TBD      | TBD           | TBD                      | N/A                  | 2.1, 2.3                 | Medium         |
| CS.P.12 | Emergency Services    | <b>EMS Battalion:</b> Relocate part of EMS Battalion 43 due to damage sustained during Hurricane Sandy.   | FDNY | DCAS    | TBD      | TBD           | TBD                      | N/A                  | 2.1, 2.2                 | Medium         |
| CS.P.13 | Emergency Services    | <b>EMS fallback sites:</b> Identify fallback sites within the EMS facility network for EMS stations (23% of FDNY EMS stations) located in or near flood zones. Sites would be equipped with basic technology and sufficient storage capacity to allow EMS to initiate operations in the event of a catastrophe.   | FDNY | DCAS    | TBD      | TBD           | TBD                      | N/A                  | 2.1, 2.3                 | Medium         |
| CS.P.14 | Emergency Services    | <b>FDNY emergency services:</b> Expand FDNY capabilities to respond to natural hazards. In the wake of Hurricane Sandy, the FDNY identified initiatives that would enhance its capabilities—including GPS for apparatus, additional boats for high-water rescue and pumping, and other all-weather vehicles—and ultimately allow the FDNY to act as the City's primary response agency. | FDNY | DHS     | TBD      | TBD           | DHS                      | N/A                  | 2.1, 2.3                 | Medium         |
| CS.P.15 | Education & Awareness | <b>Outreach to residential building owners:</b> Develop a methodology and technology solution to provide pre- and post-disaster outreach and information to residential building owners.  | HPD  | N/A     | 2 years  | \$5 M         | Grants                   | N/A                  | 1.6, 2.6, 2.9, 2.10, 5.1 | High           |
| CS.P.16 | Property Protection   | <b>Resilient home design competition:</b> Launch a competition for resilient 1- to 4-family homes.  | HPD  | N/A     | N/A      | \$80 K        | Grants                   | N/A                  | 2.1, 2.9                 | Medium         |

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|---------|------------------------|---|---------------------------|---------|-----------|---------------|---|---|----------------------|----------------|
| CS.P.17 | Property Protection    | <b>Flood-hardening of vital communications, substations, transformers, mechanical equipment, revenue equipment, and other electronic systems at all MTA Bridges and Tunnels facilities:</b> Perform work to harden those areas that are required to maintain Bridges and Tunnels operations and relocate electronic systems to less vulnerable locations at the respective service buildings. Facilities will be elevated above ABFE + 1 foot.                                | MTA (Bridges and Tunnels) | N/A     | 2-3 years | \$15 M        | HMGP, 406                                 | Conceptual stage                              | 2.1, 2.2, 2.10       | Medium         |
| CS.P.18 | Infrastructure Project | <b>Raising Governors Island seawall for Hugh L. Carey Tunnel:</b> Raise the seawall around the artificial island on which the Governors Island ventilation building is located to prevent stormwater from entering the tunnel through the vents.  | MTA (Bridges and Tunnels) | N/A     | 5 years   | \$18 M        | HMGP, 406                                 | Conceptual stage; design study will be needed | 2.1, 2.2, 2.9        | Medium         |
| CS.P.19 | Emergency Services     | <b>Water-level monitoring/alarm systems/CCTV:</b> Provide for water-level monitoring/alarm systems/CCTV throughout Metro-North's right-of-way. Install water-level monitoring and alarm devices, including cameras, at critical key locations such as power substations, central instrument locators, yards, and stations to provide Metro-North management with information to facilitate power shutoff to avoid equipment damage and risks to customer and employee safety. | MTA (MNR)                 | FTA     | 3-4 years | \$25 M        | Sandy Emergency Relief Program Resiliency | N/A   | 2.1, 2.10            | High           |

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| CS.P.20 | Property Protection | <b>Power and communications/signal infrastructure mitigation:</b> Elevate power supply components including sectionalizing switches, snowmelters, and bond boxes; explore making equipment watertight; raise critical substation equipment at key locations; and elevate central instrument locators, signal boxes, and other on-ground signal apparatus to minimize equipment susceptibility to flooding. | MTA (MNR) | FTA                | 4 years             | \$25 M        | Sandy Emergency Relief Program Resiliency | N/A                  | 2.1, 2.2             | Medium         |
| CS.P.21 | Property Protection | <b>Hardening of vulnerable healthcare facilities:</b> Assess facilities' risk for water intrusion and power loss from a coastal storm (including those considered to be receiving facilities for surge patients) to identify gaps and inform future planning.  | NYS DOH   | DOHMH              | Potentially 2 years | \$1.12 M      | SSBG                                      | N/A                  | 1.1, 2.1             | High           |
| CS.P.22 | Property Protection | <b>Protection of hurricane shelter windows:</b> Retrofit windows to withstand winds associated with coastal storms.  | OEM       | DOE, FEMA, NYS OEM | TBD                 | TBD           | HMGP, PDM-C                               | No change            | 1.1, 2.2, 2.7        | Medium         |
| CS.P.23 | Emergency Services  | <b>Hazards U.S. Multi-Hazard (HAZUS-MH) modeling:</b> Use HAZUS-MH computer modeling to determine losses generated by a coastal storm/hurricane and engineering effectiveness and cost-benefit of various coastal storm mitigation measures. Evaluate various flood and wind design enhancements for prototypical New York City building types.  | OEM       | DOB                | 3 months            | TBD           | Agency operating budget                   | No change            | 2.5, 5.1, 5.2        | High           |
| CS.P.24 | Emergency Services  | <b>Backup power for evacuation centers:</b> Install 30 permanent generators and 30 quick-connects for the 60 schools that also serve as evacuation centers and/or hurricane shelters during a hurricane evacuation or other large-scale citywide emergency. Install eight permanent generators at schools that serve as "special medical needs shelters."  | OEM       | DOE, SCA, CUNY     | 3 years             | \$14.24 M     | HMGP                                      | N/A                  | 1.1, 2.1, 2.3        | Medium         |

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| CS.P.25 | Emergency Services  | <b>Storm shutters for the Emergency Operations Center (EOC):</b> Protect the City's EOC from hurricane-force winds and flying debris by installing storm shutters at 165 Cadman Plaza East, Brooklyn.  | OEM   | DCAS                               | 2 years  | \$800 K       | HMGP                                  | No change            | 2.1, 2.7                | High           |
| CS.P.26 | Emergency Services  | <b>Storm surge/tidal gauge real-time monitoring system:</b> Install first set of gauges well offshore to act as an early warning system; install second set at the coastline so surge levels can be assessed as surge makes landfall; install third set inland to assess expanse and height of surge impacts.  | OEM   | USACE, FEMA, USGS, DCAS            | TBD      | TBD           | TBD                                   | N/A                  | 5.2                     | Medium         |
| CS.P.27 | Property Protection | <b>Evacuation center/ hurricane shelter ADA retrofit program for DOE facilities:</b> Upgrade key elements of the Coastal Storm Plan's facilities to ensure access by individuals with special needs and disabilities. Retrofit entrances and restroom facilities in compliance with Americans with Disabilities Act (ADA).   | OEM   | DOE, SCA, MOPD, NYC Law Department | 1 year   | \$10 M        | City capital budget, CDBG             | N/A                  | 1.1, 2.1, 2.7           | Medium         |
| CS.P.28 | Prevention & Policy | <b>Updates to urban post-disaster interim neighborhood and housing design guidelines:</b> Incorporate lessons learned from Sandy into playbook developed with DCP in 2010 for post-disaster interim housing construction and site selection. Address permitting processes and legal requirements for implementation of deployable housing on a large scale, thereby creating a way to keep communities together. | OEM   | DCP, DDC, DOB, HRO                 | 1 year   | \$100 K       | FEMA, RCPGP, private foundation funds | N/A                  | 1.1, 2.5, 2.6           | High           |
| CS.P.29 | Prevention & Policy | <b>Cleanup standards for waterfront brownfields:</b> Explore strengthened cleanup standards for waterfront brownfields.  | OER   | Law Department                     | 3 months | No cost       | Staff time                            | N/A                  | 1.5, 2.1, 2.4, 2.6, 5.2 | High           |
| CS.P.30 | Prevention & Policy | <b>Building Code update for wind resiliency in new buildings:</b> Amend the Building Code and complete studies to improve wind resiliency for new and substantially improved buildings.  | OLTPS | N/A                                | TBD      | \$5 M         | TBD                                   | N/A                  | 1.3, 2.4, 2.5, 5.2      | High           |

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| CS.P.31           | Prevention & Policy | <b>Building Code update for wind resiliency in existing buildings:</b> Amend Building Code to improve wind resiliency for existing buildings and complete studies of potential retrofits.  | OLTPS            | N/A         | TBD         | \$5 M         | TBD                      | Ongoing              | 1.3, 2.4, 2.5, 5.2   | High           |
| CS.P.32           | Emergency Services  | <b>Power exercises:</b> Continue to conduct power exercises. The 249th Engineering Battalion, OEM, and representatives of other municipalities and counties on the RCPT will conduct emergency generator power assessments throughout the New York City metro area.  | USACE, OEM, RCPT | NYSDEC, DPR | TBD         | TBD           | USACE, RCPGP             | N/A                  | 2.1, 2.3             | Medium         |
| CYBER THREATS     |                     |  |                  |             |             |               |                          |                      |                      |                |
| CY.P.1            | Prevention & Policy | <b>Supplementation of IT security:</b> Develop plan to potentially utilize a future DoITT backup facility and/or identify cloud services that satisfy security concerns.   | HRA              | DoITT       | 2-year plan | TBD           | Expense budget           | N/A                  | 1.1, 2.10            | Medium         |
| CY.P.2            | Prevention & Policy | <b>Cyber-security strategy:</b> Develop MNR-wide cyber-security strategy and operational plan to identify threats and vulnerabilities to all cyber systems (including SCADA, communications, signals, corporate data, security networks), and put operational plans in place to mitigate those threats and reduce vulnerabilities. | MTA (MNR)        | N/A         | TBD         | \$500 K       | Staff time               | N/A                  | 2.1, 2.3, 2.10       | Medium         |
| DISEASE OUTBREAKS |                     |  |                  |             |             |               |                          |                      |                      |                |
| DO.P.1            | Prevention & Policy | <b>Pandemic planning:</b> Develop plans and procure Personal Protective Equipment (PPE) addressing protection of employees; maintenance of essential functions and services; support for local, state, and federal response; and communication with customers about pandemic planning and response.                                | MTA (MNR)        | TBD         | TBD         | TBD           | TBD                      | N/A                  | 1.1, 2.1             | Medium         |

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| DROUGHT    |                        |  |      |         |   |               |   |   |                      |                |
| D.P.1      | Infrastructure Project | <b>Maximizing capacity for water delivery from the Catskill/Delaware system:</b> Pressurize the Catskill Aqueduct between Kensico Reservoir and DEP's ultraviolet disinfection facility to give DEP the ability to maximize use of water from Kensico Reservoir and flow to Hillview Reservoir.          | DEP  | N/A     | Project deferred until after repair of Delaware Aqueduct leak | \$535 M       | City capital budget                           | N/A   | 2.1, 2.7, 2.8        | Medium         |
| D.P.2      | Infrastructure Project | <b>Catskill Aqueduct capacity:</b> Increase capacity to allow movement of water out of the Catskill systems, thereby providing up to 60 million gallons per day of additional flow from the Catskill watershed in the event of a localized drought or loss of access to the Croton and Delaware systems. | DEP  | N/A     | Project completed by 2021                                     | \$196 M       | City capital budget                           | No change   | 2.1, 2.7, 2.8        | Medium         |
| D.P.3      | Prevention & Policy    | <b>Construction Code revision:</b> Provide standards to encourage water recycling.   | DOB  | N/A     | Mayoral adoption Dec. 2013/ law effective Oct. 1, 2014        | TBD           | Staff time                                    | Mayoral adoption Dec. 2013/law effective Oct. 1, 2014 | 2.5, 4.3             | High           |
| D.P.4      | Prevention & Policy    | <b>Drought effects monitoring:</b> Measure, monitor, and enforce the effects of droughts on hydrant use and availability.  | FDNY | DEP     | TBD   | TBD           | TBD   | N/A   | 1.1, 1.5, 2.1        | Medium         |
| EARTHQUAKE |                        |  |      |         |   |               |   |   |                      |                |
| EQ.P.1     | Property Protection    | <b>Mechanical equipment seismic upgrade:</b> Install new mechanical equipment to resist seismic forces in 55 City-owned buildings.   | DCAS | N/A     | Ongoing   | \$500 K       | City capital budget, New York Power Authority | No change   | 2.1, 2.7             | High           |



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| EQ.P.2 | Property Protection | <b>Seismic protection for sewers:</b> Inspect and repair structural deficiencies in intercepting sewers to reduce the impact of seismic activity.   | DEP  | N/A   | Ongoing   | Unknown       | City capital budget, expense budget | No change  | 2.1, 2.7, 2.8        | High           |
| EQ.P.3 | Property Protection | <b>Seismic inspection and retrofit for drinking water distribution system:</b> Conduct study to determine seismic design standards and seismic resiliency of drinking water distribution system (tunnels, piping, clean water pump stations, dams, shafts, and tanks). Use study results to prioritize and retrofit distribution infrastructure to appropriate seismic standards as needed. | DEP  | N/A   | Ongoing   | Unknown       | City capital budget, expense budget | No change  | 2.1, 2.7, 2.8, 5.2   | High           |
| EQ.P.4 | Prevention & Policy | <b>Building code update:</b> Adopt new seismic standards for risk-based requirements, and enhanced design requirements for liquefaction.  | DOB  | Mayoral adoption Dec. 2013/<br>law effective Oct. 1, 2014 | Fall 2014 | TBD           | Staff time                          | Mayoral adoption Dec. 2013/<br>law effective Oct. 1, 2014      | 1.5, 2.5, 2.7        | High           |
| EQ.P.5 | Property Protection | <b>Seismic study and retrofit for tall buildings:</b> Perform seismic study of existing tall buildings, and retrofit buildings to exceed new Building Code seismic provisions.  | DOE  | DOE-SCA,<br>DOB   | 10 years  | TBD           | FEMA                                | No change  | 1.1, 2.1, 2.5, 2.7   | High           |
| EQ.P.6 | Prevention & Policy | <b>Building upgrades to seismic codes:</b> Retrofit MLK, Ron Brown, and Kountz pavilion superstructures at the Harlem Hospital campus to meet new seismic codes.  | HHC  | DASNY   | 12 months | \$12.9 M      | General obligation bonds            | Scope expanded to include MLK, Ron Brown, and Kountz pavilions | 1.1, 2.1, 2.7        | Medium         |
| EQ.P.7 | Property Protection | <b>HPD facility improvement:</b> Retrofit HPD site offices to withstand a magnitude 8 earthquake.   | HPD  | DCAS  | 2 years   | \$10 M        | Grants                              | N/A  | 2.1, 2.7             | Medium         |

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| EQ.P.8               | Property Protection | <b>UPACA (Site 6):</b> Reinforce building to meet earthquake codes.   | NYCHA | TBD   | TBD      | TBD           | TBD                      | N/A                  | 1.1, 2.1, 2.7        | Medium         |
| EQ.P.9               | Emergency Services  | <b>HAZUS-MH modeling:</b> Evaluate various seismic building design enhancements using HAZUS-MH to identify enhancements that reduce losses generated by earthquakes.                      | OEM   | DOB   | 3 months | TBD           | Agency operating budget  | No change            | 2.5, 5.1, 5.2        | High           |
| EXTREME TEMPERATURES |                     |   |       |   |          |               |                          |                      |                      |                |
| ET.P.1               | Emergency Services  | <b>Power redundancy in City buildings:</b> Install generators in select buildings to provide power during blackouts and emergency operations.   | DCAS  | N/A   | 5 years  | \$10 M        | City capital budget      | Ongoing              | 2.1, 2.3             | Medium         |
| ET.P.2               | Emergency Services  | <b>AC upgrade for senior centers:</b> Continue to monitor status of AC systems at senior centers to help mitigate the effects of heat. Provide for repair or replacement as required.     | DFTA  | NYCHA   | 2 years  | TBD           | TBD                      | Ongoing              | 1.1, 1.5, 2.7        | Medium         |
| ET.P.3               | Prevention & Policy | <b>AC availability and affordability:</b> Advocate for state and city funding to make ACs available and affordable to qualified seniors and people with disabilities and chronic disease. | DOHMH | City: OEM, Mayor's Office, DFTA, HRA. State: NYSDOH, OTDA       | TBD      | TBD           | Staff time               | No change            | 1.1, 1.5, 1.6        | Medium         |
| ET.P.4               | Prevention & Policy | <b>Urban heat island effect mitigation:</b> Map and evaluate mitigation strategies implemented in New York City.  | DOHMH | OLTPS, DPR, NYC Service/ Mayor's Office, NPCC, academic partner | 3 years  | \$1 M         | CDBG                     | N/A                  | 1.1, 1.5, 5.2        | High           |

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| ET.P.5   | Prevention & Policy                     | <b>Cooling centers:</b> Classify all NYCHA community centers as resident cooling centers and retrofit with enhanced AC systems.   | NYCHA | TBD     | TBD      | TBD           | TBD                      | N/A                  | 1.1, 2.7                      | Medium         |
| FLOODING |   |   |       |         |          |               |                          |                      |                               |                |
| F.P.1    | Property Protection                     | <b>Infrastructure flood protection:</b> Create spill vaults to minimize damage from flooding in below-grade fuel-storage containers.  | DCAS  | DOE     | TBD      | TBD           | FEMA                     | No change            | 2.1, 2.7                      | Medium         |
| F.P.2    | Education & Awareness                   | <b>Flood Resilient Building Design Manual:</b> Provide guidance for planning and design of new construction and retrofit of existing buildings in areas subject to flooding. Guidance will mitigate property damage and life safety dangers posed by structurally and superficially damaged buildings.  | DCP   | DOB     | 2014     | N/A           | N/A                      | N/A                  | 2.4, 2.5, 2.6, 2.7, 2.8, 2.10 | High           |
| F.P.3    | Prevention & Policy                     | <b>Zoning for flood-resistant construction, Phase I and II:</b> Make text amendments to modify zoning to encourage flood-resistant construction. The regulations would be consistent with updated flood area construction practices and the need for greater resilience in the larger flood zones established by FEMA.  | DCP   | DOB     | 2013     | N/A           | N/A                      | N/A                  | 2.4, 2.5                      | High           |
| F.P.4    | Coastal/<br>Natural Resource Protection | <b>Ecologically sensitive industrial area planning:</b> Conduct area plans for ecologically significant maritime and industrial areas that have significant environmental contamination. Work with Brownfield Opportunity Area grant recipients, local communities, and elected officials to identify next steps, and seek funding for further studies of existing conditions and strategies to promote maritime businesses and address environmental issues. | DCP   | N/A     | N/A      | N/A           | N/A                      | N/A                  | 2.4, 2.5, 2.6                 | High           |

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| F.P.5 | Infrastructure Project | <b>Croton Falls pump station rehabilitation:</b> Provide additional redundancy for water supply operations by allowing DEP to move water between the Croton and Catskill/Delaware systems to supplement the local distribution system. Upgrade pumps stations to provide 87 million additional gallons per day into distribution if there is an emergency service disruption in the Catskill or Delaware system. | DEP  | N/A        | 2017     | \$41 million  | City capital budget      | No change                                       | 2.1, 2.7, 2.8        | Medium         |
| F.P.6 | Infrastructure Project | <b>Bergen Basin and Tallman Island Wastewater Treatment Plant drainage upgrades:</b> Reconfigure and expand sewer system capacity in Bergen Basin and Tallman Island Wastewater Treatment Plant drainage areas to capture more stormwater, reduce combined sewer overflows into surrounding water bodies, and prevent sewer backups and street flooding.   | DEP  | N/A        | 2023     | \$106 M       | City capital budget      | No change                                       | 2.1, 2.7, 2.8        | Medium         |
| F.P.7 | Emergency Services     | <b>Server capacity improvements:</b> Enhance agency servers housing necessary data. Agency servers crashed due to flooding. Additional servers outside of flood zones are necessary to ensure safety of customer data and reimbursement of partners.   | DFTA | DoITT, HRA | 2 years  | \$637 K       | DFTA, TBD                | N/A   | 1.1, 2.3, 2.10       | High           |
| F.P.8 | Property Protection    | <b>DHS electrical improvements:</b> Relocate electrical closets from the lower floors/basements to higher levels at the 26 DHS sites.  | DHS  | N/A        | Ongoing  | \$13.5 M      | TBD                      | Scope reduced to 26 DHS sites from 29 DHS sites | 1.1, 2.1, 2.2        | Medium         |
| F.P.9 | Property Protection    | <b>Borden Avenue facility:</b> Dig an exterior trench around foundation to divert water to Newtown Creek, waterproof foundation, and elevate first-floor level.  | DHS  | DEP, DOB   | Ongoing  | \$4.24 M      | HMPG                     | N/A   | 1.1, 1.5, 2.1        | Medium         |

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| F.P.10 | Emergency Services     | <b>Data system upgrade:</b> Computerize data system to assist in post-storm inspections.  | DOB   | N/A     | Fall 2014   | TBD           | Staff time               | Ongoing              | 2.3, 2.5                | High           |
| F.P.11 | Prevention & Policy    | <b>Post-disaster code enforcement:</b> Hire staff to enforce mitigation measures in Sandy rebuilding efforts, specifically in accordance with NFIP standards.   | DOB   | N/A     | 3 years     | \$6.31 M      | HMGP                     | N/A                  | 1.1, 2.4, 2.5, 2.7, 2.9 | High           |
| F.P.12 | Infrastructure Project | <b>Rikers Island roadway re-grading:</b> Redesign and elevate roadways on Rikers Island to alleviate flooding conditions.   | DOC   | N/A     | TBD         | \$4.6 M       | City capital budget      | No change            | 1.1, 2.1, 2.7           | Medium         |
| F.P.13 | Property Protection    | <b>Water infiltration prevention:</b> Do thermal imaging of roofs and building facades of all DOHMH facilities to determine areas and extent of existing water infiltration.  | DOHMH | N/A     | 6-12 months | \$80 K        | Grant funds              | N/A                  | 1.1, 2.1, 5.2           | Medium         |
| F.P.14 | Property Protection    | <b>Flood-proofing 125 Worth Street vault:</b> Seal the existing window with masonry, move the HVAC system to the building's roof, install large-capacity sump pumps in the floor to pump any water out, and install a new FM-200 fire suppression system that does not use water. | DOHMH | DCAS    | 6-18 months | \$463 K       | N/A                      | N/A                  | 2.1, 2.2, 2.7           | Medium         |

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| F.P.15 | Infrastructure Project              | <b>Permeable pavement:</b> Expand use of permeable pavement in roadways, plazas, and (where appropriate) sidewalks to capture and detain stormwater to mitigate localized flooding of streets, reduce flooding of structures, make streets passable to emergency vehicles more quickly, and reduce loads on sewage treatment plants and consequent combined sewer overflows. | DOT  | DDC     | 5 years (design, construction) | \$30 M        | HMGP, DEP G.I. funding, state GIGP grants, TEP/TAP grants, City Capital Budget | Incorporates several 2009 projects (MH.P.37, F.E.15, F.E.36, F.P.8) | 2.1, 2.7, 2.8, 2.9   | High           |
| F.P.16 | Property Protection                 | <b>Flood-proofing at Olmsted site:</b> Implement flood-proofing (including possible elevation and creation of additional drainage capacity) at the Olmsted Center, DPR's capital division headquarters, which suffers repetitive flooding.   | DPR  | N/A     | 5 years                        | \$10 M        | TBD  | No change   | 2.1, 2.2, 2.7        | Low            |
| F.P.17 | Emergency Services                  | <b>Tidegate upgrade in Flushing Meadow Corona Park:</b> Update and upgrade tidegates in the floodwater flow control structure under the north fascia of the Purpose Bridge. Install automated system that can be opened and closed based on tides, replacing the current gate system, which is manually controlled and difficult to operate.                                 | DPR  | DEP     | TBD                            | \$5 M         | HMGP, other funding  | N/A   | 2.1, 2.3, 2.7        | High           |
| F.P.18 | Coastal/Natural Resource Protection | <b>Living shoreline at Conference House Park:</b> Investigate the feasibility of using offshore breakwaters, salt marsh reconstruction, reinforced dunes, and upland canopy restoration to protect Conference House Park and restore lost habitat.   | DPR  | N/A     | 3 years                        | \$36 M        | HMGP   | N/A   | 2.8, 4.3, 4.4        | Medium         |

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| F.P.19 | Emergency Services  | <b>Protection for the Manhattan 1,2,5 facility:</b> Do new design planning for the Manhattan 1,2,5 facility under construction to provide for automated flood protection gates built into the sidewalks.  | DSNY | N/A     | January 2015 | Unknown       | City capital budget      | N/A                            | 2.1, 2.7, 2.8        | Medium         |
| F.P.20 | Prevention & Policy | <b>Stapleton waterfront flood mitigation:</b> Construct a new tidal wetlands area at the Stapleton waterfront, between Canal and Water Streets, and a pilot stormwater management system in an adjacent public open space to capture stormwater before it reaches the bay.                        | EDC  | N/A     | 24 months    | \$16 M        | HMGP                     | Currently pending grant review | 2.7, 4.3, 4.4        | Medium         |
| F.P.21 | Property Protection | <b>Brooklyn Army Terminal passive flood barrier system:</b> Install 550 linear feet of passive flood barriers at Building A to prevent future flood damage.   | EDC  | N/A     | 24 months    | \$1.24 M      | HMGP                     | Currently pending grant review | 2.1, 2.7             | High           |
| F.P.22 | Property Protection | <b>Hardening of EDC Emergency Operations Center:</b> Raise the emergency generator at the Brooklyn Emergency Operations Center, and upgrade emergency backup systems related to MIS equipment at Brooklyn Emergency Operations Center and Manhattan Asset Management Emergency Operations Center. | EDC  | N/A     | 24 months    | \$ 53 K       | HMGP                     | Currently pending grant review | 2.1, 2.2, 2.3, 2.7   | High           |
| F.P.23 | Property Protection | <b>Flood effects reduction program:</b> Install electronic check valves at the street level to prevent sewer and stormwater backflow at firehouses and other locations prone to flooding and damage associated with storms.   | FDNY | DDC     | TBD          | TBD           | TBD                      | N/A                            | 2.1, 2.10            | Medium         |
| F.P.24 | Emergency Services  | <b>Dewatering pumps at FDNY facilities:</b> Purchase and install dewatering pumps at FDNY facilities in the revised FEMA flood zones, and acquire portable dewatering pumps for field units.  | FDNY | DHS     | TBD          | TBD           | TBD                      | N/A                            | 2.1                  | Medium         |

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| F.P.25 | Property Protection | <b>New construction flood mitigation:</b> Raise newly built and in-construction structures (e.g., firehouses and EMS stations) several feet in the designated flood zone(s), according to FEMA standards.                                  | FDNY | DDC     | TBD       | TBD  | TBD                                       | N/A                  | 1.1, 2.1, 2.2           | Medium         |
| F.P.26 | Property Protection | <b>Coney Island Hospital flood-proofing:</b> Install flood-proofing in Coney Island Hospital basement as part of the Phase II modernization.   | HHC  | TBD     | 7 years   | \$13.3 M                                       | General obligation bonds                  | No change            | 1.1, 2.1, 2.7, 2.8      | Medium         |
| F.P.27 | Property Protection | <b>Coney Island Hospital emergency department mitigation:</b> Relocate and elevate the emergency department and its critical systems (imaging and generators) above the base flood elevation.  | HHC  | TBD     | 3-4 years | Additional \$60 M (some parts damaged/covered) | 406, HMGP, CDBG, general obligation bonds | N/A                  | 1.1, 2.1, 2.8           | Medium         |
| F.P.28 | Property Protection | <b>Coney Island Hospital critical system protection:</b> Elevate or harden generator and essential electrical components; elevate switchgear; harden fuel tanks; harden fuel pumping stations; and elevate or harden domestic water pumps. | HHC  | TBD     | 1 year    | \$50 M   | FEMA HMGP, general obligation bonds       | N/A                  | 1.1, 2.1, 2.2, 2.7, 2.8 | Medium         |
| F.P.29 | Property Protection | <b>Metropolitan Hospital flood barriers:</b> Install flood barriers.   | HHC  | TBD     | 1-2 years | \$55 M   | HMGP, general obligation bonds            | N/A                  | 1.1, 2.1, 2.7, 2.8      | Medium         |
| F.P.30 | Property Protection | <b>Metropolitan Hospital critical systems elevation:</b> Relocate and elevate emergency department and its critical systems (imaging and generators) above the base flood elevation.   | HHC  | TBD     | 2 years   | \$7 M  | HMGP, CDBG, general obligation bonds      | N/A                  | 1.1, 2.1, 2.8           | Medium         |



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| F.P.31 | Property Protection    | <b>Coler Hospital and Nursing Facility protection:</b> Harden and elevate electrical equipment and switchgears to the 500-year expected flood elevation at Coler Hospital and Nursing Facility.   | HHC               | TBD     | 1 year          | \$30 K        | HMGP, general obligation bonds                | N/A                  | 1.1, 2.1, 2.7, 2.8   | Medium         |
| F.P.32 | Property Protection    | <b>Coler Hospital and Nursing Facility fuel-tank hardening:</b> Harden emergency fuel tanks and pumps and domestic water pumps at Coler Hospital and Nursing Facility.  | HHC               | TBD     | 1 year          | \$38 K        | HMGP, general obligation bonds                | N/A                  | 1.1, 2.1, 2.7, 2.8   | Medium         |
| F.P.33 | Property Protection    | <b>Building flood protection:</b> Supply buildings susceptible to flooding with sandbags and/or request that landlord do so.  | HRA               | N/A     | TBD             | TBD           | Expense budget                                | N/A                  | 1.1, 2.1, 2.6, 2.7   | Medium         |
| F.P.34 | Emergency Services     | <b>Water infiltration study:</b> Study flood-prone areas to determine ways to prevent water from entering system. This study will involve analyzing inflow and outflow capacity, storage, etc.; identify funding. Implement drainage master plan, if recommended by study.  | MTA (NYCT-Subway) | DEP     | 5 years (study) | TBD           | FEMA, NYCT                                    | No change            | 2.1, 2.7             | Medium         |
| F.P.35 | Infrastructure Project | <b>Double track Main Line, Phase 2.</b> Complete second track on the Main Line between Farmingdale and Ronkonkoma to allow LIRR to operate increased off-peak service on the Main Line. This added service is critical should a catastrophic event halt LIRR service on Long Island's South Shore, impacting southeast Queens stations. | MTA (LIRR)        | N/A     | TBD             | \$300 M       | Potential FTA Local Priority Resiliency funds | N/A                  | 2.1, 2.3             | Medium         |
| F.P.36 | Infrastructure Project | <b>Ventilation grate improvements:</b> Make grate improvements in Atlantic Avenue tunnels.  | MTA (LIRR)        | N/A     | TBD             | \$4 M         | Potential FTA Local Priority Resiliency Funds | N/A                  | 2.1, 2.7             | Medium         |

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| F.P.37 | Property Protection | <b>Long Island City Yard protection:</b> Implement protection measures for the Yard, which include installation of retention manholes, sump pumps, drainage systems, and flood wall; and electrification of yard tracks.   | MTA (LIRR) | N/A     | TBD                               | TBD           | TBD                      | N/A   | 2.1, 2.7             | Medium         |
| F.P.38 | Property Protection | <b>Safeguarding NYCHA cellar equipment:</b> Install duplex sump pumps for dewatering and additional floor drains; raise switchgear where possible; use watertight seals on electrical panels subject to flooding; and install elevated platforms for vital equipment. Avoid using cellars for public use (meeting rooms, centers, etc.). | NYCHA      | TBD     | Estimated time of completion 2016 | \$7.7 M       | Insurance and FEMA       | To be incorporated with Hurricane Sandy development re-design efforts | 2.2, 2.7, 2.8        | Medium         |
| F.P.39 | Property Protection | <b>New NYCHA building/development:</b> Construct a building or development adding a number of units to the NYCHA portfolio equal to the number of first-floor apartments in Evacuation Zones 1, 2, and 3 to be vacated and used for other purposes.  | NYCHA      | TBD     | TBD                               | TBD           | TBD                      | N/A   | 1.1, 2.2             | Low            |
| F.P.40 | Property Protection | <b>NYCHA floodgates and barriers:</b> Install floodgates and barrier mechanisms to control the rate of water infiltration into building areas prone to flooding.   | NYCHA      | TBD     | Estimated time of completion 2016 | TBD           | Insurance, FEMA          | N/A   | 2.1, 2.7, 2.8        | Medium         |
| F.P.41 | Property Protection | <b>NYCHA boiler rooms and electrical equipment:</b> Relocate low-lying boiler rooms and electrical switchgear panels submerged during Hurricane Sandy to areas within existing structures, new extensions, or stand-alone facilities at higher elevations.   | NYCHA      | TBD     | Estimated time of completion 2016 | \$25.08 M     | HMGP                     | N/A   | 1.1, 2.1, 2.2        | Medium         |
| F.P.42 | Property Protection | <b>Sump pump protection:</b> Upgrade sump pumps in facilities in 100-year floodplain.  | NYPD       | N/A     | TBD                               | TBD           | TBD                      | N/A   | 2.1, 2.7, 2.8        | Medium         |

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| F.P.43 | Property Protection    | <b>Building electrical protection:</b> Relocate existing electrical distribution within NYPD buildings to areas or floors above the 100-year flood level.   | NYPD  | N/A                | TBD       | TBD           | TBD                      | N/A                  | 2.1, 2.2, 2.7, 2.8   | Medium         |
| F.P.44 | Property Protection    | <b>Boiler protection:</b> Raise boilers in buildings to locations above 100-year flood level.   | NYPD  | N/A                | TBD       | TBD           | TBD                      | N/A                  | 2.1, 2.2, 2.7, 2.8   | Medium         |
| F.P.45 | Property Protection    | <b>Short-term flood mitigation of OCME emergency management storage facility at 18<sup>th</sup> Street and FDR Drive:</b> Relocate all equipment to a leased warehouse in a centralized area not prone to flooding. | OCME  | N/A                | Unknown   | \$4.4 M       | City capital budget      | N/A                  | 2.1, 2.2, 2.7, 2.9   | Medium         |
| F.P.46 | Property Protection    | <b>Flood mitigation measures for New York City's backup Emergency Operations Center:</b> Implement flood mitigation measures, including sump-pumps, wet flood-proofing, and drainage improvements.                  | OEM   | DCAS, FEMA         | 2–3 years | \$10 M        | HMGP, PDM-C              | No change            | 2.1, 2.7             | Medium         |
| F.P.47 | Emergency Services     | <b>HAZUS-MH modeling:</b> Evaluate various building design enhancements using HAZUS-MH to identify opportunities to reduce flooding.  | OEM   | DOB                | 3 months  | Staff time    | Agency operating budget  | No change            | 2.5, 5.1, 5.2        | Medium         |
| F.P.48 | Education & Awareness  | <b>Public information and guidance:</b> Disseminate mitigation information and help provide technical assistance to property owners affected by flood events.   | OEM   | DEP, FEMA, NYS OEM | TBD       | TBD           | HMGP, PDM-C              | No change            | 2.6, 5.1, 5.2, 5.3   | High           |
| F.P.49 | Infrastructure Project | <b>Local storm surge barrier for Gowanus Canal:</b> Call on and work with the USACE to develop an implementation plan and preliminary designs for a surge barrier.  | OLTPS | N/A                | TBD       | \$2 M         | TBD                      | N/A                  | 4.3, 4.4             | High           |

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| F.P.50 | Infrastructure Project | <b>Plan for flood protection along the Williamsburg, Greenpoint, and Long Island City coastlines:</b> Create an implementation plan for comprehensive improvements on public and private property.   | OLTPS | DCP, DOT, DPR | TBD      | \$1 M         | TBD                      | N/A                  | 4.3, 4.4             | High           |
| F.P.51 | Infrastructure Project | <b>Floodgate repairs at Oakwood Beach, Staten Island:</b> Continue to work with the USACE to complete emergency floodgate repairs at Oakwood Beach.  | OLTPS | N/A           | TBD      | \$1 M         | USACE                    | N/A                  | 4.3, 4.4             | Medium         |
| F.P.52 | Infrastructure Project | <b>Primary and secondary dune systems in Rockaway Peninsula:</b> Protect vulnerable neighborhoods in the Rockaway Peninsula, such as Breezy Point, against flooding from the Atlantic Ocean through a primary and secondary dune system. Protect against bay-side flooding through additional flood mitigation measures. | OLTPS | HRO/DPR       | TBD      | \$58.1 M      | HMGP/CDBG-DR             | N/A                  | 1.1, 4.3, 4.4        | High           |
| F.P.53 | Infrastructure Project | <b>Offshore breakwaters adjacent to and south of Great Kills Harbor:</b> Call on and work with the USACE to study and install offshore breakwaters.  | OLTPS | N/A           | TBD      | \$250 M       | TBD                      | N/A                  | 4.3, 4.4             | High           |
| F.P.54 | Infrastructure Project | <b>Flood protection in Hunts Point:</b> Install an integrated flood protection system.   | OLTPS | N/A           | TBD      | \$171 M       | TBD                      | N/A                  | 2.1, 4.3, 4.4        | Medium         |
| F.P.55 | Infrastructure Project | <b>Flood protection in East Harlem:</b> Install an integrated flood protection system.   | OLTPS | N/A           | TBD      | \$189 M       | TBD                      | N/A                  | 1.1, 2.1, 4.3, 4.4   | Medium         |
| F.P.56 | Infrastructure Project | <b>Lower Manhattan flood protection:</b> Install an integrated flood protection system in Lower Manhattan, including the Lower East Side.  | OLTPS | N/A           | TBD      | \$315 M       | TBD                      | N/A                  | 1.1, 2.1, 4.3, 4.4   | Medium         |

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| F.P.57 | Infrastructure Project | <b>Integrated flood protection system for Red Hook:</b> Design and construct a flexible integrated flood protection system for Red Hook that is composed of elements such as terraced berms, benches, park walls, flood-proofed buildings, or bridge abutments; drainage improvements; and temporary features such as deployable floodwalls that can be erected in advance of an extreme weather event. | OLTPS | N/A     | TBD      | \$315 M       | TBD                      | N/A                  | 1.1, 2.1, 2.7        | Medium         |
| F.P.58 | Infrastructure Project | <b>Protection of Farragut substation:</b> Continue to work with Con Ed to protect the substation.   | OLTPS | N/A     | TBD      | N/A           | Ratepayers               | N/A                  | 2.1, 2.7, 3.3        | High           |
| F.P.59 | Infrastructure Project | <b>Newtown Creek flood protection:</b> Call on and work with the USACE to study and install local storm surge barriers at Newtown Creek.  | OLTPS | N/A     | TBD      | \$1 B         | TBD                      | N/A                  | 1.1, 2.1, 4.3, 4.4   | High           |
| F.P.60 | Prevention & Policy    | <b>Flood protection research:</b> Evaluate soft infrastructure as flood protection and study innovative coastal protection techniques.  | OLTPS | N/A     | TBD      | \$4 M         | TBD                      | N/A                  | 4.3, 4.4             | High           |
| F.P.61 | Prevention & Policy    | <b>Prevention of drainage pipe flooding:</b> Evaluate the city's vulnerability to drainage pipe flooding and identify appropriate solutions to minimize those risks.  | OLTPS | N/A     | TBD      | \$13 M        | TBD                      | N/A                  | 2.1, 4.3, 5.2        | High           |
| F.P.62 | Infrastructure Project | <b>Floodgate at Mill Creek:</b> Call on and work with the USACE to study the construction of a floodgate at Mill Creek.   | OLTPS | N/A     | TBD      | No cost       | N/A                      | N/A                  | 4.3, 4.4             | High           |

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|--------|------------------------|---|-------------------|--------------|----------|---------------|-----------------------------|----------------------|----------------------|----------------|
| F.P.63 | Prevention & Policy    | <b>Community Rating System:</b> Study approaches for New York City to join FEMA's Community Rating System program.  | OLTPS             | DOB, DCP     | TBD      | \$0.5 M       | CDBG                        | N/A                  | 1.6, 5.1             | High           |
| F.P.64 | Infrastructure Project | <b>Coney Island Creek wetlands and tidal barrier:</b> Develop an implementation plan and preliminary designs for new Coney Island Creek wetlands and tidal barrier.   | OLTPS             | N/A          | TBD      | \$1 M         | TBD                         | N/A                  | 4.3, 4.4             | High           |
| F.P.65 | Prevention & Policy    | <b>Integrated flood protection for southern Manhattan:</b> Create an implementation plan and design for an integrated flood protection system for remaining southern Manhattan areas.   | OLTPS             | N/A          | TBD      | \$1 M         | TBD                         | N/A                  | 2.1, 4.4             | High           |
| F.P.66 | Property Protection    | <b>Flood protection of vital infrastructure at LaGuardia Airport:</b> Construct a floodwall around the West Field Lighting Vault; protect West End Substation by installing dikes and re-grading; construct a new East Field Lighting Vault Building. | PANYNJ (Aviation) | FAA          | 4 years  | \$21.8 M      | PANYNJ capital budget, HMGP | N/A                  | 2.1, 2.7             | Medium         |
| F.P.67 | Property Protection    | <b>Flood protection of vital infrastructure at JFK Airport:</b> Restore capacity to handle stormwater runoff captured in catch basins and conveyed into outfalls 1 and 2 through storm drainage system.   | PANYNJ (Aviation) | FAA          | 4 years  | \$5 M         | PANYNJ capital budget, HMGP | N/A                  | 2.1, 2.7             | Medium         |
| F.P.68 | Property Protection    | <b>Drainage improvements at JFK Airport:</b> Install tide gates/drainage check valves to manage drainage outfalls in low-lying areas vulnerable to reverse flow through the drainage system.  | PANYNJ (Aviation) | DEP, NYS DEC | 4 years  | \$60 M        | PANYNJ capital budget, HMGP | N/A                  | 2.1, 2.7             | Medium         |

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| F.P.69 | Infrastructure Project | <b>Protection of JFK Airport fuel farm tanks:</b> Re-design "moat" system that surrounds each fuel farm tank to prevent flooding.  | PANYNJ (Aviation) | PANYNJ          | 4 years  | \$7 M         | PANYNJ capital budget, HMGP           | No change            | 2.1, 2.7, 4.1        | Medium         |
| F.P.70 | Infrastructure Project | <b>LaGuardia Airport dike wall:</b> Reinforce dike wall along Bowery Bay and runways 13-31.  | PANYNJ (Aviation) | FAA             | 4 years  | \$5 M         | PANYNJ capital budget, HMGP, FEMA 406 | No change            | 2.1, 2.7             | Medium         |
| F.P.71 | Property Protection    | <b>JFK Airport sanitary lift station:</b> Redesign and upgrade sanitary lift station in central terminal area to prevent facility flooding.  | PANYNJ (Aviation) | PANYNJ          | 5 years  | \$8 M         | PANYNJ capital budget, HMGP           | No change            | 2.1, 2.7             | Medium         |
| F.P.72 | Property Protection    | <b>JFK Airport runway upgrade:</b> Redesign and retrofit runways 4R and 22L including raising the grade, modifying existing drainage, and installing new lighting and concrete pavement.   | PANYNJ (Aviation) | FAA             | 4 years  | \$40 M        | PANYNJ capital budget                 | No change            | 2.1, 2.7             | Medium         |
| F.P.73 | Property Protection    | <b>JFK Airport runway upgrade:</b> Redesign and retrofit runways 4L and 22R including raising the grade, modifying existing drainage, and installing new lighting and concrete pavement.   | PANYNJ (Aviation) | FAA             | 4 years  | \$47.9 M      | PANYNJ capital budget                 | No change            | 2.1, 2.7             | Medium         |
| F.P.74 | Property Protection    | <b>Improvements to George Washington Bridge anchorage drainage system:</b> Install new passive drainage system and rehabilitate the New Jersey anchorage sump pump room to mitigate the effects of heavy rainfall on the structural components in the anchoring of the bridge. | PANYNJ (TBT)      | NJ DEP, NYS DEC | 4 years  | \$9.2 M       | PANYNJ capital budget, HMGP           | N/A                  | 2.1, 2.7             | Medium         |

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| F.P.75                  | Infrastructure Project | <b>Substation mitigation:</b> Raise replacement equipment in Sandy-flooded substations to protect against another storm of similar magnitude.  | PSEG | N/A     | November 2013 start, TBD completion | \$ 28.5 M (Far Rockaway, Arverne, Rockaway Beach, and Neponsit) | Insurance, 406, NYS CDBG fund, PSEG | N/A                  | 2.1, 2.2, 3.3        | Medium         |
| INFRASTRUCTURE FAILURES |                        |  |      |         |                                     |   |                                     |                      |                      |                |
| IF.P.1                  | Emergency Services     | <b>Expansion of cogeneration:</b> Explore the feasibility of expanding cogeneration and other energy-related reliability measures to other wastewater treatment plants in the city besides North River, including the Wards Island WWTP. These measures—which could include energy efficiency, increased generation, and use of renewable energy supplies such as methane gas and solar energy, and cogeneration—would improve the ability of wastewater treatment plants to operate reliably during electrical disruptions. | DEP  | N/A     | 2014                                | \$0.5 M   | Agency operating budget             | N/A                  | 2.1, 2.3, 2.7, 4.3   | High           |
| IF.P.2                  | Infrastructure Project | <b>Repair of the Delaware Aqueduct leak:</b> Implement planned repairs to the Delaware Aqueduct—which conveys, on average, 50% of the city's water from upstate sources—by constructing a bypass tunnel and repairing sections of the tunnel.  | DEP  | N/A     | Project to be completed in 2022     | \$760 M   | City capital budget                 | N/A                  | 2.1, 2.7, 2.8        | High           |
| IF.P.3                  | Property Protection    | <b>Utilities on Buono Bridge:</b> Build redundancy, including additional water and gas mains and upgraded generators, to protect against bridge collapse.  | DOC  | DOT     | TBD                                 | \$211 M   | City capital budget                 | No change            | 1.1, 2.1, 2.3        | Low            |



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| IF.P.4 | Infrastructure Project | <b>Facility electrical power and data infrastructure upgrade:</b> Provide necessary upgrades for building services during emergencies.   | DOHMH | DDC     | 12-36 months   | \$5 M         | City capital budget      | N/A                  | 2.1, 2.3             | High           |
| IF.P.5 | Emergency Services     | <b>DOHMH generators and retrofits:</b> Equip facilities with generators for continuity of building services during power outages, including making any necessary structural improvements to support generators.  | DOHMH | DDC     | 12 to 24 months  | \$500 K       | City capital budget      | N/A                  | 1.1, 2.3             | High           |
| IF.P.6 | Infrastructure Project | <b>Session Initiation Protocol (SIP):</b> Implement SIP for voice communication between 311 and the carrier's public network, enabling the City to be less reliant on one carrier central office and have the ability to fail over to alternate locations. | DoITT | N/A     | TBD  | \$3.5 M       | TBD                      | N/A                  | 1.2, 2.1, 2.3, 2.10  | High           |
| IF.P.7 | Emergency Services     | <b>Citywide Interactive Voice Response (IVR) for employee announcements:</b> Expand the City's in-house audio conferencing solution to support 500 simultaneous calls, with overflow of another 1,000 calls to be handled in the cloud.                    | DoITT | OEM     | TBD  | \$1.05 M      | TBD                      | N/A                  | 1.2, 2.1, 2.3, 2.10  | High           |
| IF.P.8 | Infrastructure Project | <b>Telecommunications Planning and Resiliency Office:</b> Create new unit in DoITT to study telecommunications risks and formulate and advocate for solutions.   | DoITT | N/A     | Federal grant for 2-year period; long-term funding TBD | \$1.2 M       | Federal block grant      | N/A                  | 2.1, 2.3, 2.10, 3.3  | High           |
| IF.P.9 | Infrastructure Project | <b>IP routing network:</b> Harden the network, providing the City with required advanced bandwidth management devices to regulate appropriate use of ISP links during emergencies.   | DoITT | N/A     | TBD  | \$2.9 M       | TBD                      | N/A                  | 1.2, 2.1, 2.2, 2.10  | High           |

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| IF.P.10 | Emergency Services     | <b>Emergency generators in NYCHA properties:</b> Install natural gas-powered, emergency generators throughout NYCHA properties to ensure building corridors and stairwells remain lit and provide power for vital domestic water pumps (high-rise buildings) and boilers for hot water and heating during utility outages.  | NYCHA | TBD     | Estimated completion 2016 | \$120 M       | HMGP, CDBG-DR            | N/A                  | 1.1, 2.1, 2.3        | Medium         |
| IF.P.11 | Prevention & Policy    | <b>Stand-alone power generation in NYCHA developments:</b> Re-engineer and re-configure all 334 NYCHA developments for enhanced stand-alone power generation. Consider all latest technologies including Microgrid, COGEN, and CHP.   | NYCHA | TBD     | TBD                       | TBD           | HMGP, CDBG-DR            | N/A                  | 1.1, 2.1, 2.3        | Medium         |
| IF.P.12 | Emergency Services     | <b>Backup generators for NYPD facilities:</b> Procure and install backup generators and automatic transfer switches.  | NYPD  | N/A     | TBD                       | TBD           | TBD                      | N/A                  | 2.1, 2.7, 2.8        | Medium         |
| IF.P.13 | Infrastructure Project | <b>Flood mitigation of 520 First Ave. (Manhattan Morgue) and Forensic biology building:</b> Purchase approximately 100,000 square feet of space due to history of flooding in these structures. Relocate records, evidence, samples, back up OCME training lab, special operations equipment/ vehicles, and records to a temperature-controlled, secured, CCTV-monitored warehouse under the control of OCME. | OCME  | N/A     | Unknown                   | \$13.06 M     | City capital budget      | N/A                  | 2.1, 2.2, 2.7, 2.9   | Medium         |
| IF.P.14 | Emergency Services     | <b>Kings and Queens facilities:</b> Acquire backup generators and storage for generators.   | OCME  | N/A     | Unknown                   | Unknown       | City capital budget      | N/A                  | 2.1, 2.3             | Medium         |

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| IF.P.15      | Emergency Services  | <b>Generator assessment and installation of quick-connects for critical infrastructure:</b> Expand the Prime Power Assessment Program citywide to include a generator quick-connect and/or generator installation in addition to the survey.   | OEM    | USACE, FEMA, DCAS, City agencies | Immediate                                      | \$50 M              | City capital budget      | No change            | 2.1, 2.3, 2.7        | Medium         |
| IF.P.16      | Emergency Services  | <b>Backup generators for gas stations and terminals:</b> Ensure that a subset of gas stations and terminals have access to backup generators in case of widespread power outages.  | OEM    | N/A                              | 1 year   | TBD                 | Agency operating budget  | N/A                  | 2.1, 2.3             | Medium         |
| IF.P.17      | Prevention & Policy | <b>Protection from utility service interruptions:</b> Amend the Construction Codes and develop best practices to protect against service interruptions.  | OLTPS  | N/A                              | TBD  | \$1 M               | TBD                      | N/A                  | 1.3, 2.5, 5.2        | High           |
| IF.P.18      | Prevention & Policy | <b>Distributed generation (DG) and micro-grids:</b> Work with public and private partners to scale up DG and micro-grids.  | OLTPS  | N/A                              | TBD  | \$5 M               | HMGP, CDBG               | N/A                  | 2.1, 2.3             | High           |
| IF.P.19      | Property Protection | <b>Purchase of mobile substation:</b> Mitigate substation outage by developing specifications and purchasing mobile substation equipment suitable for New York City applicability due to loss of key substation equipment.   | PSEG   | N/A                              | February 2013 start, September 2014 completion | \$2.9 M (two units) | 406, NYS CDBG fund, PSEG | N/A                  | 2.1, 2.3, 3.3        | High           |
| IF.P.20      | Property Protection | <b>Purchase of mobile switchgear:</b> Mitigate substation outage by developing specifications and purchasing mobile switchgear for use in event of switchgear disruption in or near substation.  | PSEG   | N/A                              | February 2013 start, December 2013 completion  | \$2 M (two units)   | 406, NYS CDBG fund, PSEG | N/A                  | 2.1, 2.3, 3.3        | High           |
| MULTI-HAZARD |                     |  |        |                                  |  |                     |                          |                      |                      |                |
| MH.P.1       | Prevention & Policy | <b>Overhead electric system improvements:</b> Fortify the overhead system from wind and tree damage by reducing circuits into smaller segments, isolating open wire spurs from feeder main runs, improving auto-loop reliability, and selective undergrounding of overhead infrastructure. | Con Ed | N/A                              | 4 years  | \$250 M             | Con Ed operating budget  | N/A                  | 2.7, 3.3             | Medium         |

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| MH.P.2 | Prevention & Policy | <b>Underground electric system improvements:</b> Fortify the underground system by installing submersible equipment in flood-prone areas and applying sectionalizing strategies to minimize number of customers impacted by flooding.  | Con Ed | N/A     | 4 years  | \$200 M       | Con Ed operating budget  | N/A                  | 2.7, 3.3             | Medium         |
| MH.P.3 | Prevention & Policy | <b>Gas system Improvements:</b> Fortify the gas system by installing special valves to prevent water infiltration and replacing cast-iron and bare-steel mains in flood zones.   | Con Ed | N/A     | 2 years  | \$100 M       | Con Ed operating budget  | N/A                  | 2.7, 3.3             | Medium         |
| MH.P.4 | Prevention & Policy | <b>Storm-hardening of critical facilities:</b> Install new and modify existing flood protection to improve storm-hardening at critical facilities to new flood-protection levels. Modify equipment housing and penetrations to minimize water intrusion.   | Con Ed | N/A     | 3 years  | \$400 M       | Con Ed operating budget  | N/A                  | 2.2, 2.7, 3.3        | Medium         |
| MH.P.5 | Property Protection | <b>Window upgrades:</b> Replace windows at 100 Centre Street, 1 Centre Street, 2 Lafayette Street, 125 Worth Street, and 80 Centre Street.   | DCAS   | DDC     | 10 years | \$15 M        | City capital budget      | No change            | 2.1, 2.2             | Medium         |
| MH.P.6 | Prevention & Policy | <b>Retail resiliency study:</b> Examine commercial corridors in the flood zone to better understand resiliency options.  | DCP    | N/A     | 2013     | N/A           | N/A                      | N/A                  | 3.3                  | Medium         |
| MH.P.7 | Prevention & Policy | <b>Building Identification Numbers (BINs):</b> Assign BIN numbers to buildings that currently do not have them and to structures (such as bridges, tunnels, subway stations, monuments, and temporary structures) to allow the FDNY to better inspect these buildings and structures as part of its Risk Based Inspection System (RBIS). | DCP    | N/A     | N/A      | N/A           | N/A                      | N/A                  | 2.1, 2.5, 5.2        | Medium         |
| MH.P.8 | Prevention & Policy | <b>BIN Working Group recommendations:</b> Implement recommendations made as result of the seven-month analysis of BIN usage.   | DCP    | N/A     | N/A      | N/A           | N/A                      | N/A                  | 2.1, 2.5, 5.2        | Medium         |

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| MH.P.9  | Property Protection    | <b>Inspection and upgrade program for DEP facilities:</b> Implement programmatic inspection and upgrade program to ensure all critical DEP facilities maintain continuity of operations during flood, hurricane, or earthquake events. This program will include flood-proofing and structural retrofits of DEP offices, field locations, and other critical facilities. | DEP  | N/A        | Ongoing  | Included in regular agency capital/operating budget | City capital budget/expense budget | No change            | 2.1, 2.3, 2.7, 2.8   | Medium         |
| MH.P.10 | Infrastructure Project | <b>Groundwater development:</b> Construct treatment facilities throughout the southeast Queens groundwater system to provide up to 55 million gallons per day of additional water treated to meet EPA Safe Drinking Water Act standards.   | DEP  | N/A        | TBD      | TBD   | TBD                                | No change            | 1.5, 2.1, 2.7        | Medium         |
| MH.P.11 | Infrastructure Project | <b>Groundwater treatment plant:</b> Construct a treatment facility in southeast Queens with four existing groundwater wells to provide an additional 12 million gallons of water supply for the city. Remove and treat groundwater to meet EPA Safe Drinking Water Act standards.  | DEP  | N/A        | 2021     | \$40 M  | City capital budget                | No change            | 1.5, 2.1, 2.7, 2.8   | Medium         |
| MH.P.12 | Emergency Services     | <b>Laptops for DFTA essential staff:</b> Purchase additional laptops for essential personnel to continue operations in the event of flooding at DFTA offices.  | DFTA | HRA, DoITT | 2 years  | \$11 K  | TBD                                | N/A                  | 1.1, 2.3             | High           |
| MH.P.13 | Emergency Services     | <b>Generator for neighborhood hub:</b> Purchase generator for one senior center hub in each borough.   | DFTA | CBOs       | 3 years  | TBD   | TBD                                | N/A                  | 1.1, 2.3             | Medium         |

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| MH.P.14 | Emergency Services  | <b>Headlamps for home-delivered meals deliverers:</b> Purchase headlamps to deliver meals safely to homebound individuals during power outages.  | DFTA | CMOW    | 2 years  | \$10 K        | TBD                      | N/A   | 1.1, 1.6, 2.3           | Medium         |
| MH.P.15 | Property Protection | <b>Upgrades to DHS buildings:</b> Add exterior reinforcements and energy performance enhancements to 29 DHS-owned buildings, exceeding Building Code requirements.   | DHS  | N/A     | Ongoing  | TBD           | TBD                      | No change   | 1.1, 2.1, 2.4, 2.5      | Medium         |
| MH.P.16 | Property Protection | <b>DHS building roof improvements:</b> Add ballast to flat roofs of 21 DHS-owned facilities to protect against high winds, heavy rain, and flying debris, exceeding the requirements of the Building Code.         | DHS  | N/A     | Ongoing  | \$2 M         | TBD                      | No change   | 1.1, 2.1, 2.4, 2.5      | High           |
| MH.P.17 | Property Protection | <b>Window upgrade in DHS buildings:</b> Retrofit windows in 29 DHS-owned facilities by glazing to withstand effects of coastal storms, windstorms, and tornadoes, exceeding the requirements of the Building Code. | DHS  | N/A     | Ongoing  | \$18 M        | TBD                      | No change   | 1.1, 2.1, 2.4, 2.5      | Medium         |
| MH.P.18 | Emergency Services  | <b>Power redundancy at DHS buildings:</b> Install redundant power supply at all DHS-owned facilities.  | DHS  | N/A     | Ongoing  | \$6.5 M       | TBD                      | Scope expanded to include the remaining 26 DHS-owned buildings. | 1.1, 2.3                | Medium         |
| MH.P.19 | Prevention & Policy | <b>DHS shelter protection:</b> Obtain restrictive covenants on six DHS shelters to replace with non-residential structures in areas within the flood and SLOSH zones.  | DHS  | N/A     | Ongoing  | TBD           | TBD                      | No change   | 1.1, 1.5, 2.1, 2.2      | Medium         |
| MH.P.20 | Property Protection | <b>Bellevue shelter facility improvements:</b> Elevate mechanical systems, create independent heating system, purchase emergency generator, and improve windows and roofing.                                       | DHS  | N/A     | Ongoing  | \$42.8 M      | HMGP                     | N/A   | 1.1, 1.5, 2.1, 2.4, 2.5 | Medium         |

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| MH.P.21 | Property Protection    | <b>LIFE Family Residence facility improvements:</b> Elevate mechanical systems and purchase emergency generator.   | DHS  | N/A     | Ongoing  | \$17 M        | HMGP                     | N/A                  | 1.1, 1.5, 2.1, 2.2, 2.3 | Medium         |
| MH.P.22 | Emergency Services     | <b>Mobile command stations:</b> Procure three permanently available mobile command stations for flood zones in Brooklyn, Queens, and Staten Island.  | DOB  | N/A     | TBD      | \$150 K       | TBD                      | N/A                  | 2.3                     | Medium         |
| MH.P.23 | Emergency Services     | <b>DOB backup generators:</b> Procure backup generators for 280 Broadway to sufficiently meet the needs of DOB to operate the Emergency Operations Center (EOC) and power the central servers, which house data for all five boroughs, among other core functions. | DOB  | N/A     | TBD      | TBD           | TBD                      | N/A                  | 2.3                     | Low            |
| MH.P.24 | Emergency Services     | <b>DOB radios:</b> Procure 80 communication radios to effectively carry out inspections and communicate with command posts during disasters when cell phone services are typically down or unreliable.   | DOB  | N/A     | TBD      | \$120 K       | TBD                      | N/A                  | 2.3                     | Medium         |
| MH.P.25 | Emergency Services     | <b>DOB vehicles:</b> Procure 25 SUVs and 75 hybrid vehicles outfitted with "emergency packages" for disaster use to expedite inspector response and guarantee service levels, and to address the addition of nearly 40 inspectors.                                 | DOB  | N/A     | TBD      | \$2.75 M      | TBD                      | N/A                  | 2.3                     | Medium         |
| MH.P.26 | Infrastructure Project | <b>Stormwater management:</b> Upgrade steam tunnel pumps to remove water that may enter during a coastal storm or flooding event.  | DOC  | DEP     | TBD      | \$15 M        | TBD                      | No change            | 1.1, 2.1, 2.7           | Medium         |
| MH.P.27 | Infrastructure Project | <b>Rikers Island ferry dock:</b> Add new docking facility to provide additional access to Rikers Island for inmate transport and supplies such as food and medicines.  | DOC  | DOT     | TBD      | \$25 M        | City capital budget/FTA  | N/A                  | 1.1, 2.1, 2.7           | Medium         |

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| MH.P.28 | Property Protection | <b>Roof and façade improvements:</b> Upgrade roofs and facades to withstand extreme weather events.  | DOC  | N/A      | TBD      | \$78 M        | City capital budget      | N/A                  | 1.1, 2.1, 2.7        | Medium         |
| MH.P.29 | Property Protection | <b>Emergency Operations Center improvements:</b> Upgrade Emergency Operations Center building infrastructure and communications.   | DOC  | N/A      | TBD      | TBD           | City capital budget      | N/A                  | 1.1, 1.2, 2.1        | Medium         |
| MH.P.30 | Emergency Services  | <b>Off-island satellite Emergency Operations Center (EOC) for Rikers Island:</b> Procure an off-island satellite EOC to allow for continuity of operations. Currently Rikers Island Bridge is the only means of egress, and should the bridge become impaired due to high winds or collapse, operation of the existing EOC would be comprised. | DOC  | N/A      | TBD      | TBD           | City capital budget      | N/A                  | 1.1, 1.2, 2.1, 2.3   | Medium         |
| MH.P.31 | Emergency Services  | <b>Manhattan Detention Complex (MDC) cellar/backup emergency system:</b> Provide second emergency generator for 100% capacity.   | DOC  | N/A      | TBD      | \$3 M         | City capital budget      | N/A                  | 2.1, 2.3             | Medium         |
| MH.P.32 | Emergency Services  | <b>Provision of power redundancy:</b> Acquire portable generators, pumping station, lighting systems, radios, and other essential equipment to create redundancy for critical networks.  | DOE  | N/A      | TBD      | \$1 M         | FEMA                     | No change            | 1.1, 2.1, 2.3        | Medium         |
| MH.P.33 | Property Protection | <b>Protection of DOE facilities from electrical system damage from trees:</b> Implement program to prune or remove old and overgrown trees near DOE facilities to prevent damage to the electrical distribution grid and nearby structures during tornadoes, windstorms, and coastal storms.   | DOE  | DOE, SCA | TBD      | TBD           | TBD                      | No change            | 1.1, 2.1, 2.7        | Medium         |
| MH.P.34 | Property Protection | <b>DOE green roof installation:</b> Install updated building management systems that include green roof structures for DOE facilities to reduce stormwater runoff.   | DOE  | DOE, SCA | TBD      | TBD           | TBD                      | No change            | 1.1, 2.1, 2.7, 4.4   | Medium         |



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| MH.P.35 | Emergency Services    | <b>Surge protection for DOE critical electrical systems:</b> Install surge suppression protection to minimize impacts from severe weather.  | DOE   | DOE, SCA | TBD                   | TBD           | TBD                                   | No change            | 1.1, 2.1, 2.7        | Medium         |
| MH.P.36 | Emergency Services    | <b>Emergency power at DOE facilities:</b> Install emergency power-generation systems at existing facilities.  | DOE   | DOE, SCA | TBD                   | \$1.25 M      | FEMA                                  | Not started          | 1.1, 2.1, 2.3        | Medium         |
| MH.P.37 | Prevention & Policy   | <b>Emergency preparedness plans and training for DOE custodian engineers and building managers:</b> Develop site-specific plans for 72 buildings, and engage consultants to do training.  | DOE   | DOE      | 1 year                | \$150 K       | TBD                                   | N/A                  | 1.1, 1.4, 2.1        | High           |
| MH.P.38 | Education & Awareness | <b>Psychological First Aid (PFA):</b> Train New York City responders in PFA, an evidence-informed modular approach to help children, adolescents, adults, and families in the immediate aftermath of disaster to reduce the initial distress caused by traumatic events and foster short- and long-term adaptive functioning and coping.                            | DOHMH | OEM      | Immediate and ongoing | \$20 K        | TBD                                   | N/A                  | 1.4, 1.6, 1.5        | High           |
| MH.P.39 | Education & Awareness | <b>Mental Health First Aid public education program:</b> Conduct a Mental Health First Aid public education program to introduce non-mental health professionals to risk factors and warning signs of mental health problems and build understanding of their impact, and provide an overview of common treatments to increase individual and community resilience. | DOHMH | N/A      | Immediate and ongoing | \$150 K       | TBD                                   | N/A                  | 1.6                  | Medium         |
| MH.P.40 | Emergency Services    | <b>Mental health system IT improvement:</b> Convert paper records to electronic formats (including off-site backup capacity) to prevent damage and loss in the event of a disaster and to facilitate remote accessibility of client records.  | DOHMH | N/A      | One year to implement | \$6 M         | One-time expense, city capital budget | N/A                  | 2.3                  | Medium         |

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| MH.P.41 | Emergency Services     | <b>Mental health system power backup:</b> Purchase generators and needed equipment for community-based providers. Include gasoline reserves.   | DOHMH | N/A     | Immediate and ongoing                      | \$1.5 M                             | City capital budget      | N/A                  | 1.1., 2.3            | Medium         |
| MH.P.42 | Education & Awareness  | <b>Mental health system support network:</b> Establish a network of community-based mental health organizations (different types of programs located in various zones) that may develop a COOP plan to share resources and collaboratively ensure consumer safety and provide services during and following an emergency.  | DOHMH | N/A     | One year to implement and ongoing          | \$500 K                             | One-time expense         | N/A                  | 1.1, 1.6, 2.3, 5.3   | High           |
| MH.P.43 | Education & Awareness  | <b>Mental health volunteer preparedness and response:</b> Promote involvement of mental health consumers in volunteer preparedness and response activities. Peer volunteers would receive training on emergency preparedness and be linked to a network of programs that mobilize volunteers to respond to an emergency such as Community Emergency Response Teams, American Red Cross, City Serve, and NYC Cares. | DOHMH | N/A     | One year to implement and ongoing          | \$250 K                             | Expense budget           | N/A                  | 1.1, 1.4, 1.5, 1.6   | High           |
| MH.P.44 | Infrastructure Project | <b>DOHMH IT systems protection:</b> Safeguard crucial DOHMH applications and systems through the creation of a mirror system or DR Data Center (cloud). The current DOHMH Data Center at 22 Cortlandt Street in downtown Manhattan, in a flood zone, competes for power resources and priorities with the city's financial institutions.   | DOHMH | N/A     | 18 months to implement; yearly contracting | \$1.5 M up front and \$1 M per year | N/A                      | N/A                  | 2.1, 2.3             | High           |
| MH.P.45 | Property Protection    | <b>DOHMH primary data center availability:</b> Increase DOHMH's network infrastructure capacity and redundancy to improve preparedness and response during a major system failure.   | DOHMH | N/A     | 1 year to implement                        | \$6 M one-time investment           | N/A                      | N/A                  | 2.3                  | Medium         |

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| MH.P.46 | Property Protection    | <b>Riverside clinic upgrade:</b> Equip the new back-up Department of Emergency Operations Center (DEOC) with the appropriate infrastructure and technology to support DOHMH public health response to a citywide emergency.   | DOHMH | DDC, DCAS    | Estimated implementation by February 2014 | \$447 K       | City capital budget and PHEP       | N/A                  | 2.3                  | Medium         |
| MH.P.47 | Infrastructure Project | <b>DOHMH warehouse and print shop capacity:</b> Develop and install a new inventory tracking system for the DOHMH warehouse (520 Kingsland Ave.) destroyed by Hurricane Sandy. Purchase critical equipment for the DOHMH print shop to produce secure documents that can only be issued by DOHMH. | DOHMH | N/A          | 6-12 months                               | \$550 K       | Operating and IT development staff | N/A                  | 2.1, 2.3             | High           |
| MH.P.48 | Emergency Services     | <b>Health data and provider portal:</b> Create a centralized provider directory and associated reporting portal to communicate with providers as well as gather information from providers. Data can be analyzed and used to generate reports during emergencies.                                 | DOHMH | NYS DOH      | Potentially 2 years                       | \$2.6 M       | SSBG                               | N/A                  | 1.2, 1.5, 5.2        | High           |
| MH.P.49 | Emergency Services     | <b>Enhanced emergency response communication operations at DOHMH headquarters:</b> Equip 2 Gotham with enhanced Motorola 800Mhz radio capacity to allow DOHMH response operations and communication to continue even if IT and phone networks are down.   | DOHMH | OEM, NYS DOH | Potentially 2 years                       | \$1.05 M      | PHEP                               | N/A                  | 1.2, 2.3             | High           |
| MH.P.50 | Property Protection    | <b>Backup power for nursing homes and adult care facilities:</b> Ensure that the 53 nursing homes and 26 adult care facilities located in hurricane evacuation zones 2 to 4 have backup power capacity by purchasing portable generators and installing quick-connects.                           | DOHMH | OEM, NYS DOH | Potentially 3 years                       | \$19.16 M     | HMGP                               | N/A                  | 1.1, 1.5, 2.3        | Medium         |

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| MH.P.51 | Prevention & Policy    | <b>Small grants program to support community-based social cohesion:</b> Support 10 long-standing community-based organizations, schools, or faith-based organizations that serve diverse vulnerable populations (e.g. children, undocumented immigrants, precariously un-domiciled and homeless, and the elderly). Funding will be in two increments of \$25,000 each for a total award of \$50,000 per site. | DOHMH | Possibly DOE   | 12-24 months                                    | \$500 K       | N/A                                | N/A                  | 1.5, 1.6, 5.1, 5.3   | Medium         |
| MH.P.52 | Prevention & Policy    | <b>"Hub the Hood" program:</b> Develop a grant program in which neighborhood associations compete for seed money to become a "Hub" for their neighborhood by connecting block associations, buildings, and social service providers for a more socially cohesive neighborhood.  | DOHMH | DOB/HPD        | Potentially 2 years                             | TBD           | TBD                                | N/A                  | 1.6, 5.1, 5.3        | Medium         |
| MH.P.53 | Property Protection    | <b>DOHMH facility repair and upgrade:</b> Restore and strengthen DOHMH buildings, including DOHMH clinics and the Public Health Laboratory (PHL). Repair building facades, walls, parking lots, water infiltration and drainage systems; and install sump pumps and generators.   | DOHMH | DDC, EDC, DCAS | Existing: 12-24 months; potential: 24-60 months | \$15 M        | City capital budget or grant funds | N/A                  | 1.1, 1.5, 2.1        | Medium         |
| MH.P.54 | Emergency Services     | <b>Notification system for City employees:</b> Develop an enhanced system for contacting City employees using a variety of communications media to notify, alert, and/or instruct City employees prior to and during emergencies.   | DoITT | OEM            | Ongoing   | TBD           | TBD                                | No change            | 1.2, 2.1, 2.3        | Medium         |
| MH.P.55 | Infrastructure Project | <b>Hardening of the NYC wireless network (NYCWIN) network:</b> Install fixed generators at 126 NYCWiN sites to protect and enhance the reliability and resiliency of communications infrastructure.   | DoITT | N/A            | 18 months                                       | \$11.2 M      | FEMA                               | N/A                  | 2.1, 2.3, 2.10       | Medium         |

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| MH.P.56 | Infrastructure Project | <b>Data Center Site B:</b> Provide consolidated Site B capability and capacity for applications not already hosted at DoITT's 2 MTC Data Center.   | DoITT | N/A       | 12-18 months | \$50 M                       | TBD                                    | N/A                  | 2.1, 2.2, 2.10          | Medium         |
| MH.P.57 | Property Protection    | <b>Secure HAZMAT at DOT facilities:</b> Prevent release, in the event of hazard event, of herbicides at Arterials yards; combustible materials at sites such as Webster Fleet Services Shop; fuel from above-ground tanks at sites such as Conner Street Yard.   | DOT   | DDC, DCAS | TBD          | TBD                          | TBD                                    | N/A                  | 2.1, 2.2                | Medium         |
| MH.P.58 | Emergency Services     | <b>Redundant power for all mission-critical DOT sites:</b> Provide and/or upgrade generators at fleet fueling stations.  | DOT   | DCAS, OEM | TBD          | TBD                          | TBD                                    | N/A                  | 2.1, 2.3                | Medium         |
| MH.P.59 | Emergency Services     | <b>Continuity of Operations sites:</b> Prepare sites within each borough to support operations and permitting immediately following an event. Fit out sites with redundant power and infrastructure.   | DOT   | DDC, DCAS | TBD          | TBD                          | TBD                                    | N/A                  | 2.1, 2.3                | Medium         |
| MH.P.60 | Emergency Services     | <b>Information tracking:</b> Follow formalized response to natural hazard-based incidents to identify repetitive loss locations or hazards. Use this information to inform the creation and implementation of future mitigation actions.   | DOT   | OEM       | 2 years      | \$150 K                      | Expense budget and city capital budget | No change            | 2.1, 5.2                | High           |
| MH.P.61 | Infrastructure Project | <b>High-reflectivity pavements:</b> Explore and incorporate high-reflectivity/high-albedo paving (e.g. lighter-colored roadways) into street resurfacing and reconstruction to reduce the urban heat island effect. Explore and test material sourcing (e.g. for asphalt aggregate) and new approaches (e.g. whitetopping). Feasible and cost-effective options will ultimately be added to DDC and DOT's standard specifications. | DOT   | DEP       | Ongoing      | \$5 M for study plus testing | TBD                                    | No change            | 2.1, 2.7, 2.8, 2.9, 5.2 | Medium         |

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| MH.P.62 | Emergency Services                   | <b>Critical facility loss estimation:</b> Conduct a detailed natural and non-natural hazard loss estimation for critical facilities (including bridges) using increased positional accuracy-building attribute databases and available hazard maps. | DOT  | DOB, OEM | TBD      | \$500 K                   | Expense budget           | No change            | 5.2                  | Medium         |
| MH.P.63 | Infrastructure Project               | <b>Staten Island Ferry fleet upgrade:</b> Purchase new vessels to replace the Barberi class vessels, thereby improving the capability of the fleet.   | DOT  | N/A      | 6 years  | \$300 M                   | FTA ER                   | N/A                  | 2.1, 2.7             | Medium         |
| MH.P.64 | Infrastructure Project               | <b>Staten Island Ferry vessel improvement:</b> Install high-lift rudders on vessels.  | DOT  | N/A      | TBD      | \$5 M                     | FEMA HMGP, FTA ER        | N/A                  | 2.1, 2.7             | Medium         |
| MH.P.65 | Property Protection                  | <b>Green roofs on DPR buildings:</b> Install green roofs on select DPR facilities to reduce storm-water runoff and help reduce the urban heat island effect. Estimated cost is \$25 per square foot.  | DPR  | DOE, SCA | 2 years  | \$30 K to \$50 K per site | HMGP, other grants       | No change            | 2.7, 2.8, 4.3, 4.4   | High           |
| MH.P.66 | Coastal/ Natural Resource Protection | <b>Green Streets:</b> Transform selected traffic medians from concrete to areas densely planted with trees and horticulture to reduce storm-water runoff and help reduce the urban heat island effect.  | DPR  | DOT      | 2 years  | \$50 K per site           | HMGP, other grants       | No change            | 2.7, 2.8, 4.3, 4.4   | High           |
| MH.P.67 | Property Protection                  | <b>Wetlands and other land in a natural state:</b> Leave purchased or donated land and wetlands in a natural state to absorb floodwaters, mitigate storm surge impacts, reduce heat impacts, and prevent construction in flood zones.               | DPR  | N/A      | 5 years  | \$1 M per acre            | HMGP                     | No change            | 2.2, 2.5, 2.7, 4.3   | Medium         |

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| MH.P.68 | Infrastructure Project | <b>Seawall, pier, and marina structural repairs:</b> Restore docks and other seawall structures at the 79th Street Boat Basin in Manhattan. Seawalls help mitigate erosion and prevent flooding.  | DPR        | N/A        | 5 years   | \$1.5 M (\$10 per square foot for piers and \$20 per linear foot for bulk-heads) | HMGP                     | Emergency repairs to Shore Road seawall in Brooklyn completed | 2.1, 2.7             | High           |
| MH.P.69 | Property Protection    | <b>Upgrades to DPR building systems:</b> Protect vulnerable DPR buildings from flooding and other hazards by hardening or elevating electrical and mechanical systems.  | DPR        | DOB, DOHMH | TBD   | \$12 M   | HMGP                     | N/A   | 2.1, 2.2, 2.7        | Medium         |
| MH.P.70 | Emergency Services     | <b>COOP trailer compound:</b> Purchase trailers (minimum 7 trailers) to form a compound to operate daily district operations while affected permanent facilities are repaired.  | DSNY       | N/A        | Action would take approximately 24 hours to re-locate trailer or trailers to staging area | \$400 K  | City capital budget      | N/A   | 2.1, 2.3             | Medium         |
| MH.P.71 | Property Protection    | <b>Industrial property upgrades:</b> Implement planned upgrades to vulnerable City-owned industrial properties.   | EDC, BNYDC | N/A        | 60 months   | \$10 M   | HMGP                     | EDC: \$300,000 for study                                      | 2.7, 4.3             | Medium         |
| MH.P.72 | Property Protection    | <b>Hardening Staten Island Ferry and private ferry terminals from climate change-related threats:</b> Construct physical improvements to the floating infrastructure, loading gangways, pilings, and piers, as well as develop a stock of spare parts to be stored in a secure upland location. | EDC        | DOT        | 60 months   | \$15 M   | FTA                      | Ongoing   | 1.2, 2.1, 2.3, 4.4   | Medium         |

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| MH.P.73 | Infrastructure Project | <b>Construction of new ferry landings to support private ferry services:</b> Expand the network of ferry landings available for both regular and emergency use. Design and procure two new ferry landing barges that are outfitted with the required equipment for providing basic ferry service, including self-contained generators.             | EDC      | DOT     | 60 Months | \$15 M                            | FTA                      | N/A                  | 1.1, 2.1             | Medium         |
| MH.P.74 | Prevention & Policy    | <b>Waterfront fueling facilities:</b> Retrofit one or two waterfront fueling facilities to accommodate large commercial vessels, including ferry boats and other government vessels.   | EDC      | N/A     | 24 months | \$5 M                             | TBD                      | N/A                  | 2.1, 2.3             | Medium         |
| MH.P.75 | Prevention & Policy    | <b>Mobile ferry ticketing machines:</b> Procure up to 15 mobile ticketing machines to provide a flexible ticketing solution that can be moved to ferry landings experiencing high-volume ridership in post-storm periods to reduce wait times and enable a more efficient flow of passengers to final destinations.                                | EDC      | DOT     | TBD       | Approximately \$50 K per machine. | Agency capital budget    | N/A                  | 2.3                  | Medium         |
| MH.P.76 | Infrastructure Project | <b>Use of the Staten Island Ferry's Austen Class vessels for East River Ferry service during weather-related disruptions:</b> Supplement East River Ferry capacity during transit service disruptions that cause large numbers of commuters to use ferry services by retrofitting existing ferry landings to accommodate the Austen Class vessels. | EDC, DOT | N/A     | 24 months | Cost included in MH.P. 69         | EDC                      | N/A                  | 2.1, 2.7             | Medium         |
| MH.P.77 | Property Protection    | <b>Storm shutters project:</b> Install storm shutters at FDNY facilities in flood-prone areas subject to punishing winds, flying debris, and horizontal, driving rain during storms.   | FDNY     | N/A     | TBD       | TBD                               | TBD                      | N/A                  | 2.1, 2.7             | High           |



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| MH.P.78 | Emergency Services     | <b>Backup communications carrier:</b> Research the feasibility of using a commercial carrier to back up NYCWiN until NYCWiN can be hardened and made more resilient.  | FDNY | DoITT   | TBD      | TBD           | TBD                      | N/A                  | 2.1, 2.3, 2.10       | Medium         |
| MH.P.79 | Emergency Services     | <b>Voice-over IP (VOIP) architecture:</b> Explore feasibility of switching to more resilient voice-over IP architecture.  | FDNY | N/A     | TBD      | TBD           | TBD                      | N/A                  | 1.1, 2.1, 2.3, 2.10  | Medium         |
| MH.P.80 | Emergency Services     | <b>Next-generation satellite phones:</b> Purchase "smart" satellite phones for critical staff.  | FDNY | N/A     | TBD      | TBD           | TBD                      | N/A                  | 2.1, 2.3, 2.10       | Medium         |
| MH.P.81 | Infrastructure Project | <b>FDNY facilities survey:</b> Conduct a survey of FDNY facilities and facility components (e.g., roofs, doors, windows) in the revised FEMA flood zones, and schedule upgrades.  | FDNY | N/A     | TBD      | TBD           | TBD                      | N/A                  | 2.1, 2.7             | Medium         |
| MH.P.82 | Emergency Services     | <b>Fire Department Operations Center (FDOC) cell phone coverage:</b> Improve cell phone coverage of FDOC, which FDNY staffs with additional personnel during major events, taxing the already overcrowded and sometimes unavailable cell network. | FDNY | N/A     | TBD      | TBD           | TBD                      | N/A                  | 2.1, 2.10            | Low            |
| MH.P.83 | Emergency Services     | <b>FDNY cable network:</b> Upgrade FDNY's cable network, which connects dispatch centers with firehouses to relay 911 calls, to fiber to improve resiliency and reduce outages.   | FDNY | N/A     | TBD      | TBD           | TBD                      | N/A                  | 1.1, 2.1, 2.3, 2.10  | High           |
| MH.P.84 | Emergency Services     | <b>Spare radios:</b> Acquire additional portable radios to facilitate more widespread use of FDNY trunking system during cell carrier outages.  | FDNY | N/A     | TBD      | TBD           | TBD                      | N/A                  | 1.1, 2.1, 2.10       | Medium         |

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| MH.P.85 | Prevention & Policy | <b>Home-work plans:</b> Explore feasibility of telecommuting options for non-emergency personnel who support critical operations during disasters.   | FDNY | N/A     | TBD      | TBD           | TBD                            | N/A                  | 2.1, 2.10            | Medium         |
| MH.P.86 | Emergency Services  | <b>Gas vendors:</b> Negotiate with vendors to ensure they maintain spare fuel supply in the event of shortages.  | FDNY | N/A     | TBD      | TBD           | TBD                            | N/A                  | 2.1                  | Medium         |
| MH.P.87 | Emergency Services  | <b>Cache of vaccinations:</b> Ensure a sufficient supply of vaccines to inoculate all first responders.  | FDNY | DOHMH   | TBD      | TBD           | TBD                            | N/A                  | 2.1                  | Medium         |
| MH.P.88 | Emergency Services  | <b>Urban search and rescue team:</b> Increase the number of trained officers and firefighters in New York Task Force 1 to meet the growing demands of a professional, trained, and proven search and rescue team.  | FDNY | US DHS  | TBD      | TBD           | TBD                            | N/A                  | 1.1, 2.1             | Medium         |
| MH.P.89 | Prevention & Policy | <b>Coney Island Hospital HVAC:</b> Protect hospital's HVAC system.   | HHC  | TBD     | 2 years  | \$30 M        | HMGP, general obligation bonds | N/A                  | 1.1, 2.1, 2.8        | Medium         |
| MH.P.90 | Emergency Services  | <b>Coney Island Hospital quick connects for critical systems:</b> Install pre-connections on the perimeter wall of the existing building above the 500-year BFE for connection to rollup generators, chillers, and high-pressure steam boilers. This will enable the facility to rent portable, roll-up equipment and quickly restore critical services should facility equipment be subject to damage during a flood. | HHC  | TBD     | 1 year   | \$70 K        | HMGP, general obligation bonds | N/A                  | 1.1, 2.1, 2.7, 2.8   | Medium         |

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| MH.P.91 | Prevention & Policy | <b>Metropolitan Hospital HVAC:</b> Protect the HVAC system.  | HHC  | TBD     | 2 years  | \$30 M        | HMGP, CDBG, general obligation bonds | N/A                  | 1.1, 2.1, 2.7, 2.8      | High           |
| MH.P.92 | Emergency Services  | <b>Metropolitan Hospital quick connects:</b> Install quick connects for external generators, temp boilers, and temp chillers.  | HHC  | TBD     | 1 year   | \$2.06 M      | HMGP, general obligation bonds       | N/A                  | 1.1, 2.1, 2.7, 2.8      | High           |
| MH.P.93 | Prevention & Policy | <b>Bellevue Hospital/critical systems protection:</b> Install generators, electrical wiring, controls, and automatic transfer switches to support multiple HVAC systems throughout the Bellevue hospital campus. | HHC  | TBD     | 1 year   | \$2.25 M      | HMGP, CDBG, general obligation bonds | N/A                  | 1.1, 2.1, 2.7, 2.8      | High           |
| MH.P.94 | Emergency Services  | <b>Bellevue Hospital power quick connects:</b> Install quick connects for external generators for in-patient areas of Bellevue Hospital.   | HHC  | TBD     | 1 year   | \$96 K        | HMGP, CDBG, general obligation bonds | N/A                  | 1.1, 2.1, 2.7, 2.8      | High           |
| MH.P.95 | Emergency Services  | <b>Central Office Emergency Command Center (ECC) and alternate ECC:</b> Designate and equip a new central office command center as well as an alternate central office command center.                           | HHC  | TBD     | 3 months | \$300 K       | HMGP, CDBG, general obligation bonds | N/A                  | 1.1, 2.1, 2.3           | Medium         |
| MH.P.96 | Emergency Services  | <b>Henry J. Carter Hospital improvements:</b> Purchase backup generator and make associated structural improvements.   | HHC  | TBD     | 2 months | \$920 K       | HMGP, CDBG, general obligation bonds | N/A                  | 1.1, 2.1, 2.3, 2.7, 2.8 | High           |

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| MH.P.97  | Education & Awareness | <b>Outreach to residential building owners:</b> Develop a methodology and technology solution to provide pre- and post-disaster outreach and information to residential building owners. This may include the creation of a new online emergency notification contact system. | HPD                       | N/A                | 2 years   | \$1.5 M plus ongoing maintenance costs | Grants                     | N/A   | 1.2, 1.6, 2.6, 5.1   | Medium         |
| MH.P.98  | Education & Awareness | <b>Flood protection for critical facilities:</b> Evaluate flood-protection measures in long-term-lease buildings in or near flood zones and Coastal Storm Evacuation zones 1 and 2. Make recommendations to building owners.  | HRA                       | N/A                | 5 years   | TBD                                    | Lease budget, AOTPS budget | Equipped key buildings that are most vulnerable with sandbags. Maintaining an inventory of portable generators. | 1.1, 2.1, 2.6, 2.7   | High           |
| MH.P.99  | Education & Awareness | <b>Exploration of loss-reduction actions for landmarked properties:</b> Assist owners of locally designated landmarked structures in flood hazard areas to identify appropriate resiliency measures.  | LPC                       | DOB, DOT, DCP, DEP | As needed | TBD                                    | Expense budget             | Studying need   | 2.6, 2.9             | High           |
| MH.P.100 | Education & Awareness | <b>Public education and outreach for landmarked buildings:</b> Provide information on site and building preservation issues for locally designated landmarked structures in flood hazard areas.   | LPC                       | DCP                | Unknown   | TBD                                    | Expense budget             | Studying need   | 2.6, 2.9, 5.1, 5.3   | High           |
| MH.P.101 | Prevention & Policy   | <b>Marine Parkway/Cross Bay Bridge mitigation master plan:</b> Compare various long-term capital investment strategies to rehabilitate/reconstruct the crossings while building resiliency and robustness into the structures.  | MTA (Bridges and Tunnels) | N/A                | 3 years   | \$10 M                                 | HMGP                       | Procurement for study has commenced   | 2.1, 2.7, 2.8, 2.9   | High           |

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| MH.P.102 | Prevention & Policy    | <b>Engineering flood studies at non-tunnel facilities:</b> Determine vulnerabilities and prepare conceptual designs for mitigation work.                    | MTA (Bridges and Tunnels) | N/A             | 2 years              | \$6 M         | MTA capital budget, HMGP | Contracts have been awarded for studies for several bridges and one facility. | 2.1, 2.7, 2.8, 2.9   | Medium         |
| MH.P.103 | Infrastructure Project | <b>Far Rockaway depot green roof:</b> Design and install green roof to reduce the volume of stormwater runoff and help reduce the urban heat island effect. | MTA (Buses)               | NYSDE, DEP, FTA | 2 years              | \$4.7 M       | MTA capital budget       | No change   | 2.1, 2.7             | Medium         |
| MH.P.104 | Prevention & Policy    | <b>Hazards/threats planning:</b> Develop comprehensive planning guidance and contingency/response plans for all hazards/threats.                            | MTA (MNR)                 | N/A             | Indefinite/12 months | \$500 K       | Staff time               | N/A   | 2.1, 5.2             | High           |
| MH.P.105 | Prevention & Policy    | <b>Fueling capabilities/backup for emergency response:</b> Conduct an assessment for providing emergency fueling capabilities to MNR's rubber-tire fleet.   | MTA (MNR)                 | N/A             | 12 months            | \$500 K       | Staff time               | N/A   | 2.1, 2.3             | High           |

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| MH.P.106 | Infrastructure Project | <b>Penn Station access:</b> Add resiliency to the Metro-North system to enable the New Haven Line service to access Manhattan in a catastrophic event. There are three points of failure for Metro-North Service into Manhattan: Mott Haven Junction, the Harlem River Lift Bridge, and GCT and its viaduct and tunnel approaches. A catastrophic event at any of these points would cut off Metro-North service to midtown Manhattan, affecting over 700 trains and over 220,000 commuters daily. In addition, there is a risk of terrorist attack, a ship or large construction barge with a crane hitting the bridge, or fire. Resiliency improvements would protect service into midtown Manhattan. | MTA (MNR)  | Amtrak, LIRR | Design completion<br>3-4 years | \$40 M        | Sandy Emergency Relief Program Resiliency     | N/A                  | 2.1, 2.2, 2.8        | High           |
| MH.P.107 | Infrastructure Project | <b>Harlem-125 Street Station improvements:</b> Make improvements to the Harlem-125 Street Station to allow Metro-North to maintain service to and from Manhattan should a catastrophic event disrupt service at Grand Central Terminal.   | MTA (MNR)  | N/A          | TBD                            | TBD           | TBD   | N/A                  | 2.1, 2.2, 2.8        | High           |
| MH.P.108 | Property Protection    | <b>Emergency management equipment:</b> Purchase mobile vehicle fueling equipment, install East End fueling station, make communication upgrades to trucks and mobile command center, and purchase mobile substations that can be mounted on trailers and emergency generators.  | MTA (LIRR) | N/A          | November 2013-November 2014    | \$20 M        | Potential FTA Local Priority Resiliency Funds | N/A                  | 2.1, 2.3, 2.7, 2.10  | High           |
| MH.P.109 | Property Protection    | <b>NYCHA grounds, pavements, and drainage improvements:</b> Install planting for soil stabilization and to create buffer zones. Strengthen anchorage/footings for play equipment and pole lighting in nine developments (91 buildings).   | NYCHA      | TBD          | TBD                            | \$9.39 M      | Capital improvement budget                    | Ongoing              | 2.1, 2.7             | High           |

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| MH.P.110 | Property Protection | <b>Category 4 distributed power-generation feasibility studies:</b> Assess NYCHA developments severely damaged by Hurricane Sandy to combine/centrally locate utility systems where feasible. Combine developments to continue operations during utility outages and include within future NYCHA distributed power-generation systems (CHP, COGEN, micrgrid, etc.). Current developments include RedHook East and West, Ocean Bay (Bayside), Coney Island Site 8, O'Dwyer Gardens, and Surfside, but may include others if deemed appropriate by future feasibility studies. | NYCHA | TBD     | Estimated completion 2016 | TBD           | TBD                      | N/A                  | 2.1, 2.2, 2.3        | Medium         |
| MH.P.111 | Property Protection | <b>Morrisania Air Rights:</b> Repair/re-support building.  | NYCHA | TBD     | TBD                       | TBD           | TBD                      | N/A                  | 2.1, 2.7             | Low            |
| MH.P.112 | Prevention & Policy | <b>NYCHA AC improvements:</b> Outfit all 334 NYCHA developments with central AC systems. AC central chiller plants can increase COGEN/CHP efficiencies during summer months, provide cool air to building residents during extreme heat events, and keep buildings pressurized, thereby preventing airborne hazardous waste from entering buildings.   | NYCHA | TBD     | TBD                       | TBD           | TBD                      | N/A                  | 1.1, 2.1             | Medium         |
| MH.P.113 | Property Protection | <b>NYPD precinct facility protection:</b> Enhance design of the 40 <sup>th</sup> , 66 <sup>th</sup> , 70 <sup>th</sup> , 110 <sup>th</sup> , 120 <sup>th</sup> , 121 <sup>st</sup> , and Central Park precinct facilities to withstand severe wind, rain, and flooding events.   | NYPD  | TBD     | TBD                       | \$59 K        | HMGP                     | No change            | 2.1, 2.7, 2.8        | Medium         |
| MH.P.114 | Property Protection | <b>NYPD facility protection:</b> Enhance facility design of Public Safety Answering Center I, Public Safety Answering Center II, and Joint Operations Center to withstand severe wind, rain, and flooding events.  | NYPD  | TBD     | TBD                       | TBD           | TBD                      | No change            | 2.1, 2.7, 2.8        | Medium         |

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| MH.P.115 | Property Protection   | <b>NYPD critical facilities protection:</b> Promote hardening of existing and future critical facilities from the primary and secondary effects of natural hazards.   | NYPD | N/A                 | TBD      | TBD           | TBD                      | No change   | 2.1, 2.7, 2.8        | Medium         |
| MH.P.116 | Emergency Services    | <b>OCME unified agency command center:</b> Relocate all critical communications function into one unified workspace on emergency generator power.   | OCME | DDC                 | TBD      | \$2.27 M      | City capital budget      | N/A   | 2.1, 2.10            | High           |
| MH.P.117 | Education & Awareness | <b>Educational outreach to private sector:</b> Coordinate and provide educational outreach on mitigation strategies the private sector can use to reduce or eliminate the impacts of hazards on private-sector services and infrastructure. Opportunities to educate OEM's private-sector partners include conferences, OEM website, and presentations. | OEM  | N/A                 | TBD      | TBD           | TBD                      | OEM's website hosts information on hazard mitigation. | 3.1, 3.3, 3.4, 3.5   | Medium         |
| MH.P.118 | Property Protection   | <b>OEM facilities protection:</b> Conduct or update natural-hazard vulnerability assessments for all OEM facilities, and harden facilities to prevent or minimize damage from natural hazard events.  | OEM  | DCAS, FEMA, NYS OEM | TBD      | TBD           | HMGP, PDM-C              | Assessments still pending                             | 2.1, 2.7, 2.8        | Medium         |
| MH.P.119 | Emergency Services    | <b>HAZUS-MH software:</b> Update software to optimize use of HAZUS-MH modeling for New York City's unique urban environment. The software update will allow New York City to generate more accurate loss estimates for various hazards.   | OEM  | FEMA, NYS OEM       | 1 year   | TBD           | HMGP, PDM-C              | No change   | 2.5, 5.1, 5.2        | High           |
| MH.P.120 | Education & Awareness | <b>Community Emergency Response Team (CERT) curriculum:</b> Adapt CERT curriculum to educate team members on strategies that mitigate the impact of natural hazards on the city, including protecting utility services and property and providing redundant communication and continuity of business services (for corporate CERTs).                    | OEM  | NYPD, FDNY          | Ongoing  | \$200 K       | UASI                     | No change   | 3.2, 3.4, 3.5, 5.3   | High           |



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| MH.P.121 | Emergency Services    | <b>Infrastructure systems modeling:</b> Coordinate the development of a multi-hazard infrastructure vulnerability model.   | OEM  | FEMA, NYS OEM, academic institutions | 3 years  | TBD           | HMGP                     | No change  | 5.1, 5.2                | Medium         |
| MH.P.122 | Emergency Services    | <b>Loss estimation:</b> Assist agencies in determining loss estimates using HAZUS-MH.  | OEM  | MPC                                  | 5 years  | TBD           | HMGP, PDM-C, FEMA        | No change  | 5.1, 5.2                | Medium         |
| MH.P.123 | Emergency Services    | <b>Natural hazard event database:</b> Create a natural hazard event database to capture description, severity, location, impact, and potential loss/damage estimates from events. Use data to update the hazard analysis and mitigation actions for New York City. | OEM  | FEMA, NYS OEM                        | 5 years  | TBD           | Agency operating budget  | No change  | 5.1, 5.2                | Medium         |
| MH.P.124 | Education & Awareness | <b>CERT collaboration with community groups:</b> Partner the CERT program with local community organizations—including civic, faith-based, and tenant associations—to promote mitigation strategies.   | OEM  | NYPD, FDNY                           | Ongoing  | \$200 K       | UASI                     | No change  | 3.1, 3.3, 3.4, 3.5, 5.3 | High           |
| MH.P.125 | Education & Awareness | <b>Ready New York update:</b> Expand guide for seniors and people with disabilities.   | OEM  | DFTA, MOPD                           | 1 year   | TBD           | OEM                      | Ready New York: My Emergency Plan, created especially for seniors and people with special needs, launched in October 2011. | 1.1, 1.6, 5.3           | High           |
| MH.P.126 | Education & Awareness | <b>Public/private mitigation initiatives:</b> Support the resiliency of New York City's private sector through information sharing, partnership building, and education on mitigation principles and the City's HMP.   | OEM  | N/A                                  | Ongoing  | TBD           | TBD                      | No change  | 3.1, 3.3, 3.4, 3.5      | High           |

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|----------|-----------------------|---|------|----------------------------|-----------|---------------|--------------------------|----------------------|-------------------------|----------------|
| MH.P.127 | Emergency Services    | <b>Regional critical infrastructure mapping:</b> Map critical infrastructure of the New York City region to better understand the interrelationships among components of the region's infrastructure and support the Risk Assessment section of the HMP.  | OEM  | DHS, NYSOH, NYSOH, PA-NYNJ | 12 months | TBD           | TBD                      | No change            | 5.1, 5.2                | Medium         |
| MH.P.128 | Emergency Services    | <b>Subway depths mapping:</b> Collaborate with NYCT to assign depth-below-street-level and absolute-depth-below-sea-level elevations for subway stations and tunnels to support planning for flooding and secondary impacts from other natural hazards.   | OEM  | NYCT                       | 12 months | TBD           | TBD                      | No change            | 5.1, 5.2                | Medium         |
| MH.P.129 | Prevention & Policy   | <b>Vegetation data:</b> Develop vegetation data for New York City for use in HAZUS-MH and other hazard-impact models to allow for better debris estimates and to identify areas more susceptible to the urban heat island effect.   | OEM  | DPR                        | 6 months  | TBD           | TBD                      | No change            | 5.1, 5.2                | Medium         |
| MH.P.130 | Prevention & Policy   | <b>Zoning for hazard-prone areas:</b> Correlate natural hazard-vulnerable areas with existing zoning districts to identify areas where mitigation actions would be necessary to maintain responsible and sustainable development.   | OEM  | DCP                        | 12 months | TBD           | TBD                      | No change            | 2.4, 2.5, 5.1, 5.2      | Medium         |
| MH.P.131 | Education & Awareness | <b>Mitigation public outreach:</b> Develop a mitigation guide and online training course for homeowners and property managers on risk reduction before and after a hazard event, and work with community-based organizations and non-governmental organizations to engage the community in advance of an emergency. | OEM  | N/A                        | 3 years   | \$1 M         | HMGP                     | No change            | 1.6, 2.6, 2.9, 5.1, 5.3 | High           |

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|----------|-----------------------|---|------|---|-----------|---------------|---------------------------|---|-------------------------|----------------|
| MH.P.132 | Emergency Services    | <b>Emergency Operations Center (EOC):</b> Create and build out a new backup EOC to include room and capability for all citywide operations (e.g., EOC, Logistics Center [LC], Unified Operations and Resource Center [UORC], Commodity Distribution Point Command Center [CCC], Healthcare Evacuation Center [HEC], and other Continuity of Operations [COOP] working needs). | OEM  | DCAS, FEMA  | 2-3 years | TBD           | City capital budget, HMGP | Real estate search under way—250,000 square feet of space has been scoped out   | 2.1, 2.2, 2.3, 2.7      | Medium         |
| MH.P.133 | Emergency Services    | <b>OEM warehouse:</b> Identify a new warehouse space or build out a new OEM warehouse (the current warehouse is not large enough to accommodate the existing stockpile of supplies to support New York City during an emergency). Include adequate spacing for all citywide operational needs, storage, and functioning.  | OEM  | DCAS  | 2-3 years | TBD           | City capital budget       | N/A   | 2.1, 2.2                | High           |
| MH.P.134 | Education & Awareness | <b>New York City mitigation guide and education:</b> Educate New Yorkers about hazard mitigation techniques that they can use to reduce long-term risks from natural hazards. Include a mitigation guide for homeowners and property managers; online training; flood-risk information; and CBO/NGO outreach—all to be incorporated into OEM's website.                       | OEM  | OLTPS, DEP, DOB, DOHM, DOF, DOT, NYC Service/Citizen Corps Council member agencies/ other City agencies | 1 year    | \$1 M         | HMGP (5%)                 | Citizen Corps sponsored a hazard mitigation presentation to Citizen Corps members in 2013 and followed up with information on hazard mitigation on OEM's website. | 1.6, 2.6, 2.9, 5.1, 5.3 | High           |
| MH.P.135 | Education & Awareness | <b>Building community capacity:</b> Launch pilot program to identify and address gaps in community capacity.  | OEM  | N/A   | Ongoing   | \$1 M         | CDBG                      | N/A   | 1.6, 5.1, 5.3           | Medium         |

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| MH.P.136 | Prevention & Policy | <b>Urban post-disaster housing site identification in New York City:</b> Prepare communities and agencies for deployment of post-disaster housing units by identifying potential sites and evaluating feasibility for use in terms of constructability and livability.                     | OEM               | FEMA, USACE, DOB, DEP, DOT, MTA             | 1 year                   | \$100 K          | FEMA, CTL, RCPGP                   | N/A                  | 1.1, 2.1, 2.5            | High           |
| MH.P.137 | Prevention & Policy | <b>Executive decision-making guide for deployable post-disaster housing:</b> Provide executives with information needed to evaluate deployable post-disaster housing option, with the goal of preventing population loss and creating quality interim housing.                             | OEM               | DDC, DOB, USACE, FEMA, HUD, EDC, NYCHA, CAU | 2014                     | \$25 K           | FEMA, CTL, RCPGP                   | N/A                  | 1.1, 2.5, 2.9            | High           |
| MH.P.138 | Prevention & Policy | <b>Request for proposal for urban post-disaster housing:</b> Prepare RFP to procure deployable housing to help people soon after a disaster. This is a time-of-event document for the USACE to select housing manufacturers who can meet the City's criteria for urban deployable housing. | OEM               | DDC, USACE, FEMA, HUD                       | 6 months                 | \$10 K           | FEMA, CTL, RCPGP                   | N/A                  | 1.1, 2.5, 2.9            | High           |
| MH.P.139 | Property Protection | <b>NYC Brownfield Incentive Grant (BIG) program:</b> Seek more funding to facilitate financial assistance to property owners seeking to investigate and clean up contaminated properties, as well as to community groups, for public outreach, planning, and technical assistance.         | OER               | OMB, NYSEDC, EDC, USEPA                     | 3 months pending funding | \$2.5 M per year | OMB budget allocation, REDC, USEPA | N/A                  | 1.5, 2.1, 2.4, 2.6, 2.10 | High           |
| MH.P.140 | Emergency Services  | <b>Fuel advance warning system:</b> Implement advance-warning system for emergency fuel shutoff during a natural disaster.   | PANYNJ (Aviation) | PANYNJ                                      | 3 years                  | \$500 K          | PANYNJ capital budget              | No change            | 1.1, 1.2, 4.1            | High           |
| MH.P.141 | Emergency Services  | <b>JFK Airport electrical system resiliency:</b> Rehabilitate Bergen substation to enhance the airport's ability to withstand extreme events that disrupt power transmission.  | PANYNJ (Aviation) | FAA   | 5 years                  | \$39.8 M         | PANYNJ capital budget, HMGP        | N/A                  | 2.1, 2.7, 2.10           | Medium         |

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|----------|------------------------|--|-------------------|---------|----------|---------------|-----------------------------|----------------------|----------------------|----------------|
| MH.P.142 | Emergency Services     | <b>LaGuardia Airport central electric substation:</b> Rehabilitate the supervisory controls and data acquisition of the Central Electric and West End substation SCADA system to enhance the airport's ability to manage and recover from emergencies. | PANYNJ (Aviation) | PANYNJ  | 4 years  | \$1.5 M       | PANYNJ capital budget, HMGP | N/A                  | 2.1, 2.7, 2.10       | High           |
| MH.P.143 | Emergency Services     | <b>LaGuardia Airport electrical system enhancement:</b> Upgrade generator equipment to provide enhanced capacity. Currently outdated backup power sources cannot provide reliable power during critical periods.                                       | PANYNJ (Aviation) | PANYNJ  | 2 years  | \$31 M        | PANYNJ capital budget, HMGP | N/A                  | 2.1, 2.3             | Medium         |
| MH.P.144 | Emergency Services     | <b>LaGuardia Airport power system redundancy:</b> Install a secondary power supply for the airport.  | PANYNJ (Aviation) | Con Ed  | 5 years  | \$25.1 M      | PANYNJ capital budget, HMGP | N/A                  | 2.1, 2.3             | Medium         |
| MH.P.145 | Emergency Services     | <b>JFK Airport power system redundancy:</b> Install a secondary power supply for the airport.  | PANYNJ (Aviation) | Con Ed  | 4 years  | \$50 M        | PANYNJ capital budget, HMGP | N/A                  | 2.1, 2.3             | Medium         |
| MH.P.146 | Emergency Services     | <b>Stewart Airport standby emergency generator:</b> Provide power redundancy to allow for safe evacuation of the airport and the maintenance of limited operations during extreme weather events.  | PANYNJ (Aviation) | PANYNJ  | 2 years  | \$2.5 M       | PANYNJ capital budget, HMGP | N/A                  | 2.1, 2.3             | High           |
| MH.P.147 | Emergency Services     | <b>Stewart Airport power system redundancy:</b> Install a secondary power supply for the airport.  | PANYNJ (Aviation) | Con Ed  | 4 years  | \$10 M        | PANYNJ capital budget, HMGP | N/A                  | 2.1, 2.3             | High           |
| MH.P.148 | Infrastructure Project | <b>JFK Airport fuel storage:</b> Elevate storage tank and pumping station on a structural platform.  | PANYNJ (Aviation) | PANYNJ  | 4 years  | \$2 M         | PANYNJ capital budget, HMGP | N/A                  | 2.1, 2.3             | High           |

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|----------|--------------------|---|-------------------|------------------------------|----------|---------------|-----------------------------|----------------------|----------------------|----------------|
| MH.P.149 | Emergency Services | <b>Intelligent Transportation System (ITS) at JFK and Newark Airports:</b> Enhance intra-agency visibility and regional situation awareness—critical to manage traffic during emergencies—by investing in a comprehensive multi-facility Intelligent Transportation System (ITS) program. | PANYNJ (Aviation) | New York DOT, New Jersey DOT | 5 years  | \$69.3 M      | PANYNJ capital budget, HMGP | N/A                  | 2.1, 2.10            | Medium         |
| MH.P.150 | Emergency Services | <b>Emergency generator capacity for Red Hook and Howland Hook container terminals:</b> Add backup power to improve the resiliency of the terminals and mitigate the effects of power loss from a flooding or other weather event.   | PANYNJ (Ports)    | PANYNJ                       | 2 years  | \$1.5 M       | PANYNJ capital budget, HMGP | N/A                  | 2.1, 2.3             | High           |
| MH.P.151 | Emergency Services | <b>Lincoln Tunnel electrical and power system improvements:</b> Upgrade the electrical and power system to prevent the loss of power to pumps and ventilation systems, thus averting flooding and disruption in tunnel use.   | PANYNJ (TBT)      | PANYNJ                       | 3 years  | \$14 M        | PANYNJ capital budget, HMGP | N/A                  | 2.1, 2.7, 2.10       | Medium         |
| MH.P.152 | Emergency Services | <b>George Washington Bridge (GWB) electrical and power system improvements:</b> Upgrade GWB's emergency power feed and low-voltage power distribution, and rehabilitate high-tension switchgear.  | PANYNJ (TBT)      | PSEG, Con Ed                 | 4 years  | \$40.6 M      | PANYNJ capital budget, HMGP | N/A                  | 2.1, 2.7             | Medium         |
| MH.P.153 | Emergency Services | <b>GWB tower transformers:</b> Replace the GWB tower transformers to provide a reliable source of power for tower lighting, communications systems, tower elevators, and security system.   | PANYNJ (TBT)      | PANYNJ                       | 3 years  | \$3.2 M       | PANYNJ capital budget, HMGP | N/A                  | 2.1, 2.7             | High           |
| MH.P.154 | Emergency Services | <b>Multi-facility real-time traffic information software:</b> Develop Enterprise Transportation Management Center software to process data collected from sensors in the field and present up-to-minute information to operators.   | PANYNJ (TBT)      | New York DOT, New Jersey DOT | 5 years  | \$18.5 M      | PANYNJ capital budget, HMGP | N/A                  | 2.1, 2.10            | Medium         |

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|----------|------------------------|--|--------------|------------------------------|--|---------------|----------------------------------|----------------------|----------------------|----------------|
| MH.P.155 | Emergency Services     | <b>Intelligent Transportation System (ITS) program:</b> Develop a comprehensive multi-facility ITS program to provide a cost-effective system to unify multiple facilities within PANYNJ and connect with other regional transportation agencies to provide real-time traffic information for emergencies. | PANYNJ (TBT) | New York DOT, New Jersey DOT | 5 years                                | \$146 M       | PANYNJ capital budget, FHA, HMGP | N/A                  | 2.1, 2.10            | Medium         |
| MH.P.156 | Property Protection    | <b>Overhead electric infrastructure:</b> Raise/relocate the overhead electric infrastructure to mitigate proximity violations as a result of homes being raised to comply with FEMA guidelines.  | PSEG         | N/A                          | Ongoing and as required                | \$500 K       | Insurance, FEMA, NYS CDBG, PSEG  | N/A                  | 1.1, 2.1, 2.2, 3.3   | Low            |
| MH.P.157 | Infrastructure Project | <b>Storm damage mitigation:</b> Place overhead distribution lines underground in high-risk areas with extreme exposure to falling trees, and replace existing lines with aerial spacer cable construction in areas of moderate risk. Install automated sectionalizing switches to isolate flood zones.     | PSEG         | N/A                          | March 2014 start, June 2015 completion | \$3.5 M       | 406, PSEG                        | N/A                  | 2.1, 2.2, 2.7, 3.3   | Low            |
| MH.P.158 | Education & Awareness  | <b>SBS outreach:</b> Update SBS website with information on emergency preparedness and mitigation best practices, and email-blast business and neighborhood organization customers to inform them of mitigation best practices and how to prepare for an upcoming hazard.                                  | SBS          | TBD                          | TBD                                    | TBD           | TBD                              | N/A                  | 3.3, 3.4, 5.1, 5.3   | Medium         |

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|----------|-----------------------|--|------|--|----------|---------------|--------------------------|----------------------|-------------------------|----------------|
| MH.P.159 | Emergency Services    | <b>Toolkit and training materials for volunteer groups:</b> Create toolkit and training materials to enable volunteer groups to help businesses. Materials may include training videos, best practices documentation, and checklists. Volunteers will communicate available services to business owners in the field as well as gather critical data that would allow SBS to connect business owners to necessary recovery services. | SBS  | OEM and other City partners as necessary | TBD      | TBD           | TBD                      | N/A                  | 3.2, 3.3, 3.4, 3.5, 5.1 | Medium         |
| MH.P.160 | Education & Awareness | <b>Small business outreach:</b> Partner with OEM to hold a series of workshops for small businesses in areas vulnerable to coastal storms and flooding. Workshops will cover disaster preparedness and recovery planning, marketing, social media, and financing.  | SBS  | OEM                                      | TBD      | TBD           | TBD                      | N/A                  | 3.2, 3.3, 3.4, 3.5, 5.1 | Medium         |
| MH.P.161 | Education & Awareness | <b>Hazard mitigation education for businesses:</b> Work with OEM to create hazard mitigation planning materials/resources to be distributed/presented during business services (launches, courses, and financing assistance) to encourage businesses to include hazard mitigation planning in their business plans, thereby increasing the likelihood of businesses surviving a hazard.  | SBS  | OEM                                      | TBD      | TBD           | TBD                      | N/A                  | 3.1, 3.2, 3.3, 3.4, 3.5 | Medium         |
| MH.P.162 | Education & Awareness | <b>Ready New York materials:</b> Work with OEM to update/create Ready New York materials geared to businesses with information on mitigation actions.  | SBS  | OEM                                      | TBD      | TBD           | TBD                      | N/A                  | 3.2, 3.3, 3.4, 5.3      | Medium         |



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|----------------|--------------------------------------|--|---------------|-----------|----------|---------------|--------------------------|----------------------|-----------------------------------|----------------|
| MH.P.163       | Education & Awareness                | <b>Toolkit and training materials for Business Improvement Districts (BID) and Local Development Corporations (LDC) on mitigation best practices:</b> Partner with OEM to create toolkit and training materials to train BIDs and LDCs on mitigation best practices. BID representatives and AvenueNYC contract managers will partner with OEM to present on mitigation best practices at meetings in the field. | SBS           | OEM       | TBD      | TBD           | TBD                      | N/A                  | 3.1, 3.2, 3.3, 3.4, 3.5           | Medium         |
| MH.P.164       | Education & Awareness                | <b>Hazard mitigation seminar for BIDs and LDCs:</b> Partner with OEM to hold annual seminar on hazardous mitigation best practices.  | SBS           | OEM       | TBD      | TBD           | N/A                      | N/A                  | 3.1, 3.2, 3.3, 3.4, 3.5           | Medium         |
| MH.P.165       | Education & Awareness                | <b>Dissemination of hazard information:</b> Distribute personal preparedness materials created by OEM on an occasional basis to 200,000+ jobseekers in SBS database. Help New Yorkers be better prepared for or more aware of potential hazards by getting information out about impending hazards and how to react in the wake of a hazard event.   | SBS           | OEM       | TBD      | TBD           | N/A                      | N/A                  | 3.1, 3.2, 3.3, 3.4, 3.5, 5.1, 5.3 | Medium         |
| MH.P.166       | Coastal/ Natural Resource Protection | <b>Rockaway Reformulation Study:</b> Complete Rockaway Reformulation Study with sea level rise considerations for future long-term coastal protection recommendations, design, and construction.   | USACE,NYS-DEC | DPR       | 3 years  | TBD           | USACE, NYC, RCPGP        | N/A                  | 4.1, 4.3, 4.4                     | High           |
| MH.P.167       | Coastal/ Natural Resource Protection | <b>T-groins at Coney Island:</b> Construct T-groins at Coney Island to protect coastline.  | USACE,NYS-DEC | NYSDE,DPR | 1 year   | TBD           | USACE, NYC, RCPGP        | N/A                  | 2.7, 4.3                          | High           |
| SEVERE WEATHER |                                      |  |               |           |          |               |                          |                      |                                   |                |
| SW.P.1         | Property Protection                  | <b>Protection of NYCDOT facilities from high winds:</b> Focus on locations including trailer yards and roofs.  | DOT           | DDC, DCAS | TBD      | TBD           | TBD                      | N/A                  | 2.1, 2.7                          | Medium         |

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|----------------------|------------------------|--|---------------------------|---------------------------|--|---------------|---|--|-------------------------|----------------|
| SW.P.2               | Emergency Services     | <b>Sign inspection program:</b> Develop enhanced inspection program of key street, parking, and life-protecting signs throughout the city to ensure these do not become potentially hazardous debris during high-wind events.  | DOT                       | N/A                       | 3 years                                      | \$3.25 M      | Consolidated Highway Improvement Program  | N/A  | 2.1, 2.7                | High           |
| SW.P.3               | Property Protection    | <b>Rooftop equipment protection at HRA facilities:</b> Secure rooftop equipment to withstand high-wind events.   | HRA                       | OEM, DEP, DDC, DCAS, FEMA | 5 years                                      | \$5 M         | City capital budget                       | Recommendations were made to landlord                    | 1.1, 2.1, 2.7           | Medium         |
| SW.P.4               | Infrastructure Project | <b>Bridge reinforcement:</b> Study and design bridge features that mitigate the effects of high-wind events.   | MTA (Bridges and Tunnels) | N/A                       | TBD  | TBD           | TBD                                       | Incorporated into facility state-of-good-repair projects | 2.1, 2.7, 2.8, 2.9      | Medium         |
| SW.P.5               | Property Protection    | <b>Increased line clearance tree trim program:</b> Expand line clearance tree trim program to shorten tree trim cycle and increase removal of hazardous trees outside normal trim zones.   | PSEG                      | N/A                       | January 2014 start, December 2014 completion | \$500 M       | NYS CDBG, PSEG                            | N/A  | 2.1, 2.7, 3.3           | Medium         |
| <b>WINTER STORMS</b> |                        |  |                           |                           |  |               |   |  |                         |                |
| WS.P.1               | Infrastructure Project | <b>Improved snow and ice melt:</b> Research and, if appropriate, test and monitor the effectiveness of permeable pavement and other paving techniques to speed snowmelt and icemelt on streets. The goal is to clear paved areas more quickly, thereby reducing vehicular crashes and improving emergency access post-snowstorm. | DOT                       | N/A                       | 1 year (consultant study)                    | \$250 M       | HMGP, city capital budget, expense budget | No change  | 2.1, 2.7, 2.8, 2.9, 5.2 | Medium         |
| WS.P.2               | Education & Awareness  | <b>Outreach to property owners on impacts of snow loads:</b> Partner with DOB to educate property owners about the impacts of snow load, snow drift loads, and sliding snow loads.   | OEM                       | DOB                       | 1 year                                       | TBD           | Agency operating budget                   | No change  | 2.6, 3.4, 5.3           | High           |

**v. Private Institutions and Non-Profit Organizations—Potential Mitigation Actions**

Like other groups in New York City, private institutions and non-profit organizations are vulnerable to hazards; they are also interested in formulating mitigation strategies. The City works closely with private institutions and non-profits before, during, and after emergencies. This partnership is critical to strengthen resiliency and preparedness throughout the city.

The private and non-profit world in New York City encompasses hundreds of entities that can be categorized according to five primary sectors:

- Human services—special needs
- Healthcare
- Cultural institutions
- Education
- Emergency services

For each sector, there are corresponding mitigation actions.

**Human Services—Special Needs**

The human services sector includes organizations that aim to improve quality-of-life issues for the local community, addressing the human element in response and recovery operations. This sector includes organizations that provide services and advocacy to special needs populations and thus make the City's plans and operations all-inclusive. The sector also encompasses organizations responsible for mass-care operations including sheltering, feeding, and volunteer and donation coordination and management. Also included in this sector are affordable housing providers, nursing homes, and assisted living complexes.

Organizations within the human services sector may implement a variety of mitigation actions to help reduce or eliminate long-term risk. For instance, they may take property protection actions to prevent flooding at an affordable housing complex and, in addition, install backup generators to ensure continuity in a

power outage.

Public messaging is a key component of ensuring inclusive human services efforts.

**Healthcare**

The organizations in this sector include private hospitals and other healthcare facilities, such as nursing homes, adult care facilities, senior centers, and dialysis centers. In New York City, many hospitals belong to a larger umbrella organization called Greater New York Hospitals Association (GNYHA), a trade association comprising nearly 250 hospitals and continuing care facilities, both voluntary and public, in the New York metropolitan area and throughout New York State, New Jersey, Connecticut, and Rhode Island. After Hurricane Sandy, New York City hospitals reviewed general building codes and healthcare regulations to determine recommendations for existing buildings and new construction standards.

In particular, NYU Langone Medical Center and Memorial Sloan-Kettering Cancer Center have identified several mitigation projects focusing on property protection and emergency services.

Mitigation actions within this sector can include flood-gate installation and equipment elevation to ensure that critical hospital functions and research programs continue uninterrupted under hazardous conditions. Additional emergency power distribution is vital to mitigate power outages. Such outages rendered all hospital functions at the two above mentioned facilities inoperable during Sandy.

**Cultural Institutions**

Museums, cultural facilities, libraries, historic places, and conservation societies are all included in the cultural institutions sector. Many of these organizations are part of the Alliance for Response NYC, an initiative of the non-profit organization Heritage Preservation, which brings cultural institutions and the first-responder community together to prepare for and respond to emergencies. These organizations may propose actions to mitigate flooding, such as designing drainage systems, constructing seawalls, and installing leak-de-

tection equipment. Property protection mitigation actions may also include elevating generator equipment or moving historic collections from the basements of buildings to higher floors.

### **Education**

The education sector includes high schools, private colleges, universities, and other educational institutions. Many of the mitigation actions proposed by these entities address emergency services (for instance, promoting backup power generation to ensure continuity in the event of a power outage); others address property protection (facilities in low-lying areas may consider elevating electrical equipment or installing drainage systems to protect buildings from flooding). It is critical to maintain power and ensure that physical structures are resilient in the event of a hazard.

### **Emergency Services**

Organizations that provide ambulatory services and/or alert notification systems are part of the emergency services sector. These organizations may propose backup power measures to prevent the loss of communication services due to power outages during an emergency.

## **B. Analysis of Potential Mitigation Actions**

The Planning Team and Steering Committee analyzed potential mitigation actions using the FEMA STAPLEE (social, technical, administrative, political, legal, economic, and environmental) review method. This analysis helped determine whether actions achieved one or more of the five hazard mitigation goals and 28 objectives of the HMP. The analysis also established the opportunities and constraints of implementing each potential mitigation action.

### **i. STAPLEE Analysis**

The STAPLEE review method is a systematic evaluation process developed by FEMA to help identify the benefits and constraints of a particular mitigation action. Figure 4.1, below, summarizes the STAPLEE criteria.

Figure 4.1: STAPLEE Evaluation Criteria

**S**ocial **T**echnical **A**dministrative **P**olitical **L**egal **E**conomic **E**nvironmental

**Social:** The public must support the overall implementation and specific mitigation actions.

Will the proposed action adversely affect one segment of the population?  
Will the action disrupt established neighborhoods, break up voting districts, or cause the relocation of lower income people?  
Is the action compatible with present and future community values?

How effective is the action in avoiding or reducing future losses?  
Will it create more problems than it solves?  
Does it solve the problem or only the symptom?

**Technical:** It is important to determine if the proposed action is technically feasible and will help reduce losses in the long term.

**Administrative:** Determine if the city has the staff and capabilities necessary to implement the action.

Does the jurisdiction have the capability (staff, technical experts, and/or funding) to implement the action, or can it be readily obtained?  
Can the community provide the necessary maintenance?  
Can it be accomplished in a timely manner?

Is there Political support to implement and maintain the action?  
Is there a local champion willing to see the action to completion?  
Is there enough public support to ensure the success of the action?

**Political:** Understanding how the community and political leadership feel about issues related to the environment, economic development, safety and emergency management.

**Legal:** Without appropriate legal authority, the action cannot lawfully be undertaken.

Are the proper laws, ordinances, and resolutions in place to implement the action? Are there potential legal consequences?

Will the community be liable for the actions or support of actions, or lack of action?

Is the action likely to be challenged by stakeholders who may be negatively affected?

Are there currently sources of funds that can be used to implement the action?

What benefits will the action provide? Does the cost seem reasonable for the size of the problem and likely benefits?

What burden will be place on the tax base to implement the action?

Does the action contribute to the community economic goals, such as capital improvements or economic development?

**Economic:** Economic considerations must include the present economic base and projected growth.

**Environmental:**

Impact on the environment is an important consideration because of public desire for sustainable and environmentally healthy communities.

How will this action affect the environment (land, water, endangered species)?

Will this action comply with local, state, and federal environmental laws or regulations?

Is the action consistent with community environmental goals?

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The Planning Team used the seven STAPLEE evaluation criteria to assign values to the actions. A score of plus 1 (1) was assigned if the proposed action is favorable; a minus 1 (-1) was assigned if the action is unfavorable; and 0 (0) was assigned if the evaluation criteria does not apply to the mitigation action (see Table 4.9).

Table 4.9: STAPLEE Analysis of Potential Mitigation Actions

| Index                  | Mitigation Action   | Lead Agency   | Social               |                                 | Technical            |                    | Administrative    |          |                    | Political              |                   | Legal          |                 | Economic                 |                           | Environment       |                |                          |                      |
|------------------------|---|---------------|----------------------|---------------------------------|----------------------|--------------------|-------------------|----------|--------------------|------------------------|-------------------|----------------|-----------------|--------------------------|---------------------------|-------------------|----------------|--------------------------|----------------------|
|                        |   |               | Community Acceptance | Effect on Segment of Population | Technically Feasible | Long-Term Solution | Secondary Impacts | Staffing | Funding Allocation | Maintenance/Operations | Political Support | Public Support | State Authority | Existing Local Authority | Potential Legal Challenge | Benefit of Action | Cost of Action | Outside Funding Required | Effect on Land/Water |
| <b>CBRN</b>            |   |               |                      |                                 |                      |                    |                   |          |                    |                        |                   |                |                 |                          |                           |                   |                |                          |                      |
| CB.P.1                 | Construction Code revision  | DOB           | 1                    | 1                               | 1                    | 1                  | 0                 | 0        | 0                  | 0                      | 1                 | 1              | 1               | 1                        | 0                         | 1                 | 1              | 0                        | 1                    |
| CB.P.2                 | Harlem River lift bridge  | MNR           | 1                    | 0                               | 1                    | 1                  | 1                 | 1        | 0                  | 0                      | 1                 | 1              | 0               | 1                        | 1                         | 1                 | 0              | 0                        | 0                    |
| CB.P.3                 | NYCHA fresh water supply  | NYCHA         | 1                    | 1                               | 1                    | 1                  | 0                 | 1        | 0                  | -1                     | 1                 | 1              | 1               | 1                        | 0                         | 1                 | 0              | 0                        | 1                    |
| CB.P.4                 | Brownfield cleanup in the 100-year floodplain                             | OER           | 1                    | 1                               | 1                    | 0                  | 1                 | 1        | 0                  | 0                      | 1                 | 1              | 1               | 1                        | 1                         | 1                 | 1              | 1                        | 1                    |
| CB.P.5                 | Environmental research  | OER           | 1                    | 0                               | 1                    | 1                  | 0                 | 0        | 0                  | -1                     | 1                 | 0              | 1               | 1                        | 1                         | 1                 | 1              | 1                        | 1                    |
| CB.P.6                 | BrownfieldWORKS!  | OER           | 1                    | -1                              | 1                    | 1                  | -1                | 1        | 0                  | 0                      | 1                 | 1              | 1               | 1                        | -1                        | 1                 | 1              | -1                       | 1                    |
| CB.P.7                 | Environmental Project Information Center (EPIC)                           | OER           | 1                    | 0                               | 1                    | 1                  | 0                 | 0        | 0                  | -1                     | 1                 | 1              | 1               | 1                        | 1                         | 1                 | -1             | 1                        | 1                    |
| <b>Coastal Erosion</b> |   |               |                      |                                 |                      |                    |                   |          |                    |                        |                   |                |                 |                          |                           |                   |                |                          |                      |
| CE.P.1                 | Protection of Rikers Island east, west, and south shorelines              | DOC           | 1                    | 1                               | 1                    | 1                  | 0                 | 0        | 0                  | 0                      | 1                 | 0              | 1               | 1                        | 1                         | 1                 | 0              | 1                        | 0                    |
| CE.P.2                 | Beach restoration   | DPR           | 1                    | 1                               | 1                    | -1                 | -1                | 0        | 0                  | -1                     | 1                 | 1              | 1               | 1                        | 0                         | 1                 | 0              | 0                        | 0                    |
| CE.P.3                 | Renourishment of Orchard Beach, Bronx                                     | USACE/NYC P&R | 1                    | 0                               | 1                    | -1                 | -1                | 1        | 0                  | -1                     | 1                 | 1              | 1               | 1                        | -1                        | 1                 | 1              | 1                        | -1                   |
| <b>Coastal Storms</b>  |   |               |                      |                                 |                      |                    |                   |          |                    |                        |                   |                |                 |                          |                           |                   |                |                          |                      |
| CS.P.1                 | Flooding prevention   | DCAS          | 0                    | 1                               | 1                    | 1                  | -1                | 0        | 0                  | 1                      | -1                | -1             | 0               | 0                        | 0                         | 1                 | 0              | 0                        | 0                    |
| CS.P.2                 | Resilient neighborhoods planning studies                                  | DCP           | 1                    | 1                               | 1                    | 0                  | 1                 | 0        | 0                  | 0                      | 1                 | 1              | 1               | 1                        | 1                         | 1                 | 0              | 0                        | 1                    |
| CS.P.3                 | DCP planning support and technical assistance for Sandy disaster recovery | DCP           | 1                    | 1                               | 1                    | 0                  | 1                 | 0        | 0                  | 0                      | 1                 | 1              | 1               | 1                        | 1                         | 1                 | 0              | 0                        | 1                    |

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**CHAPTER 4: MITIGATION STRATEGY**

| Index   | Mitigation Action   | Lead Agency               | Social               |                                 | Technical            |                    |                   | Administrative |                    |                        | Political         |                | Legal           |                          |                           | Economic          |                | Environment              |                      |  |
|---------|---|---------------------------|----------------------|---------------------------------|----------------------|--------------------|-------------------|----------------|--------------------|------------------------|-------------------|----------------|-----------------|--------------------------|---------------------------|-------------------|----------------|--------------------------|----------------------|--|
|         |   |                           | Community Acceptance | Effect on Segment of Population | Technically Feasible | Long-Term Solution | Secondary Impacts | Staffing       | Funding Allocation | Maintenance/Operations | Political Support | Public Support | State Authority | Existing Local Authority | Potential Legal Challenge | Benefit of Action | Cost of Action | Outside Funding Required | Effect on Land/Water | Consistency with Community Environmental Goals |
| CS.P.4  | Emergency contracts   | DDC                       | 1                    | 0                               | 1                    | 0                  | 0                 | 0              | 0                  | 0                      | 1                 | 1              | 1               | 1                        | -1                        | 1                 | 0              | 0                        | 0                    | 1  |
| CS.P.5  | Hardening pumping stations  | DEP                       | 1                    | 1                               | 0                    | 1                  | -1                | -1             | 0                  | -1                     | 1                 | 1              | 1               | 1                        | 0                         | 1                 | -1             | -1                       | 0                    | 0  |
| CS.P.6  | Hardening wastewater treatment plants   | DEP                       | 1                    | 0                               | 1                    | 1                  | 1                 | 1              | 1                  | 1                      | 1                 | 1              | 1               | 1                        | 1                         | 1                 | -1             | 1                        | 1                    | 1  |
| CS.P.7  | Alternatives for Rockaway Wastewater Treatment Plant  | DEP                       | 1                    | 0                               | 1                    | -1                 | -1                | 0              | 0                  | 0                      | 0                 | 0              | 1               | 1                        | 0                         | 1                 | -1             | 1                        | 0                    | 0  |
| CS.P.8  | Vernon C. Bain Center (VCBC) mooring system and site access improvement   | DOC                       | 1                    | 0                               | 1                    | 1                  | 0                 | 0              | 0                  | 0                      | 1                 | 1              | 1               | 1                        | 0                         | 1                 | 0              | 1                        | 0                    | 1  |
| CS.P.9  | Division I, II and III storehouse   | DOC                       | 1                    | 0                               | 1                    | 0                  | 0                 | 0              | -1                 | -1                     | 1                 | 0              | 1               | 1                        | 0                         | 1                 | 0              | 1                        | 0                    | 1  |
| CS.P.10 | Sunset Cove Parks sustainable shoreline at Broad Channel, Jamaica Bay   | DPR                       | 1                    | 1                               | 1                    | 1                  | 1                 | 0              | -1                 | -1                     | 1                 | 1              | 1               | 1                        | 1                         | 1                 | 1              | -1                       | 1                    | 1  |
| CS.P.11 | FDNY storehouse improvement   | FDNY                      | 1                    | 0                               | 1                    | 1                  | 0                 | 0              | 0                  | -1                     | 1                 | 1              | 1               | 1                        | 0                         | 1                 | 0              | 0                        | 0                    | 1  |
| CS.P.12 | EMS Battalion   | FDNY                      | 1                    | 1                               | 0                    | 1                  | -1                | 0              | 0                  | 0                      | 1                 | 1              | 1               | 1                        | 1                         | 1                 | 0              | 0                        | 0                    | 1  |
| CS.P.13 | EMS fallback sites  | FDNY                      | 1                    | 1                               | 1                    | 0                  | 1                 | 0              | 0                  | 0                      | 1                 | 1              | 1               | 1                        | 1                         | 1                 | 0              | 0                        | 0                    | 1  |
| CS.P.14 | FDNY emergency services   | FDNY                      | 1                    | 1                               | 0                    | 1                  | 0                 | 1              | 0                  | -1                     | 1                 | 1              | 1               | 1                        | 1                         | 1                 | 0              | 0                        | 0                    | 1  |
| CS.P.15 | Outreach to residential building owners   | HPD                       | 1                    | 1                               | 1                    | 0                  | 0                 | 1              | 0                  | 1                      | 1                 | 1              | 1               | 1                        | 1                         | 1                 | 1              | -1                       | 0                    | 1  |
| CS.P.16 | Resilient home design competition   | HPD                       | 1                    | 1                               | 1                    | 0                  | 0                 | 1              | 0                  | 0                      | 1                 | 1              | 1               | 1                        | 1                         | 1                 | 1              | 1                        | 0                    | 1  |
| CS.P.17 | Flood-hardening of vital communications, substations, transformers, mechanical equipment, revenue equipment, and other electronic systems at all MTA Bridges and Tunnels facilities | MTA (Bridges and Tunnels) | 1                    | 1                               | 0                    | 0                  | -1                | -1             | 0                  | -1                     | 1                 | 1              | 1               | 1                        | 0                         | 1                 | 0              | -1                       | 0                    | 0  |
| CS.P.18 | Raising Governors Island seawall for Hugh L. Carey Tunnel   | MTA (Bridges and Tunnels) | 1                    | 0                               | 1                    | 1                  | 1                 | 0              | 0                  | -1                     | 1                 | 1              | 1               | 1                        | 0                         | 1                 | -1             | 1                        | 0                    | 1  |
| CS.P.19 | Water-level monitoring/alarm systems/CCTV   | MTA (MNR)                 | 1                    | 1                               | 1                    | 1                  | 0                 | 0              | 0                  | -1                     | 1                 | 1              | 1               | 1                        | 0                         | 1                 | 0              | -1                       | 0                    | 1  |



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**CHAPTER 4: MITIGATION STRATEGY**

| Index                | Mitigation Action  | Lead Agency        | Social               |                                 | Technical            |                    |                   | Administrative |                    |                        | Political         |                | Legal           |                          | Economic                  |                   |                | Environment              |                      |  |
|----------------------|--|--------------------|----------------------|---------------------------------|----------------------|--------------------|-------------------|----------------|--------------------|------------------------|-------------------|----------------|-----------------|--------------------------|---------------------------|-------------------|----------------|--------------------------|----------------------|--|
|                      |  |                    | Community Acceptance | Effect on Segment of Population | Technically Feasible | Long-Term Solution | Secondary Impacts | Staffing       | Funding Allocation | Maintenance/Operations | Political Support | Public Support | State Authority | Existing Local Authority | Potential Legal Challenge | Benefit of Action | Cost of Action | Outside Funding Required | Effect on Land/Water | Consistency with Community Environmental Goals |
| CS.P.20              | Power and communications/signal infrastructure mitigation                    | MTA (MNR)          | 1                    | 0                               | 0                    | 1                  | 0                 | 0              | 0                  | 1                      | 1                 | 1              | 1               | 1                        | 0                         | 1                 | 0              | -1                       | 0                    | 1  |
| CS.P.21              | Hardening of vulnerable healthcare facilities                                | NYS DOH            | 1                    | 1                               | 1                    | 0                  | 0                 | 0              | 0                  | 1                      | 1                 | 1              | 1               | 1                        | 1                         | 1                 | 1              | -1                       | 0                    | 1  |
| CS.P.22              | Protection of hurricane shelter windows                                      | OEM                | 1                    | 1                               | 1                    | 1                  | 0                 | 0              | 0                  | 0                      | 1                 | 1              | 1               | 1                        | 0                         | 1                 | 0              | 0                        | 0                    | 1  |
| CS.P.23              | Hazards U.S. Multi-Hazard (HAZUS-MH) modeling                                | OEM                | 1                    | 0                               | 0                    | 0                  | 0                 | 1              | 0                  | 1                      | 1                 | 1              | 1               | 1                        | 1                         | 1                 | 0              | -1                       | 0                    | 1  |
| CS.P.24              | Backup power for evacuation centers  | OEM                | 1                    | 1                               | 0                    | 1                  | 0                 | 0              | 0                  | -1                     | 1                 | 1              | 1               | 1                        | 0                         | 1                 | 0              | -1                       | -1                   | 0  |
| CS.P.25              | Storm shutters for the Emergency Operations Center                           | OEM                | 1                    | 1                               | 1                    | 1                  | 0                 | 0              | 0                  | -1                     | 1                 | 1              | 1               | 1                        | 0                         | 1                 | 1              | 0                        | 0                    | 1  |
| CS.P.26              | Storm surge/tidal gauge real-time monitoring system                          | OEM                | 1                    | 1                               | 0                    | 1                  | 0                 | -1             | 0                  | -1                     | 1                 | 1              | 1               | 1                        | 0                         | 1                 | 0              | -1                       | 0                    | 1  |
| CS.P.27              | Evacuation center/ hurricane shelter ADA retrofit program for DOE facilities | OEM                | 1                    | 1                               | -1                   | 1                  | 0                 | -1             | 0                  | -1                     | 1                 | 1              |                 | 1                        | -1                        | 1                 | 0              | -1                       | 0                    | 1  |
| CS.P.28              | Updates to urban post-disaster interim neighborhood design guidelines        | OEM                | 1                    | 1                               | 1                    | 1                  | 1                 | 1              | 1                  | 0                      | 1                 | 1              | 1               | 1                        | 0                         | 1                 | 1              | -1                       | 0                    | 1  |
| CS.P.29              | Cleanup standards for waterfront brownfields                                 | OER                | 1                    | 1                               | 1                    | 0                  | 1                 | 0              | 0                  | 0                      | 1                 | 1              | 1               | 1                        | 0                         | 1                 | 1              | 1                        | 1                    | 1  |
| CS.P.30              | Building Code update for wind resiliency in new buildings                    | OLTPS              | 1                    | 1                               | 0                    | 1                  | 0                 | 0              | 0                  | 0                      | 1                 | 1              | 1               | 1                        | 0                         | 1                 | 1              | -1                       | 0                    | 1  |
| CS.P.31              | Building Code update for wind resiliency in existing buildings               | OLTPS              | 1                    | 1                               | 0                    | 1                  | 0                 | 0              | 0                  | 0                      | 1                 | 1              | 1               | 1                        | 0                         | 1                 | 1              | -1                       | 0                    | 1  |
| CS.P.32              | Power exercises  | USACE/NYCO-EM/RCPT | 1                    | 1                               | 1                    | 0                  | 0                 | 0              | 0                  | 0                      | 1                 | 1              | 1               | 1                        | 0                         | 1                 | 0              | 1                        | 0                    | 1  |
| <b>Cyber Threats</b> |  |                    |                      |                                 |                      |                    |                   |                |                    |                        |                   |                |                 |                          |                           |                   |                |                          |                      |  |
| CY.P.1               | Supplementation of IT security   | HRA                | 1                    | 1                               | 1                    | 1                  | 0                 | 1              | -1                 | -1                     | 1                 | 1              | 1               | 1                        | 1                         | 1                 | -1             | -1                       | 0                    | 0  |
| CY.P.2               | Cyber-security strategy  | MTA (MNR)          | 0                    | 0                               | 1                    | 1                  | 0                 | 0              | 1                  | -1                     | 1                 | 0              | 1               | 1                        | 0                         | 1                 | -1             | 1                        | 0                    | 0  |

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|-----------------------------|--|-------------|----------------------|---------------------------------|----------------------|--------------------|-------------------|----------------|--------------------|------------------------|-------------------|----------------|-----------------|--------------------------|---------------------------|-------------------|----------------|--------------------------|----------------------|--|
|                             |  |             | Community Acceptance | Effect on Segment of Population | Technically Feasible | Long-Term Solution | Secondary Impacts | Staffing       | Funding Allocation | Maintenance/Operations | Political Support | Public Support | State Authority | Existing Local Authority | Potential Legal Challenge | Benefit of Action | Cost of Action | Outside Funding Required | Effect on Land/Water | Consistency with Community Environmental Goals |
| <b>Disease Outbreaks</b>    |  |             |                      |                                 |                      |                    |                   |                |                    |                        |                   |                |                 |                          |                           |                   |                |                          |                      |  |
| DO.P.1                      | Pandemic Planning  | MTA (MNR)   | 1                    | 1                               | 1                    | -1                 | 1                 | 1              | 0                  | 0                      | 1                 | 1              | 1               | 1                        | 1                         | 1                 | 0              | 0                        | 0                    |  |
| <b>Drought</b>              |  |             |                      |                                 |                      |                    |                   |                |                    |                        |                   |                |                 |                          |                           |                   |                |                          |                      |  |
| D.P.1                       | Maximizing capacity for water delivery from the Catskill/Delaware system | DEP         | 1                    | 0                               | 1                    | 1                  | 0                 | -1             | 1                  | -1                     | 1                 | 0              | 1               | 1                        | -1                        | 1                 | -1             | 0                        | 0                    | 1  |
| D.P.2                       | Catskill Aqueduct capacity   | DEP         | 1                    | 0                               | 1                    | 1                  | 0                 | -1             | 1                  | -1                     | 1                 | 0              | 1               | 1                        | -1                        | 1                 | -1             | 0                        | 0                    | 1  |
| D.P.3                       | Construction Code revision   | DOB         | 1                    | 1                               | 1                    | 1                  | 1                 | 1              | 1                  | 1                      | 1                 | 1              | 1               | 1                        | 1                         | 1                 | 1              | 1                        | 1                    | 1  |
| D.P.4                       | Drought effects monitoring   | FDNY        | 1                    | -1                              | 1                    | 1                  | -1                | -1             | 1                  | -1                     | 1                 | 1              | 1               | 1                        | 1                         | 1                 | 0              | 0                        | 1                    | 1  |
| <b>Earthquakes</b>          |  |             |                      |                                 |                      |                    |                   |                |                    |                        |                   |                |                 |                          |                           |                   |                |                          |                      |  |
| EQ.P.1                      | Mechanical equipment seismic upgrade                                     | DCAS        | 1                    | 1                               | 1                    | 1                  | 0                 | 0              | 0                  | 1                      | 1                 | 1              | 0               | 1                        | 1                         | 1                 | 1              | 1                        | 0                    | 0  |
| EQ.P.2                      | Seismic protection for sewers  | DEP         | 1                    | 1                               | 1                    | 1                  | 0                 | 1              | 1                  | -1                     | 1                 | 1              | 1               | 1                        | 1                         | 1                 | 0              | 0                        | 1                    | 1  |
| EQ.P.3                      | Seismic inspection and retrofit for drinking water distribution system   | DEP         | 1                    | 1                               | 1                    | 0                  | 0                 | 1              | 1                  | 0                      | 1                 | 1              | 1               | 1                        | 1                         | 1                 | 0              | 0                        | 1                    | 1  |
| EQ.P.4                      | Building code update   | DOB         | 1                    | 1                               | 1                    | 1                  | 0                 | 0              | 0                  | 0                      | 1                 | 1              | 1               | 1                        | 0                         | 1                 | 1              | 1                        | 0                    | 1  |
| EQ.P.5                      | Seismic study and retrofit for tall buildings                            | DOE         | 1                    | 1                               | 1                    | 1                  | 1                 | 0              | 1                  | -1                     | 1                 | 1              | 1               | 1                        | 1                         | 1                 | 0              | 1                        | 0                    | 0  |
| EQ.P.6                      | Building upgrades to seismic codes                                       | HHC         | 1                    | 1                               | 1                    | 1                  | 1                 | 0              | -1                 | -1                     | 1                 | 1              | 1               | 1                        | 1                         | 1                 | -1             | -1                       | 0                    | 0  |
| EQ.P.7                      | HPD facility improvement   | HPD         | 1                    | 1                               | 1                    | 1                  | 1                 | -1             | -1                 | 0                      | 1                 | 1              | 1               | 1                        | 1                         | 1                 | -1             | -1                       | 0                    | 0  |
| EQ.P.8                      | UPACA (Site 6)   | NYCHA       | 1                    | 1                               | 1                    | 1                  | -1                | -1             | 0                  | -1                     | 1                 | 1              | 1               | 1                        | 1                         | 1                 | 0              | 0                        | 0                    | 0  |
| EQ.P.9                      | HAZUS-MH modeling  | OEM         | 0                    | 1                               | 1                    | 1                  | 0                 | 1              | -1                 | 1                      | 1                 | 1              | 0               | 0                        | 1                         | 1                 | -1             | 1                        | 0                    | 0  |
| <b>Extreme Temperatures</b> |  |             |                      |                                 |                      |                    |                   |                |                    |                        |                   |                |                 |                          |                           |                   |                |                          |                      |  |
| ET.P.1                      | Power redundancy in City buildings                                       | DCAS        | 1                    | 1                               | 1                    | 0                  | -1                | 0              | 0                  | -1                     | 1                 | 1              | 1               | 1                        | 1                         | 1                 | 0              | 1                        | 0                    | 0  |
| ET.P.2                      | AC upgrade for senior centers  | DFTA        | 1                    | 1                               | 1                    | 0                  | 0                 | 0              | 0                  | -1                     | 1                 | 1              | 1               | 1                        | 1                         | 1                 | 0              | 0                        | 0                    | 0  |
| ET.P.3                      | AC availability and affordability  | DOHMH       | 1                    | 1                               | 1                    | 1                  | -1                | 0              | -1                 | 0                      | 1                 | 1              | -1              | 0                        | 0                         | 1                 | -1             | -1                       | -1                   | -1   |
| ET.P.4                      | Urban heat island effect mitigation                                      | DOHMH       | 1                    | 1                               | 1                    | 1                  | 1                 | -1             | 0                  | 0                      | 1                 | 1              | 0               | 1                        | 0                         | 1                 | 0              | -1                       | 1                    | 1  |

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| Index           | Mitigation Action  | Lead Agency | Social               |                                 | Technical            |                    |                   | Administrative |                    |                        | Political         |                | Legal           |                          | Economic                  |                   | Environment    |                          |                      |
|-----------------|--|-------------|----------------------|---------------------------------|----------------------|--------------------|-------------------|----------------|--------------------|------------------------|-------------------|----------------|-----------------|--------------------------|---------------------------|-------------------|----------------|--------------------------|----------------------|
|                 |  |             | Community Acceptance | Effect on Segment of Population | Technically Feasible | Long-Term Solution | Secondary Impacts | Staffing       | Funding Allocation | Maintenance/Operations | Political Support | Public Support | State Authority | Existing Local Authority | Potential Legal Challenge | Benefit of Action | Cost of Action | Outside Funding Required | Effect on Land/Water |
| ET.P.5          | Cooling centers  | NYCHA       | 1                    | 1                               | 1                    | 0                  | -1                | 0              | 0                  | -1                     | 1                 | 1              | 1               | 1                        | 1                         | 0                 | 0              | -1                       | -1                   |
| <b>Flooding</b> |  |             |                      |                                 |                      |                    |                   |                |                    |                        |                   |                |                 |                          |                           |                   |                |                          |                      |
| F.P.1           | Infrastructure flood protection  | DCAS        | 0                    | 1                               | 1                    | 1                  | 0                 | 0              | -1                 | 0                      | 0                 | 0              | 1               | 0                        | 1                         | -1                | 0              | 1                        | 1                    |
| F.P.2           | Flood Resilient Building Design Manual                                       | DCP         | 1                    | 1                               | 1                    | 1                  | 1                 | 1              | 1                  | 1                      | 1                 | 1              | 0               | 1                        | 1                         | 1                 | 0              | 1                        | 1                    |
| F.P.3           | Zoning for flood-resistant construction, Phase I and II                      | DCP         | 1                    | 1                               | 1                    | 1                  | 1                 | 1              | 1                  | 1                      | 1                 | 1              | 0               | 1                        | 1                         | 1                 | 0              | 1                        | 1                    |
| F.P.4           | Ecologically sensitive industrial area planning                              | DCP         | 1                    | 1                               | 1                    | 1                  | 1                 | 1              | 1                  | 1                      | 1                 | 1              | 0               | 1                        | 1                         | 1                 | 0              | 1                        | 1                    |
| F.P.5           | Croton Falls pump station rehabilitation                                     | DEP         | 1                    | 1                               | 1                    | 1                  | 0                 | 0              | -1                 | -1                     | 1                 | 1              | -1              | 1                        | 0                         | 1                 | -1             | 0                        | 1                    |
| F.P.6           | Bergen Basin and Tallman Island Wastewater Treatment Plant drainage upgrades | DEP         | 1                    | 1                               | 1                    | 1                  | 0                 | 0              | -1                 | -1                     | 1                 | 1              | -1              | 1                        | 0                         | 1                 | -1             | 0                        | 1                    |
| F.P.7           | Server capacity improvements   | DFTA        | 1                    | 1                               | 1                    | 1                  | 0                 | 0              | -1                 | 1                      | 1                 | 1              | 0               | 1                        | 0                         | 1                 | -1             | 0                        | 0                    |
| F.P.8           | DHS electrical improvements  | DHS         | 1                    | 1                               | 1                    | 1                  | 0                 | 0              | -1                 | 1                      | 1                 | 1              | 0               | 1                        | 0                         | 1                 | -1             | 0                        | 0                    |
| F.P.9           | Borden Avenue facility   | DHS         | 1                    | 1                               | 1                    | 1                  | 0                 | 0              | -1                 | 1                      | 1                 | 0              | 0               | 1                        | 0                         | 1                 | -1             | 0                        | -1                   |
| F.P.10          | Data system upgrade  | DOB         | 1                    | 1                               | 1                    | 1                  | 1                 | 1              | 1                  | 1                      | 1                 | 1              | 0               | 1                        | 1                         | 1                 | -1             | 0                        | 1                    |
| F.P.11          | Post-disaster code enforcement   | DOB         | -1                   | 1                               | 1                    | 1                  | 1                 | -1             | 1                  | -1                     | 1                 | 1              | 0               | 1                        | 1                         | 1                 | -1             | 1                        | 1                    |
| F.P.12          | Rikers Island roadway re-grading   | DOC         | 1                    | 1                               | 1                    | 1                  | 0                 | 0              | -1                 | 1                      | 1                 | 0              | 0               | 1                        | 0                         | 1                 | -1             | 0                        | 0                    |
| F.P.13          | Water infiltration prevention  | DOHMH       | 0                    | 0                               | 1                    | 1                  | 0                 | 0              | -1                 | 1                      | 0                 | 0              | 0               | 1                        | 0                         | 1                 | -1             | 0                        | 0                    |
| F.P.14          | Flood-proofing 125 Worth Street vault  | DOHMH       | 1                    | 1                               | 1                    | 1                  | 0                 | 0              | -1                 | 0                      | 1                 | 1              | 0               | 1                        | 0                         | 1                 | -1             | -1                       | 0                    |
| F.P.15          | Permeable pavement   | DOT         | 1                    | 0                               | 1                    | 1                  | 1                 | 1              | -1                 | -1                     | 1                 | 0              | 1               | 1                        | 1                         | 1                 | -1             | 1                        | 1                    |
| F.P.16          | Flood-proofing at Olmsted site   | DPR         | 0                    | 0                               | 1                    | 1                  | 0                 | 0              | 0                  | 0                      | 0                 | 0              | 0               | -1                       | 0                         | 1                 | -1             | 0                        | 0                    |
| F.P.17          | Tidegate upgrade in Flushing Meadow Corona Park                              | DPR         | 1                    | 1                               | 1                    | 1                  | 0                 | 1              | 1                  | -1                     | 1                 | 1              | 1               | 1                        | 1                         | 1                 | -1             | 1                        | 1                    |
| F.P.18          | Living shoreline at Conference House Park                                    | DPR         | 1                    | 1                               | 1                    | 1                  | 0                 | -1             | 0                  | -1                     | 1                 | 1              | 0               | 1                        | 1                         | 1                 | 0              | -1                       | 1                    |
| F.P.19          | Protection for the Manhattan 1,2,5 facility                                  | DSNY        | 1                    | 1                               | 1                    | 1                  | -1                | 0              | 0                  | -1                     | 0                 | 1              | 0               | 1                        | 0                         | 1                 | -1             | 0                        | 1                    |
| F.P.20          | Stapleton waterfront flood mitigation  | EDC         | 1                    | 1                               | 1                    | 1                  | 1                 | 0              | 0                  | 0                      | 1                 | 1              | 0               | 1                        | 0                         | 1                 | -1             | 0                        | 1                    |
| F.P.21          | Brooklyn Army Terminal passive flood barrier system                          | EDC         | 1                    | 1                               | 1                    | 1                  | -1                | 0              | 0                  | -1                     | 0                 | 1              | 0               | 1                        | 0                         | 1                 | -1             | 0                        | 1                    |

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**CHAPTER 4: MITIGATION STRATEGY**

| Index  | Mitigation Action                                       | Lead Agency       | Social               |                                 | Technical            |                    |                   | Administrative |                    |                        | Political         |                | Legal           |                          |                           | Economic          |                | Environment              |                      |  |
|--------|---|-------------------|----------------------|---------------------------------|----------------------|--------------------|-------------------|----------------|--------------------|------------------------|-------------------|----------------|-----------------|--------------------------|---------------------------|-------------------|----------------|--------------------------|----------------------|--|
|        |   |                   | Community Acceptance | Effect on Segment of Population | Technically Feasible | Long-Term Solution | Secondary Impacts | Staffing       | Funding Allocation | Maintenance/Operations | Political Support | Public Support | State Authority | Existing Local Authority | Potential Legal Challenge | Benefit of Action | Cost of Action | Outside Funding Required | Effect on Land/Water | Consistency with Community Environmental Goals |
| F.P.22 | Hardening of EDC Emergency Operations Center            | EDC               | 1                    | 1                               | 1                    | 1                  | -1                | 0              | 0                  | -1                     | 0                 | 1              | 0               | 1                        | 0                         | 1                 | -1             | 0                        | 1                    | 1  |
| F.P.23 | Flood effects reduction program                         | FDNY              | 1                    | 1                               | 1                    | 1                  | -1                | 0              | 0                  | -1                     | 0                 | 1              | 0               | 1                        | 0                         | 1                 | -1             | 0                        | 1                    | 1  |
| F.P.24 | Dewatering pumps at FDNY facilities                     | FDNY              | 1                    | 1                               | 1                    | 1                  | -1                | 0              | 0                  | -1                     | 0                 | 1              | 0               | 1                        | 0                         | 1                 | -1             | 0                        | 1                    | 1  |
| F.P.25 | New construction flood mitigation                       | FDNY              | 1                    | 0                               | 1                    | 1                  | 0                 | -1             | -1                 | 1                      | 1                 | 1              | 1               | 1                        | 0                         | 1                 | 0              | -1                       | 0                    | 1  |
| F.P.26 | Coney Island Hospital flood-proofing                    | HHC               | 1                    | 1                               | 1                    | 1                  | 0                 | 0              | 0                  | -1                     | 0                 | 1              | 0               | 1                        | 0                         | 1                 | -1             | 0                        | 0                    | 0  |
| F.P.27 | Coney Island Hospital emergency department mitigation   | HHC               | 1                    | 1                               | 1                    | 1                  | 0                 | 0              | 0                  | -1                     | 0                 | 1              | 0               | 1                        | 0                         | 1                 | -1             | 0                        | 0                    | 0  |
| F.P.28 | Coney Island Hospital critical system protection        | HHC               | 1                    | 1                               | 1                    | 1                  | 0                 | 0              | 0                  | -1                     | 0                 | 1              | 0               | 1                        | 0                         | 1                 | -1             | 0                        | 0                    | 0  |
| F.P.29 | Metropolitan Hospital flood barriers                    | HHC               | 1                    | 1                               | 1                    | 1                  | 0                 | 0              | 0                  | -1                     | 0                 | 1              | 0               | 1                        | 0                         | 1                 | -1             | 0                        | 0                    | 0  |
| F.P.30 | Metropolitan Hospital critical systems elevation        | HHC               | 1                    | 1                               | 1                    | 1                  | 0                 | 0              | 0                  | -1                     | 0                 | 1              | 0               | 1                        | 0                         | 1                 | -1             | 0                        | 0                    | 0  |
| F.P.31 | Coler Hospital and Nursing Facility protection          | HHC               | 1                    | 1                               | 1                    | 1                  | 0                 | 0              | 0                  | -1                     | 0                 | 1              | 0               | 1                        | 0                         | 1                 | -1             | 0                        | 0                    | 0  |
| F.P.32 | Coler Hospital and Nursing Facility fuel-tank hardening | HHC               | 1                    | 1                               | 1                    | 1                  | 0                 | 0              | 0                  | -1                     | 0                 | 1              | 0               | 1                        | 0                         | 1                 | -1             | 0                        | 0                    | 0  |
| F.P.33 | Building flood protection                               | HRA               | 1                    | 1                               | 1                    | 0                  | 0                 | 0              | 0                  | -1                     | 0                 | 1              | 0               | 1                        | 0                         | 1                 | -1             | 0                        | 0                    | 0  |
| F.P.34 | Water-balance study                                     | MTA (NYCT-Subway) | 1                    | 1                               | 1                    | 0                  | 0                 | 0              | 0                  | -1                     | 0                 | 1              | 0               | 1                        | 0                         | 1                 | -1             | 0                        | 0                    | 0  |
| F.P.35 | Double track Main Line, Phase 2                         | MTA/LIRR          | 1                    | 1                               | 1                    | 1                  | 1                 | 0              | 0                  | -1                     | 0                 | 1              | 0               | 1                        | 0                         | 1                 | -1             | 0                        | 0                    | 0  |
| F.P.36 | Ventilation grate improvements                          | MTA/LIRR          | 1                    | 1                               | 1                    | 0                  | 0                 | 0              | 0                  | -1                     | 0                 | 1              | 0               | 1                        | 0                         | 1                 | -1             | 0                        | 0                    | 0  |
| F.P.37 | Long Island City Yard protection                        | MTA/LIRR          | 1                    | 1                               | 1                    | 1                  | 0                 | 0              | 0                  | -1                     | 0                 | 1              | 0               | 1                        | 0                         | 1                 | -1             | 0                        | 0                    | 0  |
| F.P.38 | Safeguarding NYCHA cellar equipment                     | NYCHA             | 1                    | 1                               | 1                    | 1                  | 0                 | 0              | 0                  | -1                     | 1                 | 1              | 0               | 1                        | 0                         | 1                 | -1             | 0                        | 0                    | 0  |
| F.P.39 | New NYCHA building/development                          | NYCHA             | -1                   | -1                              | 1                    | 1                  | -1                | 0              | -1                 | -1                     | 0                 | -1             | -1              | 1                        | -1                        | 1                 | -1             | -1                       | -1                   | 0  |
| F.P.40 | NYCHA floodgates and barriers                           | NYCHA             | 1                    | 1                               | 1                    | 1                  | 0                 | 0              | 0                  | -1                     | 1                 | 1              | 0               | 1                        | 0                         | 1                 | -1             | 0                        | 0                    | 0  |
| F.P.41 | NYCHA boiler rooms and electrical equipment             | NYCHA             | 1                    | 1                               | 1                    | 1                  | 0                 | 0              | 0                  | -1                     | 1                 | 1              | 0               | 1                        | 0                         | 1                 | -1             | 0                        | 0                    | 0  |

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| Index  | Mitigation Action  | Lead Agency | Social               |                                 | Technical            |                    |                   | Administrative |                    |                        | Political         |                | Legal           |                          | Economic                  |                   | Environment    |                          |                      |  |
|--------|--|-------------|----------------------|---------------------------------|----------------------|--------------------|-------------------|----------------|--------------------|------------------------|-------------------|----------------|-----------------|--------------------------|---------------------------|-------------------|----------------|--------------------------|----------------------|--|
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| F.P.42 | Sump pump protection   | NYPD        | 1                    | 1                               | 1                    | 1                  | 0                 | 0              | 0                  | -1                     | 1                 | 1              | 0               | 1                        | 0                         | 1                 | -1             | 0                        | 0                    | 0  |
| F.P.43 | Building electrical protection   | NYPD        | 1                    | 1                               | 1                    | 1                  | 0                 | 0              | 0                  | -1                     | 1                 | 1              | 0               | 1                        | 0                         | 1                 | -1             | 0                        | 0                    | 0  |
| F.P.44 | Boiler protection  | NYPD        | 1                    | 1                               | 1                    | 1                  | 0                 | 0              | 0                  | -1                     | 1                 | 1              | 0               | 1                        | 0                         | 1                 | -1             | 0                        | 0                    | 0  |
| F.P.45 | Short-term flood mitigation of OCME emergency management storage facility at 18 <sup>th</sup> Street and FDR Drive | OCME        | 1                    | 1                               | 1                    | 0                  | 0                 | 0              | 0                  | -1                     | 1                 | 1              | 0               | 1                        | 0                         | 1                 | -1             | 0                        | 0                    | 0  |
| F.P.46 | Flood mitigation measures for New York City's backup Emergency Operations Center                                   | OEM         | 1                    | 1                               | 1                    | 1                  | 0                 | 0              | 0                  | -1                     | 1                 | 1              | 0               | 1                        | 0                         | 1                 | -1             | 0                        | 0                    | 0  |
| F.P.47 | HAZUS-MH modeling  | OEM         | 0                    | 0                               | 1                    | 1                  | 0                 | -1             | 0                  | -1                     | 1                 | 1              | 0               | 1                        | 0                         | 1                 | -1             | 0                        | 0                    | 0  |
| F.P.48 | Public information and guidance  | OEM         | 1                    | 1                               | 1                    | 1                  | 1                 | 0              | 0                  | 0                      | 1                 | 1              | 0               | 1                        | 0                         | 1                 | 1              | 0                        | 0                    | 0  |
| F.P.49 | Local storm surge barrier for Gowanus Canal  | OLTPS       | 1                    | 1                               | 1                    | 1                  | 1                 | 0              | 0                  | 0                      | 1                 | 1              | 0               | 1                        | 0                         | 1                 | 0              | -1                       | 1                    | 0  |
| F.P.50 | Plan for flood protection along the Williamsburg, Greenpoint, and Long Island City coastlines                      | OLTPS       | 1                    | 1                               | 1                    | 1                  | 1                 | 0              | -1                 | 0                      | 1                 | 1              | 0               | 1                        | 0                         | 1                 | 1              | 0                        | 1                    | 1  |
| F.P.51 | Floodgate repairs at Oakwood Beach, Staten Island  | OLTPS       | 1                    | 1                               | 1                    | 1                  | 1                 | 0              | -1                 | -1                     | 1                 | 1              | 0               | 1                        | 0                         | 1                 | -1             | -1                       | 0                    | 0  |
| F.P.52 | Primary and secondary dune systems in Rockaway Peninsula   | OLTPS       | 1                    | 1                               | 1                    | 1                  | 1                 | 0              | 1                  | 0                      | 1                 | 1              | 0               | 1                        | 0                         | 1                 | 0              | 0                        | 1                    | 1  |
| F.P.53 | Offshore breakwaters adjacent to and south of Great Kills Harbor   | OLTPS       | 1                    | 1                               | 1                    | 1                  | 1                 | 0              | 1                  | 0                      | 1                 | 1              | 0               | 1                        | 0                         | 1                 | 0              | 0                        | 1                    | 1  |
| F.P.54 | Flood protection in Hunts Point  | OLTPS       | 1                    | 1                               | 1                    | 1                  | 0                 | 0              | -1                 | 0                      | 1                 | 1              | 0               | 1                        | 0                         | 1                 | -1             | -1                       | 1                    | 1  |
| F.P.55 | Flood protection in East Harlem  | OLTPS       | 1                    | 1                               | 1                    | 1                  | 0                 | 0              | -1                 | 0                      | 1                 | 1              | 0               | 1                        | 0                         | 1                 | -1             | -1                       | 1                    | 1  |
| F.P.56 | Lower Manhattan flood protection   | OLTPS       | 1                    | 1                               | 1                    | 1                  | 0                 | 0              | -1                 | 0                      | 1                 | 1              | 0               | 1                        | 0                         | 1                 | -1             | -1                       | 1                    | 1  |
| F.P.57 | Integrated flood protection system for Red Hook  | OLTPS       | 1                    | 1                               | 1                    | 1                  | 1                 | 0              | -1                 | 0                      | 1                 | 1              | 0               | 1                        | 0                         | 1                 | 1              | 0                        | 1                    | 1  |
| F.P.58 | Protection of Farragut substation  | OLTPS       | 1                    | 1                               | 1                    | 1                  | 1                 | 0              | 0                  | 0                      | 1                 | 1              | 0               | 1                        | 0                         | 1                 | 0              | 0                        | 1                    | 1  |
| F.P.59 | Newtown Creek flood protection   | OLTPS       | 1                    | 1                               | 1                    | 1                  | 1                 | 0              | 1                  | 0                      | 1                 | 1              | 0               | 1                        | 0                         | 1                 | 0              | 0                        | 1                    | 1  |

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|--------|--|-------------------|----------------------|---------------------------------|----------------------|--------------------|-------------------|----------------|--------------------|------------------------|-------------------|----------------|-----------------|--------------------------|---------------------------|-------------------|----------------|--------------------------|----------------------|--|
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| F.P.60 | Flood protection research  | OLTPS             | 1                    | 1                               | 1                    | 1                  | 1                 | 0              | 0                  | 0                      | 1                 | 1              | 0               | 1                        | 0                         | 1                 | 0              | 0                        | 1                    | 1  |
| F.P.61 | Prevention of drainage pipe flooding                               | OLTPS             | 1                    | 1                               | 1                    | 1                  | 1                 | 0              | 0                  | 0                      | 1                 | 1              | 0               | 1                        | 0                         | 1                 | 0              | 0                        | 1                    | 1  |
| F.P.62 | Floodgate at Mill Creek  | OLTPS             | 1                    | 1                               | 1                    | 1                  | 1                 | 0              | 1                  | 0                      | 1                 | 1              | 0               | 1                        | 0                         | 1                 | 0              | 0                        | 1                    | 1  |
| F.P.63 | Community Rating System  | OLTPS             | 1                    | 1                               | 1                    | 1                  | 1                 | 0              | 0                  | 0                      | 1                 | 1              | 0               | 1                        | 0                         | 1                 | 0              | 0                        | 1                    | 1  |
| F.P.64 | Coney Island Creek wetlands and tidal barrier                      | OLTPS             | 1                    | 1                               | 1                    | 1                  | 1                 | 0              | -1                 | 0                      | 1                 | 1              | 0               | 1                        | 0                         | 1                 | 1              | 0                        | 1                    | 1  |
| F.P.65 | Integrated flood protection for southern Manhattan                 | OLTPS             | 1                    | 1                               | 1                    | 1                  | 1                 | 0              | 0                  | 0                      | 1                 | 1              | 0               | 1                        | 0                         | 1                 | 0              | 0                        | 1                    | 1  |
| F.P.66 | Flood protection of vital infrastructure at LaGuardia Airport      | PANYNJ (Aviat.)   | 0                    | 0                               | 1                    | 1                  | 1                 | 0              | -1                 | -1                     | 1                 | 1              | 1               | -1                       | 0                         | 1                 | -1             | -1                       | 1                    | 0  |
| F.P.67 | Flood protection of vital infrastructure at JFK Airport            | PANYNJ (Aviat.)   | 0                    | 0                               | 1                    | 1                  | 1                 | 0              | -1                 | -1                     | 1                 | 1              | 1               | -1                       | 0                         | 1                 | -1             | -1                       | 1                    | 0  |
| F.P.68 | Drainage improvements at JFK Airport                               | PANYNJ (Aviat.)   | 0                    | 0                               | 1                    | 1                  | 1                 | 0              | -1                 | -1                     | 1                 | 1              | 1               | -1                       | 0                         | 1                 | -1             | -1                       | 1                    | 0  |
| F.P.69 | Protection of JFK Airport fuel farm tanks                          | PANYNJ (Aviation) | 0                    | 0                               | 1                    | 1                  | 1                 | 0              | -1                 | -1                     | 1                 | 1              | 1               | -1                       | 0                         | 1                 | -1             | -1                       | 1                    | 0  |
| F.P.70 | LaGuardia Airport dike wall  | PANYNJ (Aviation) | 0                    | 0                               | 1                    | 1                  | 1                 | 0              | -1                 | -1                     | 1                 | 1              | 1               | -1                       | 0                         | 1                 | -1             | -1                       | 1                    | 0  |
| F.P.71 | JFK Airport sanitary lift station                                  | PANYNJ (Aviation) | 0                    | 0                               | 1                    | 1                  | 1                 | 0              | -1                 | -1                     | 1                 | 1              | 1               | -1                       | 0                         | 1                 | -1             | -1                       | 1                    | 0  |
| F.P.72 | JFK Airport runway upgrade   | PANYNJ (Aviation) | 0                    | 0                               | 1                    | 1                  | 1                 | 0              | -1                 | -1                     | 1                 | 1              | 1               | -1                       | 0                         | 1                 | -1             | -1                       | 1                    | 0  |
| F.P.73 | JFK Airport runway upgrade   | PANYNJ (Aviation) | 0                    | 0                               | 1                    | 1                  | 1                 | 0              | -1                 | -1                     | 1                 | 1              | 1               | -1                       | 0                         | 1                 | -1             | -1                       | 1                    | 0  |
| F.P.74 | Improvements to George Washington Bridge anchorage drainage system | PANYNJ(TBT)       | 0                    | 0                               | 1                    | 1                  | 1                 | 0              | -1                 | -1                     | 1                 | 1              | 1               | -1                       | 0                         | 1                 | -1             | -1                       | 1                    | 0  |

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| F.P.75                         | Substation mitigation   | PSEG        | 1                    | 1                               | 1                    | 1                  | 0                 | 0              | 0                  | -1                     | 0                 | 1              | 0               | 1                        | 0                         | 1                 | -1             | 0                        | 0                    | 0  |
| <b>Infrastructure Failures</b> |   |             |                      |                                 |                      |                    |                   |                |                    |                        |                   |                |                 |                          |                           |                   |                |                          |                      |  |
| IF.P.1                         | Expansion of cogeneration   | DEP         | 1                    | 1                               | 1                    | 1                  | 0                 | -1             | 1                  | 0                      | 1                 | 1              | 0               | 0                        | 1                         | 1                 | 1              | 1                        | 1                    | 1  |
| IF.P.2                         | Repair of the Delaware Aqueduct leak  | DEP         | 1                    | 0                               | 1                    | 1                  | 1                 | 1              | 1                  | 1                      | 1                 | 1              | 1               | 1                        | 1                         | 1                 | 1              | 1                        | 0                    | 0  |
| IF.P.3                         | Utilities on Buono Bridge   | DOC         | -1                   | 1                               | 1                    | 1                  | 0                 | 1              | -1                 | -1                     | -1                | -1             | 0               | 1                        | 1                         | 1                 | -1             | 1                        | 0                    | 0  |
| IF.P.4                         | Facility electrical power and data infrastructure upgrade                           | DOHMH       | 1                    | 1                               | 1                    | 1                  | 1                 | 1              | 1                  | 1                      | 1                 | 1              | 0               | 1                        | 1                         | 1                 | 1              | 1                        | 0                    | 0  |
| IF.P.5                         | DOHMH generators and retrofits  | DOHMH       | 1                    | 1                               | 1                    | -1                 | 0                 | 1              | 1                  | 1                      | 1                 | 1              | 0               | 1                        | 1                         | 1                 | 1              | 1                        | 0                    | 0  |
| IF.P.6                         | Session Initiation Protocol (SIP)   | DoITT       | 1                    | 1                               | 1                    | 1                  | 0                 | 1              | 1                  | 0                      | 1                 | 1              | 0               | 1                        | 1                         | 1                 | 1              | 0                        | 0                    | 0  |
| IF.P.7                         | Citywide IVR for employee announcements   | DoITT       | 1                    | 0                               | 1                    | 1                  | 0                 | 1              | 1                  | 1                      | 1                 | 1              | 0               | 1                        | 1                         | 1                 | 1              | 0                        | 0                    | 0  |
| IF.P.8                         | Telecommunications Planning and Resiliency Office                                   | DoITT       | 1                    | 1                               | 1                    | 1                  | 1                 | 1              | 1                  | 1                      | 1                 | 1              | 0               | 1                        | 1                         | 1                 | 0              | 0                        | 0                    | 0  |
| IF.P.9                         | IP routing network  | DoITT       | 1                    | 1                               | 1                    | 1                  | 1                 | 1              | 1                  | 1                      | 1                 | 1              | 0               | 1                        | 1                         | 1                 | 1              | 0                        | 0                    | 0  |
| IF.P.10                        | Emergency generators in NYCHA properties  | NYCHA       | 1                    | 1                               | 1                    | -1                 | 0                 | 1              | -1                 | -1                     | 1                 | 1              | 0               | 1                        | 1                         | 1                 | 0              | 0                        | 0                    | 0  |
| IF.P.11                        | Stand-alone power generation in NYCHA developments                                  | NYCHA       | 1                    | 1                               | 1                    | 1                  | -1                | 1              | -1                 | -1                     | 1                 | 1              | 1               | 1                        | 1                         | 1                 | -1             | -1                       | 0                    | 0  |
| IF.P.12                        | Backup generators for NYPD facilities   | NYPD        | 1                    | 1                               | 1                    | -1                 | 0                 | 1              | 1                  | 1                      | 1                 | 1              | 0               | 1                        | 1                         | 1                 | 0              | 0                        | 0                    | 0  |
| IF.P.13                        | Flood mitigation of 520 First Ave. (Manhattan Morgue) and Forensic biology building | OCME        | 1                    | 1                               | 1                    | 1                  | -1                | 0              | 1                  | 1                      | 1                 | 1              | 0               | 1                        | 1                         | 1                 | -1             | 1                        | 0                    | 0  |
| IF.P.14                        | Kings and Queens facilities   | OCME        | 0                    | 0                               | 1                    | -1                 | 1                 | 1              | 1                  | 1                      | 1                 | 1              | 0               | 1                        | 1                         | 1                 | 0              | -1                       | 0                    | 0  |
| IF.P.15                        | Generator assessment and installation of quick-connects for critical infrastructure | OEM         | 1                    | 1                               | 1                    | -1                 | 0                 | -1             | 1                  | -1                     | 1                 | 1              | 1               | 1                        | 1                         | 1                 | 0              | -1                       | 0                    | 0  |
| IF.P.16                        | Backup generators for gas stations and terminals                                    | OEM         | 1                    | 1                               | 1                    | -1                 | 1                 | -1             | 1                  | -1                     | 1                 | 1              | 1               | 1                        | 1                         | 1                 | 0              | -1                       | 0                    | 0  |
| IF.P.17                        | Protection from utility service interruptions                                       | OLTPS       | 1                    | 1                               | 1                    | 1                  | 1                 | 1              | -1                 | 0                      | 1                 | 1              | 1               | 1                        | 1                         | 1                 | 0              | 0                        | 1                    | 1  |

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| IF.P.18              | Distributed generation (DG) and micro-grids       | OLTPS       | 1                    | 1                               | 1                    | 1                  | 1                 | 1              | 1                  | 0                      | 1                 | 1              | 1               | 1                        | 1                         | 1                 | 0              | 0                        | 0                    |  |
| IF.P.19              | Purchase of mobile substation                     | PSEG        | 1                    | 1                               | 1                    | 1                  | 1                 | 1              | 1                  | 1                      | 1                 | 1              | 1               | 1                        | 1                         | 1                 | -1             | 0                        | 0                    |  |
| IF.P.20              | Purchase of mobile switchgear                     | PSEG        | 1                    | 1                               | 1                    | 1                  | 1                 | 1              | 1                  | -1                     | 1                 | 1              | 0               | 1                        | 1                         | 1                 | -1             | 0                        | 0                    |  |
| <b>Multi-Hazards</b> |   |             |                      |                                 |                      |                    |                   |                |                    |                        |                   |                |                 |                          |                           |                   |                |                          |                      |  |
| MH.P.1               | Overhead electric system improvements             | Con Ed      | 1                    | 1                               | 0                    | 1                  | 0                 | 0              | 0                  | -1                     | 1                 | 1              | 1               | 1                        | 0                         | 1                 | -1             | 1                        | 0                    | 1  |
| MH.P.2               | Underground electric system improvements          | Con Ed      | 1                    | 1                               | 0                    | 1                  | 0                 | 0              | 0                  | -1                     | 1                 | 1              | 1               | 1                        | 0                         | 1                 | -1             | 1                        | 0                    | 0  |
| MH.P.3               | Gas system Improvements                           | Con Ed      | 1                    | 1                               | 0                    | 1                  | 0                 | 0              | 0                  | -1                     | 1                 | 1              | 1               | 1                        | 0                         | 1                 | -1             | 0                        | 0                    | 0  |
| MH.P.4               | Storm-hardening of critical facilities            | Con Ed      | 1                    | 1                               | 0                    | 1                  | 0                 | 0              | 0                  | -1                     | 1                 | 1              | 1               | 1                        | 0                         | 1                 | -1             | 0                        | 0                    | 1  |
| MH.P.5               | Window upgrades                                   | DCAS        | 1                    | 0                               | 1                    | 1                  | 0                 | 0              | 0                  | -1                     | 1                 | 1              | 1               | 1                        | 1                         | 1                 | 0              | 1                        | 0                    | 1  |
| MH.P.6               | Retail resiliency study                           | DCP         | 1                    | 1                               | 1                    | 0                  | 0                 | 0              | 0                  | 1                      | 1                 | 1              | 1               | 1                        | 1                         | 1                 | 0              | 0                        | 0                    | 0  |
| MH.P.7               | Building Identification Numbers (BINs)            | DCP         | 1                    | 0                               | 1                    | 0                  | 0                 | 0              | 0                  | 1                      | 1                 | 1              | 0               | 0                        | 0                         | 1                 | 0              | 0                        | 0                    | 1  |
| MH.P.8               | BIN Working Group recommendations                 | DCP         | 1                    | 1                               | 0                    | 1                  | 0                 | 0              | 0                  | 0                      | 1                 | 1              | 0               | 0                        | 0                         | 1                 | 0              | 0                        | 0                    | 1  |
| MH.P.9               | Inspection and upgrade program for DEP facilities | DEP         | 0                    | 0                               | 0                    | 1                  | 0                 | 0              | 0                  | -1                     | 1                 | 1              | 1               | 1                        | 0                         | 1                 | 0              | 0                        | 0                    | 1  |
| MH.P.10              | Groundwater development                           | DEP         | 0                    | 0                               | 1                    | 1                  | 1                 | 1              | 0                  | 1                      | 1                 | 1              | 1               | 1                        | 0                         | 1                 | 1              | 1                        | 1                    | 1  |
| MH.P.11              | Groundwater treatment plant                       | DEP         | 0                    | 1                               | 0                    | 0                  | 1                 | 0              | 0                  | -1                     | 1                 | 1              | 1               | 1                        | -1                        | 1                 | 0              | 1                        | 1                    | 1  |
| MH.P.12              | Laptops for DFTA essential staff                  | DFTA        | 1                    | 1                               | 1                    | 0                  | 0                 | 1              | 0                  | -1                     | 1                 | 1              | 1               | 1                        | 0                         | 1                 | 1              | 0                        | 0                    | 1  |
| MH.P.13              | Generator for neighborhood hub                    | DFTA        | 1                    | 1                               | 0                    | 0                  | -1                | 0              | 0                  | -1                     | 1                 | 1              | 1               | 1                        | 0                         | 1                 | 0              | 0                        | -1                   | 0  |
| MH.P.14              | Headlamps for home-delivered meals deliverers     | DFTA        | 1                    | 1                               | 1                    | 0                  | 0                 | 0              | 0                  | 0                      | 1                 | 1              | 1               | 1                        | 0                         | 1                 | 1              | 0                        | 0                    | 1  |
| MH.P.15              | Upgrades to DHS buildings                         | DHS         | 1                    | 1                               | 0                    | 1                  | 0                 | 0              | 0                  | -1                     | 1                 | 1              | 1               | 1                        | 0                         | 1                 | 0              | 0                        | 0                    | 1  |
| MH.P.16              | DHS building roof improvements                    | DHS         | 1                    | 1                               | 0                    | 1                  | 0                 | 0              | 0                  | -1                     | 1                 | 1              | 1               | 1                        | 0                         | 1                 | 1              | 0                        | 0                    | 1  |
| MH.P.17              | Window upgrade in DHS buildings                   | DHS         | 1                    | 1                               | 0                    | 1                  | 0                 | 0              | 0                  | -1                     | 1                 | 1              | 1               | 1                        | 0                         | 1                 | 0              | 0                        | 0                    | 1  |
| MH.P.18              | Power redundancy at DHS buildings                 | DHS         | 1                    | 1                               | 0                    | 1                  | 0                 | 0              | 0                  | 0                      | 1                 | 1              | 1               | 1                        | 0                         | 1                 | 1              | 0                        | 0                    | 0  |
| MH.P.19              | DHS shelter protection                            | DHS         | 0                    | 0                               | 0                    | 1                  | -1                | 0              | 0                  | 0                      | 0                 | -1             | 0               | 0                        | -1                        | 1                 | 0              | 0                        | 0                    | 1  |
| MH.P.20              | Bellevue shelter facility improvements            | DHS         | 1                    | 1                               | 0                    | 1                  | 0                 | 0              | 0                  | -1                     | 1                 | 1              | 1               | 1                        | 0                         | 1                 | 0              | -1                       | -1                   | 0  |
| MH.P.21              | LIFE Family Residence facility improvements       | DHS         | 1                    | 1                               | 0                    | 1                  | 0                 | 0              | 0                  | -1                     | 1                 | 1              | 1               | 1                        | 0                         | 1                 | 0              | -1                       | -1                   | 0  |



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|---------|---|-------------|----------------------|---------------------------------|----------------------|--------------------|-------------------|----------------|--------------------|------------------------|-------------------|----------------|-----------------|--------------------------|---------------------------|-------------------|----------------|--------------------------|----------------------|--|
|         |   |             | Community Acceptance | Effect on Segment of Population | Technically Feasible | Long-Term Solution | Secondary Impacts | Staffing       | Funding Allocation | Maintenance/Operations | Political Support | Public Support | State Authority | Existing Local Authority | Potential Legal Challenge | Benefit of Action | Cost of Action | Outside Funding Required | Effect on Land/Water | Consistency with Community Environmental Goals |
| MH.P.22 | Mobile command stations   | DOB         | 1                    | 0                               | 1                    | 0                  | 0                 | 0              | 0                  | 0                      | 0                 | 0              | 0               | 0                        | -1                        | 1                 | 1              | 0                        | 0                    | 1  |
| MH.P.23 | DOB backup generators   | DOB         | 1                    | 0                               | 1                    | 0                  | 0                 | 0              | 0                  | -1                     | 1                 | 0              | 1               | 1                        | 0                         | 1                 | 0              | 0                        | -1                   | 0  |
| MH.P.24 | DOB radios  | DOB         | 1                    | 0                               | 1                    | 1                  | 0                 | 0              | 0                  | 0                      | 1                 | 0              | 1               | 1                        | 0                         | 1                 | -1             | 0                        | 0                    | 1  |
| MH.P.25 | DOB vehicles  | DOB         | 1                    | 0                               | 1                    | 1                  | -1                | 0              | 0                  | -1                     | 1                 | 0              | 0               | 0                        | 0                         | 1                 | 1              | 0                        | -1                   | 0  |
| MH.P.26 | Stormwater management   | DOC         | 1                    | 1                               | 0                    | 0                  | 1                 | 0              | 0                  | 0                      | 1                 | 0              | 1               | 1                        | 0                         | 1                 | 0              | 0                        | 0                    | 1  |
| MH.P.27 | Rikers Island ferry dock  | DOC         | 1                    | 0                               | 0                    | 0                  | 0                 | 0              | 0                  | -1                     | 1                 | 0              | 1               | 1                        | 0                         | 1                 | 0              | 0                        | 0                    | 1  |
| MH.P.28 | Roof and façade improvements  | DOC         | 1                    | 1                               | 0                    | 1                  | 0                 | 0              | 0                  | -1                     | 1                 | 0              | 1               | 1                        | 0                         | 1                 | 0              | 1                        | 0                    | 1  |
| MH.P.29 | Emergency Operations Center improvements  | DOC         | 1                    | 1                               | 0                    | 1                  | 0                 | 0              | 0                  | 0                      | 1                 | 0              | 1               | 1                        | 0                         | 1                 | 0              | 1                        | 0                    | 1  |
| MH.P.30 | Off-island satellite Emergency Operations Center (EOC) for Rikers Island                    | DOC         | 1                    | 0                               | 0                    | 1                  | 0                 | 0              | 0                  | -1                     | 1                 | 0              | 1               | 1                        | 0                         | 1                 | 0              | 1                        | 0                    | 1  |
| MH.P.31 | MDC cellar/backup emergency system  | DOC         | 1                    | 0                               | 1                    | 1                  | -1                | 0              | 0                  | -1                     | 1                 | 1              | 1               | 1                        | 0                         | 1                 | 1              | 1                        | -1                   | 0  |
| MH.P.32 | Provision of power redundancy   | DOE         | 1                    | 1                               | 0                    | 1                  | 0                 | 0              | 0                  | -1                     | 1                 | 1              | 1               | 1                        | 0                         | 1                 | 1              | 0                        | 0                    | 0  |
| MH.P.33 | Protection of DOE facilities from electrical system damage from trees                       | DOE         | 1                    | 1                               | 1                    | 0                  | 0                 | 0              | 0                  | -1                     | 1                 | 0              | 1               | 1                        | 0                         | 1                 | 0              | 0                        | 0                    | 0  |
| MH.P.34 | DOE green roof installation   | DOE         | 1                    | 1                               | 1                    | 1                  | 1                 | 0              | 0                  | -1                     | 1                 | 1              | 1               | 1                        | 0                         | 1                 | 0              | 0                        | 1                    | 1  |
| MH.P.35 | Surge protection for DOE critical electrical systems  | DOE         | 1                    | 1                               | 0                    | 1                  | 0                 | 0              | 0                  | 0                      | 1                 | 1              | 1               | 1                        | 0                         | 1                 | 0              | 0                        | 0                    | 1  |
| MH.P.36 | Emergency power at DOE facilities   | DOE         | 1                    | 0                               | 1                    | 1                  | 0                 | 0              | 0                  | -1                     | 1                 | 0              | 1               | 1                        | 0                         | 1                 | 1              | 0                        | -1                   | 0  |
| MH.P.37 | Emergency preparedness plans and training for DOE custodian engineers and building managers | DOE         | 1                    | 0                               | 1                    | 0                  | 0                 | 0              | 0                  | 0                      | 1                 | 0              | 1               | 1                        | 0                         | 1                 | 1              | 0                        | 0                    | 1  |
| MH.P.38 | Psychological First Aid (PFA)   | DOHMH       | 1                    | 1                               | 1                    | 1                  | 0                 | -1             | 0                  | 1                      | 1                 | 1              | 1               | 1                        | 0                         | 1                 | 1              | 1                        | 0                    | 1  |
| MH.P.39 | Mental Health First Aid public education program  | DOHMH       | 1                    | 1                               | 1                    | 0                  | 0                 | 0              | 0                  | 1                      | 1                 | 1              | 1               | 1                        | 0                         | 1                 | 1              | 1                        | 0                    | 1  |
| MH.P.40 | Mental health system IT improvement   | DOHMH       | 1                    | 1                               | 0                    | 1                  | 0                 | 0              | 0                  | 0                      | 1                 | 1              | 1               | 1                        | 0                         | 1                 | 1              | 1                        | 0                    | 1  |
| MH.P.41 | Mental health system power backup   | DOHMH       | 1                    | 1                               | 0                    | 0                  | -1                | 0              | 0                  | -1                     | 1                 | 1              | 1               | 1                        | 0                         | 1                 | 1              | 1                        | -1                   | 0  |
| MH.P.42 | Mental health system support network  | DOHMH       | 1                    | 1                               | 1                    | 0                  | 0                 | 0              | 0                  | 0                      | 1                 | 1              | 1               | 1                        | 0                         | 1                 | 1              | 0                        | 0                    | 1  |

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|---------|--|-------------|----------------------|---------------------------------|----------------------|--------------------|-------------------|----------|--------------------|------------------------|-------------------|----------------|-----------------|--------------------------|---------------------------|-------------------|----------------|--------------------------|----------------------|--|
|         |  |             | Community Acceptance | Effect on Segment of Population | Technically Feasible | Long-Term Solution | Secondary Impacts | Staffing | Funding Allocation | Maintenance/Operations | Political Support | Public Support | State Authority | Existing Local Authority | Potential Legal Challenge | Benefit of Action | Cost of Action | Outside Funding Required | Effect on Land/Water | Consistency with Community Environmental Goals |
| MH.P.43 | Mental health volunteer preparedness and response                          | DOHMH       | 1                    | 1                               | 1                    | 0                  | 0                 | 0        | 0                  | 0                      | 1                 | 1              | 1               | 1                        | 0                         | 1                 | 1              | 1                        | 0                    | 1  |
| MH.P.44 | DOHMH IT systems protection  | DOHMH       | 1                    | 0                               | 0                    | 1                  | 0                 | 0        | 0                  | -1                     | 1                 | 1              | 1               | 1                        | 0                         | 1                 | 1              | 0                        | 0                    | 1  |
| MH.P.45 | DOHMH primary data center availability                                     | DOHMH       | 1                    | 0                               | 0                    | 1                  | 0                 | 0        | 0                  | 0                      | 1                 | 1              | 1               | 1                        | 0                         | 1                 | 1              | 0                        | 0                    | 1  |
| MH.P.46 | Riverside clinic upgrade   | DOHMH       | 1                    | 1                               | 0                    | 1                  | 0                 | 0        | 0                  | -1                     | 1                 | 1              | 1               | 1                        | 0                         | 1                 | 1              | 0                        | 0                    | 1  |
| MH.P.47 | DOHMH warehouse and print shop capacity                                    | DOHMH       | 1                    | 0                               | 0                    | 1                  | 0                 | 0        | 0                  | 0                      | 1                 | 1              | 1               | 1                        | 0                         | 1                 | 1              | 1                        | 0                    | 1  |
| MH.P.48 | Health data and provider portal  | DOHMH       | 1                    | 1                               | 0                    | 1                  | 0                 | 0        | 0                  | -1                     | 1                 | 1              | 1               | 1                        | 0                         | 1                 | 1              | 0                        | 0                    | 1  |
| MH.P.49 | Enhanced emergency response communication operations at DOHMH headquarters | DOHMH       | 1                    | 0                               | 1                    | 1                  | 0                 | 0        | 0                  | 0                      | 1                 | 0              | 1               | 1                        | 0                         | 1                 | 1              | -1                       | 0                    | 1  |
| MH.P.50 | Backup power for nursing homes and adult care facilities                   | DOHMH       | 1                    | 1                               | 1                    | 0                  | 0                 | 0        | 0                  | -1                     | 1                 | 1              | 1               | 1                        | 0                         | 1                 | 0              | -1                       | -1                   | 0  |
| MH.P.51 | Small grants program to support community-based social cohesion            | DOHMH       | 1                    | 1                               | 1                    | 1                  | 1                 | 0        | -1                 | 0                      | 1                 | 1              | 0               | -1                       | -1                        | 1                 | 0              | 0                        | 0                    | 0  |
| MH.P.52 | "Hub the Hood" program   | DOHMH       | 1                    | 1                               | 1                    | 1                  | 1                 | 0        | 0                  | 0                      | 1                 | 1              | 0               | -1                       | -1                        | 1                 | 0              | 0                        | 0                    | 0  |
| MH.P.53 | DOHMH facility repair and upgrade  | DOHMH       | 1                    | 1                               | 1                    | 1                  | 1                 | -1       | -1                 | -1                     | 1                 | 1              | 0               | -1                       | -1                        | 1                 | -1             | -1                       | 0                    | 0  |
| MH.P.54 | Notification system for City employees                                     | DoITT       | 1                    | 1                               | 1                    | 1                  | 0                 | 0        | -1                 | -1                     | 1                 | 1              | 1               | 1                        | 1                         | -1                | 0              | 0                        | 0                    | 0  |
| MH.P.55 | Hardening of NYCWiN network  | DoITT       | 1                    | 1                               | 1                    | 1                  | 0                 | 0        | -1                 | -1                     | 1                 | 1              | 1               | 1                        | 1                         | -1                | 0              | 0                        | 0                    | 0  |
| MH.P.56 | Data Center Site B   | DoITT       | 1                    | 1                               | 1                    | 1                  | 0                 | 0        | -1                 | -1                     | 1                 | 1              | 1               | 1                        | 1                         | -1                | 0              | 0                        | 0                    | 0  |
| MH.P.57 | Secure HAZMAT at DOT facilities  | DOT         | 1                    | 1                               | 1                    | 1                  | 0                 | -1       | 0                  | 0                      | 1                 | 1              | 1               | 1                        | 1                         | 1                 | 0              | 0                        | 1                    | 1  |
| MH.P.58 | Redundant power for all mission-critical DOT sites                         | DOT         | 0                    | 0                               | 1                    | 1                  | 1                 | 1        | -1                 | 1                      | 1                 | 0              | 1               | 1                        | 1                         | 1                 | -1             | 0                        | 0                    | 0  |
| MH.P.59 | Continuity of Operations sites   | DOT         | 1                    | 1                               | 1                    | 1                  | 1                 | -1       | -1                 | -1                     | 1                 | 1              | 0               | 0                        | -1                        | 1                 | -1             | -1                       | 0                    | 0  |
| MH.P.60 | Information tracking   | DOT         | 0                    | 0                               | 1                    | 1                  | 1                 | 1        | 0                  | -1                     | 1                 | 0              | 1               | 1                        | 1                         | 1                 | 0              | 0                        | 0                    | 0  |
| MH.P.61 | High-reflectivity pavements  | DOT         | 1                    | 1                               | 1                    | 1                  | 1                 | -1       | -1                 | -1                     | 1                 | 1              | 0               | 0                        | -1                        | 1                 | -1             | 0                        | 0                    | 0  |
| MH.P.62 | Critical facility loss estimation  | DOT         | 1                    | 0                               | 1                    | 1                  | 1                 | 0        | -1                 | 0                      | 1                 | -1             | 0               | 0                        | -1                        | 1                 | 0              | 0                        | 0                    | 1  |
| MH.P.63 | Staten Island Ferry fleet upgrade  | DOT         | 1                    | 1                               | 1                    | 1                  | 1                 | 0        | -1                 | 0                      | 1                 | 1              | 0               | 0                        | 0                         | 1                 | -1             | -1                       | 0                    | 0  |

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|---------|---|-------------|----------------------|---------------------------------|----------------------|--------------------|-------------------|----------|--------------------|------------------------|-------------------|----------------|-----------------|--------------------------|---------------------------|-------------------|----------------|--------------------------|----------------------|--|
|         |   |             | Community Acceptance | Effect on Segment of Population | Technically Feasible | Long-Term Solution | Secondary Impacts | Staffing | Funding Allocation | Maintenance/Operations | Political Support | Public Support | State Authority | Existing Local Authority | Potential Legal Challenge | Benefit of Action | Cost of Action | Outside Funding Required | Effect on Land/Water | Consistency with Community Environmental Goals |
| MH.P.64 | Staten Island Ferry vessel improvement  | DOT         | 1                    | 0                               | 1                    | 1                  | 1                 | 0        | -1                 | 0                      | 1                 | 1              | 0               | -1                       | -1                        | 1                 | -1             | 0                        | 0                    | 0  |
| MH.P.65 | Green roofs on DPR buildings  | DPR         | 1                    | 1                               | 1                    | 1                  | 1                 | 1        | -1                 | -1                     | 1                 | 1              | 0               | 1                        | 1                         | 1                 | 1              | -1                       | 1                    | 1  |
| MH.P.66 | Green Streets   | DPR         | 1                    | 1                               | 1                    | 1                  | 1                 | 1        | 1                  | -1                     | 1                 | 1              | 0               | 1                        | 1                         | 1                 | 1              | 1                        | 1                    | 1  |
| MH.P.67 | Wetlands and other land in a natural state  | DPR         | 1                    | 1                               | 1                    | 1                  | 1                 | 1        | -1                 | -1                     | 1                 | 1              | 0               | 0                        | -1                        | 1                 | -1             | -1                       | 1                    | 1  |
| MH.P.68 | Seawall, pier, and marina structural repairs  | DPR         | 1                    | 1                               | 1                    | 1                  | 1                 | 1        | 1                  | -1                     | 0                 | 0              | -1              | -1                       | 1                         | 1                 | 1              | 1                        | -1                   | 0  |
| MH.P.69 | Upgrades to DPR building systems  | DPR         | 1                    | 1                               | 1                    | 1                  | 0                 | 1        | -1                 | -1                     | 1                 | 1              | 1               | 1                        | 1                         | 1                 | 0              | 0                        | 1                    | 1  |
| MH.P.70 | COOP trailer compound   | DSNY        | 1                    | 1                               | 1                    | 1                  | 1                 | -1       | -1                 | -1                     | 1                 | 1              | 0               | 0                        | 0                         | 1                 | -1             | 0                        | 0                    | 0  |
| MH.P.71 | Industrial property upgrades  | EDC/BNYDC   | 1                    | 1                               | 1                    | 1                  | 1                 | 1        | -1                 | -1                     | 1                 | 1              | 1               | 1                        | 1                         | 1                 | 1              | -1                       | 1                    | 1  |
| MH.P.72 | Hardening Staten Island Ferry and private ferry terminals from climate change-related threats                         | EDC         | 1                    | 1                               | 1                    | 1                  | 1                 | -1       | -1                 | -1                     | 1                 | -1             | 0               | 0                        | -1                        | 1                 | -1             | -1                       | 1                    | 1  |
| MH.P.73 | Construction of new ferry landings to support private ferry services  | EDC         | 1                    | 0                               | 1                    | 1                  | 1                 | -1       | -1                 | -1                     | 1                 | 1              | 0               | 0                        | -1                        | 1                 | -1             | -1                       | 0                    | 0  |
| MH.P.74 | Waterfront fueling facilities   | EDC         | 1                    | 0                               | 1                    | 1                  | 1                 | -1       | -1                 | -1                     | 1                 | 1              | 0               | 0                        | -1                        | 1                 | -1             | -1                       | 0                    | 0  |
| MH.P.75 | Mobile ferry ticketing machines   | EDC         | 1                    | 1                               | 1                    | 1                  | 1                 | 0        | -1                 | -1                     | 1                 | 1              | 0               | 0                        | 0                         | 1                 | -1             | -1                       | 0                    | 0  |
| MH.P.76 | Use of the Staten Island Ferry's Austen Class vessels for East River Ferry service during weather-related disruptions | EDC/DOT     | 1                    | 1                               | 1                    | 1                  | 1                 | -1       | 0                  | -1                     | 1                 | 1              | 0               | 0                        | -1                        | 1                 | -1             | -1                       | 0                    | 1  |
| MH.P.77 | Storm shutters project  | FDNY        | 1                    | 0                               | 1                    | 1                  | 0                 | 1        | -1                 | 1                      | 1                 | 1              | 1               | 1                        | 0                         | 1                 | 0              | -1                       | 0                    | 1  |
| MH.P.78 | Backup communications carrier   | FDNY        | 1                    | 0                               | 1                    | 1                  | 1                 | 1        | -1                 | -1                     | 1                 | 1              | 1               | 1                        | 0                         | 1                 | -1             | -1                       | 0                    | 0  |
| MH.P.79 | Voice-over IP architecture  | FDNY        | 1                    | 0                               | 1                    | 1                  | 1                 | 0        | -1                 | 0                      | 1                 | 1              | 0               | -1                       | -1                        | 1                 | -1             | 0                        | 0                    | 0  |
| MH.P.80 | Next-generation satellite phones  | FDNY        | 1                    | 1                               | 1                    | 1                  | 1                 | 0        | -1                 | -1                     | 1                 | 1              | 0               | 1                        | 1                         | 1                 | -1             | -1                       | 0                    | 0  |
| MH.P.81 | FDNY facilities survey  | FDNY        | 1                    | 1                               | 1                    | 1                  | 1                 | -1       | 0                  | 0                      | 1                 | 1              | 0               | 0                        | 0                         | 1                 | -1             | 0                        | 0                    | 1  |
| MH.P.82 | FDOC cell phone coverage  | FDNY        | 1                    | -1                              | 1                    | 1                  | 1                 | 0        | -1                 | 0                      | 0                 | 0              | 0               | -1                       | -1                        | 1                 | 0              | 0                        | 0                    | 0  |
| MH.P.83 | FDNY cable network  | FDNY        | 1                    | 1                               | 1                    | 1                  | 0                 | 1        | 1                  | 1                      | 1                 | 1              | 1               | 1                        | 0                         | 1                 | 0              | -1                       | 0                    | 0  |
| MH.P.84 | Spare radios  | FDNY        | 1                    | 1                               | 1                    | 1                  | 1                 | 1        | 0                  | -1                     | 1                 | 1              | 1               | 1                        | 0                         | 1                 | -1             | 0                        | 0                    | 0  |

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|----------|---|---------------------------|----------------------|---------------------------------|----------------------|--------------------|-------------------|----------------|--------------------|------------------------|-------------------|----------------|-----------------|--------------------------|---------------------------|-------------------|----------------|--------------------------|----------------------|
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| MH.P.85  | Home-work plans   | FDNY                      | 1                    | 1                               | 1                    | 1                  | 1                 | 1              | 0                  | 1                      | -1                | -1             | -1              | -1                       | 1                         | 0                 | 0              | 0                        | 0                    |
| MH.P.86  | Gas vendors   | FDNY                      | 1                    | 1                               | 1                    | 1                  | -1                | 0              | 0                  | 0                      | 1                 | 1              | 0               | 0                        | -1                        | 1                 | 0              | 0                        | 0                    |
| MH.P.87  | Cache of vaccinations   | FDNY                      | 1                    | 0                               | 1                    | 1                  | 1                 | 1              | 1                  | 1                      | 1                 | 1              | 0               | -1                       | -1                        | 1                 | -1             | -1                       | 0                    |
| MH.P.88  | Urban search and rescue team                                    | FDNY                      | 1                    | 1                               | 1                    | 1                  | 1                 | -1             | 0                  | 0                      | 1                 | 1              | 0               | -1                       | 0                         | 1                 | 1              | 0                        | 0                    |
| MH.P.89  | Coney Island Hospital HVAC                                      | HHC                       | 1                    | 1                               | 1                    | 1                  | 1                 | 0              | -1                 | -1                     | 1                 | 1              | 0               | 0                        | 0                         | 1                 | -1             | -1                       | 0                    |
| MH.P.90  | Coney Island Hospital quick connects for critical systems       | HHC                       | 1                    | 1                               | 1                    | 1                  | 1                 | 0              | -1                 | -1                     | 1                 |                | 0               | 0                        | 0                         | 1                 | -1             | -1                       | 0                    |
| MH.P.91  | Metropolitan Hospital HVAC                                      | HHC                       | 1                    | 1                               | 1                    | 1                  | 1                 | 0              | 0                  | -1                     | 1                 | 1              | 1               | 1                        | 0                         | 1                 | -1             | 0                        | 0                    |
| MH.P.92  | Metropolitan Hospital quick connects                            | HHC                       | 1                    | 1                               | 1                    | 1                  | 1                 | 0              | 0                  | -1                     | 1                 | 1              | 1               | 1                        | 0                         | 1                 | -1             | 0                        | 0                    |
| MH.P.93  | Bellevue Hospital/critical systems protection                   | HHC                       | 1                    | 1                               | 1                    | 1                  | 1                 | 0              | 0                  | -1                     | 1                 | 1              | 1               | 1                        | 0                         | 1                 | -1             | 0                        | 0                    |
| MH.P.94  | Bellevue Hospital power quick connects                          | HHC                       | 1                    | 1                               | 1                    | 1                  | 1                 | 0              | 0                  | -1                     | 1                 | 1              | 1               | 1                        | 0                         | 1                 | -1             | 0                        | 0                    |
| MH.P.95  | Central Office Emergency Command Center (ECC) and alternate ECC | HHC                       | 1                    | 1                               | 1                    | 1                  | 1                 | 0              | 0                  | -1                     | 1                 | 1              | 1               | 1                        | 0                         | 1                 | -1             | -1                       | 0                    |
| MH.P.96  | Henry J. Carter Hospital improvements                           | HHC                       | 1                    | 1                               | 1                    | 1                  | 1                 | 0              | -1                 | -1                     | 1                 | 1              | 1               | 1                        | 0                         | 1                 | -1             | 0                        | 0                    |
| MH.P.97  | Outreach to residential building owners                         | HPD                       | 1                    | 1                               | 1                    | 1                  | 1                 | -1             | -1                 | -1                     | 1                 | 1              | 0               | 0                        | -1                        | 1                 | -1             | 0                        | 0                    |
| MH.P.98  | Flood protection for critical facilities                        | HRA                       | 1                    | 1                               | 1                    | 1                  | 1                 | -1             | 1                  | 1                      | 1                 | 1              | 0               | 1                        | 0                         | 1                 | 0              | 1                        | 1                    |
| MH.P.99  | Exploration of loss-reduction actions for landmarked properties | LPC                       | 1                    | 1                               | 1                    | 1                  | 1                 | 1              | 1                  | 1                      | 1                 | 1              | 0               | 1                        | 1                         | 1                 | 0              | 1                        | 1                    |
| MH.P.100 | Public education and outreach for landmarked buildings          | LPC                       | 1                    | 1                               | 1                    | 1                  | 0                 | 1              | 1                  | -1                     | 1                 | 1              | 0               | 1                        | 1                         | 1                 | 0              | 1                        | 0                    |
| MH.P.101 | Marine Parkway/Cross Bay Bridge mitigation master plan          | MTA (Bridges and Tunnels) | 1                    | 1                               | 1                    | 1                  | 1                 | -1             | 0                  | 0                      | 1                 | 1              | 1               | 1                        | 0                         | 1                 | 0              | 0                        | 0                    |
| MH.P.102 | Engineering flood studies at non-tunnel facilities              | MTA (Bridges and Tunnels) | 1                    | 0                               | 1                    | 1                  | 1                 | 0              | -1                 | 0                      | 1                 | 1              | -1              | -1                       | -1                        | 1                 | -1             | 0                        | 0                    |
| MH.P.103 | Far Rockaway depot green roof                                   | MTA (Buses)               | 1                    | 1                               | 1                    | 1                  | 1                 | 1              | 1                  | -1                     | 1                 | 1              | 0               | 1                        | 1                         | 1                 | 1              | 1                        | 1                    |

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| Index    | Mitigation Action   | Lead Agency | Social               |                                 | Technical            |                    |                   | Administrative |                    |                        | Political         |                | Legal           |                          |                           | Economic          |                |                          | Environment          |  |
|----------|---|-------------|----------------------|---------------------------------|----------------------|--------------------|-------------------|----------------|--------------------|------------------------|-------------------|----------------|-----------------|--------------------------|---------------------------|-------------------|----------------|--------------------------|----------------------|--|
|          |   |             | Community Acceptance | Effect on Segment of Population | Technically Feasible | Long-Term Solution | Secondary Impacts | Staffing       | Funding Allocation | Maintenance/Operations | Political Support | Public Support | State Authority | Existing Local Authority | Potential Legal Challenge | Benefit of Action | Cost of Action | Outside Funding Required | Effect on Land/Water | Consistency with Community Environmental Goals |
| MH.P.104 | Hazards/threats planning                                    | MTA (MNR)   | 1                    | 1                               | 1                    | 1                  | 1                 | -1             | 0                  | 0                      | 1                 | 1              | 1               | 1                        | 0                         | 1                 | 0              | 0                        | 0                    | 0  |
| MH.P.105 | Fueling capabilities/backup for emergency response          | MTA (MNR)   | 1                    | 1                               | 1                    | 1                  | 1                 | -1             | 0                  | 0                      | 1                 | 1              | 1               | 1                        | 0                         | 1                 | 0              | 0                        | 0                    | 0  |
| MH.P.106 | Penn Station access   | MTA (MNR)   | 1                    | 1                               | 1                    | 1                  | -1                | 1              | 1                  | -1                     | 1                 | 1              | 0               | 1                        | 1                         | 1                 | -1             | 1                        | 0                    | 0  |
| MH.P.107 | Harlem-125 Street Station improvements                      | MTA (MNR)   | 1                    | 1                               | 1                    | 1                  | -1                | 1              | 1                  | -1                     | 1                 | 1              | 1               | 1                        | 1                         | 1                 | 0              | 0                        | 0                    | 0  |
| MH.P.108 | Emergency management equipment                              | MTA/LIRR    | 1                    | 0                               | 1                    | 1                  | 0                 | 1              | 1                  | 1                      | 1                 | 1              | 1               | 1                        | 0                         | 1                 | -1             | -1                       | -1                   | 1  |
| MH.P.109 | NYCHA grounds, pavements, and drainage improvements         | NYCHA       | 1                    | 1                               | 1                    | 1                  | 1                 | -1             | 1                  | -1                     | 1                 | 1              | 0               | 1                        | 1                         | 1                 | 1              | 1                        | 1                    | 1  |
| MH.P.110 | Category 4 distributed power-generation feasibility studies | NYCHA       | 1                    | 1                               | 1                    | 1                  | 1                 | -1             | 0                  | 0                      | 1                 | 1              | 0               | 1                        | 1                         | 1                 | -1             | -1                       | 0                    | 0  |
| MH.P.111 | Morrisania Air Rights                                       | NYCHA       | -1                   | -1                              | 1                    | 1                  | -1                | -1             | 0                  | -1                     | -1                | -1             | 1               | 1                        | 1                         | 1                 | -1             | -1                       | 0                    | 0  |
| MH.P.112 | NYCHA AC improvements                                       | NYCHA       | 1                    | 1                               | 1                    | 0                  | -1                | -1             | 1                  | -1                     | 1                 | 1              | 0               | 1                        | 1                         | 1                 | 0              | 0                        | -1                   | 0  |
| MH.P.113 | NYPD precinct facility protection                           | NYPD        | 1                    | 1                               | 1                    | 1                  | 1                 | 1              | 1                  | 1                      | 1                 | 1              | 1               | 1                        | 1                         | 1                 | -1             | -1                       | 0                    | 0  |
| MH.P.114 | NYPD facility protection                                    | NYPD        | 1                    | 1                               | 1                    | 1                  | 1                 | 1              | 1                  | 1                      | 1                 | 1              | 1               | 1                        | 1                         | 1                 | -1             | -1                       | 0                    | 0  |
| MH.P.115 | NYPD critical facilities protection                         | NYPD        | 1                    | 1                               | 1                    | 1                  | 1                 | 1              | 1                  | 1                      | 1                 | 1              | 1               | 1                        | 1                         | 1                 | -1             | -1                       | 0                    | 0  |
| MH.P.116 | OCME unified agency command center                          | OCME        | 1                    | 0                               | 1                    | -1                 | 1                 | 1              | 1                  | 1                      | 1                 | 1              | 0               | 1                        | 1                         | 1                 | 1              | 1                        | 0                    | 0  |
| MH.P.117 | Educational outreach to private sector                      | OEM         | 1                    | 1                               | 1                    | 1                  | 1                 | 1              | -1                 | -1                     | 1                 | 1              | 0               | 1                        | 1                         | 1                 | 0              | -1                       | 0                    | 0  |
| MH.P.118 | OEM facilities protection                                   | OEM         | 1                    | 0                               | 1                    | 1                  | 1                 | 1              | -1                 | -1                     | 1                 | 1              | 0               | 1                        | 1                         | 1                 | 0              | -1                       | 0                    | 0  |
| MH.P.119 | HAZUS-MH software   | OEM         | 1                    | 0                               | 1                    | 1                  | 1                 | 1              | 1                  | 1                      | 1                 | 1              | 0               | 1                        | 1                         | 1                 | -1             | -1                       | 1                    | 0  |
| MH.P.120 | Community Emergency Response Team (CERT) curriculum         | OEM         | 1                    | 1                               | 1                    | 1                  | 0                 | 1              | 1                  | -1                     | 1                 | 1              | 0               | 1                        | 1                         | 1                 | 1              | 1                        | 0                    | 0  |
| MH.P.121 | Infrastructure systems modeling                             | OEM         | 1                    | 1                               | 1                    | -1                 | 1                 | 1              | 1                  | 1                      | 1                 | 1              | 1               | 1                        | -1                        | 1                 | 0              | -1                       | -1                   | 1  |
| MH.P.122 | Loss estimation   | OEM         | 1                    | 0                               | 1                    | -1                 | 0                 | 1              | -1                 | 1                      | 1                 | 1              | 0               | 1                        | 1                         | 1                 | 0              | -1                       | 0                    | 0  |
| MH.P.123 | Natural hazard event database                               | OEM         | 1                    | 0                               | 1                    | -1                 | 0                 | 1              | 1                  | 1                      | 1                 | 1              | 0               | 1                        | 1                         | 1                 | 0              | 1                        | 0                    | 0  |
| MH.P.124 | CERT collaboration with community groups                    | OEM         | 1                    | -1                              | 1                    | 1                  | 0                 | 1              | 1                  | 1                      | 1                 | 1              | 0               | 1                        | 1                         | 1                 | 1              | 1                        | 0                    | 0  |
| MH.P.125 | Ready New York update                                       | OEM         | 1                    | 1                               | 1                    | 1                  | 0                 | 1              | 1                  | 1                      | 1                 | 1              | 1               | 1                        | 1                         | 1                 | 0              | 0                        | 0                    | 0  |

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|----------|--|-------------------|----------------------|---------------------------------|----------------------|--------------------|-------------------|----------|--------------------|------------------------|-------------------|----------------|-----------------|--------------------------|---------------------------|-------------------|----------------|--------------------------|----------------------|--|
|          |  |                   | Community Acceptance | Effect on Segment of Population | Technically Feasible | Long-Term Solution | Secondary Impacts | Staffing | Funding Allocation | Maintenance/Operations | Political Support | Public Support | State Authority | Existing Local Authority | Potential Legal Challenge | Benefit of Action | Cost of Action | Outside Funding Required | Effect on Land/Water | Consistency with Community Environmental Goals |
| MH.P.126 | Public/private mitigation initiatives                                | OEM               | 1                    | 0                               | 1                    | 1                  | 1                 | 1        | -1                 | -1                     | 1                 | 1              | 0               | 1                        | 1                         | 1                 | 0              | -1                       | 1                    | 0  |
| MH.P.127 | Regional critical infrastructure mapping                             | OEM               | 1                    | 0                               | 1                    | -1                 | 0                 | 1        | -1                 | -1                     | 1                 | 1              | 0               | 1                        | 1                         | 1                 | 0              | -1                       | 0                    | 0  |
| MH.P.128 | Subway depths mapping  | OEM               | -1                   | 0                               | 1                    | -1                 | 0                 | 1        | -1                 | 1                      | 1                 | 1              | 0               | 1                        | -1                        | 1                 | 0              | -1                       | 0                    | 0  |
| MH.P.129 | Vegetation data  | OEM               | -1                   | 0                               | 1                    | -1                 | 0                 | 1        | -1                 | 1                      | 1                 | 1              | 0               | 1                        | -1                        | 1                 | 0              | -1                       | 0                    | 0  |
| MH.P.130 | Zoning for hazard-prone areas  | OEM               | 1                    | 1                               | 1                    | 1                  | 1                 | 1        | -1                 | -1                     | 1                 | 1              | 0               | 1                        | -1                        | 1                 | 0              | -1                       | 1                    | 1  |
| MH.P.131 | Mitigation public outreach   | OEM               | 1                    | 1                               | 1                    | 1                  | 1                 | -1       | -1                 | -1                     | 1                 | 1              | 1               | 1                        | 1                         | 1                 | 0              | -1                       | 1                    | 1  |
| MH.P.132 | Emergency Operations Center (EOC)                                    | OEM               | 1                    | 0                               | 1                    | 1                  | 1                 | 1        | -1                 | -1                     | 1                 | 1              | 0               | 1                        | 1                         | 1                 | -1             | -1                       | 0                    | 0  |
| MH.P.133 | OEM warehouse:   | OEM               | 1                    | 1                               | 1                    | 1                  | 1                 | 1        | 1                  | -1                     | 1                 | 1              | 0               | 1                        | 1                         | 1                 | 1              | 1                        | 0                    | 0  |
| MH.P.134 | New York City mitigation guide and education                         | OEM               | 1                    | 1                               | 1                    | 1                  | 1                 | 1        | 1                  | 1                      | 1                 | 1              | 0               | 1                        | 1                         | 1                 | 1              | -1                       | 1                    | 1  |
| MH.P.135 | Building community capacity  | OEM               | 1                    | 1                               | 1                    | -1                 | 0                 | -1       | -1                 | -1                     | 1                 | 1              | 0               | 1                        | 1                         | 1                 | 1              | 0                        | 0                    | 0  |
| MH.P.136 | Urban post-disaster housing site identification in New York City     | OEM               | 1                    | 1                               | 1                    | 1                  | 1                 | 1        | 1                  | 0                      | 1                 | 1              | 1               | 1                        | 0                         | 1                 | 1              | 1                        | 0                    | 1  |
| MH.P.137 | Executive decision-making guide for deployable post-disaster housing | OEM               | 1                    | 1                               | 1                    | 1                  | 1                 | 1        | 1                  | 0                      | 1                 | 1              | 1               | 1                        | 0                         | 1                 | 1              | 1                        | 0                    | 1  |
| MH.P.138 | Request for proposal for urban post-disaster housing                 | OEM               | 1                    | 1                               | 1                    | 1                  | 1                 | 1        | 1                  | 0                      | 1                 | 1              | 0               | 1                        | 0                         | 1                 | 1              | -1                       | 0                    | 1  |
| MH.P.139 | NYC Brownfield Incentive Grant (BIG) program                         | OER               | 1                    | 1                               | 1                    | 1                  | 1                 | -1       | -1                 | 1                      | 1                 | 1              | 1               | 1                        | 1                         | 1                 | 1              | -1                       | 1                    | 1  |
| MH.P.140 | Fuel advance warning system  | PANYNJ (Aviation) | 1                    | 0                               | 1                    | -1                 | 0                 | 1        | 1                  | 1                      | 1                 | 1              | 1               | 1                        | 1                         | 1                 | 1              | 1                        | 0                    | 0  |
| MH.P.141 | JFK Airport electrical system resiliency                             | PANYNJ(Aviat.)    | 1                    | 1                               | 1                    | 1                  | 1                 | 1        | 1                  | -1                     | 1                 | 1              | 1               | 1                        | 1                         | 1                 | 0              | -1                       | 0                    | 0  |
| MH.P.142 | LaGuardia Airport central electric substation                        | PANYNJ(Aviat.)    | 1                    | 1                               | 1                    | 1                  | 1                 | 1        | 1                  | 1                      | 1                 | 1              | 1               | 1                        | 1                         | 1                 | 1              | -1                       | 0                    | 0  |
| MH.P.143 | LaGuardia Airport electrical system enhancement                      | PANYNJ(Aviat.)    | 1                    | 1                               | 1                    | -1                 | 1                 | 1        | 1                  | -1                     | 1                 | 1              | 1               | 1                        | 1                         | 1                 | -1             | -1                       | 0                    | 0  |
| MH.P.144 | LaGuardia Airport power system redundancy                            | PANYNJ(Aviat.)    | 1                    | 1                               | 1                    | -1                 | 1                 | 1        | 1                  | -1                     | 1                 | 1              | 1               | 1                        | 1                         | 1                 | -1             | -1                       | 0                    | 0  |
| MH.P.145 | JFK Airport power system redundancy                                  | PANYNJ(Aviat.)    | 1                    | 1                               | 1                    | -1                 | 1                 | 1        | 1                  | -1                     | 1                 | 1              | 1               | 1                        | 1                         | 1                 | -1             | -1                       | 0                    | 0  |

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|----------|--|----------------|----------------------|---------------------------------|----------------------|--------------------|-------------------|----------------|--------------------|------------------------|-------------------|----------------|-----------------|--------------------------|---------------------------|-------------------|----------------|--------------------------|----------------------|--|
|          |  |                | Community Acceptance | Effect on Segment of Population | Technically Feasible | Long-Term Solution | Secondary Impacts | Staffing       | Funding Allocation | Maintenance/Operations | Political Support | Public Support | State Authority | Existing Local Authority | Potential Legal Challenge | Benefit of Action | Cost of Action | Outside Funding Required | Effect on Land/Water | Consistency with Community Environmental Goals |
| MH.P.146 | Stewart Airport standby emergency generator: Provide power redundancy to allow for safe evacuation of the airport and the maintenance of limited operations during extreme weather events. | PANYNJ(Aviat.) | 1                    | 1                               | 1                    | -1                 | 1                 | 1              | 1                  | -1                     | 1                 | 1              | 1               | 1                        | 1                         | 1                 | 1              | -1                       | 0                    | 0  |
| MH.P.147 | Stewart Airport power system redundancy  | PANYNJ(Aviat.) | 1                    | 1                               | 1                    | -1                 | 1                 | 1              | 1                  | -1                     | 1                 | 1              | 1               | 1                        | 1                         | 1                 | 1              | -1                       | 0                    | 0  |
| MH.P.148 | JFK Airport fuel storage   | PANYNJ(Aviat.) | 1                    | 1                               | 1                    | 1                  | -1                | 1              | 1                  | 1                      | 1                 | 1              | 1               | 1                        | 1                         | 1                 | 1              | -1                       | -1                   | -1   |
| MH.P.149 | Intelligent Transportation System (ITS) at JFK and Newark Airports   | PANYNJ(Aviat.) | 1                    | 1                               | 1                    | -1                 | 1                 | 1              | 1                  | 1                      | 1                 | 1              | 1               | 1                        | 1                         | 1                 | -1             | -1                       | 0                    | 0  |
| MH.P.150 | Emergency generator capacity for Red Hook and Howland Hook container terminals   | PANYNJ(Ports)  | 1                    | 1                               | 1                    | -1                 | 1                 | 1              | 1                  | 1                      | 1                 | 1              | 1               | 1                        | 1                         | 1                 | 1              | -1                       | -1                   | -1   |
| MH.P.151 | Lincoln Tunnel electrical and power system improvements  | PANYNJ(TBT)    | 1                    | 1                               | 1                    | 1                  | 1                 | 1              | 1                  | -1                     | 1                 | 1              | 1               | 1                        | 1                         | 1                 | -1             | -1                       | 0                    | 0  |
| MH.P.152 | George Washington Bridge (GWB) electrical and power system improvements  | PANYNJ(TBT)    | -1                   | 1                               | 1                    | 1                  | -1                | 1              | 1                  | -1                     | 1                 | 1              | 1               | 1                        | 1                         | 1                 | -1             | -1                       | -1                   | 0  |
| MH.P.153 | GWB tower transformers   | PANYNJ(TBT)    | 1                    | 1                               | 1                    | 1                  | 1                 | 1              | 1                  | -1                     | 1                 | 1              | 1               | 1                        | 1                         | 1                 | 1              | -1                       | 0                    | 0  |
| MH.P.154 | Multi-facility real-time traffic information software  | PANYNJ(TBT)    | 0                    | 0                               | 1                    | 1                  | 1                 | 1              | 1                  | 1                      | 1                 | 1              | 1               | 1                        | 1                         | 1                 | 1              | -1                       | 0                    | 0  |
| MH.P.155 | Intelligent Transportation System (ITS) program  | PANYNJ(TBT)    | 0                    | 0                               | 1                    | 1                  | 1                 | 1              | -1                 | 0                      | 1                 | 1              | 1               | 1                        | 1                         | 1                 | -1             | -1                       | 0                    | 0  |
| MH.P.156 | Overhead electric infrastructure   | PSEG           | -1                   | -1                              | 1                    | -1                 | -1                | 0              | 0                  | 0                      | 0                 | -1             | 0               | -1                       | -1                        | 0                 | -1             | -1                       | 0                    | 0  |
| MH.P.157 | Storm damage mitigation  | PSEG           | -1                   | 0                               | 1                    | 0                  | 0                 | 0              | -1                 | -1                     | -1                | -1             | 0               | 0                        | -1                        | 0                 | -1             | 0                        | -1                   | 0  |
| MH.P.158 | SBS outreach   | SBS            | 1                    | 1                               | 1                    | 1                  | 1                 | 1              | -1                 | -1                     | 1                 | 1              | 0               | 1                        | 1                         | 1                 | 0              | 0                        | 0                    | 0  |
| MH.P.159 | Toolkit and training materials for volunteer groups  | SBS            | 1                    | 1                               | 1                    | 1                  | 1                 | 1              | -1                 | -1                     | 1                 | 1              | 0               | 1                        | 1                         | 1                 | 0              | 0                        | 0                    | 0  |
| MH.P.160 | Small business outreach  | SBS            | 1                    | 1                               | 1                    | 1                  | 1                 | 1              | -1                 | -1                     | 1                 | 1              | 0               | 1                        | 1                         | 1                 | 0              | 0                        | 0                    | 0  |

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| Index                 | Mitigation Action   | Lead Agency               | Social               |                                 | Technical            |                    |                   | Administrative |                    |                        | Political         |                | Legal           |                          |                           | Economic          |                | Environment              |                      |  |
|-----------------------|---|---------------------------|----------------------|---------------------------------|----------------------|--------------------|-------------------|----------------|--------------------|------------------------|-------------------|----------------|-----------------|--------------------------|---------------------------|-------------------|----------------|--------------------------|----------------------|--|
|                       |   |                           | Community Acceptance | Effect on Segment of Population | Technically Feasible | Long-Term Solution | Secondary Impacts | Staffing       | Funding Allocation | Maintenance/Operations | Political Support | Public Support | State Authority | Existing Local Authority | Potential Legal Challenge | Benefit of Action | Cost of Action | Outside Funding Required | Effect on Land/Water | Consistency with Community Environmental Goals |
| MH.P.161              | Hazard mitigation education for businesses                                    | SBS                       | 1                    | 1                               | 1                    | 1                  | 1                 | 1              | -1                 | -1                     | 1                 | 1              | 0               | 1                        | 1                         | 1                 | 0              | 0                        | 0                    | 0  |
| MH.P.162              | Ready New York materials  | SBS                       | 1                    | 1                               | 1                    | 1                  | 1                 | 1              | -1                 | -1                     | 1                 | 1              | 0               | 1                        | 1                         | 1                 | 0              | 0                        | 0                    | 0  |
| MH.P.163              | Toolkit and training materials for BIDs and LDCs on mitigation best practices | SBS                       | 1                    | 1                               | 1                    | 1                  | 1                 | 1              | -1                 | -1                     | 1                 | 1              | 0               | 1                        | 1                         | 1                 | 0              | 0                        | 0                    | 0  |
| MH.P.164              | Hazard mitigation seminar for BIDs and LDCs                                   | SBS                       | 1                    | 1                               | 1                    | 1                  | 1                 | 1              | -1                 | -1                     | 1                 | 1              | 0               | 1                        | 1                         | 1                 | 0              | 0                        | 0                    | 0  |
| MH.P.165              | Dissemination of hazard information   | SBS                       | 1                    | 1                               | 1                    | 1                  | 1                 | 1              | -1                 | -1                     | 1                 | 1              | 0               | 1                        | 1                         | 1                 | 0              | 0                        | 0                    | 0  |
| MH.P.166              | Rockaway Reformulation Study  | USACE/NYSDEC              | 1                    | 1                               | 1                    | 1                  | 1                 | 1              | 1                  | 0                      | 1                 | 1              | 1               | 1                        | 1                         | 1                 | 0              | -1                       | 1                    | 1  |
| MH.P.167              | T-groins at Coney Island  | USACE/NYSDEC              | 1                    | 1                               | 1                    | 1                  | 1                 | 1              | 1                  | -1                     | 1                 | 1              | 1               | 1                        | 1                         | 1                 | 0              | -1                       | 1                    | 1  |
| <b>Severe Weather</b> |   |                           |                      |                                 |                      |                    |                   |                |                    |                        |                   |                |                 |                          |                           |                   |                |                          |                      |  |
| SW.P.1                | Protection of NYCDOT facilities from high winds                               | DOT                       | 1                    | 1                               | 1                    | 1                  | 1                 | 0              | 0                  | -1                     | 1                 | 1              | -1              | -1                       | -1                        | 1                 | 0              | 0                        | 0                    | 0  |
| SW.P.2                | Sign inspection program   | DOT                       | 0                    | 0                               | 1                    | 1                  | 1                 | 1              | -1                 | 1                      | 1                 | 0              | 1               | 1                        | 1                         | 1                 | 1              | -1                       | 0                    | 0  |
| SW.P.3                | Rooftop equipment protection at HRA facilities                                | HRA                       | 1                    | 1                               | 1                    | 1                  | 0                 | -1             | 0                  | -1                     | 1                 | 1              | -1              | -1                       | 1                         | 1                 | 0              | 0                        | 0                    | 0  |
| SW.P.4                | Bridge reinforcement  | MTA (Bridges and Tunnels) | 1                    | 1                               | 1                    | 1                  | -1                | -1             | -1                 | -1                     | 1                 | 1              | -1              | -1                       | 1                         | 1                 | -1             | 1                        | 0                    | 0  |
| SW.P.5                | Increased line clearance tree trim program                                    | PSEG                      | -1                   | -1                              | 1                    | 1                  | 0                 | -1             | 0                  | -1                     | 1                 | 1              | 1               | 1                        | 1                         | 1                 | 0              | 0                        | 1                    | 1  |
| <b>Winter Weather</b> |   |                           |                      |                                 |                      |                    |                   |                |                    |                        |                   |                |                 |                          |                           |                   |                |                          |                      |  |
| WS.P.1                | Improved snow and ice melt  | DOT                       | -1                   | 0                               | 1                    | 1                  | -1                | 0              | -1                 | -1                     | 1                 | -1             | 1               | 1                        | -1                        | 1                 | -1             | -1                       | 1                    | 1  |
| WS.P.2                | Outreach to property owners on impacts of snow loads                          | OEM                       | 1                    | 1                               | 1                    | 1                  | 1                 | 0              | 0                  | 0                      | 1                 | 1              | 1               | 1                        | 1                         | 1                 | 0              | 0                        | 1                    | 1  |



ii. Recent Select Mitigation Actions

Table 4.10 to Table 4.15, below, provide an overview of recent select mitigation actions. These tables supply additional information beyond the STAPLEE analysis and elaborate on the sorts of considerations that went into each project identified in the HMP.

**Table 4.10: Flood Resilience Zoning Text Amendment**

| Flood Resilience Zoning Text Amendment (F.P.4) |   |
|--|---|
| RISK   |   |
| <b>Hazard Addressed</b>                        | Flooding and Coastal Storms   |
| <b>Original Problem and Estimated Damages</b>  | Coastal storms and flooding events have repetitively damaged buildings along the coastline of New York City. In 2012, Hurricane Sandy flooded an area that included approximately 88,700 buildings; of these, according to Department of Buildings (DOB) inspections, 82,000 were identified as having some form of damage. Owners are required to comply with flood-resistant construction standards when they rebuild if their properties are more than 50% damaged. However, many of the zoning regulations in effect made it difficult for owners to rebuild after Sandy. |
| Action – Description                           |   |
| <b>Action Category</b>                         | Prevention and Policy   |
| <b>Action Type</b>                             | Zoning/regulatory   |
| <b>Action Description</b>                      | The Flood Resilience Zoning Text Amendment encourages flood-resilient building construction throughout designated flood zones. The amendment removes regulatory barriers that would hinder or prevent the reconstruction of storm-damaged properties. It also enables new and existing buildings to comply with new, higher flood elevations issued by FEMA in addition to new requirements in the New York City Building Code.   |
| <b>Existing/Potential</b>                      | Existing—the text amendment became effective after a vote by City Council on October 9, 2013.   |
| Action – Alternative                           |   |
| <b>Other Option</b>                            | Do nothing, which would keep zoning restrictions in place, resulting in increased risk of flood-prone structures during the Sandy rebuilding process.   |
| Action – Evaluation                            |   |
| <b>Risk Reduction (losses avoided)</b>         | This zoning amendment will avoid future damages to structures rebuilding after Sandy by encouraging the elevation of existing buildings or the construction of new replacement buildings that are the same size as the previous buildings, but elevated to new levels.  |
| <b>Social</b>                                  | There is public support for the text amendment by homeowners so that they are permitted to rebuild homes to be flood-resistant. However, New York City's dense urban environment may make it difficult to implement flood-proofing strategies in denser neighborhoods.  |
| <b>Political</b>                               | The text amendment was a recommendation identified in <i>A Stronger, More Resilient New York</i> , a City document with mayoral support. Mayor Bloomberg issued a temporary executive order to allow property owners rebuilding after Sandy to meet updated Federal Emergency Management Agency (FEMA) flood standards.   |
| <b>Environmental</b>                           | The amendment facilitates adaptation to a changing environment.   |
| Implementation                                 |   |
| <b>Priority</b>                                | High  |
| <b>Cost Estimate</b>                           | Agency staff time   |
| <b>Potential Funding Source</b>                | Agency staff time   |

|  |   |
|--|---|
| <b>Local Planning Mechanism</b>                            | Zoning Resolution   |
| <b>Responsible Agency</b>                                  | Department of City Planning   |
| <b>Timeline</b>  | Adopted October 9, 2013   |
| <b>Progress</b>  |   |
| <b>How well the project performed in subsequent events</b> | There have been no significant flooding events since Hurricane Sandy. |

**Table 4.11: Building Code Update**

| <b>Building Code Update (F.E.14)</b>          |   |
|---|---|
| <b>RISK</b>                                   |   |
| <b>Hazard Addressed</b>                       | Flood and Coastal Storms  |
| <b>Original Problem and Estimated Damages</b> | Buildings in New York City are often damaged during coastal storms and flooding events. In 2012, Hurricane Sandy flooded an area that included approximately 88,700 buildings; of these, according to DOB inspections, 82,000 were identified as having some form of damage. Many of the buildings damaged by Sandy were built prior to 1983 and thus were constructed to codes and standards that did not incorporate flood resistance.  |
| <b>Action – Description</b>                   |   |
| <b>Action Category</b>                        | Property Protection   |
| <b>Action Type</b>                            | Building Code Update  |
| <b>Action Description</b>                     | On January 31, 2013, the New York City Building Code was updated to match New York State standards for flood protection. The update will help protect newly constructed buildings because it incorporates the latest flood-resistant building requirements and references the Preliminary Flood Insurance Rate Maps that are based on most recent data. The update requires new and substantially improved buildings in the 100-year floodplain to protect to a level one or two feet higher than the FEMA-designated flood elevation, depending on building type. One- and two- family homes are now required to provide two feet of extra protection above flood elevation, and most other buildings are required to provide a foot of freeboard. |
| <b>Existing/Potential</b>                     | Existing  |
| <b>Action – Alternative</b>                   |   |
| <b>Other option</b>                           | Do nothing, which would have kept outdated building codes in place, resulting in increased risk of flood-prone structures during future storms. In addition, the Building Code would not be in alignment with the latest edition of the NYS Uniform Fire Prevention and Building Code (2010) that require two-feet of freeboard for one- and two-family dwellings, and the latest edition of ASCE 24 (2005) that require one or two feet of freeboard for building with certain flood risks.  |
| <b>Action – Evaluation</b>                    |   |
| <b>Risk Reduction (losses avoided)</b>        | The Building Code update will avert future damages to structures rebuilding from Sandy, as well as new buildings and buildings performing substantial improvements in the flood zone.   |
| <b>Social</b>                                 | The Building Code update will help New Yorkers limit the cost of future federal flood insurance premiums by ensuring flood zone compliance, better protect properties in flood-prone areas from risk and damage, and reduce the likelihood of housing displacement in the future.   |

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| <b>Political</b>   | The Building Code update ensures homeowners are in compliance with FEMA flood-resistant construction standards and allows New York City to continue to be eligible to participate in the National Flood Insurance Program. |
| <b>Environmental</b>                                       | The building code update facilitates adaptation to a changing environment.   |
| <b>Implementation</b>                                      |  |
| <b>Priority</b>  | High   |
| <b>Cost Estimate</b>                                       | Agency staff time  |
| <b>Potential Funding Source</b>                            | Agency staff time  |
| <b>Local Planning Mechanism</b>                            | Building Code  |
| <b>Responsible Agency</b>                                  | DOB  |
| <b>Timeline</b>  | The update passed January 31, 2013.  |
| <b>Progress</b>  |  |
| <b>How well the project performed in subsequent events</b> | There have been no significant flooding events since Hurricane Sandy.  |

**Table 4.12: Expansion of the Bluebelt Program**

| <b>Expansion of the Bluebelt Program (MH.E.13)</b> |   |
|--|---|
| <b>RISK</b>  |   |
| <b>Hazard Addressed</b>                            | Flooding and Coastal Storms   |
| <b>Original Problem and Estimated Damages</b>      | Periods of heavy rainfall, flooding, and severe coastal storms can cause street flooding and extensive flood-related damage to property.  |
| <b>Action – Description</b>                        |   |
| <b>Action Category</b>                             | Infrastructure Projects   |
| <b>Action Type</b>                                 | Infrastructure Projects   |
| <b>Action Description</b>                          | The Bluebelt Program makes use of natural drainage corridors including streams, ponds, and other wetlands to manage stormwater. Bluebelt systems convey, store, and filter stormwater. This approach has saved millions of dollars by relying on sustainable solutions and reducing the need to build traditional sewer systems. Since the program's inception, the City has acquired 325 acres of wetland property. Furthermore, it has provided effective stormwater management for more than 14,000 acres of Staten Island. While the City continues to build out the Bluebelt in Staten Island, it is also applying the Bluebelt concept in other parts of the city. For instance, in 2011 the City expanded the Bluebelt program to Oakland Lake Park in Queens, and in 2012 the City completed construction of the first Bluebelt in the Bronx, at the New York Botanical Garden. |
| <b>Existing/Potential</b>                          | Existing and ongoing  |
| <b>Action – Alternative</b>                        |   |
| <b>Other option</b>                                | Build traditional sewer systems. This option would be very costly and would place a burden on ratepayers.   |
| <b>Action – Evaluation</b>                         |   |
| <b>Risk Reduction (losses avoided)</b>             | Bluebelts help reduce street flooding and avoid future damages to property and structures.  |
| <b>Social</b>                                      | Bluebelt systems help reduce street flooding, raise property values, improve water quality for recreation, and provide attractive open spaces for the community.  |

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|--|--|
| <b>Political</b>   | Bluebelt systems decrease the financial impacts on the local tax base by relying on natural systems instead of costly "grey" infrastructure (traditional sewer systems). Expanding the Bluebelt Program is a strategy identified in PlaNYC, <i>Vision 2020: New York City Comprehensive Waterfront Plan</i> , and <i>A Stronger, More Resilient New York</i> —all City documents with mayoral support. |
| <b>Environmental</b>                                       | Bluebelt systems enhance the environment by protecting natural eco-systems, restoring natural habitats, and maintaining natural floodplains. The Bluebelt Program promotes a sustainable system that allows for adaptation to climate change.  |
| <b>Implementation</b>                                      |  |
| <b>Priority</b>  | High   |
| <b>Cost Estimate</b>                                       | Millions of dollars have been spent in Staten Island and continue to be spent as the City extends the system both in Staten Island and to other boroughs.  |
| <b>Potential Funding Source</b>                            | Capital budget, HMGP, Emergency Watershed Protection Program (USDA), wetland mitigation banking  |
| <b>Local Planning Mechanism</b>                            | Plans: PlaNYC, <i>Vision 2020: New York City Comprehensive Waterfront Plan</i> , and <i>A Stronger, More Resilient New York</i>  |
| <b>Responsible Agency</b>                                  | Department of Environmental Protection (DEP)   |
| <b>Timeline</b>  | Program was launched in the early 1990s in Staten Island, and will continue to be expanded to other boroughs.  |
| <b>Progress</b>  |  |
| <b>How well the project performed in subsequent events</b> | Since its inception, the Staten Island Bluebelt system effectively drains 15 watersheds at the southern end of the Island in addition to Richmond Creek, New Creek, South Beach, and Oakwood Beach. This system has helped protect adjacent and downstream property owners from flood damage.  |

**Table 4.13: Wetlands Restoration and Protection**

| <b>Wetlands Restoration and Creation (F.E.5 &amp; MH.E.54)</b> |   |
|--|---|
| <b>RISK</b>  |   |
| <b>Hazard Addressed</b>  | Multi-hazards   |
| <b>Original Problem and Estimated Damages</b>                  | Although much of New York City's original waterfront consisted of wetlands, over the past century many of the wetlands have been overtaken by development or degraded due to human modifications to natural systems, industrial pollution, and changes to water and sediment quality. Because wetlands help absorb stormwater, development that destroys wetlands can increase flood-related damage to adjoining properties.  |
| <b>Action - Description</b>                                    |   |
| <b>Action Category</b>   | Coastal/Natural Resource Protection   |
| <b>Action Type</b>   | Coastal/Natural Resource Protection   |
| <b>Action Description</b>                                      | To protect existing wetlands, which improve water quality and aid in the retention of stormwater, the City has designated three Special Natural Waterfront Areas (SNWAs): Northwestern Staten Island, Jamaica Bay, and the East River-Long Island Sound area. The Waterfront Revitalization Program helps protect and restore the SNWAs by prioritizing both public and private actions. Over the past 20 years, the City has completed or planned restoration projects on 69 acres of salt marsh and 18 acres of freshwater marsh. Some of these projects are in connection with the construction of recent CSO-detention facilities. For example, at Alley Pond Park in Queens, the city recently completed 16 acres of restoration to revive the local ecosystem and improve water quality.<br>The City's work with state and federal partners has resulted in over 175 acres of restored or enhanced wetlands since 2002. |

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|  |   |
|--|---|
| <b>Existing/Potential</b>                                  | Existing and ongoing  |
| <b>Action - Alternative</b>                                |   |
| <b>Other option</b>  | Do not protect or create wetlands. This option may lead to more development and increase the occurrence of flood-related damage to property.  |
| <b>Action - Evaluation</b>                                 |   |
| <b>Risk Reduction (losses avoided)</b>                     | Wetlands help absorb floodwaters, mitigate storm surge impacts, filter stormwater, improve water quality, and reduce extreme heat impacts.  |
| <b>Social</b>  | Restoring and creating wetlands offers a variety of social benefits, including improving water quality for recreation, protecting properties from storm surge, and creating attractive environments for community use.  |
| <b>Political</b>   | Restoring and creating wetlands is a strategy identified in PlaNYC and aligns with strategies put forth in <i>Vision 2020: New York City Comprehensive Waterfront Plan</i> and <i>A Stronger, More Resilient New York</i> —all City documents with mayoral support. |
| <b>Environmental</b>                                       | Preserving and enhancing the city's valuable wetlands improves the city's natural environment, provides habitats for diverse wildlife, and aids in reducing the impacts of coastal erosion.   |
| <b>Implementation</b>                                      |   |
| <b>Priority</b>  | High  |
| <b>Cost Estimate</b>                                       | Working with state and federal partners, the city has invested over \$74 million to restore wetlands since 2002.  |
| <b>Potential Funding Source</b>                            | Capital budget/federal/state funding  |
| <b>Local Planning Mechanism</b>                            | Plans: PlaNYC, <i>Vision 2020: New York City Comprehensive Waterfront Plan</i> , New York City Wetlands Strategy, and <i>A Stronger, More Resilient New York</i>  |
| <b>Responsible Agency</b>                                  | Department of Environmental Protection (DEP), New York City Department of Parks and Recreation (DPR), Department of City Planning (DCP)   |
| <b>Timeline</b>  | Program was launched in the early 1990s in Staten Island, and will continue to be expanded to the other boroughs.   |
| <b>Progress</b>  |   |
| <b>How well the project performed in subsequent events</b> | Wetlands have helped protect properties from storm surge and flooding events, and they have filtered stormwater, improved water quality, and helped reduce the urban heat island effect.  |

**Table 4.14: Ready New York Campaign**

|   |   |
|---|---|
| <b>Ready New York Campaign (MH.E.102)</b>     |   |
| <b>RISK</b>                                   |   |
| <b>Hazard Addressed</b>                       | Multi-hazard  |
| <b>Original Problem and Estimated Damages</b> | If New Yorkers are not aware of hazards and prepared for hazard events, they may be at greater personal risk. |
| <b>Action - Description</b>                   |   |
| <b>Action Category</b>                        | Education and Awareness   |
| <b>Action Type</b>                            | Education and Awareness   |

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|  |  |
|--|--|
| <b>Action Description</b>                                  | The Ready New York campaign, launched in 2003 and expanded every year, encourages New Yorkers to be ready for all types of emergencies. Geared to both the public and private sectors, it provides instruction on how to develop a disaster plan, gather emergency supplies, and keep informed about the hazards that may occur in New York City. Ready New York also publishes a dozen guides and workbooks and has produced several informational DVDs.  |
| <b>Existing/Potential</b>                                  | Existing and ongoing   |
| <b>Action - Alternative</b>                                |  |
| <b>Other option</b>  | No Action. If there was no emergency preparedness campaign for the city, New Yorkers would be at greater personal risk in future emergencies.  |
| <b>Action – Evaluation</b>                                 |  |
| <b>Risk Reduction (losses avoided)</b>                     | The Ready New York Campaign increases awareness on how the public can better prepare for emergencies, reducing injury and saving lives. This campaign reduces the demand for first responders and reliance on government resources because members of the public can modify their behavior to ensure safety.   |
| <b>Social</b>  | The campaign actively focuses on the city's most vulnerable populations. Government agencies (local and state), community boards, houses of worship, schools (elementary through senior high), senior centers, social service agencies, private non-profits, grassroots organizations, large and small businesses, organized labor, and many other groups request OEM to do Ready New York presentations. The campaign makes a strong effort to reach all populations, including seniors, youth (and their households), people with special needs, immigrant populations and communities with limited English proficiency, low-income New Yorkers, and university/college students. Brochures and materials are available in as many as 23 languages for 2013. |
| <b>Political</b>   | There is local, state, and federal support for emergency preparedness education. The Ready New York campaign facilitated National Preparedness Month in New York City during September 2013. OEM Commissioner Joseph Bruno and FEMA Administrator Craig Fugate hosted the kickoff event at the Staten Island Children's Museum.  |
| <b>Environmental</b>                                       | This campaign has no adverse impact on the environment.  |
| <b>Implementation</b>                                      |  |
| <b>Priority</b>  | High   |
| <b>Cost Estimate</b>                                       | The budget is \$2.4 million per year for staff, guide development, translation, printing, and related costs.   |
| <b>Potential Funding Source</b>                            | U.S. Department of Homeland Security Urban Area Security Initiative Grant  |
| <b>Local Planning Mechanism</b>                            | Office of Emergency Management - External Affairs Division   |
| <b>Responsible Agency</b>                                  | Office of Emergency Management   |
| <b>Timeline</b>  | Ongoing  |
| <b>Progress</b>  |  |
| <b>How well the project performed in subsequent events</b> | In 2013, the program participated in over 1,000 events, providing a variety of presentations and maintaining a presence at a range of resource fairs across the city. During hurricane/coastal storm season, mailings of around 1,500 pieces target elected officials, non-profits, senior centers, houses of worship, and schools around the city. In 2013, OEM mailed the updated hurricane guide to 1.4 million households and businesses in the city's hurricane evacuation zones.   |

Table 4.15: Notify NYC

| Notify NYC (part of MH.E. 98)                              |   |
|--|---|
| RISK   |   |
| <b>Hazard Addressed</b>                                    | Multi-hazards   |
| <b>Original Problem and Estimated Damages</b>              | Prior to Notify NYC, the City lacked a central system for communicating localized emergency information to city residents. Emergency information was distributed through press releases and/or press conferences or directly by emergency personnel on the street. Several incidents that occurred in 2007—including tornadoes, a steam pipe explosion, a major fire, and crane collapses—prompted the City to look for ways to quickly provide New Yorkers with emergency information.   |
| Action - Description                                       |   |
| <b>Action Category</b>                                     | Emergency Services  |
| <b>Action Type</b>   | Advanced Warning System   |
| <b>Action Description</b>                                  | New York City has created a dedicated emergency notification program operating out of the Office of Emergency Management (OEM). Notify NYC staff work in OEM Watch Command, where they constantly monitor emergency activity in New York City and the metropolitan area. Notify NYC communicates localized emergency information quickly to city residents. This alert system includes the following types of notification types: emergency alerts, significant event notifications, public health notifications, public school closing/delay advisories, unscheduled parking rules suspensions, and combined sewer overflow notifications. |
| <b>Existing/Potential</b>                                  | Existing  |
| Action - Alternative                                       |   |
| <b>Other option</b>  | Distribute emergency information through press releases and/or press conferences or directly by emergency personnel on the street. This option would create delay in communicating important emergency information to the public.   |
| Action - Evaluation  |   |
| <b>Risk Reduction (losses avoided)</b>                     | Notify NYC increases awareness of urgent emergency information, allowing the public to better prepare and take action to prevent loss of life, property, and time. Notify NYC also has quality-of-life messages (road closures, transit disruptions, etc.) that enable members of the public to alter their routes to avoid delay/loss in productivity. This warning system also reduces the demand for first responders because the public can modify their behavior to ensure safety.   |
| <b>Social</b>  | The Notify NYC service is available to the general public by signing up via the OEM website.  |
| <b>Political</b>   | The program gives the city's elected executive branch another avenue to communicate emergency information/risk avoidance strategies directly to the public.   |
| <b>Environmental</b>                                       | There is no significant adverse effect on the environment.  |
| Implementation   |   |
| <b>Priority</b>  | High  |
| <b>Cost Estimate</b>                                       | \$2 million   |
| <b>Potential Funding Source</b>                            | U.S. Department of Homeland Security Urban Area Security Initiative Grant and City Tax Levy   |
| <b>Local Planning Mechanism</b>                            | Office of Emergency Management: Watch Command Division  |
| <b>Responsible Agency</b>                                  | Office of Emergency Management (OEM)  |
| <b>Timeline</b>  | Existing and ongoing  |
| Progress   |   |
| <b>How well the project performed in subsequent events</b> | Since its inception, Notify NYC has sent out thousands of notifications about local emergencies. In addition, more than 180,000 people receive information directly.  |

**4. Prioritization of Potential Mitigation Actions**

The Planning Team developed a methodology for prioritizing the potential mitigation actions by assigning a high, medium, or low ranking for each action. This ranking is based on a set of 10 criteria comprised of the STAPLEE criteria (presented in Analysis of Potential Mitigation Actions, above) and three additional implementation criteria.

**A. Calculating STAPLEE scores**

The first step in the prioritization process was reducing the 18 measures addressed in the STAPLEE analysis to seven scores. For example, each criterion (social, technological, administrative, political, legal, economic, and environmental), had two to three measures that were taken into consideration. The Planning Team calculated the scores of the measures so that each criterion had one score. Table 4.16 shows how the Planning Team determined each criterion's overall value based on the frequency of -1s, 1s, or 0s assigned to the measures.

**Table 4.16: Example of Calculating STAPLEE Criteria to Prioritization**

| Index               | Mitigation Action          | Lead Agency | Social               |                                 | Technical            |                    | Administrative    |          |                    | Political              |                   | Legal          |                 | Economic                 |                           |                   | Environment    |                          |                      |  |
|---------------------|----------------------------|-------------|----------------------|---------------------------------|----------------------|--------------------|-------------------|----------|--------------------|------------------------|-------------------|----------------|-----------------|--------------------------|---------------------------|-------------------|----------------|--------------------------|----------------------|--|
|                     |                            |             | Community Acceptance | Effect on Segment of Population | Technically Feasible | Long-Term Solution | Secondary Impacts | Staffing | Funding Allocation | Maintenance/Operations | Political Support | Public Support | State Authority | Existing Local Authority | Potential Legal Challenge | Benefit of Action | Cost of Action | Outside Funding Required | Effect on Land/Water | Consistency with Community Environmental Goals |
| CB.P.1              | Construction Code revision | DOB         | 1                    | 1                               | 1                    | 1                  | 0                 | 0        | 0                  | 0                      | 1                 | 1              | 1               | 1                        | 0                         | 1                 | 1              | 1                        | 0                    | 1  |
| <b>Final Scores</b> |                            |             | <b>1</b>             |                                 | <b>1</b>             |                    | <b>0</b>          |          |                    | <b>1</b>               |                   | <b>1</b>       |                 | <b>1</b>                 |                           |                   | <b>1</b>       |                          |                      |  |
|                     |                            |             | Social               |                                 | Technical            |                    | Administrative    |          |                    | Political              |                   | Legal          |                 | Economic                 |                           |                   | Environment    |                          |                      |  |



## PRIORITIZATION OF POTENTIAL MITIGATION ACTIONS

### CHAPTER 4: Mitigation Strategy

#### B. Calculating Implementation Criteria

The second step to the prioritization process was to add three additional criteria. These three criteria are based on: (1) number of objectives the action meets, (2) projected costs, and (3) projected timeline. Using the same rating system as used in the STAPLEE analysis, each criterion was assigned a value of -1, 0, or 1. The Planning Team established quantifiable ranges for each criterion that met the parameters of the -1, 0, or 1 values (see Table 4.2: Mitigation Actions Summary Tabulation).

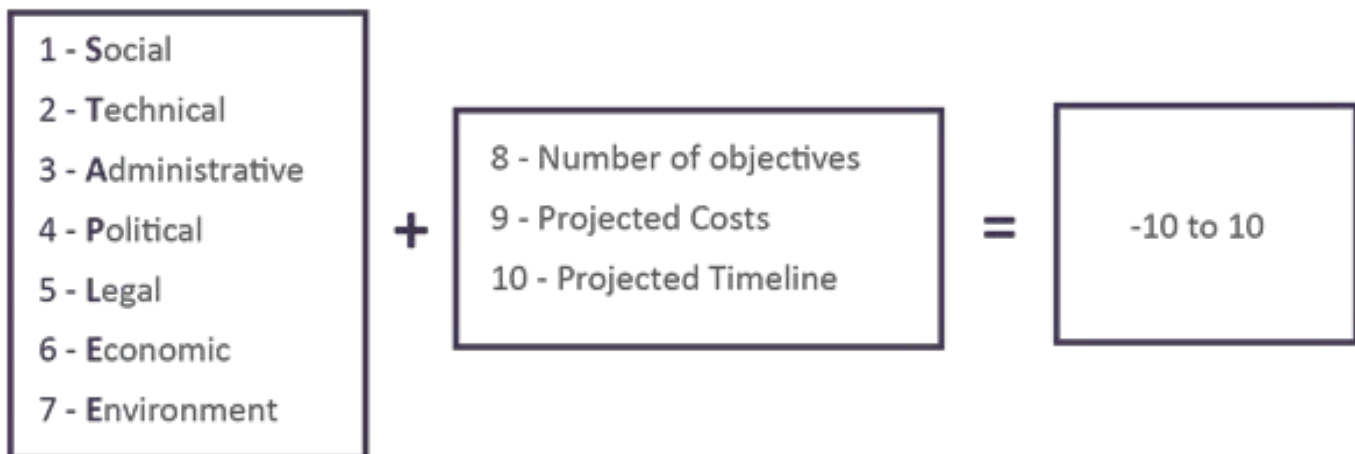
Adding up the values of the 10 criteria was the third step in prioritizing the mitigation actions. The 162 potential mitigation actions received a cumulative value ranging from -10 to 10 (see Figure 4.3). The overall value was used to assign a final prioritization of low, medi-

um, or high. Actions with a final score of zero or lower were determined "low" priority because these actions have as many or more negative attributes as positive attributes. Actions with a final score of 1–5 were prioritized as "medium," while actions with a final score of 6–10 were prioritized as "high" because they have many positive attributes and few, if any, negative attributes. Table 4.17 presents the distribution of actions by final prioritization value (see Table 4.18).

Figure 4.2: Prioritization Criteria

| 1. Project Timeline   | 2. Project Cost   | 3. Number of objectives the action meets                       |
|---|---|--|
| -1 = $\geq 10$ yrs<br>0 = TBD, ongoing,<br>$\geq 5$ yrs to $< 10$ yrs<br>1 = $\leq 5$ yrs | -1 = $> \$100$ million<br>0 = TBD, $> \$10$ million<br>to $< \$100$ million<br>1 = $< \$10$ million | -1 = 1 objective<br>0 = 2 to 3 objectives<br>1 = 4+ objectives |

Figure 4.3: Implementation Criteria



**Table 4.17: Summary of Mitigation Action Prioritization**

| Hazard                  | Priority Ranking |            |            |            |
|-------------------------|------------------|------------|------------|------------|
|                         | Low              | Medium     | High       | Total      |
| CBRN releases           | 0                | 3          | 4          | <b>7</b>   |
| Coastal erosion         | 0                | 3          | 0          | <b>3</b>   |
| Coastal storms          | 0                | 19         | 13         | <b>31</b>  |
| Cyber threats           | 0                | 2          | 0          | <b>2</b>   |
| Disease outbreaks       | 0                | 1          | 0          | <b>1</b>   |
| Drought                 | 0                | 3          | 1          | <b>4</b>   |
| Earthquakes             | 0                | 3          | 6          | <b>9</b>   |
| Extreme temperatures    | 0                | 4          | 1          | <b>5</b>   |
| Flood                   | 2                | 50         | 23         | <b>78</b>  |
| Infrastructure failures | 1                | 7          | 12         | <b>20</b>  |
| Severe weather          | 0                | 4          | 1          | <b>5</b>   |
| Winter storms           | 0                | 1          | 1          | <b>2</b>   |
| Multi-Hazard*           | 5                | 109        | 53         | <b>168</b> |
| <b>Total</b>            | <b>8</b>         | <b>209</b> | <b>115</b> | <b>332</b> |

\* Although wildfires are not individually addressed by any actions, they are addressed by the multi-hazard actions.

**Changes since the 2009 HMP**

The 2014 HMP reflects changes in priorities that have developed since the 2009 HMP. For example, due to the extensive impacts of Hurricane Sandy in 2012, the City has sharpened its focus on flood and coastal storm mitigation strategies and resiliency efforts.

**C. Benefit-Cost Analysis for Specific Projects**

A benefit-cost analysis (BCA) is a method for determining the potential positive effects of a specific mitigation action and comparing them to the cost of the action. To assess and demonstrate the cost-effectiveness of mitigation actions, FEMA has developed a suite of BCA software, including hazard-specific modules. Agencies seeking funding from one of FEMA's mitigation grant programs must perform a detailed BCA using this software for the submission of the grant application. OEM will assist agencies with this effort.

**PRIORITIZATION OF POTENTIAL MITIGATION ACTIONS**

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**Table 4.18: Prioritization of Potential Mitigation Actions**

| HMP Index No.          | Mitigation Action   | Lead Agency | S | T | A  | P  | L | Ec | Ev | TIMELINE | Project Cost | GOALS and OBJECTIVES | Prioritization Score | Prioritization |
|------------------------|---|-------------|---|---|----|----|---|----|----|----------|--------------|----------------------|----------------------|----------------|
| <b>CBRN</b>            |   |             |   |   |    |    |   |    |    |          |              |                      |                      |                |
| CB.P.1                 | Construction Code revision  | DOB         | 1 | 1 | 0  | 1  | 1 | 1  | 1  | 1        | 0            | 0                    | 7                    | High           |
| CB.P.2                 | Harlem River lift bridge  | MNR         | 1 | 1 | 0  | 1  | 1 | 1  | 0  | -1       | 0            | 0                    | 4                    | Medium         |
| CB.P.3                 | NYCHA fresh water supply  | NYCHA       | 1 | 1 | 0  | 1  | 1 | 0  | 1  | 0        | 0            | 0                    | 5                    | Medium         |
| CB.P.4                 | Brownfield cleanup in the 100-year floodplain                             | OER         | 1 | 1 | 0  | 1  | 1 | 1  | 1  | 1        | 1            | 0                    | 8                    | High           |
| CB.P.5                 | Environmental research  | OER         | 1 | 1 | 0  | 1  | 1 | 1  | 1  | 1        | 1            | 0                    | 8                    | High           |
| CB.P.6                 | BrownfieldWORKS!  | OER         | 0 | 0 | 0  | 1  | 0 | 0  | 1  | 1        | 1            | 0                    | 4                    | Medium         |
| CB.P.7                 | Environmental Project Information Center (EPIC)                           | OER         | 1 | 1 | 0  | 1  | 1 | 0  | 1  | 1        | 1            | 0                    | 7                    | High           |
| <b>Coastal Erosion</b> |   |             |   |   |    |    |   |    |    |          |              |                      |                      |                |
| CE.P.1                 | Protection of Rikers Island east, west, and south shorelines              | DOC         | 1 | 1 | 0  | 1  | 1 | 1  | 0  | 0        | 0            | 0                    | 5                    | Medium         |
| CE.P.2                 | Beach restoration   | DPR         | 1 | 0 | 0  | 1  | 1 | 0  | 0  | 0        | 0            | 0                    | 3                    | Medium         |
| CE.P.3                 | Renourishment of Orchard Beach, Bronx                                     | USACE/DPR   | 1 | 0 | 0  | 1  | 0 | 1  | -1 | 1        | 1            | 0                    | 4                    | Medium         |
| <b>Coastal Storms</b>  |   |             |   |   |    |    |   |    |    |          |              |                      |                      |                |
| CS.P.1                 | Flooding prevention   | DCAS        | 1 | 1 | 1  | -1 | 0 | 1  | 0  | 0        | 0            | 0                    | 3                    | Medium         |
| CS.P.2                 | Resilient neighborhoods planning studies                                  | DCP         | 1 | 1 | 0  | 1  | 1 | 0  | 1  | 0        | 0            | 1                    | 6                    | High           |
| CS.P.3                 | DCP planning support and technical assistance for Sandy disaster recovery | DCP         | 1 | 1 | 0  | 1  | 1 | 0  | 1  | 0        | 0            | 0                    | 5                    | Medium         |
| CS.P.4                 | Emergency contracts   | DDC         | 1 | 0 | 0  | 1  | 0 | 0  | 1  | 0        | 0            | -1                   | 2                    | Medium         |
| CS.P.5                 | Hardening pumping stations  | DEP         | 1 | 0 | -1 | 1  | 1 | 0  | 0  | 0        | -1           | 0                    | 1                    | Medium         |
| CS.P.6                 | Hardening wastewater treatment plants                                     | DEP         | 1 | 1 | 1  | 1  | 1 | 0  | 1  | 0        | -1           | 1                    | 6                    | High           |
| CS.P.7                 | Alternatives for Rockaway Wastewater Treatment Plant                      | DEP         | 1 | 0 | 0  | 0  | 1 | 0  | 0  | 1        | -1           | 1                    | 3                    | Medium         |
| CS.P.8                 | Vernon C. Bain Center (VCBC) mooring system and site access improvement   | DOC         | 1 | 1 | 0  | 1  | 1 | 1  | 1  | 0        | 0            | 0                    | 6                    | High           |
| CS.P.9                 | Division I, II and III storehouse   | DOC         | 1 | 0 | -1 | 1  | 1 | 1  | 1  | 0        | 0            | -1                   | 3                    | Medium         |
| CS.P.10                | Sunset Cove Parks sustainable shoreline at Broad Channel, Jamaica Bay     | DPR         | 1 | 1 | -1 | 1  | 1 | 1  | 1  | 1        | 1            | 0                    | 7                    | High           |

**PRIORITIZATION OF POTENTIAL MITIGATION ACTIONS**

**CHAPTER 4: MITIGATION STRATEGY**

| HMP Index No. | Mitigation Action   | Lead Agency               | S | T | A  | P | L | Ec | Ev | TIMELINE | Project Cost | GOALS and OBJECTIVES | Prioritization Score | Prioritization |
|---------------|---|---------------------------|---|---|----|---|---|----|----|----------|--------------|----------------------|----------------------|----------------|
| CS.P.11       | FDNY storehouse improvement   | FDNY                      | 1 | 1 | 0  | 1 | 1 | 0  | 1  | 0        | 0            | 0                    | 5                    | Medium         |
| CS.P.12       | EMS Battalion   | FDNY                      | 1 | 0 | 0  | 1 | 1 | 0  | 1  | 0        | 0            | 0                    | 4                    | Medium         |
| CS.P.13       | EMS fallback sites  | FDNY                      | 1 | 1 | 0  | 1 | 1 | 0  | 1  | 0        | 0            | 0                    | 5                    | Medium         |
| CS.P.14       | FDNY emergency services   | FDNY                      | 1 | 0 | 0  | 1 | 1 | 0  | 1  | 0        | 0            | 0                    | 4                    | Medium         |
| CS.P.15       | Outreach to residential building owners   | HPD                       | 1 | 0 | 1  | 1 | 1 | 0  | 1  | 1        | 1            | 1                    | 8                    | High           |
| CS.P.16       | Resilient home design competition   | HPD                       | 1 | 0 | 0  | 1 | 1 | 1  | 1  | 0        | 0            | 0                    | 5                    | Medium         |
| CS.P.17       | Flood-hardening of vital communications, substations, transformers, mechanical equipment, revenue equipment, and other electronic systems at all MTA Bridges and Tunnels facilities | MTA (Bridges and Tunnels) | 1 | 0 | -1 | 1 | 1 | 0  | 0  | 1        | 0            | 0                    | 3                    | Medium         |
| CS.P.18       | Raising Governors Island seawall for Hugh L. Carey Tunnel   | MTA (Bridges and Tunnels) | 1 | 1 | 0  | 1 | 1 | 0  | 1  | 0        | 0            | 0                    | 5                    | Medium         |
| CS.P.19       | Water-level monitoring/alarm systems/CCTV   | MTA (MNR)                 | 1 | 1 | 0  | 1 | 1 | 0  | 1  | 1        | 0            | 0                    | 6                    | High           |
| CS.P.20       | Power and communications/signal infrastructure mitigation   | MTA (MNR)                 | 1 | 0 | 0  | 1 | 1 | 0  | 1  | 1        | 0            | 0                    | 5                    | Medium         |
| CS.P.21       | Hardening of vulnerable healthcare facilities   | NYS DOH                   | 1 | 0 | 0  | 1 | 1 | 0  | 1  | 1        | 1            | 0                    | 6                    | High           |
| CS.P.22       | Protection of hurricane shelter windows   | OEM                       | 1 | 1 | 0  | 1 | 1 | 0  | 1  | 0        | 0            | 0                    | 5                    | Medium         |
| CS.P.23       | Hazards U.S. Multi-Hazard (HAZUS-MH) modeling   | OEM                       | 1 | 0 | 1  | 1 | 1 | 0  | 1  | 1        | 0            | 0                    | 6                    | High           |
| CS.P.24       | Backup power for evacuation centers   | OEM                       | 1 | 0 | 0  | 1 | 1 | 0  | -1 | 1        | 0            | 0                    | 3                    | Medium         |
| CS.P.25       | Storm shutters for the Emergency Operations Center  | OEM                       | 1 | 1 | 0  | 1 | 1 | 1  | 1  | 1        | 1            | 0                    | 8                    | High           |
| CS.P.26       | Storm surge/tidal gauge real-time monitoring system   | OEM                       | 1 | 0 | -1 | 1 | 1 | 0  | 1  | 0        | 0            | -1                   | 2                    | Medium         |
| CS.P.27       | Evacuation center/ hurricane shelter ADA retrofit program for DOE facilities  | OEM                       | 1 | 0 | -1 | 1 | 0 | 0  | 1  | 1        | 0            | 0                    | 3                    | Medium         |
| CS.P.28       | Updates to urban post-disaster interim neighborhood design guidelines   | OEM                       | 1 | 1 | 1  | 1 | 1 | 1  | 1  | 1        | 1            | 0                    | 9                    | High           |

**PRIORITIZATION OF POTENTIAL MITIGATION ACTIONS**

**CHAPTER 4: MITIGATION STRATEGY**

| HMP Index No.            | Mitigation Action  | Lead Agency        | S | T | A  | P | L | Ec | Ev | TIMELINE | Project Cost | GOALS and OBJECTIVES | Prioritization Score | Prioritization |
|--------------------------|--|--------------------|---|---|----|---|---|----|----|----------|--------------|----------------------|----------------------|----------------|
| CS.P.29                  | Cleanup standards for waterfront brownfields                             | OER                | 1 | 1 | 0  | 1 | 1 | 1  | 1  | 1        | 1            | 1                    | 9                    | High           |
| CS.P.30                  | Building Code update for wind resiliency in new buildings                | OLTPS              | 1 | 0 | 0  | 1 | 1 | 0  | 1  | 0        | 1            | 1                    | 6                    | High           |
| CS.P.31                  | Building Code update for wind resiliency in existing buildings           | OLTPS              | 1 | 0 | 0  | 1 | 1 | 0  | 1  | 0        | 1            | 1                    | 6                    | High           |
| CS.P.32                  | Power exercises  | USACE/NYCO-EM/RCPT | 1 | 0 | 0  | 1 | 1 | 1  | 1  | 0        | 0            | 0                    | 5                    | Medium         |
| <b>Cyber Threats</b>     |  |                    |   |   |    |   |   |    |    |          |              |                      |                      |                |
| CY.P.1                   | Supplementation of IT security   | HRA                | 1 | 1 | -1 | 1 | 1 | -1 | 0  | 1        | 0            | 0                    | 3                    | Medium         |
| CY.P.2                   | Cyber-security strategy  | MTA (MNR)          | 0 | 1 | 0  | 1 | 1 | 1  | 0  | 0        | 1            | 0                    | 5                    | Medium         |
| <b>Disease Outbreaks</b> |  |                    |   |   |    |   |   |    |    |          |              |                      |                      |                |
| DO.P.1                   | Pandemic Planning  | MTA (MNR)          | 1 | 1 | 1  | 1 | 1 | 0  | 0  | 0        | 0            | 0                    | 5                    | Medium         |
| <b>Drought</b>           |  |                    |   |   |    |   |   |    |    |          |              |                      |                      |                |
| D.P.1                    | Maximizing capacity for water delivery from the Catskill/Delaware system | DEP                | 1 | 1 | -1 | 1 | 1 | 0  | 1  | -1       | -1           | 0                    | 2                    | Medium         |
| D.P.2                    | Catskill Aqueduct capacity   | DEP                | 1 | 1 | -1 | 1 | 1 | 0  | 1  | 0        | -1           | 0                    | 3                    | Medium         |
| D.P.3                    | Construction Code revision   | DOB                | 1 | 1 | 1  | 1 | 1 | 1  | 1  | 1        | 0            | 0                    | 8                    | High           |
| D.P.4                    | Drought effects monitoring   | FDNY               | 0 | 1 | -1 | 1 | 1 | 1  | 1  | 0        | 0            | 0                    | 4                    | Medium         |
| <b>Earthquakes</b>       |  |                    |   |   |    |   |   |    |    |          |              |                      |                      |                |
| EQ.P.1                   | Mechanical equipment seismic upgrade                                     | DCAS               | 1 | 1 | 1  | 1 | 1 | 1  | 0  | 0        | 1            | 0                    | 7                    | High           |
| EQ.P.2                   | Seismic protection for sewers  | DEP                | 1 | 1 | 1  | 1 | 1 | 1  | 1  | 0        | 0            | 0                    | 7                    | High           |
| EQ.P.3                   | Seismic inspection and retrofit for drinking water distribution system   | DEP                | 1 | 1 | 1  | 1 | 1 | 1  | 1  | 0        | 0            | 1                    | 8                    | High           |
| EQ.P.4                   | Building code update   | DOB                | 1 | 1 | 0  | 1 | 1 | 1  | 1  | 1        | 0            | 0                    | 7                    | High           |
| EQ.P.5                   | Seismic study and retrofit for tall buildings                            | DOE                | 1 | 1 | 0  | 1 | 1 | 1  | 0  | 0        | 0            | 1                    | 6                    | High           |
| EQ.P.6                   | Building upgrades to seismic codes                                       | HHC                | 1 | 1 | -1 | 1 | 1 | -1 | 0  | 1        | 0            | 0                    | 3                    | Medium         |
| EQ.P.7                   | HPD facility improvement   | HPD                | 1 | 1 | -1 | 1 | 1 | -1 | 0  | 1        | 0            | 0                    | 3                    | Medium         |
| EQ.P.8                   | UPACA (Site 6)   | NYCHA              | 1 | 1 | -1 | 1 | 1 | 1  | 0  | 0        | 0            | 0                    | 4                    | Medium         |

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**CHAPTER 4: MITIGATION STRATEGY**

| HMP Index No.               | Mitigation Action  | Lead Agency | S | T | A  | P | L  | Ec | Ev | TIMELINE | Project Cost | GOALS and OBJECTIVES | Prioritization Score | Prioritization |
|-----------------------------|--|-------------|---|---|----|---|----|----|----|----------|--------------|----------------------|----------------------|----------------|
| EQ.P.9                      | HAZUS-MH modeling  | OEM         | 1 | 1 | 1  | 1 | 0  | 1  | 0  | 1        | 0            | 0                    | 6                    | High           |
| <b>Extreme Temperatures</b> |  |             |   |   |    |   |    |    |    |          |              |                      |                      |                |
| ET.P.1                      | Power redundancy in City buildings   | DCAS        | 1 | 0 | 0  | 1 | 1  | 1  | 0  | 0        | 0            | 0                    | 4                    | Medium         |
| ET.P.2                      | AC upgrade for senior centers  | DFTA        | 1 | 0 | 0  | 1 | 1  | 0  | 0  | 1        | 0            | 0                    | 4                    | Medium         |
| ET.P.3                      | AC availability and affordability  | DOHMH       | 1 | 0 | 0  | 1 | 0  | 0  | -1 | 0        | 0            | 0                    | 1                    | Medium         |
| ET.P.4                      | Urban heat island effect mitigation  | DOHMH       | 1 | 1 | 0  | 1 | 0  | 0  | 1  | 1        | 1            | 0                    | 6                    | High           |
| ET.P.5                      | Cooling centers  | NYCHA       | 1 | 0 | 0  | 1 | 1  | 0  | -1 | 0        | 0            | 0                    | 2                    | Medium         |
| <b>Flooding</b>             |  |             |   |   |    |   |    |    |    |          |              |                      |                      |                |
| F.P.1                       | Infrastructure flood protection  | DCAS        | 1 | 1 | -1 | 0 | 1  | 0  | 1  | 0        | 0            | 0                    | 3                    | Medium         |
| F.P.2                       | Flood Resilient Building Design Manual                                       | DCP         | 1 | 1 | 1  | 1 | 1  | 1  | 1  | 1        | 0            | 1                    | 9                    | High           |
| F.P.3                       | Zoning for flood-resistant construction, Phase I and II                      | DCP         | 1 | 1 | 1  | 1 | 1  | 1  |    | 1        | 0            | 0                    | 7                    | High           |
| F.P.4                       | Ecologically sensitive industrial area planning                              | DCP         | 1 | 1 | 1  | 1 | 1  | 1  | 1  | 0        | 0            | 0                    | 7                    | High           |
| F.P.5                       | Croton Falls pump station rehabilitation                                     | DEP         | 1 | 1 | -1 | 1 | 0  | 0  | 1  | 1        | 0            | 0                    | 4                    | Medium         |
| F.P.6                       | Bergen Basin and Tallman Island Wastewater Treatment Plant drainage upgrades | DEP         | 1 | 1 | -1 | 1 | 0  | 1  | 1  | 0        | -1           | 0                    | 3                    | Medium         |
| F.P.7                       | Server capacity improvements   | DFTA        | 1 | 1 | 0  | 1 | 1  | 0  | 0  | 1        | 1            | 0                    | 6                    | High           |
| F.P.8                       | DHS electrical improvements  | DHS         | 1 | 1 | 0  | 1 | 1  | 0  | 0  | 0        | 0            | 0                    | 4                    | Medium         |
| F.P.9                       | Borden Avenue facility   | DHS         | 1 | 1 | 0  | 1 | 1  | 0  | -1 | 0        | 0            | 0                    | 3                    | Medium         |
| F.P.10                      | Data system upgrade  | DOB         | 1 | 1 | 1  | 1 | 1  | 1  | 1  | 1        | 0            | 0                    | 8                    | High           |
| F.P.11                      | Post-disaster code enforcement   | DOB         | 0 | 1 | -1 | 1 | 1  | 1  | 1  | 1        | 1            | 1                    | 7                    | High           |
| F.P.12                      | Rikers Island roadway re-grading   | DOC         | 1 | 1 | 0  | 1 | 1  | 0  | 0  | 0        | 1            | 0                    | 5                    | Medium         |
| F.P.13                      | Water infiltration prevention  | DOHMH       | 0 | 1 | 0  | 0 | 1  | 0  | 0  | 1        | 1            | 0                    | 4                    | Medium         |
| F.P.14                      | Flood-proofing 125 Worth Street vault  | DOHMH       | 1 | 1 | -1 | 1 | 1  | -1 | 1  | 1        | 1            | 0                    | 5                    | Medium         |
| F.P.15                      | Permeable pavement   | DOT         | 1 | 1 | -1 | 1 | 1  | 1  | 1  | 0        | 0            | 1                    | 6                    | High           |
| F.P.16                      | Flood-proofing at Olmsted site   | DPR         | 0 | 1 | 0  | 0 | -1 | 0  | 0  | 0        | 0            | 0                    | 0                    | Low            |

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**CHAPTER 4: MITIGATION STRATEGY**

| HMP Index No. | Mitigation Action                                       | Lead Agency       | S  | T | A  | P  | L  | Ec | Ev | TIMELINE | Project Cost | GOALS and OBJECTIVES | Prioritization Score | Prioritization |
|---------------|---|-------------------|----|---|----|----|----|----|----|----------|--------------|----------------------|----------------------|----------------|
| F.P.17        | Tidegate upgrade in Flushing Meadow Corona Park         | DPR               | 1  | 1 | 1  | 1  | 1  | 1  | 1  | 0        | 1            | 0                    | 8                    | High           |
| F.P.18        | Living shoreline at Conference House Park               | DPR               | 1  | 1 | -1 | 1  | 1  | 0  | 1  | 1        | 0            | 0                    | 5                    | Medium         |
| F.P.19        | Protection for the Manhattan 1,2,5 facility             | DSNY              | 1  | 1 | -1 | 1  | 1  | 0  | 1  | 1        | 0            | 0                    | 5                    | Medium         |
| F.P.20        | Stapleton waterfront flood mitigation                   | EDC               | 1  | 1 | 0  | 1  | 1  | 0  | 1  | 1        | 0            | 0                    | 6                    | Medium         |
| F.P.21        | Brooklyn Army Terminal passive flood barrier system     | EDC               | 1  | 1 | -1 | 1  | 1  | 0  | 1  | 1        | 1            | 0                    | 6                    | High           |
| F.P.22        | Hardening of EDC Emergency Operations Center            | EDC               | 1  | 1 | -1 | 1  | 1  | 0  | 1  | 1        | 1            | 1                    | 7                    | High           |
| F.P.23        | Flood effects reduction program                         | FDNY              | 1  | 1 | -1 | 1  | 1  | 0  | 1  | 0        | 0            | 0                    | 4                    | Medium         |
| F.P.24        | Dewatering pumps at FDNY facilities                     | FDNY              | 1  | 1 | 0  | 1  | 1  | 0  | 1  | 0        | 0            | -1                   | 4                    | Medium         |
| F.P.25        | New construction flood mitigation                       | FDNY              | 1  | 1 | -1 | 1  | 1  | 0  | 1  | 0        | 0            | 0                    | 4                    | Medium         |
| F.P.26        | Coney Island Hospital flood-proofing                    | HHC               | 1  | 1 | -1 | 0  | 1  | 0  | 0  | 0        | 0            | 1                    | 3                    | Medium         |
| F.P.27        | Coney Island Hospital emergency department mitigation   | HHC               | 1  | 1 | -1 | 0  | 1  | 0  | 0  | 0        | 0            | 1                    | 3                    | Medium         |
| F.P.28        | Coney Island Hospital critical system protection        | HHC               | 1  | 1 | -1 | 0  | 1  | 0  | 0  | 0        | 0            | 1                    | 3                    | Medium         |
| F.P.29        | Metropolitan Hospital flood barriers                    | HHC               | 1  | 1 | -1 | 0  | 1  | 0  | 0  | 0        | 0            | 1                    | 3                    | Medium         |
| F.P.30        | Metropolitan Hospital critical systems elevation        | HHC               | 1  | 1 | -1 | 0  | 1  | 0  | 0  | 0        | 0            | 1                    | 3                    | Medium         |
| F.P.31        | Coler Hospital and Nursing Facility protection          | HHC               | 1  | 1 | -1 | 0  | 1  | 0  | 0  | 0        | 0            | 1                    | 3                    | Medium         |
| F.P.32        | Coler Hospital and Nursing Facility fuel-tank hardening | HHC               | 1  | 1 | -1 | 0  | 1  | 0  | 0  | 0        | 0            | 1                    | 3                    | Medium         |
| F.P.33        | Building flood protection                               | HRA               | 1  | 1 | -1 | 1  | 1  | 0  | 0  | 1        | 0            | 1                    | 5                    | Medium         |
| F.P.34        | Water-balance study                                     | MTA (NYCT-Subway) | 1  | 1 | -1 | 1  | 1  | 0  | 0  | 0        | 0            | 0                    | 3                    | Medium         |
| F.P.35        | Double track Main Line, Phase 2                         | MTA/LIRR          | 1  | 1 | -1 | 1  | 1  | 0  | 0  | 0        | -1           | 0                    | 2                    | Medium         |
| F.P.36        | Ventilation grate improvements                          | MTA/LIRR          | 1  | 1 | -1 | 1  | 1  | 0  | 0  | 0        | 1            | 0                    | 4                    | Medium         |
| F.P.37        | Long Island City Yard protection                        | MTA/LIRR          | 1  | 1 | -1 | 1  | 0  | 1  | 0  | 0        | 0            | 0                    | 3                    | Medium         |
| F.P.38        | Safeguarding NYCHA cellar equipment                     | NYCHA             | 1  | 1 | -1 | 1  | 1  | 0  | 0  | 1        | 1            | 0                    | 5                    | Medium         |
| F.P.39        | New NYCHA building/development                          | NYCHA             | -1 | 1 | -1 | -1 | -1 | -1 | -1 | 0        | 0            | 0                    | -5                   | Low            |

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| HMP Index No. | Mitigation Action  | Lead Agency | S | T | A  | P | L | Ec | Ev | TIMELINE | Project Cost | GOALS and OBJECTIVES | Prioritization Score | Prioritization |
|---------------|--|-------------|---|---|----|---|---|----|----|----------|--------------|----------------------|----------------------|----------------|
| F.P.40        | NYCHA floodgates and barriers  | NYCHA       | 1 | 1 | -1 | 1 | 1 | 0  | 0  | 1        | 0            | 0                    | 4                    | Medium         |
| F.P.41        | NYCHA boiler rooms and electrical equipment  | NYCHA       | 1 | 1 | -1 | 1 | 0 | 0  | 0  | 1        | 0            | 0                    | 3                    | Medium         |
| F.P.42        | Sump pump protection   | NYPD        | 1 | 1 | -1 | 1 | 1 | 0  | 0  | 0        | 0            | 0                    | 3                    | Medium         |
| F.P.43        | Building electrical protection   | NYPD        | 1 | 1 | -1 | 1 | 0 | 0  | 0  | 0        | 0            | 1                    | 3                    | Medium         |
| F.P.44        | Boiler protection  | NYPD        | 1 | 1 | -1 | 1 | 1 | 0  | 0  | 0        | 0            | 1                    | 4                    | Medium         |
| F.P.45        | Short-term flood mitigation of OCME emergency management storage facility at 18 <sup>th</sup> Street and FDR Drive | OCME        | 1 | 1 | -1 | 1 | 1 | 0  | 0  | 0        | 1            | 1                    | 5                    | Medium         |
| F.P.46        | Flood mitigation measures for New York City's backup Emergency Operations Center                                   | OEM         | 1 | 1 | -1 | 1 | 1 | 0  | 0  | 1        | 0            | 0                    | 4                    | Medium         |
| F.P.47        | HAZUS-MH modeling  | OEM         | 0 | 1 | -1 | 1 | 1 | 0  | 0  | 1        | 0            | 0                    | 3                    | Medium         |
| F.P.48        | Public information and guidance  | OEM         | 1 | 1 | 0  | 1 | 1 | 1  | 0  | 0        | 0            | 1                    | 6                    | High           |
| F.P.49        | Local storm surge barrier for Gowanus Canal  | OLTPS       | 1 | 1 | 0  | 1 | 1 | 0  | 1  | 0        | 1            | 0                    | 6                    | High           |
| F.P.50        | Plan for flood protection along the Williamsburg, Greenpoint, and Long Island City coastlines                      | OLTPS       | 1 | 1 | -1 | 1 | 1 | 1  | 1  | 0        | 1            | 0                    | 6                    | High           |
| F.P.51        | Floodgate repairs at Oakwood Beach, Staten Island  | OLTPS       | 1 | 1 | -1 | 1 | 1 | -1 | 0  | 0        | 1            | 0                    | 3                    | Medium         |
| F.P.52        | Primary and secondary dune systems in Rockaway Peninsula   | OLTPS       | 1 | 1 | 1  | 1 | 1 | 1  | 1  | 0        | 0            | 0                    | 7                    | High           |
| F.P.53        | Offshore breakwaters adjacent to and south of Great Kills Harbor   | OLTPS       | 1 | 1 | 1  | 1 | 1 | 1  | 1  | 0        | -1           | 0                    | 6                    | High           |
| F.P.54        | Flood protection in Hunts Point  | OLTPS       | 1 | 1 | -1 | 1 | 1 | -1 | 1  | 0        | -1           | 0                    | 2                    | Medium         |
| F.P.55        | Flood protection in East Harlem  | OLTPS       | 1 | 1 | -1 | 1 | 1 | -1 | 1  | 0        | -1           | 1                    | 3                    | Medium         |
| F.P.56        | Lower Manhattan flood protection   | OLTPS       | 1 | 1 | -1 | 1 | 1 | -1 | 1  | 0        | -1           | 1                    | 3                    | Medium         |
| F.P.57        | Integrated flood protection system for Red Hook  | OLTPS       | 1 | 1 | -1 | 1 | 1 | 1  | 1  | 0        | -1           | 0                    | 4                    | Medium         |
| F.P.58        | Protection of Farragut substation  | OLTPS       | 1 | 1 | 0  | 1 | 1 | 1  | 1  | 0        | 1            | 0                    | 7                    | High           |
| F.P.59        | Newtown Creek flood protection   | OLTPS       | 1 | 1 | 1  | 1 | 0 | 1  | 1  | 0        | -1           | 1                    | 6                    | High           |
| F.P.60        | Flood protection research  | OLTPS       | 1 | 1 | 0  | 1 | 1 | 1  | 1  | 0        | 1            | 0                    | 7                    | High           |



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**CHAPTER 4: MITIGATION STRATEGY**

| HMP Index No.                  | Mitigation Action  | Lead Agency       | S | T | A  | P  | L | Ec | Ev | TIMELINE | Project Cost | GOALS and OBJECTIVES | Prioritization Score | Prioritization |
|--------------------------------|--|-------------------|---|---|----|----|---|----|----|----------|--------------|----------------------|----------------------|----------------|
| F.P.61                         | Prevention of drainage pipe flooding                               | OLTPS             | 1 | 1 | 0  | 1  | 1 | 1  | 1  | 0        | 0            | 0                    | 6                    | High           |
| F.P.62                         | Floodgate at Mill Creek  | OLTPS             | 1 | 1 | 1  | 1  | 1 | 1  | 1  | 0        | 1            | 0                    | 8                    | High           |
| F.P.63                         | Community Rating System  | OLTPS             | 1 | 1 | 0  | 1  | 1 | 1  | 1  | 0        | 1            | 0                    | 7                    | High           |
| F.P.64                         | Coney Island Creek wetlands and tidal barrier                      | OLTPS             | 1 | 1 | 0  | 1  | 0 | 1  | 1  | 0        | 1            | 0                    | 6                    | High           |
| F.P.65                         | Integrated flood protection for southern Manhattan                 | OLTPS             | 1 | 1 | 0  | 1  | 1 | 1  | 1  | 0        | 1            | 0                    | 7                    | High           |
| F.P.66                         | Flood protection of vital infrastructure at LaGuardia Airport      | PANYNJ (Aviation) | 0 | 1 | -1 | 1  | 0 | -1 | 1  | 1        | 0            | 0                    | 2                    | Medium         |
| F.P.67                         | Flood protection of vital infrastructure at JFK Airport            | PANYNJ (Aviation) | 0 | 1 | -1 | 1  | 0 | -1 | 1  | 1        | 0            | 0                    | 2                    | Medium         |
| F.P.68                         | Drainage improvements at JFK Airport                               | PANYNJ (Aviation) | 0 | 1 | -1 | 1  | 0 | -1 | 1  | 1        | 0            | 0                    | 2                    | Medium         |
| F.P.69                         | Protection of JFK Airport fuel farm tanks                          | PANYNJ (Aviation) | 0 | 1 | -1 | 1  | 0 | -1 | 1  | 1        | 1            | 0                    | 3                    | Medium         |
| F.P.70                         | LaGuardia Airport dike wall  | PANYNJ (Aviation) | 0 | 1 | -1 | 1  | 0 | -1 | 1  | 1        | 1            | 0                    | 3                    | Medium         |
| F.P.71                         | JFK Airport sanitary lift station                                  | PANYNJ (Aviation) | 0 | 1 | -1 | 1  | 0 | -1 | 1  | 0        | 1            | 0                    | 2                    | Medium         |
| F.P.72                         | JFK Airport runway upgrade   | PANYNJ (Aviation) | 0 | 1 | -1 | 1  | 0 | -1 | 1  | 1        | 0            | 0                    | 2                    | Medium         |
| F.P.73                         | JFK Airport runway upgrade   | PANYNJ (Aviation) | 0 | 1 | -1 | 1  | 0 | -1 | 1  | 1        | 0            | 0                    | 2                    | Medium         |
| F.P.74                         | Improvements to George Washington Bridge anchorage drainage system | PANYNJ(TBT)       | 0 | 1 | -1 | 1  | 0 | -1 | 1  | 1        | 1            | 0                    | 3                    | Medium         |
| F.P.75                         | Substation mitigation  | PSEG              | 1 | 1 | -1 | 1  | 1 | 0  | 0  | 1        | 0            | 0                    | 4                    | Medium         |
| <b>Infrastructure Failures</b> |  |                   |   |   |    |    |   |    |    |          |              |                      |                      |                |
| IF.P.1                         | Expansion of cogeneration  | DEP               | 1 | 1 | 0  | 1  | 0 | 1  | 1  | 1        | 1            | 1                    | 8                    | High           |
| IF.P.2                         | Repair of the Delaware Aqueduct leak                               | DEP               | 1 | 1 | 1  | 1  | 1 | 1  | 1  | 0        | -1           | 0                    | 6                    | High           |
| IF.P.3                         | Utilities on Buono Bridge  | DOC               | 0 | 1 | 0  | -1 | 1 | 0  | 0  | 0        | -1           | 0                    | 0                    | Low            |
| IF.P.4                         | Facility electrical power and data infrastructure upgrade          | DOHMH             | 1 | 1 | 1  | 1  | 1 | 1  | 1  | 1        | 1            | 0                    | 9                    | High           |

## PRIORITIZATION OF POTENTIAL MITIGATION ACTIONS

### CHAPTER 4: MITIGATION STRATEGY

| HMP Index No.        | Mitigation Action   | Lead Agency | S | T | A  | P | L | Ec | Ev | TIMELINE | Project Cost | GOALS and OBJECTIVES | Prioritization Score | Prioritization |
|----------------------|---|-------------|---|---|----|---|---|----|----|----------|--------------|----------------------|----------------------|----------------|
| IF.P.5               | DOHMH generators and retrofits  | DOHMH       | 1 | 0 | 1  | 1 | 1 | 1  | 1  | 1        | 1            | 0                    | 8                    | High           |
| IF.P.6               | Session Initiation Protocol (SIP)   | DoITT       | 1 | 1 | 1  | 1 | 1 | 1  | 0  | 0        | 1            | 1                    | 8                    | High           |
| IF.P.7               | Citywide IVR for employee announcements   | DoITT       | 1 | 1 | 1  | 1 | 1 | 1  | 0  | 0        | 1            | 1                    | 8                    | High           |
| IF.P.8               | Telecommunications Planning and Resiliency Office                                   | DoITT       | 1 | 1 | 1  | 1 | 1 | 0  | 0  | 1        | 1            | 1                    | 8                    | High           |
| IF.P.9               | IP routing network  | DoITT       | 1 | 1 | 1  | 1 | 1 | 1  | 0  | 0        | 1            | 1                    | 8                    | High           |
| IF.P.10              | Emergency generators in NYCHA properties  | NYCHA       | 1 | 0 | 0  | 1 | 1 | 0  | 0  | 1        | -1           | 0                    | 3                    | Medium         |
| IF.P.11              | Stand-alone power generation in NYCHA developments                                  | NYCHA       | 1 | 0 | -1 | 1 | 1 | -1 | 0  | 0        | 0            | 0                    | 1                    | Medium         |
| IF.P.12              | Backup generators for NYPD facilities   | NYPD        | 1 | 0 | 1  | 1 | 1 | 0  | 0  | 0        | 0            | 0                    | 4                    | Medium         |
| IF.P.13              | Flood mitigation of 520 First Ave. (Manhattan Morgue) and Forensic biology building | OCME        | 0 | 0 | 1  | 1 | 1 | 0  | 0  | 0        | 0            | 1                    | 4                    | Medium         |
| IF.P.14              | Kings and Queens facilities   | OCME        | 0 | 0 | 1  | 1 | 1 | 0  | 0  | 0        | 0            | 0                    | 3                    | Medium         |
| IF.P.15              | Generator assessment and installation of quick-connects for critical infrastructure | OEM         | 0 | 0 | 0  | 1 | 1 | 0  | 0  | 1        | 0            | 0                    | 3                    | Medium         |
| IF.P.16              | Backup generators for gas stations and terminals                                    | OEM         | 1 | 0 | 0  | 1 | 1 | 0  | 0  | 1        | 0            | 0                    | 4                    | Medium         |
| IF.P.17              | Protection from utility service interruptions                                       | OLTPS       | 1 | 1 | 0  | 1 | 1 | 0  | 1  | 0        | 1            | 0                    | 6                    | High           |
| IF.P.18              | Distributed generation (DG) and micro-grids   | OLTPS       | 1 | 1 | 1  | 1 | 1 | 1  | 0  | 0        | 1            | 0                    | 7                    | High           |
| IF.P.19              | Purchase of mobile substation   | PSEG        | 1 | 1 | 1  | 1 | 1 | 0  | 0  | 1        | 1            | 0                    | 7                    | High           |
| IF.P.20              | Purchase of mobile switchgear   | PSEG        | 1 | 1 | 0  | 1 | 1 | 0  | 0  | 1        | 1            | 0                    | 6                    | High           |
| <b>Multi-Hazards</b> |   |             |   |   |    |   |   |    |    |          |              |                      |                      |                |
| MH.P.1               | Overhead electric system improvements   | Con Ed      | 1 | 0 | 0  | 1 | 0 | 0  | 1  | 1        | -1           | 0                    | 3                    | Medium         |
| MH.P.2               | Underground electric system improvements  | Con Ed      | 1 | 0 | 0  | 1 | 0 | 0  | 0  | 1        | -1           | 0                    | 2                    | Medium         |
| MH.P.3               | Gas system Improvements   | Con Ed      | 1 | 0 | 0  | 1 | 0 | 0  | 0  | 1        | -1           | 0                    | 2                    | Medium         |

**PRIORITIZATION OF POTENTIAL MITIGATION ACTIONS**

**CHAPTER 4: MITIGATION STRATEGY**

| HMP Index No. | Mitigation Action  | Lead Agency | S | T | A | P  | L | Ec | Ev | TIMELINE | Project Cost | GOALS and OBJECTIVES | Prioritization Score | Prioritization |
|---------------|--|-------------|---|---|---|----|---|----|----|----------|--------------|----------------------|----------------------|----------------|
| MH.P.4        | Storm-hardening of critical facilities                                   | Con Ed      | 1 | 0 | 0 | 1  | 0 | 0  | 1  | 1        | -1           | 0                    | 3                    | Medium         |
| MH.P.5        | Window upgrades  | DCAS        | 1 | 1 | 0 | 1  | 1 | 1  | 1  | -1       | -1           | 0                    | 4                    | Medium         |
| MH.P.6        | Retail resiliency study  | DCP         | 1 | 0 | 0 | 1  | 1 | 0  | 0  | 1        | 0            | -1                   | 3                    | Medium         |
| MH.P.7        | Building Identification Numbers (BINs)                                   | DCP         | 1 | 0 | 0 | 1  | 0 | 0  | 1  | 0        | 0            | 0                    | 3                    | Medium         |
| MH.P.8        | BIN Working Group recommendations  | DCP         | 1 | 0 | 0 | 1  | 0 | 0  | 1  | 0        | 0            | 0                    | 3                    | Medium         |
| MH.P.9        | Inspection and upgrade program for DEP facilities                        | DEP         | 0 | 0 | 0 | 1  | 0 | 0  | 1  | 0        | 0            | 1                    | 3                    | Medium         |
| MH.P.10       | Groundwater development  | DEP         | 0 | 1 | 1 | 1  | 0 | 1  | 1  | 0        | 0            | 0                    | 5                    | Medium         |
| MH.P.11       | Groundwater treatment plant  | DEP         | 1 | 0 | 0 | 1  | 0 | 1  | 1  | 0        | 0            | 1                    | 5                    | Medium         |
| MH.P.12       | Laptops for DFTA essential staff   | DFTA        | 1 | 0 | 0 | 1  | 0 | 1  | 1  | 1        | 1            | 0                    | 6                    | High           |
| MH.P.13       | Generator for neighborhood hub   | DFTA        | 1 | 0 | 0 | 1  | 0 | 0  | -1 | 0        | 0            | 0                    | 1                    | Medium         |
| MH.P.14       | Headlamps for home-delivered meals deliverers                            | DFTA        | 1 | 0 | 0 | 1  | 0 | 1  | 1  | 0        | 1            | 0                    | 5                    | Medium         |
| MH.P.15       | Upgrades to DHS buildings  | DHS         | 1 | 0 | 0 | 1  | 0 | 0  | 1  | 0        | 0            | 1                    | 4                    | Medium         |
| MH.P.16       | DHS building roof improvements   | DHS         | 1 | 0 | 0 | 1  | 0 | 1  | 1  | 0        | 1            | 1                    | 6                    | High           |
| MH.P.17       | Window upgrade in DHS buildings  | DHS         | 1 | 0 | 0 | 1  | 0 | 0  | 1  | 0        | 0            | 1                    | 4                    | Medium         |
| MH.P.18       | Power redundancy at DHS buildings  | DHS         | 1 | 0 | 0 | 1  | 0 | 1  | 0  | 0        | 1            | 0                    | 4                    | Medium         |
| MH.P.19       | DHS shelter protection   | DHS         | 0 | 0 | 0 | -1 | 0 | 0  | 1  | 0        | 0            | 1                    | 1                    | Medium         |
| MH.P.20       | Bellevue shelter facility improvements                                   | DHS         | 1 | 0 | 0 | 1  | 0 | 0  | -1 | 0        | 0            | 1                    | 2                    | Medium         |
| MH.P.21       | LIFE Family Residence facility improvements                              | DHS         | 1 | 0 | 0 | 1  | 0 | 0  | -1 | 0        | 0            | 1                    | 2                    | Medium         |
| MH.P.22       | Mobile command stations  | DOB         | 1 | 0 | 0 | 0  | 0 | 1  | 1  | 0        | 1            | -1                   | 3                    | Medium         |
| MH.P.23       | DOB backup generators  | DOB         | 1 | 0 | 0 | 1  | 0 | 0  | -1 | 0        | 0            | -1                   | 0                    | Low            |
| MH.P.24       | DOB radios   | DOB         | 1 | 1 | 0 | 1  | 0 | 0  | 1  | 0        | 1            | -1                   | 4                    | Medium         |
| MH.P.25       | DOB vehicles   | DOB         | 1 | 0 | 0 | 1  | 0 | 1  | -1 | 0        | 1            | -1                   | 2                    | Medium         |
| MH.P.26       | Stormwater management  | DOC         | 1 | 0 | 0 | 1  | 0 | 0  | 1  | 0        | 0            | 0                    | 3                    | Medium         |
| MH.P.27       | Rikers Island ferry dock   | DOC         | 1 | 0 | 0 | 1  | 0 | 0  | 1  | 0        | 0            | 0                    | 3                    | Medium         |
| MH.P.28       | Roof and façade improvements   | DOC         | 1 | 0 | 0 | 1  | 0 | 1  | 1  | 0        | 0            | 0                    | 4                    | Medium         |
| MH.P.29       | Emergency Operations Center improvements                                 | DOC         | 1 | 0 | 0 | 1  | 0 | 1  | 1  | 0        | 0            | 0                    | 4                    | Medium         |
| MH.P.30       | Off-island satellite Emergency Operations Center (EOC) for Rikers Island | DOC         | 1 | 0 | 0 | 1  | 0 | 1  | 1  | 0        | 0            | 1                    | 5                    | Medium         |

**PRIORITIZATION OF POTENTIAL MITIGATION ACTIONS**

**CHAPTER 4: MITIGATION STRATEGY**

| HMP Index No. | Mitigation Action   | Lead Agency | S | T | A | P | L  | Ec | Ev | TIMELINE | Project Cost | GOALS and OBJECTIVES | Prioritization Score | Prioritization |
|---------------|---|-------------|---|---|---|---|----|----|----|----------|--------------|----------------------|----------------------|----------------|
| MH.P.31       | MDC cellar/backup emergency system  | DOC         | 1 | 0 | 0 | 1 | 0  | 1  | -1 | 0        | 1            | 0                    | 3                    | Medium         |
| MH.P.32       | Provision of power redundancy   | DOE         | 1 | 0 | 0 | 1 | 0  | 1  | 0  | 0        | 1            | 0                    | 4                    | Medium         |
| MH.P.33       | Protection of DOE facilities from electrical system damage from trees                       | DOE         | 1 | 0 | 0 | 1 | 0  | 0  | 0  | 0        | 0            | 0                    | 2                    | Medium         |
| MH.P.34       | DOE green roof installation   | DOE         | 1 | 1 | 0 | 1 | 0  | 0  | 1  | 0        | 0            | 1                    | 5                    | Medium         |
| MH.P.35       | Surge protection for DOE critical electrical systems  | DOE         | 1 | 0 | 0 | 1 | 0  | 0  | 1  | 0        | 0            | 0                    | 3                    | Medium         |
| MH.P.36       | Emergency power at DOE facilities   | DOE         | 1 | 1 | 0 | 1 | 0  | 1  | -1 | 0        | 1            | 0                    | 4                    | Medium         |
| MH.P.37       | Emergency preparedness plans and training for DOE custodian engineers and building managers | DOE         | 1 | 0 | 0 | 1 | 0  | 1  | 1  | 1        | 1            | 0                    | 6                    | High           |
| MH.P.38       | Psychological First Aid (PFA)   | DOHMH       | 1 | 1 | 0 | 1 | 0  | 1  | 1  | 0        | 1            | 0                    | 6                    | High           |
| MH.P.39       | Mental Health First Aid public education program  | DOHMH       | 1 | 0 | 0 | 1 | 0  | 1  | 1  | 0        | 1            | -1                   | 4                    | Medium         |
| MH.P.40       | Mental health system IT improvement   | DOHMH       | 1 | 0 | 0 | 1 | 0  | 1  | 1  | 1        | 1            | -1                   | 5                    | Medium         |
| MH.P.41       | Mental health system power backup   | DOHMH       | 1 | 0 | 0 | 1 | 0  | 1  | -1 | 0        | 1            | 0                    | 3                    | Medium         |
| MH.P.42       | Mental health system support network  | DOHMH       | 1 | 0 | 0 | 1 | 0  | 1  | 1  | 1        | 1            | 1                    | 7                    | High           |
| MH.P.43       | Mental health volunteer preparedness and response   | DOHMH       | 1 | 0 | 0 | 1 | 0  | 1  | 1  | 1        | 1            | 1                    | 7                    | High           |
| MH.P.44       | DOHMH IT systems protection   | DOHMH       | 1 | 0 | 0 | 1 | 0  | 1  | 1  | 1        | 1            | 0                    | 6                    | High           |
| MH.P.45       | DOHMH primary data center availability  | DOHMH       | 1 | 0 | 0 | 1 | 0  | 1  | 1  | 1        | 1            | -1                   | 5                    | Medium         |
| MH.P.46       | Riverside clinic upgrade  | DOHMH       | 1 | 0 | 0 | 1 | 0  | 1  | 1  | 1        | 1            | -1                   | 5                    | Medium         |
| MH.P.47       | DOHMH warehouse and print shop capacity   | DOHMH       | 1 | 0 | 0 | 1 | 0  | 1  | 1  | 1        | 1            | 0                    | 6                    | High           |
| MH.P.48       | Health data and provider portal   | DOHMH       | 1 | 0 | 0 | 1 | 0  | 1  | 1  | 1        | 1            | 0                    | 6                    | High           |
| MH.P.49       | Enhanced emergency response communication operations at DOHMH headquarters                  | DOHMH       | 1 | 1 | 0 | 1 | 0  | 0  | 1  | 1        | 1            | 0                    | 6                    | High           |
| MH.P.50       | Backup power for nursing homes and adult care facilities                                    | DOHMH       | 1 | 0 | 0 | 1 | 0  | 0  | -1 | 1        | 0            | 0                    | 2                    | Medium         |
| MH.P.51       | Small grants program to support community-based social cohesion                             | DOHMH       | 1 | 1 | 0 | 1 | -1 | 0  | 0  | 1        | 1            | 1                    | 5                    | Medium         |

**PRIORITIZATION OF POTENTIAL MITIGATION ACTIONS**

**CHAPTER 4: MITIGATION STRATEGY**

| HMP Index No. | Mitigation Action   | Lead Agency | S | T | A  | P | L  | Ec | Ev | TIMELINE | Project Cost | GOALS and OBJECTIVES | Prioritization Score | Prioritization |
|---------------|---|-------------|---|---|----|---|----|----|----|----------|--------------|----------------------|----------------------|----------------|
| MH.P.52       | "Hub the Hood" program  | DOHMH       | 1 | 1 | 0  | 1 | -1 | 0  | 0  | 1        |              | 0                    | 3                    | Medium         |
| MH.P.53       | DOHMH facility repair and upgrade   | DOHMH       | 1 | 1 | -1 | 1 | -1 | -1 | 0  | 1        | 0            | 0                    | 1                    | Medium         |
| MH.P.54       | Notification system for City employees  | DoITT       | 1 | 1 | -1 | 1 | 1  | 0  | 0  | 0        | 0            | 0                    | 3                    | Medium         |
| MH.P.55       | Hardening of NYCWiN network   | DoITT       | 1 | 1 | -1 | 1 | 1  | 0  | 0  | 1        | 0            | 0                    | 4                    | Medium         |
| MH.P.56       | Data Center Site B  | DoITT       | 1 | 1 | -1 | 1 | 1  | 0  | 0  | 1        | 0            | 0                    | 4                    | Medium         |
| MH.P.57       | Secure HAZMAT at DOT facilities   | DOT         | 1 | 1 | 0  | 1 | 1  | 0  | 1  | 0        | 0            | 0                    | 5                    | Medium         |
| MH.P.58       | Redundant power for all mission-critical DOT sites  | DOT         | 0 | 1 | 1  | 1 | 1  | 1  | 0  | 0        | 0            | 0                    | 5                    | Medium         |
| MH.P.59       | Continuity of Operations sites  | DOT         | 1 | 1 | -1 | 1 | 0  | -1 | 0  | 0        | 0            | 0                    | 1                    | Medium         |
| MH.P.60       | Information tracking  | DOT         | 0 | 1 | 0  | 1 | 1  | 1  | 0  | 1        | 1            | 0                    | 6                    | High           |
| MH.P.61       | High-reflectivity pavements   | DOT         | 1 | 1 | -1 | 1 | 0  | 0  | 0  | 0        | 1            | 1                    | 4                    | Medium         |
| MH.P.62       | Critical facility loss estimation   | DOT         | 1 | 1 | 0  | 0 | 0  | 0  | 1  | 0        | 1            | -1                   | 3                    | Medium         |
| MH.P.63       | Staten Island Ferry fleet upgrade   | DOT         | 1 | 1 | 0  | 1 | 0  | -1 | 0  | 0        | 0            | 0                    | 2                    | Medium         |
| MH.P.64       | Staten Island Ferry vessel improvement  | DOT         | 1 | 1 | 0  | 1 | -1 | 0  | 0  | 0        | 1            | 0                    | 3                    | Medium         |
| MH.P.65       | Green roofs on DPR buildings  | DPR         | 1 | 1 | -1 | 1 | 1  | 1  | 1  | 1        | 1            | 1                    | 8                    | High           |
| MH.P.66       | Green Streets   | DPR         | 1 | 1 | -1 | 1 | 1  | 1  | 1  | 1        | 1            | 1                    | 8                    | High           |
| MH.P.67       | Wetlands and other land in a natural state  | DPR         | 1 | 1 | -1 | 1 | -1 | -1 | 1  | 0        | 1            | 1                    | 3                    | Medium         |
| MH.P.68       | Seawall, pier, and marina structural repairs  | DPR         | 1 | 1 | 1  | 1 | 1  | -1 | 1  | 0        | 1            | 0                    | 6                    | High           |
| MH.P.69       | Upgrades to DPR building systems  | DPR         | 1 | 1 | -1 | 1 | 1  | 0  | 1  | 0        | 0            | 0                    | 4                    | Medium         |
| MH.P.70       | COOP trailer compound   | DSNY        | 1 | 1 | -1 | 1 | 0  | 0  | 0  |          | 1            | 0                    | 3                    | Medium         |
| MH.P.71       | Industrial property upgrades  | EDC/BNYDC   | 1 | 1 | -1 | 1 | 1  | 1  | 1  | 0        | 0            | 0                    | 5                    | Medium         |
| MH.P.72       | Hardening Staten Island Ferry and private ferry terminals from climate change-related threats | EDC         | 1 | 1 | -1 | 0 | 0  | -1 | 1  | 1        | 0            | 1                    | 3                    | Medium         |
| MH.P.73       | Construction of new ferry landings to support private ferry services                          | EDC         | 1 | 1 | -1 | 1 | 0  | -1 | 0  | 1        | 0            | 0                    | 2                    | Medium         |
| MH.P.74       | Waterfront fueling facilities   | EDC         | 1 | 1 | -1 | 1 | 0  | -1 | 0  | 1        | 1            | 0                    | 3                    | Medium         |

**PRIORITIZATION OF POTENTIAL MITIGATION ACTIONS**

**CHAPTER 4: MITIGATION STRATEGY**

| HMP Index No. | Mitigation Action   | Lead Agency | S | T | A  | P  | L  | Ec | Ev | TIMELINE | Project Cost | GOALS and OBJECTIVES | Prioritization Score | Prioritization |
|---------------|---|-------------|---|---|----|----|----|----|----|----------|--------------|----------------------|----------------------|----------------|
| MH.P.75       | Mobile ferry ticketing machines   | EDC         | 1 | 1 | -1 | 1  | 0  | -1 | 0  | 1        | 1            | -1                   | 2                    | Medium         |
| MH.P.76       | Use of the Staten Island Ferry's Austen Class vessels for East River Ferry service during weather-related disruptions | EDC/DOT     | 1 | 1 | -1 | 1  | 0  | -1 | 1  | 1        | 0            | 0                    | 3                    | Medium         |
| MH.P.77       | Storm shutters project  | FDNY        | 1 | 1 | 1  | 1  | 1  | 0  | 1  | 0        | 0            | 0                    | 6                    | High           |
| MH.P.78       | Backup communications carrier   | FDNY        | 1 | 1 | -1 | 1  | 1  | -1 | 0  | 0        | 0            | 0                    | 2                    | Medium         |
| MH.P.79       | Voice-over IP architecture  | FDNY        | 1 | 1 | 0  | 1  | -1 | 0  | 0  | 0        | 0            | 1                    | 3                    | Medium         |
| MH.P.80       | Next-generation satellite phones  | FDNY        | 1 | 1 | -1 | 1  | 1  | -1 | 0  | 0        | 0            | 0                    | 2                    | Medium         |
| MH.P.81       | FDNY facilities survey  | FDNY        | 1 | 1 | 0  | 1  | 0  | 0  | 1  | 0        | 0            | 0                    | 4                    | Medium         |
| MH.P.82       | FDOC cell phone coverage  | FDNY        | 0 | 1 | 0  | 0  | -1 | 0  | 0  | 0        | 0            | 0                    | 0                    | Low            |
| MH.P.83       | FDNY cable network  | FDNY        | 1 | 1 | 1  | 1  | 1  | 0  | 0  | 0        | 0            | 1                    | 6                    | High           |
| MH.P.84       | Spare radios  | FDNY        | 1 | 1 | 0  | 1  | 1  | 0  | 0  | 0        | 0            | 0                    | 4                    | Medium         |
| MH.P.85       | Home-work plans   | FDNY        | 1 | 1 | 1  | -1 | -1 | 0  | 0  | 0        | 0            | 0                    | 1                    | Medium         |
| MH.P.86       | Gas vendors   | FDNY        | 1 | 1 | 0  | 1  | 0  | 0  | 0  | 0        | 0            | -1                   | 2                    | Medium         |
| MH.P.87       | Cache of vaccinations   | FDNY        | 1 | 1 | 1  | 1  | -1 | -1 | 0  | 0        | 0            | -1                   | 1                    | Medium         |
| MH.P.88       | Urban search and rescue team  | FDNY        | 1 | 1 | 0  | 1  | 0  | 1  | 0  | 0        | 0            | 0                    | 4                    | Medium         |
| MH.P.89       | Coney Island Hospital HVAC  | HHC         | 1 | 1 | -1 | 1  | 0  | -1 | 0  | 1        | 0            | 0                    | 2                    | Medium         |
| MH.P.90       | Coney Island Hospital quick connects for critical systems   | HHC         | 1 | 1 | -1 | 1  | 0  | -1 | 0  | 1        | 1            | 1                    | 4                    | Medium         |
| MH.P.91       | Metropolitan Hospital HVAC  | HHC         | 1 | 1 | 0  | 1  | 1  | 0  | 0  | 1        | 0            | 1                    | 6                    | High           |
| MH.P.92       | Metropolitan Hospital quick connects  | HHC         | 1 | 1 | 0  | 1  | 1  | 0  | 0  | 1        | 0            | 1                    | 6                    | High           |
| MH.P.93       | Bellevue Hospital/critical systems protection   | HHC         | 1 | 1 | 0  | 1  | 1  | 0  | 0  | 1        | 0            | 1                    | 6                    | High           |
| MH.P.94       | Bellevue Hospital power quick connects  | HHC         | 1 | 1 | 0  | 1  | 1  | 0  | 0  | 1        | 1            | 1                    | 7                    | High           |
| MH.P.95       | Central Office Emergency Command Center (ECC) and alternate ECC   | HHC         | 1 | 1 | 0  | 1  | 1  | -1 | 0  | 1        | 1            | 0                    | 5                    | Medium         |

**PRIORITIZATION OF POTENTIAL MITIGATION ACTIONS**

**CHAPTER 4: MITIGATION STRATEGY**

| HMP Index No. | Mitigation Action   | Lead Agency               | S  | T | A  | P  | L  | Ec | Ev | TIMELINE | Project Cost | GOALS and OBJECTIVES | Prioritization Score | Prioritization |
|---------------|---|---------------------------|----|---|----|----|----|----|----|----------|--------------|----------------------|----------------------|----------------|
| MH.P.96       | Henry J. Carter Hospital improvements                           | HHC                       | 1  | 1 | -1 | 1  | 1  | 0  | 0  | 1        | 1            | 1                    | 6                    | High           |
| MH.P.97       | Outreach to residential building owners                         | HPD                       | 1  | 1 | -1 | 1  | 0  | 0  | 0  | 1        | 1            | 1                    | 5                    | Medium         |
| MH.P.98       | Flood protection for critical facilities                        | HRA                       | 1  | 1 | 1  | 1  | 0  | 1  | 1  | 1        | 0            | 1                    | 8                    | High           |
| MH.P.99       | Exploration of loss-reduction actions for landmarked properties | LPC                       | 1  | 1 | 1  | 1  | 1  | 1  | 1  | 0        | 0            | 0                    | 7                    | High           |
| MH.P.100      | Public education and outreach for landmarked buildings          | LPC                       | 1  | 1 | 1  | 1  | 1  | 1  | 0  | 0        | 0            | 1                    | 7                    | High           |
| MH.P.101      | Marine Parkway/Cross Bay Bridge mitigation master plan          | MTA (Bridges and Tunnels) | 1  | 1 | 0  | 1  | 1  | 0  | 0  | 1        | 0            | 1                    | 6                    | High           |
| MH.P.102      | Engineering flood studies at non-tunnel facilities              | MTA (Bridges and Tunnels) | 1  | 1 | 0  | 1  | -1 | 0  | 0  | 1        | 1            | 1                    | 5                    | Medium         |
| MH.P.103      | Far Rockaway depot green roof                                   | MTA (Buses)               | 1  | 1 | 1  | 1  | 1  | 1  | 1  | 1        | 1            | 0                    | 9                    | Medium         |
| MH.P.104      | Hazards/threats planning  | MTA (MNR)                 | 1  | 1 | 0  | 1  | 1  | 0  | 0  | 1        | 1            | 0                    | 6                    | High           |
| MH.P.105      | Fueling capabilities/backup for emergency response              | MTA (MNR)                 | 1  | 1 | 0  | 1  | 1  | 0  | 0  | 1        | 1            | 0                    | 6                    | High           |
| MH.P.106      | Penn Station access   | MTA (MNR)                 | 1  | 1 | 1  | 1  | 1  | 1  | 0  | 1        | 0            | 0                    | 7                    | High           |
| MH.P.107      | Harlem-125 Street Station improvements                          | MTA (MNR)                 | 1  | 1 | 1  | 1  | 1  | 1  | 0  | 0        | 0            | 0                    | 6                    | High           |
| MH.P.108      | Emergency management equipment                                  | MTA/LIRR                  | 1  | 1 | 1  | 1  | 1  | -1 | 0  | 1        | 0            | 1                    | 6                    | High           |
| MH.P.109      | NYCHA grounds, pavements, and drainage improvements             | NYCHA                     | 1  | 1 | -1 | 1  | 1  | 1  | 1  | 0        | 1            | 0                    | 6                    | High           |
| MH.P.110      | Category 4 distributed power-generation feasibility studies     | NYCHA                     | 1  | 1 | -1 | 1  | 1  | -1 | 0  | 1        | 0            | 0                    | 3                    | Medium         |
| MH.P.111      | Morrisania Air Rights   | NYCHA                     | -1 | 1 | -1 | -1 | 1  | -1 | 0  | 0        | 0            | 0                    | -2                   | Low            |
| MH.P.112      | NYCHA AC improvements   | NYCHA                     | 1  | 0 | -1 | 1  | 1  | 0  | -1 | 0        | 0            | 0                    | 1                    | Medium         |
| MH.P.113      | NYPD precinct facility protection                               | NYPD                      | 1  | 1 | 1  | 1  | 1  | -1 | 0  | 0        | 0            | 0                    | 4                    | Medium         |
| MH.P.114      | NYPD facility protection  | NYPD                      | 1  | 1 | 1  | 1  | 1  | -1 | 0  | 0        | 0            | 0                    | 4                    | Medium         |
| MH.P.115      | NYPD critical facilities protection                             | NYPD                      | 1  | 1 | 1  | 1  | 1  | -1 | 0  | 0        | 0            | 0                    | 4                    | Medium         |
| MH.P.116      | OCME unified agency command center                              | OCME                      | 1  | 1 | 1  | 1  | 1  | 1  | 1  | 0        | 1            | 0                    | 8                    | High           |
| MH.P.117      | Educational outreach to private sector                          | OEM                       | 1  | 1 | -1 | 1  | 1  | 0  | 0  | 0        | 0            | 1                    | 4                    | Medium         |

**PRIORITIZATION OF POTENTIAL MITIGATION ACTIONS**

**CHAPTER 4: MITIGATION STRATEGY**

| HMP Index No. | Mitigation Action  | Lead Agency       | S  | T | A  | P | L | Ec | Ev | TIMELINE | Project Cost | GOALS and OBJECTIVES | Prioritization Score | Prioritization |
|---------------|--|-------------------|----|---|----|---|---|----|----|----------|--------------|----------------------|----------------------|----------------|
| MH.P.118      | OEM facilities protection  | OEM               | 1  | 1 | -1 | 1 | 1 | 0  | 0  | 0        | 0            | 0                    | 3                    | Medium         |
| MH.P.119      | HAZUS-MH software  | OEM               | 1  | 1 | 1  | 1 | 1 | -1 | 1  | 1        | 0            | 0                    | 6                    | High           |
| MH.P.120      | Community Emergency Response Team (CERT) curriculum                  | OEM               | 1  | 1 | 1  | 1 | 1 | 1  | 0  | 1        | 1            | 1                    | 9                    | High           |
| MH.P.121      | Infrastructure systems modeling                                      | OEM               | 1  | 0 | 1  | 1 | 0 | 0  | 0  | 1        | 0            | 0                    | 4                    | Medium         |
| MH.P.122      | Loss estimation  | OEM               | 1  | 0 | 1  | 1 | 1 | 0  | 0  | 0        | 0            | 0                    | 4                    | Medium         |
| MH.P.123      | Natural hazard event database  | OEM               | 1  | 0 | 1  | 1 | 1 | 1  | 0  | 0        | 0            | 0                    | 5                    | Medium         |
| MH.P.124      | CERT collaboration with community groups                             | OEM               | 0  | 1 | 1  | 1 | 1 | 1  | 0  | 1        | 1            | 1                    | 8                    | High           |
| MH.P.125      | Ready New York update  | OEM               | 1  | 1 | 1  | 1 | 1 | 1  | 0  | 1        | 0            | 0                    | 7                    | High           |
| MH.P.126      | Public/private mitigation initiatives                                | OEM               | 1  | 1 | 0  | 1 | 1 | 0  | 0  | 1        | 0            | 1                    | 6                    | High           |
| MH.P.127      | Regional critical infrastructure mapping                             | OEM               | 1  | 0 | -1 | 1 | 1 | 0  | 0  | 1        | 0            | 0                    | 3                    | Medium         |
| MH.P.128      | Subway depths mapping  | OEM               | -1 | 0 | 1  | 1 | 1 | 0  | 0  | 1        | 0            | 0                    | 3                    | Medium         |
| MH.P.129      | Vegetation data  | OEM               | -1 | 0 | 1  | 1 | 0 | 0  | 0  | 1        | 0            | 0                    | 2                    | Medium         |
| MH.P.130      | Zoning for hazard-prone areas  | OEM               | 1  | 1 | -1 | 1 | 0 | 0  | 1  | 1        | 0            | 1                    | 5                    | Medium         |
| MH.P.131      | Mitigation public outreach   | OEM               | 1  | 1 | -1 | 1 | 1 | 0  | 1  | 1        | 1            | 1                    | 7                    | High           |
| MH.P.132      | Emergency Operations Center (EOC)                                    | OEM               | 1  | 1 | -1 | 1 | 1 | -1 | 1  | 1        | -1           | 1                    | 4                    | Medium         |
| MH.P.133      | OEM warehouse:   | OEM               | 1  | 1 | 0  | 1 | 1 | 1  | 0  | 1        | 0            | 0                    | 6                    | High           |
| MH.P.134      | New York City mitigation guide and education                         | OEM               | 1  | 1 | 1  | 1 | 1 | 1  | 1  | 1        | 1            | 1                    | 10                   | High           |
| MH.P.135      | Building community capacity  | OEM               | 1  | 0 | -1 | 1 | 1 | 1  | 0  | 1        | 1            | 0                    | 5                    | Medium         |
| MH.P.136      | Urban post-disaster housing site identification in New York City     | OEM               | 1  | 1 | 1  | 1 | 1 | 1  | 1  | 1        | 1            | 0                    | 9                    | High           |
| MH.P.137      | Executive decision-making guide for deployable post-disaster housing | OEM               | 1  | 1 | 1  | 1 | 0 | 1  | 1  | 1        | 1            | 0                    | 8                    | High           |
| MH.P.138      | Request for proposal for urban post-disaster housing                 | OEM               | 1  | 1 | 1  | 1 | 0 | 1  | 1  | 1        | 1            | 0                    | 8                    | High           |
| MH.P.139      | NYC Brownfield Incentive Grant (BIG) program                         | OER               | 1  | 1 | -1 | 1 | 1 | 0  | 1  | 1        | 1            | 1                    | 7                    | High           |
| MH.P.140      | Fuel advance warning system  | PANYNJ (Aviation) | 1  | 0 | 1  | 1 | 1 | 1  | 0  | 1        | 1            | 0                    | 7                    | High           |
| MH.P.141      | JFK Airport electrical system resiliency                             | PANYNJ (Aviation) | 1  | 1 | 0  | 1 | 1 | 0  | 0  | 0        | 0            | 0                    | 4                    | Medium         |
| MH.P.142      | LaGuardia Airport central electric substation                        | PANYNJ (Aviation) | 1  | 1 | 1  | 1 | 1 | 0  | 0  | 1        | 1            | 0                    | 7                    | High           |



**PRIORITIZATION OF POTENTIAL MITIGATION ACTIONS**

**CHAPTER 4: MITIGATION STRATEGY**

| HMP Index No. | Mitigation Action  | Lead Agency       | S  | T  | A  | P  | L  | Ec | Ev | TIMELINE | Project Cost | GOALS and OBJECTIVES | Prioritization Score | Prioritization |
|---------------|--|-------------------|----|----|----|----|----|----|----|----------|--------------|----------------------|----------------------|----------------|
| MH.P.143      | LaGuardia Airport electrical system enhancement  | PANYNJ (Aviation) | 1  | 1  | 1  | 1  | 1  | -1 | 0  | 1        | 0            | 0                    | 5                    | Medium         |
| MH.P.144      | LaGuardia Airport power system redundancy  | PANYNJ (Aviation) | 1  | 1  | 1  | 1  | 1  | -1 | 0  | 0        | 0            | 0                    | 4                    | Medium         |
| MH.P.145      | JFK Airport power system redundancy  | PANYNJ (Aviation) | 1  | 1  | 1  | 1  | 1  | -1 | 0  | 1        | 0            | 0                    | 5                    | Medium         |
| MH.P.146      | Stewart Airport standby emergency generator: Provide power redundancy to allow for safe evacuation of the airport and the maintenance of limited operations during extreme weather events. | PANYNJ (Aviation) | 1  | 1  | 1  | 1  | 1  | 1  | 0  | 1        | 1            | 0                    | 8                    | High           |
| MH.P.147      | Stewart Airport power system redundancy  | PANYNJ (Aviation) | 1  | 1  | 1  | 1  | 1  | 1  | 0  | 1        | 0            | 0                    | 7                    | High           |
| MH.P.148      | JFK Airport fuel storage   | PANYNJ (Aviation) | 1  | 1  | 1  | 1  | 1  | 1  | -1 | 1        | 1            | 0                    | 7                    | High           |
| MH.P.149      | Intelligent Transportation System (ITS) at JFK and Newark Airports   | PANYNJ (Aviation) | 1  | 1  | 1  | 1  | 1  | -1 | 0  | 0        | 0            | 0                    | 4                    | Medium         |
| MH.P.150      | Emergency generator capacity for Red Hook and Howland Hook container terminals   | PANYNJ (Ports)    | 1  | 1  | 1  | 1  | 1  | 1  | -1 | 1        | 1            | 0                    | 7                    | High           |
| MH.P.151      | Lincoln Tunnel electrical and power system improvements  | PANYNJ (TBT)      | 1  | 1  | 1  | 1  | 1  | -1 | 0  | 1        | 0            | 0                    | 5                    | Medium         |
| MH.P.152      | George Washington Bridge (GWB) electrical and power system improvements  | PANYNJ (TBT)      | 0  | 1  | 1  | 1  | 1  | -1 | -1 | 1        | 0            | 0                    | 3                    | Medium         |
| MH.P.153      | GWB tower transformers   | PANYNJ (TBT)      | 1  | 1  | 1  | 1  | 1  | 1  | 0  | 1        | 1            | 0                    | 8                    | High           |
| MH.P.154      | Multi-facility real-time traffic information software  | PANYNJ (TBT)      | 0  | 1  | 1  | 1  | 1  | 1  | 0  | 0        | 0            | 0                    | 5                    | Medium         |
| MH.P.155      | Intelligent Transportation System (ITS) program  | PANYNJ (TBT)      | 0  | 1  | 0  | 1  | 1  | -1 | 0  | 0        | -1           | 0                    | 1                    | Medium         |
| MH.P.156      | Overhead electric infrastructure   | PSEG              | -1 | -1 | 0  | 0  | -1 | -1 | 0  | 0        | 1            | 1                    | -2                   | Low            |
| MH.P.157      | Storm damage mitigation  | PSEG              | -1 | 0  | -1 | -1 | 0  | 0  | 0  | 1        | 1            | 1                    | 0                    | Low            |
| MH.P.158      | SBS outreach   | SBS               | 1  | 1  | -1 | 1  | 1  | 1  | 0  | 0        | 0            | 1                    | 5                    | Medium         |
| MH.P.159      | Toolkit and training materials for volunteer groups  | SBS               | 1  | 1  | -1 | 1  | 1  | 1  | 0  | 0        | 0            | 1                    | 5                    | Medium         |

## PRIORITIZATION OF POTENTIAL MITIGATION ACTIONS

### CHAPTER 4: MITIGATION STRATEGY

| HMP Index No.         | Mitigation Action   | Lead Agency               | S  | T | A  | P | L  | Ec | Ev | TIMELINE | Project Cost | GOALS and OBJECTIVES | Prioritization Score | Prioritization |
|-----------------------|---|---------------------------|----|---|----|---|----|----|----|----------|--------------|----------------------|----------------------|----------------|
| MH.P.160              | Small business outreach   | SBS                       | 1  | 1 | -1 | 1 | 1  | 1  | 0  | 0        | 0            | 1                    | 5                    | Medium         |
| MH.P.161              | Hazard mitigation education for businesses                                    | SBS                       | 1  | 1 | -1 | 1 | 1  | 1  | 0  | 0        | 0            | 1                    | 5                    | Medium         |
| MH.P.162              | Ready New York materials  | SBS                       | 1  | 1 | -1 | 1 | 1  | 1  | 0  | 0        | 0            | 1                    | 5                    | Medium         |
| MH.P.163              | Toolkit and training materials for BIDs and LDCs on mitigation best practices | SBS                       | 1  | 1 | -1 | 1 | 1  | 1  | 0  | 0        | 0            | 1                    | 5                    | Medium         |
| MH.P.164              | Hazard mitigation seminar for BIDs and LDCs                                   | SBS                       | 1  | 1 | -1 | 1 | 1  | 1  | 0  | 0        | 0            | 1                    | 5                    | Medium         |
| MH.P.165              | Dissemination of hazard information   | SBS                       | 1  | 1 | -1 | 1 | 1  | 1  | 0  | 0        | 0            | 1                    | 5                    | Medium         |
| MH.P.166              | Rockaway Reformulation Study  | USACE/NYSDEC              | 1  | 1 | 1  | 1 | 1  | 0  | 1  | 1        | 0            | 0                    | 7                    | High           |
| MH.P.167              | T-groins at Coney Island  | USACE/NYSDEC              | 1  | 1 | 1  | 1 | 1  | 0  | 1  | 1        | 0            | 0                    | 7                    | High           |
| <b>Severe Weather</b> |   |                           |    |   |    |   |    |    |    |          |              |                      |                      |                |
| SW.P.1                | Protection of NYCDOT facilities from high winds                               | DOT                       | 1  | 1 | 0  | 1 | -1 | 0  | 0  | 0        | 0            | 0                    | 2                    | Medium         |
| SW.P.2                | Sign inspection program   | DOT                       | 0  | 1 | 1  | 1 | 1  | 1  | 0  | 1        | 1            | 0                    | 7                    | High           |
| SW.P.3                | Rooftop equipment protection at HRA facilities                                | HRA                       | 1  | 1 | -1 | 1 | -1 | 0  | 0  | 1        | 1            | 0                    | 3                    | Medium         |
| SW.P.4                | Bridge reinforcement  | MTA (Bridges and Tunnels) | 1  | 1 | -1 | 1 | -1 | 1  | 0  | 0        | 0            | 1                    | 3                    | Medium         |
| SW.P.5                | Increased line clearance tree trim program                                    | PSEG                      | -1 | 1 | -1 | 1 | 1  | 0  | 1  | 1        | 1            | 0                    | 4                    | Medium         |
| <b>Winter Weather</b> |   |                           |    |   |    |   |    |    |    |          |              |                      |                      |                |
| WS.P.1                | Improved snow and ice melt  | DOT                       | 0  | 1 | -1 | 0 | 1  | -1 | 1  | 1        | 1            | 1                    | 4                    | Medium         |
| WS.P.2                | Outreach to property owners on impacts of snow loads                          | OEM                       | 1  | 1 | 0  | 1 | 1  | 0  | 1  | 1        | 0            | 0                    | 6                    | High           |

### 5. Capability Assessment

The Capability Assessment describes the tools in the city's toolbox for implementing mitigation actions to reduce disaster losses. These tools can be grouped into the following categories: planning and regulatory, administrative and technical, financial, and education and outreach (see Figure 4.4).

Within those broad categories, New York City, through its various agencies and departments, has local policies, regulations, funding, and practices currently in place that will help facilitate its Mitigation Strategy. These mechanisms include: building and construction codes, floodplain management plans, land use plans, local laws and ordinances, master and comprehensive plans, and zoning and land use regulations.

The Planning Team and Steering Committee created the following four tables (Table 4.19 through Table 4.22) to describe New York City's current capabilities to implement mitigation actions. The tables contain the capability classification, agency responsible, description for each initiative or capability, and how it relates to hazard mitigation. The mechanisms described in these tables will serve to help implement many of the actions described in the HMP.

Figure 4.4: Capability Assessment Categories



Table 4.19: Planning and Regulatory Capabilities

| Capability Type: Ordinance/Plan/Regulation/Site Plan Review/Study | Agency | Description  | How does this capability address mitigation and risk assessment?   |
|---|--------|--|--|
| Ordinance   | DCP    | <b>Zoning Amendments:</b> DCP is responsible for zoning amendments that change the applicable use, bulk, and density regulations for a location or area. Since 2002, DCP has sponsored 80 area-wide rezoning projects that are adopted into law, covering approximately one sixth of the city. All rezonings are required to pass through the City Environmental Quality Review (CEQR). Many of the rezonings incorporate additional provisions for waterfront access and green spaces and hazard mitigation considerations, such as flood-resilience measures, where appropriate. | Several of these rezonings help mitigate the impact of the following hazards: coastal erosion, coastal storms/hurricanes, tornadoes/windstorms, extreme temperatures, earthquakes, flooding, winter storms, and infrastructure failures.                   |
| Ordinance   | DCP    | <b>Steep slope ordinances–Hillsides Preservation Districts; Special Natural Area Districts:</b> The City Planning Commission reviews site plans to maximize protection of natural areas, including reducing hillside erosion, landslides, and excessive stormwater runoff associated with development. This is accomplished through conserving vegetation and protecting natural terrain.  | Natural area preservation helps mitigate hazards such as flooding, coastal erosion, and hurricanes, as appropriate.  |
| Ordinance   | DCP    | <b>Zoning Resolution:</b> The Zoning Resolution sets forth the regulations governing land use and development. Articles I through VII contain the use, bulk, parking, and other applicable regulations for each zoning district.   | The Zoning Resolution helps promote green, sustainable land use and mitigates a wide range of hazards, including coastal erosion, coastal storms, severe weather, extreme temperatures, earthquakes, flooding, winter storms, and infrastructure failures. |
| Ordinance   | DCP    | <b>Flood Resilience Zoning Text Amendment:</b> This amendment encourages flood-resilient building construction throughout designated flood zones. The amendment removes regulatory barriers that would hinder or prevent the reconstruction of storm-damaged properties. It also enables new and existing buildings to comply with new, higher flood elevations issued by the Federal Emergency Management Agency (FEMA) and new requirements in the Building Code.  | The Flood Resilience Text Amendment addresses flooding and coastal storm hazards.  |
| Plan  | DCP    | <b>New York City Design Manual for Risk and Resilience: A Guide for New Construction and Retrofitting of Existing Buildings in Flood Zones:</b> This plan provides guidance for planning and design of new construction and retrofitting existing buildings in areas subject to flooding. Guidance mitigates property damage and life-safety dangers posed by structurally and superficially damaged buildings.  | The plan addresses the following hazards: flooding, coastal erosion, coastal storms, severe weather, and infrastructure failures.  |

## CAPABILITY ASSESSMENT

### CHAPTER 4: MITIGATION STRATEGY

| Capability Type:<br>Ordinance/Plan/<br>Regulation/Site<br>Plan Review/Study | Agency | Description   | How does this capability address mitigation and risk assessment?  |
|---|--------|---|---|
| Plan  | DCP    | <b>Vision 2020: New York City Comprehensive Waterfront Plan:</b> This 10-year plan for the future of the city's 520 miles of shoreline provides a sustainable framework for more water transport, increased public access to the waterfront, and economic opportunities that will help make the water part of New Yorkers' everyday lives.                          | The plan addresses the following hazards: flooding, coastal erosion, coastal storms, severe weather, and infrastructure failures.   |
| Plan  | DCP    | <b>Urban Waterfront Adaptive Strategies (UWAS):</b> This plan is a resource to help guide planners and policy makers in New York City and beyond in identifying and evaluating potential coastal protection strategies.   | The plan addresses the following hazards: flooding, coastal erosion, coastal storms, severe weather, and infrastructure failures.   |
| Plan  | DCP    | <b>Designing for Flood Risk:</b> This plan identifies key principles to guide the design of new buildings in flood zones to promote construction that can withstand coastal flood events and support the vibrancy of the urban public realm.  | The plan addresses the following hazards: flooding, coastal erosion, coastal storms, severe weather, and infrastructure failures.   |
| Site Plan Review  | DCP    | <b>City Planning Commission Discretionary Review:</b> In cases where discretionary action by the City Planning Commission is necessary, various borough and technical staff members review site plan applications for consistency with sound planning policy, environmental reviews consistent with CEQR guidelines, and any other relevant findings as applicable. | Discretionary reviews ensure consistency with environmental reviews and address a wide range of hazards, such as flooding, coastal erosion, and coastal storms.   |
| Ordinance   | DEP    | <b>Wildland-Urban Interface:</b> Bureau of Water & Sewer Operations enforces a 25-foot setback around vegetated areas, where possible, to help mitigate potential for wildfire in the Staten Island Bluebelt.   | This ordinance reduces impacts of wildfire on properties surrounding the Staten Island Bluebelt.  |
| Plan  | DEP    | <b>Guidelines for the Design and Construction of Stormwater Management Systems:</b> DEP is responsible for providing adequate draining services to the city. DEP also governs the construction of private sewers and drains to ensure compliance and adequate drainage capabilities.  | This plan ensures that new developments have adequate stormwater management systems to reduce pressure on City sewers.  |
| Plan  | DEP    | <b>Water Demand Management Plan 2021:</b> DEP plans for water shortage as a result of natural conditions and planned and unplanned infrastructure outage by identifying demand management strategies in government, residential, and commercial properties and by optimizing system operation to reduce water loss.   | This plan reduces overall in-city water consumption in advance of planned shutdown of Rondout-West Branch Tunnel as part of Water for the Future, and mitigates future natural and non-natural water shortages. |

## CAPABILITY ASSESSMENT

### CHAPTER 4: MITIGATION STRATEGY

| Capability Type:<br>Ordinance/Plan/<br>Regulation/Site<br>Plan Review/Study | Agency | Description   | How does this capability address mitigation and risk assessment?   |
|---|--------|---|--|
| Plan  | DEP    | <b>NYC Wastewater Resiliency Plan:</b> This comprehensive plan describes cost-effective strategies for reducing flooding damage to wastewater infrastructure and safeguarding public health and the environment. It examines buildings and infrastructure at DEP's 96 pumping stations and 14 wastewater treatment plants, identifying and prioritizing infrastructure that is most at risk of flood damage. It offers a set of recommended design standards and cost-effective protective measures tailored to each facility to improve resiliency in the face of future flood events. | This plan considers climate risk in capital planning and incorporates a design standard of the 100-year floodplain plus 30 inches of sea level rise in all new wastewater infrastructure projects. |
| Plan  | DEP    | <b>Maps of Right-To-Know Facilities:</b> DEP maps facilities with hazardous substances located within the FEMA 100 yr floodplain. Such maps may be used for planning purposes and as a resource to determine potential contamination during a flood event. These maps will be updated with the FEMA Preliminary Flood Insurance Rate Maps (FIRMs).  | These maps help focus facility-level planning and outreach in advance of coastal storms to mitigate flood risk.  |
| Plan  | DEP    | <b>NYC Green Infrastructure Plan:</b> This plan presents an alternative approach to improving water quality that integrates "green infrastructure," such as swales and green roofs, with investments to optimize the existing system and build targeted, cost-effective "grey," or traditional, infrastructure.   | Green infrastructure projects capture rainwater that would otherwise enter the combined sewer system, thereby reducing street flooding and combined sewer overflows (CSOs) in New York Harbor.     |
| Plan  | DEP    | <b>Water Shortage Operations Plan:</b> This plan is used during droughts to modify DEP procedures to maximize different water sources and prioritize leak detection programs that minimize water loss. It reviews hydrant-locking procedures to ensure areas with illegal hydrant use are compliant with water-use restrictions.  | This capability reduces the impact of natural and non-natural water shortages on the city's population and critical water-dependent operations.  |
| Plan  | DEP    | <b>Downstream Flooding Reduction Program:</b> This plan provides for the reduction of downstream flooding through attenuation of runoff; this is achieved by lowering reservoir elevation at a controlled rate in anticipation of forecasted storms and snow pack melting.  | This plan mitigates impacts of flooding caused by forecasted storms and snow pack melting.   |
| Plan  | DEP    | <b>Reservoir Release Notification Plan:</b> This plan provides for the notification of reservoir releases/spilling rates at predefined levels to all downstream counties' emergency management officials.   | This plan assesses and mitigates the impacts of reservoir releases on stream and river flooding of downstream communities.   |

## CAPABILITY ASSESSMENT

### CHAPTER 4: MITIGATION STRATEGY

| Capability Type:<br>Ordinance/Plan/<br>Regulation/Site<br>Plan Review/Study | Agency | Description   | How does this capability address mitigation and risk assessment?   |
|---|--------|---|--|
| Plan  | DEP    | <b>Drainage Plans for Areas Lacking Sewers:</b> These plans are developed to provide adequate storm and sanitary infrastructure for areas of the City lacking fully built-out sewer systems. Build out is concentrated in populated areas lacking existing infrastructure and areas where improvements or needs are identified.                                     | Sewer upgrades specified in these plans may increase system capacity, alleviating flooding.  |
| Plan  | DEP    | <b>Trunk Water Main Master Plans:</b> These plans provide for expansion and improvement of the water distribution system.   | Provides adequate water supply and fire protection for existing and future development.  |
| Regulation  | DEP    | <b>Land Use Regulations—Recreational Land Use Regulations:</b> These regulations govern the public recreational use of City-owned lands and waters.   | These regulations protect water quality in City reservoirs.  |
| Site Plan Review  | DEP    | <b>Site Plan Review Requirements—Site Connection Applications for New Developments:</b> The Bureau of Water and Sewer Operations (BWSO) issues certifications indicating the ability of existing sewers to accommodate increased usage to all new development projects. Certification is needed before a construction permit is issued.                             | These regulations ensure that the sewer system has the capacity to handle additional wastewater and stormwater flow from new developments.   |
| Ordinances/<br>Regulations  | DEP    | <b>Watershed Ordinance – Watershed Rules and Regulations:</b> DEP enforces and develops regulations to protect New York City's reservoirs from contamination from human activity and stormwater.  | These regulations protect water quality in City reservoirs.  |
| Study   | DEP    | <b>Hydrological/Hydraulic Studies—Reservoir Basin Hydrologic/Hydraulic Study:</b> DEP conducts H&H studies to confirm probable maximum precipitation and probable maximum flood for reservoir basins.   | These studies assess impacts of precipitation and flooding on reservoir operations and water quality.  |
| Study   | DEP    | <b>Hydrological/Hydraulic Studies – High Hazard Dams:</b> BWS maintains studies of its high hazard dams and dikes.  | These studies assess risk of dam failure, impacts to watershed communities, and impacts to in-city supply.   |
| Study   | DEP    | <b>Hydrological/Hydraulic Studies – Hydraulic Analyses of Problem Areas:</b> DEP performs hydraulic analyses of sewer systems in areas experiencing sewer problems to determine the need for and scope of future capital projects. These studies often occur before a drainage plan is developed and guide the determination of where improvements will be focused. | DEP's sewer construction program seeks to improve storm and wastewater drainage in areas lacking a fully built-out system or whose population and land use characteristics have changed significantly to warrant system reconstruction. Sewer upgrades may increase system capacity, alleviate flooding, and increase the reliability of the system. |

## CAPABILITY ASSESSMENT

### CHAPTER 4: MITIGATION STRATEGY

| Capability Type:<br>Ordinance/Plan/<br>Regulation/Site<br>Plan Review/Study | Agency | Description  | How does this capability address mitigation and risk assessment?  |
|---|--------|--|---|
| Study   | DEP    | <b>Capital Improvement Program – Sewer Construction:</b> DEP maps and studies areas of New York City to create a comprehensive plan for sewer upgrades.  | DEP's sewer construction program seeks to improve drainage and wastewater infrastructure in areas lacking a fully built-out system or whose population and land use characteristics have changed significantly to warrant system reconstruction. Sewer upgrades may increase system capacity, alleviate flooding, and increase the reliability of the system.   |
| Study   | DEP    | <b>Anticipate Future Vulnerabilities and Needs:</b> DEP assesses long-term and strategic goals, vulnerabilities, and opportunities for management of the water supply system for optimal dependability/reliability.  | These long-term and strategic goals, include hazard mitigation, resilience, regulatory reform, and dependability.   |
| Regulation  | DOB    | <b>New York City Construction Codes:</b> Patterned after the International Code Council (ICC) family of codes, the Construction Codes are updated on a 3-year cycle similar to the revision cycle of the ICC codes. This ensures the codes are updated regularly to the most recent safety and technological advances.   | Many mitigation strategies and goals—such as protecting public health and safety, preserving properties, sustaining a healthy environment, and disaster preparedness—can be achieved by applying the Codes to building construction and site preparation. The Codes address, to a certain extent, many of the risks identified, such as flooding, drought, extreme heat, earthquakes, high winds, and building collapses. |
| Regulation  | DOB    | <b>Plan Review Requirements:</b> Except for minor alterations and repairs, construction work generally requires a construction permit, which can only be obtained if the work is found to be in compliance with the Construction Codes. If an owner chooses not to have the project done by a NYS-registered design professional, the work must then be reviewed by a DOB plan examiner before a permit is given. DOB possesses an extensive plan review system to ensure lawful compliance with the City's Building Code, Electrical Code, Zoning Resolution, New York State Labor Law, and New York State Multiple Dwelling Law. | By ensuring construction work is designed in accordance with the Construction Codes and other applicable laws, buildings and properties are protected from a variety of hazards.  |
| Plan  | DPR    | <b>Parks Department Parkland Plans:</b> The Planning Division coordinates specific plans for new uses of parkland and for remediation of environmental damage.   | DPR planning staff have grant experience and experience remediating brownfields and other damaged sites.  |



## CAPABILITY ASSESSMENT

### CHAPTER 4: MITIGATION STRATEGY

| Capability Type:<br>Ordinance/Plan/<br>Regulation/Site<br>Plan Review/Study | Agency | Description   | How does this capability address mitigation and risk assessment?  |
|---|--------|---|---|
| Regulation  | DPR    | <b>Local Waterfront Revitalization Plans—Consistency Review:</b> Local discretionary actions, including those subject to land use (ULURP), environmental (CEQR) and Board of Standards and Appeals (BSA) review procedures, are reviewed for consistency with the New York City Waterfront Revitalization Program policies.                       | These regulations stipulate appropriate siting of waterfront infrastructure to reduce damage from hazard events.  |
| Site Plan Review  | DPR    | <b>DPR Site Plan Review:</b> The Forestry Division reviews site plans for capital work and ensures that all trees and horticulture are protected. Parks also reviews any work that might affect street trees and governs the removal or planting of any public tree in New York City.   | Protection of existing trees helps mitigate future events due to rainwater absorption, reduction of flooding, and other factors.  |
| Site Plan Review  | DPR    | <b>Tree and Horticulture Protection Site Plan Review:</b> The Forestry division reviews site plans citywide for capital work and ensures that all trees and horticulture are protected. The Capital division reviews plans for projects in parks to ensure the protection of trees and horticulture.  | Trained forestry staff review design and construction practices to ensure preservation of healthy trees to reduce risk and protect the environment.   |
| Plan  | EDC    | <b>Waterfront Vision and Enhancement Strategy (WAVES):</b> This plan establishes a set of 125 specific, high-priority projects for realizing New York City's waterfront and waterways as a world-class destination, a globally competitive port, and a rich and vital natural resource that draws all New Yorkers to its edge and onto the water. | Several of the goals identified in the WAVES agenda address hazard mitigation, including restoring the natural waterfront, improving water quality, enhancing water-borne transportation, and increasing climate resilience.                    |
| Ordinance   | FDNY   | <b>Fire Code:</b> Compiled and periodically revised by the Fire Department of New York (FDNY), the fire code deals with the operation and maintenance of buildings and fire safety systems, emergency planning and preparedness, regulation of hazardous materials, and regulation of businesses and activities involving fire safety concerns.   | The Fire Code revision process and adoption takes into account changing factors and lessons learned through experience and applied fire science. The code helps protect property from structural collapses, fires, and infrastructure failures. |
| Plan  | FDNY   | <b>Strategic Plans:</b> FDNY's Strategic Plans outline the goals and objectives deemed a priority for the Fire Commissioner and the Chief of the Department and guide the Department's planning, decision-making, and resource allocation.  | The Strategic Plans respond to the challenges anticipated in the coming decade, and the actions it plans to take to deter them, largely based on natural and non-natural hazards.   |

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### CHAPTER 4: MITIGATION STRATEGY

| Capability Type:<br>Ordinance/Plan/<br>Regulation/Site<br>Plan Review/Study | Agency | Description   | How does this capability address mitigation and risk assessment?  |
|---|--------|---|---|
| Plan  | FDNY   | <b>Community Wildfire Protection Plan:</b> This plan positions fire protection agencies, community leaders, and natural resource professionals to be better prepared to protect residents and natural resources from the negative impacts of wildfire.  | The plan enables the FDNY to deliver a planned, effective, and deliberate response to any wildfire and describes the impacts/damages associated with wildfires. |
| Plan  | FDNY   | <b>Continuity of Operations Plan (COOP):</b> In the event of a disaster, the FDNY would implement its COOP. The Department yearly updates the COOP for its major bureaus, including Fire Operations, EMS Operations, Bureau of Health Services, Communications, Fire Prevention, and Fire Investigations.   | COOP plans help ensure that the FDNY is able to perform emergency response operations during a disaster.  |
| Plan  | MTA    | <b>Evacuation Plans:</b> MTA's evacuation plans facilitate an orderly and efficient evacuation when ordered by the Mayor.   | These plans aid in the evacuation of populations who may or may not have access to a car and also reduces vehicular traffic congestion.                         |
| Plan  | MTA    | <b>System Shut Down Plan:</b> This plan affects an orderly shutdown of the system to protect employees and assets.  | This plan helps infrastructure failures as well as protect employees and customers.   |
| Plan  | OEM    | <b>Disaster Housing Recovery Plan:</b> This plan provides guidance for the implementation of interim housing and the restoration of permanent housing following a catastrophic event. It is a start-up kit, outlining coordination and communication of all participants involved in post-disaster housing recovery. It serves as a template for any jurisdiction to implement after a disaster.  | This plan guides the deployment of temporary housing after a disaster.  |
| Plan  | OEM    | <b>Community Recovery Playbook:</b> This playbook guides the use of Community Development Block Grants for Disaster Recovery by helping people and communities receive assistance as quickly as possible through block grant distributions. It contains a user-friendly catalog of 60 block-grant-funded programs that can form the basis for a comprehensive housing recovery effort and associated waivers. The Housing Group/State-Led Disaster Task Force/Recovery Authority can activate these programs immediately. | This playbook helps communities receive assistance after a disaster.  |

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| Capability Type:<br>Ordinance/Plan/<br>Regulation/Site<br>Plan Review/Study | Agency | Description   | How does this capability address mitigation and risk assessment?  |
|---|--------|---|---|
| Plan  | OEM    | <b>Housing Recovery Center Plan:</b> This plan provides a "one-stop-shop" for people who need housing assistance and other related services after a catastrophic event. It outlines the Concept of Operations for the entire Housing Recovery Center network so all participating service providers can efficiently provide housing recovery services. This plan is a scalable and flexible administrative and management system that is essential to coordinated and consistent operation of the housing recovery center(s). | This plan helps people in need of housing assistance after a disaster.  |
| Plan  | OEM    | <b>Participatory Urban Planning Toolkit:</b> This plan is a resource for coordinating emergency management response and recovery operations with non-governmental organizations. It contains a Participatory Urban Planning Interagency Task Force document with key roles and actions and a Communications Guide that facilitates recovery of the whole community.   | This plan helps non-governmental organizations receive help in response and recovery operations after a disaster. |
| Plan  | OEM    | <b>Continuity of Operations (COOP):</b> COOP plans ensure that City agencies can provide essential services to the public during emergencies while maintaining internal critical functions. Agencies are developing plans that build contingencies around essential services, mitigate the impact of disruptions to services, and enhance the ability to provide City Wide Incident Management System (CIMS) operations, social services, and government operations.  | These plans help minimize disruptions and allow agencies to continue critical services after a disaster.          |
| Plan  | OEM    | <b>Coastal Storm Plan:</b> This plan describes the citywide efforts before, during, and after a coastal storm event, particularly a hurricane. The plan contains components relating to decisions-making, sheltering, advance warning systems, logistics, public information, debris management, and post-disaster reconstruction.  | This plan guides the city's efforts in preparedness, response, and recovery for coastal storm events.             |
| Plan  | OEM    | <b>Flash Flood Plan:</b> This plan contains detailed procedures to mitigate the effects of inland flash floods on people and property and guides agency stakeholders through the decisions and actions that will be required before, during, and after such an event.   | This plan guides the city's efforts in preparedness, response, and recovery for inland flash floods.              |
| Plan  | OEM    | <b>Heat Emergency Plan:</b> This plan contains detailed procedures to mitigate the effects of extreme heat on critical infrastructure, at-risk populations, and New York City operations. The contents of the plan guide New York City stakeholders (including local and state agencies, the private sector, non-profits, and volunteer organizations) through the complex decisions that may be necessary during a heat emergency.   | This plan guides the city's efforts in preparedness, response, and recovery for extreme heat events.              |

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### CHAPTER 4: MITIGATION STRATEGY

| Capability Type:<br>Ordinance/Plan/<br>Regulation/Site<br>Plan Review/Study | Agency      | Description  | How does this capability address mitigation and risk assessment?   |
|---|-------------|--|--|
| Plan  | OEM         | <b>H1N1 Playbook:</b> This plan guides interagency support for a public health response to an H1N1 outbreak in New York City.  | This plan guides response to pandemic flu spread.  |
| Plan  | OEM         | <b>Earthquake Response Playbook:</b> This plan provides a framework for guiding and coordinating the City's initial (immediate hours and days) response to a major earthquake in the New York City area.   | This plan guides response to a major earthquake.   |
| Plan  | OEM         | <b>Winter Weather Emergency Plan:</b> This plan outlines procedures to reduce the hazardous effects of winter weather on general and at-risk populations. It details specific strategies for snow plowing and salt spreading on city streets and responding to incidents such as frozen fire hydrants, heat outages, and carbon monoxide emissions.  | This plan guides the city's efforts in preparedness, response, and recovery for winter storms.   |
| Plan  | OEM/<br>DCP | <b>Hazard Mitigation Plan (HMP):</b> The plan is a federally mandated compliance document required for update every five years to maintain eligibility for certain disaster recovery and future mitigation funding. DCP has partnered with OEM under a FEMA-funded grant to update the City's 2009 HMP.  | The HMP addresses a comprehensive list of identified hazards: coastal erosion, coastal storms, disease outbreaks, drought, earthquakes, extreme temperatures, flooding, severe weather, wildfires, winter storms, cyber threats, and infrastructure failures, along with chemical, biological, radiological, and nuclear releases. |
| Study   | OEM         | <b>Hurricane Evacuation Study and SLOSH Model:</b> SLOSH model for New York Basin determines which areas of New York City would be inundated in a coastal storm. The Hurricane Evacuation Study uses the model as a basis for understanding evacuation and sheltering behavior.  | The model and study guides planning, evacuation and sheltering operations as outlined in the Coastal Storm Plan.   |
| Plan  | OLTPS       | <b>PlaNYC:</b> The city's long-term, comprehensive sustainability plan focuses on improving the city's environment while accommodating an increase in population of almost one million people by 2030.   | PlaNYC helps the city prepare for population growth, combat climate change, and become more resilient to future hazards.   |
| Ordinance   | OLTPS       | <b>PlaNYC Green Building Task Force:</b> OLTPS will lead a task force that will develop amendments to the Building Code to incorporate climate change impacts.   | Amendments to the Building Code will make the built environment more resistant to future hazards.  |
| Plan  | SIRR        | <b>A Stronger, More Resilient New York:</b> This plan addresses how to create a more resilient New York City in the wake of Hurricane Sandy, with a focus on preparing for and protecting against the impacts of climate change. The report presents actionable recommendations for rebuilding the communities impacted by Sandy and increasing the resilience of infrastructure and buildings citywide. | This plan offers strategies to make New York City more resilient in the face of coastal storms, flooding events, and other climate changed-related effects.  |

Table 4.20: Administrative and Technical Capabilities

| Capability Type: Administration/ Staff/Technical | Agency | Description  | How does this capability address mitigation and risk assessment?  |
|--|--------|--|---|
| Administrative                                   | DCP    | <b>City Planning Commission:</b> This commission is responsible for the conduct of planning relating to the orderly growth and development of the city and its population, including adequate and appropriate resources for housing, business, industry, transportation, distribution, recreation, culture, comfort, convenience, disaster protection and recovery, and health and welfare.  | The Planning Commission helps promote green and sustainable land use, ensures consistency with environmental review, and considers mitigation actions that address a wide range of hazards, such as flooding, coastal erosion, and hurricanes, as appropriate.  |
| Staff  | DEP    | <b>Bureau of Water &amp; Sewer Operations (BWSO):</b> BWSO staff is responsible for the maintenance of sanitary, storm, and combined sewers. DEP inspects and cleans the city's 140,000 catch basins on a three-year cycle. The agency makes repairs to the sewer system as needed.  | Programmatic sewer and catch basin maintenance increases system capacity and reliability and reduces the risk and extremity of street flooding.   |
| Technical  | DEP    | <b>Watersheds Stream Maintenance:</b> DEP rehabilitates and stabilizes stream banks to mitigate turbidity as part of its filtration avoidance determination obligations in New York City watershed areas.  | Reduces impacts of extreme weather and flooding on water quality in City reservoirs.  |
| Administrative                                   | DOB    | <b>Floodplain Administrator:</b> The floodplain administrator has the capacity and responsibility to implement and enforce floodplain regulations that meet National Flood Insurance Program (NFIP) criteria.  | The floodplain administrator has the authority for issuing/denying floodplain development building permits, inspecting properties for floodplain compliance, assisting in the preparation of floodplain maps, and helping residents to obtain information on flood hazards, flood map data, and proper construction measures. After a flood, the administrator determines what damage has occurred. |
| Staff  | DOB    | <b>Department of Buildings (DOB):</b> DOB staff ensures the safe and lawful use of more than 950,000 buildings and properties through enforcing the City's Building Code, Electrical Code, Zoning Resolution, New York State Labor Law, and New York State Multiple Dwelling Law. DOB's activities include performing plan examinations, issuing construction permits, inspecting properties, and maintaining the Construction Codes and licensing trades. | DOB has the authority in ensuring code compliance and enforcing the rules and regulations related to hazards.   |
| Technical  | DOB    | <b>Advance Warning System:</b> This system provides advanced warning of wind and other weather hazards to registered construction superintendents, site safety managers, and the media.  | This system allows construction sites to take mitigating steps prior to the onset of hazardous weather.   |
| Administrative                                   | DOHMH  | <b>Commissioner's Orders:</b> DOHMH Commissioner issues orders related to the enforcement of the NYC Health Code.  | This capability helps enforce health codes that protect the health of New York City residents.  |

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### CHAPTER 4: MITIGATION STRATEGY

| Capability Type: Administration/ Staff/Technical | Agency | Description   | How does this capability address mitigation and risk assessment?   |
|--|--------|---|--|
| Technical  | DOHMH  | <b>BioWatch and Bio Threat Response Laboratory (BTRL) and Other Specimens Testing:</b> The Public Health Laboratory analyzes collected samples from BioWatch and trains others to assist in surge sampling. The BTRL operates in the public interest by testing samples/specimens deemed to pose a significant biological hazard of morbidity and mortality.                    | This capability helps protect the health of New York City residents.   |
| Technical  | DOHMH  | <b>Critical Complaint Response:</b> DOHMH responds to critical complaints related to environmental health. These complaints are routed to DOHMH from the 311 phone service.   | Critical Complaint Response allows for better response to public health-related hazards.   |
| Technical  | DOHMH  | <b>Public Beach Surveillance:</b> DOHMH provides surveillance of beach water (including specimen transport) and notifies the public of results.   | This capability helps protect the health of New York City residents.   |
| Technical  | DOHMH  | <b>Larval Adult Mosquito Surveillance and Control:</b> This DOHMH program provides larval surveillance and larvicide application to potential breeding sites. Performs mosquito population and arborvirus surveillance. Applies adulticide if human health or the quality of life is impacted.  | This capability helps protect New York City residents from mosquito-borne viruses.   |
| Technical  | DOHMH  | <b>Communicable Disease Surveillance and Investigation:</b> DOHMH's Bureau of Communicable Diseases analyzes electronic data from syndromic surveillance systems to detect citywide increases or clusters that may signify outbreak   | Surveillance and Investigation helps detect disease outbreaks.   |
| Staff  | DPR    | <b>City Park Drainage Maintenance:</b> The Central Technical Services Division and Borough Shops maintain catch basins and storm drains in all the city parks.  | Catch basin and drain maintenance reduces flooding.  |
| Staff  | DPR    | <b>Bronx River Natural Resources Group:</b> This group works in conjunction with the Bronx River Alliance, an associated non-profit, the focuses on the Bronx River.  | Wetlands absorb runoff and prevent flooding and damage to the built environment.   |
| Staff  | DPR    | <b>Central Forestry division:</b> This division oversees the block pruning and commitment-pruning program. Block pruning is done by contractors on a 7- to 8-year schedule and involves pruning all street trees on a block. Commitment pruning addresses emergency issues, such as tree limbs obscuring traffic signals. This division also performs in-park pruning of trees. | Pruning maintains tree health and reduces damage during extreme weather events by removing weak limbs that might otherwise harm people and property. |

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### CHAPTER 4: MITIGATION STRATEGY

| Capability Type:<br>Administration/<br>Staff/Technical | Agency | Description  | How does this capability address mitigation and risk assessment?   |
|--|--------|--|--|
| Technical  | FDNY   | <b>Coordinated Building Inspection and Data Analysis System (CBIDAS):</b> The Risk Based Inspection System (RBIS) collects and shares data on buildings in real time to prevent fires and protect firefighters. The FDNY's new Analytics Unit is working towards incorporating 13 different factors that will actively play a part in determining structures that pose the greatest risk to fires. | This system evaluates risk and improves the building inspection program by identifying at risk buildings and decreasing the likelihood of potential fires.   |
| Staff  | FDNY   | <b>Urban Search and Rescue (USAR):</b> FDNY's Urban Search and Rescue (USAR) teams have extensive training and experience in structural collapses, confined spaces, and high-angle rescues.  | Utilizing USAR teams in unique, challenging settings enables FDNY to guarantee a level of professionalism and a technically proficient force to meet the ever-changing disaster-like situations intermittently present in New York City. |
| Administrative   | MTA    | <b>Identification of Alternate Work Sites:</b> MTA identifies and maintains the availability of alternative work locations for executive decision-makers to participate in executive activities during an emergency in case current locations are unavailable or at risk.  | Ensures management can continue to function and lead during an emergency.  |
| Technical  | MTA    | <b>Advance Warning System:</b> This system monitors forecasts of wind speed to issue speed restrictions or ensure suspension of service for all elevated structures prior to major wind impact.  | Protects rolling stock, customers, and employees from possible harm during a high-wind event.  |
| Staff  | MTA    | <b>Survey Property for Areas Subject to Flooding:</b> MTA staff identifies and develops plans to protect against flooding under various weather scenarios.   | Identifies appropriate project locations to mitigate potential water intrusion projects.   |
| Staff  | NYPD   | <b>Life Safety and Site Security:</b> Mobilized officers respond to an incident, secure devastated regions, and ensure the safety and wellness of citizens.  | This capability aids response protocols.   |
| Staff  | NYPD   | <b>Search and Rescue Operations:</b> These operations are conducted primarily by personnel assigned to the Special Operations Division, including Emergency Services, Harbor, and Aviation personnel.  | This capability aids response protocols.   |
| Staff  | NYPD   | <b>Traffic Management:</b> This capability ensures the free flow of traffic to and from affected areas, assists stranded motorists when necessary, and performs escorts for critical relief supplies.  | This capability assists in minimizing transportation disruptions caused by a disaster and aids in disaster relief.   |
| Technical  | NYPD   | <b>Crime Suppression:</b> This capability ensures the safety and security of affected regions by suppressing opportunistic crimes.   | This capability helps protect the safety of New York City residents.   |

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### CHAPTER 4: MITIGATION STRATEGY

| Capability Type:<br>Administration/<br>Staff/Technical | Agency      | Description   | How does this capability address mitigation and risk assessment?   |
|--|-------------|---|--|
| Technical  | NYPD        | <b>Site Security and Force Protection:</b> This capability provides security and protection at important locations such as gas stations and critical infrastructure locations. Preserves evidence when necessary.   | This capability helps protect the safety of New York City residents.   |
| Staff  | OEM/<br>DCP | <b>Hazard Mitigation:</b> As part of the Hazard Mitigation Plan Grant, OEM and DCP have hired four new staff (two per agency) to help develop and manage the Hazard Mitigation Plan and associated projects, such as the New York City Design Manual for Risk and Resilience: A Guide for New Construction and Retrofitting of Existing Buildings in Flood Zones.   | The new staff helps ensure that the HMP profiles natural and man-made hazards, assesses the city's vulnerability to these hazards, and identifies and analyzes existing projects and proposed actions to lessen the impact from these hazards. |
| Staff  | OER         | <b>NYC Brownfield Partnership:</b> This partnership provides expert pro-bono environmental services.  | This capability helps facilitate hazardous waste clean-up of contaminated properties.  |
| Technical  | OEM         | <b>Sahana:</b> This database application gives the City of New York the ability to manage the complex tasks needed to activate and operate the Coastal Storm Plan sheltering system or any other response operation that requires a large number of staff deployed, messaged (via phone, email, text), and tracked among facilities. The Sahana system can also track clients of a facility or group of facilities discretely using a check-in/check-out system. Pre-events scenarios are loaded into the deployment module of the system to facilitate immediate staff contact for deployment. | This capability aids response protocols for New York City's sheltering system pre-disaster.  |
| Technical  | OEM         | <b>Notify NYC:</b> This warning system communicates localized emergency information quickly to city residents. This alert system includes the following types of notification types: emergency alerts, significant event notifications, public health notifications, public school closing/delay advisories, and unscheduled parking rules suspensions.   | This tool supports preparedness for New York City residents.   |
| Technical  | OEM         | <b>Special Needs Advance Warning System (AWS):</b> This advanced warning system is an all-hazards tool designed to push targeted information to individuals with special needs during hazardous weather, utility or transportation disruptions, public health emergencies, and incidents requiring evacuation. AWS is designed to alert individuals with special needs to these and other hazards that may affect their independence and ability to conduct their daily lives.  | This tool supports preparedness, disaster response, and post-disaster recovery.  |
| Technical  | OER         | <b>FAST (Financial Assistance Search Tool):</b> This tool helps the public find grants and other financial assistance for environmental investigation and cleanup in New York City.   | This capability helps facilitate hazardous waste clean-up of contaminated properties.  |



Table 4.21: Financial Capabilities

| Capability Type: Financial (Local, State, Federal) | Agency | Description  | How does this capability address mitigation and risk assessment?   |
|--|--------|--|--|
| Federal  | FEMA   | <b>Public Assistance Grant Program (PA):</b> (website provided at the end of chapter 4) This grant assists states, tribes, local governments and certain private nonprofit (PNP) organizations with response to and recovery from major emergencies or disasters declared by the President of the United States under the Stafford Act. Through the PA Program, FEMA provides supplemental federal disaster grant assistance for debris removal, emergency protective measures, and the repair, replacement, or restoration of disaster-damaged public-owned facilities and facilities of certain PNP organizations. | The PA program also encourages protection of these damaged facilities from future events by providing assistance for hazard mitigation measures during the recovery process. |
| Federal  | FEMA   | <b>Section 406:</b> (website provided at the end of chapter 4) These grants assist the restoration of facilities that have sustained damage due to a presidentially declared disaster. It also funds mitigation measures in conjunction with the repair of disaster-damaged facilities. The grants apply to parts of the facility that were damaged by a disaster and to mitigation measure that provide protection from subsequent events.  | Section 406 provides funding for mitigation measures for disaster-damaged facilities.  |
| Federal  | FEMA   | <b>Hazard Mitigation Grant Program (HMGP):</b> (website provided at the end of chapter 4) Grants under this program assist in implementing long-term hazard mitigation measures following presidential disaster declarations. The purpose of the grant program is to reduce the loss of life and property due to natural disasters and enable mitigation measures to be implemented during the immediate recovery from a disaster. HMGP is distinct from Section 406 because funds can be applied to undamaged parts of a facility.  | HMGP provides funding for mitigation actions and strategies.   |
| Federal  | FEMA   | <b>Pre-Disaster Mitigation (PDM):</b> (website provided at the end of chapter 4) These grants provide funds on an annual basis for hazard mitigation planning and the implementation of mitigation projects prior to a disaster. The goal of the PDM program is to reduce overall risk to the population and structures while reducing reliance on federal funding after disaster declarations.  | PDM provides funds to mitigation projects prior to a disaster.   |
| Federal  | FEMA   | <b>Flood Mitigation Assistance (FMA):</b> (website provided at the end of chapter 4) This grant provides funds on an annual basis so that measures can be taken to reduce or eliminate the risk of flood damage to buildings insured under the National Flood Insurance Program (NFIP).  | These funds help reduce flood-related damages to property.   |

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| Capability Type: Financial (Local, State, Federal) | Agency   | Description  | How does this capability address mitigation and risk assessment?  |
|--|--|--|---|
| Federal  | U.S. Department of Housing and Urban Development | <b>Community Development Block Grant—Disaster Recovery Assistance (CDBG-DR):</b> (website provided at the end of chapter 4) This grant provides flexible funds to help cities, counties, and states recover from presidentially declared disasters, especially in low-income areas, subject to availability of supplemental appropriations. Congress may appropriate additional funding for the CDBG program as Disaster Recovery grants to rebuild the affected areas and provide crucial seed money to start the recovery process. | CDBG-DR funds are used for recovery efforts involved in prevention of further damage to areas affected by disasters.  |
| Federal  | U.S. Department of Homeland Security             | <b>Urban Area Initiative Security Grant (UASI):</b> (website provided at the end of chapter 4) Program funds address the unique planning, organization, equipment, training, and exercise needs of high-threat, high-density urban areas, and assists them in building an enhanced and sustainable capacity to prevent, protect against, mitigate, respond to, and recover from acts of terrorism.   | UASI funds help mitigate the impacts from acts of terrorism.  |
| State  | MTA  | <b>Capital Program:</b> (website provided at the end of chapter 4) MTA's capital program identifies and prioritizes capital projects to be undertaken over a five-year period.   | Ensures mitigation projects are included in capital funding envelope.   |
| Local  | DPR  | <b>Capital Projects Division:</b> (website provided at the end of chapter 4) This division is responsible for capital improvements and reconstruction of playgrounds, structures, and parkland. The division currently has over \$1 billion in active restoration contracts. The Operations division assists with drafting of maintenance and operational agreements for new park developments such as the Highline.   | Capital architects and engineers and capital funds are available to assist with the design of mitigation projects.  |
| Local  | DEP  | <b>DEP's Capital Budget:</b> This budget is used to achieve and maintain a state of good repair for the water and wastewater infrastructure as well as address increased regulatory requirements.  | DEP's capital budget plans for future capital projects, including those cited in the HMP.   |
| Local  | DEP  | <b>Green Infrastructure Grant Program:</b> (website provided at the end of chapter 4) This program funds up to \$6 million in design and construction costs for green infrastructure projects that manage 1 inch of stormwater from the contributing impervious areas on private property in combined sewer areas of New York City.  | Green infrastructure projects capture rainwater that would otherwise enter the combined sewer system, reducing street flooding and CSOs in New York Harbor. |
| Local  | DEP  | <b>Water and Sewer Funds:</b> DEP's water and wastewater operating budget and debt service are paid by the New York City Water Board with revenue collected per water and sewer rates.   | Water and sewer funds represent the primary source of funding for DEP operations and capital improvements, including those cited in the HMP.                |

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| Capability Type: Financial (Local, State, Federal) | Agency | Description  | How does this capability address mitigation and risk assessment?                     |
|--|--------|--|--|
| Local  | FDNY   | <b>City Capital Budget:</b> City budget allocations for capital expenses for FDNY, including physical plant and large vehicle acquisitions.  | This capability allows for basic agency services, which includes emergency response. |
| Local  | FDNY   | <b>Grants:</b> City budget funds received via the competitive grant application process from the federal and state governments and private and non-profit sources.   | This capability allows for basic agency services, which includes emergency response. |
| Local  | FDNY   | <b>Revenue:</b> City budget revenue that includes income sources such as payments received from FDNY ambulance transports and FDNY permit and license fees.  | This capability allows for basic agency services, which includes emergency response. |
| Local  | OER    | <b>NYC Brownfield Incentive Grant:</b> (website provided at the end of chapter 4) This program provides financial assistance to property owners seeking to investigate and clean up contaminated properties, as well as to community groups for public outreach, planning, and technical assistance. | This financial tool helps mitigate the impact of hazardous waste release.            |

**Table 4.22: Education and Outreach Capabilities**

| Capability: Education and Outreach | Agency | Description   | How does this capability address mitigation and risk assessment?  |
|------------------------------------|--------|---|---|
| Education and Outreach             | DOB    | <b>Floodplain Maps/Flood Insurance Studies:</b> As part of the National Flood Insurance Program (NFIP), New York City has adopted floodplain maps developed by FEMA. DOB provides bulletins, notices, and website information to communicate NFIP floodplain requirements.  | These communication tools inform the public of floodplain requirements and provide floodplain design training for design professionals. |
| Education and Outreach             | DPR    | <b>Recreation and Education Programming:</b> DPR's Recreation Division runs 34 recreation centers and provides extensive recreation and education programming. Its Urban Park Rangers provide classroom and on-site environmental programming and operate 10 Nature Centers. The Operations division runs educational programs promoting the use of marinas and the waterfront. DPR is also associated with non-profit partners such as the City Parks Foundation and Historic House Trust; these partners augment the agency's educational and cultural offerings. | Increasing public awareness of risk factors related to climate changes increases social resilience.                                     |
| Education and Outreach             | DEP    | <b>Annual Right to Know and Hazardous Awareness Communications:</b> DEP conducts annual Right to Know and Hazard Awareness Communications with its employees and submits SARA III reports that inform the public of any hazardous and toxic chemicals at DEP facilities.  | Reduces risk and mitigates impacts of hazardous materials release at DEP facilities.  |

## CAPABILITY ASSESSMENT

### CHAPTER 4: MITIGATION STRATEGY

| Capability: Education and Outreach | Agency | Description   | How does this capability address mitigation and risk assessment?   |
|------------------------------------|--------|---|--|
| Education and Outreach             | DEP    | <b>Right-to-Know Outreach:</b> This outreach provides recommendations (via palm card and email blast) to private and public facilities to address chemical safety and spill prevention during flood events.   | Educates staff at facilities about proper hazardous materials management procedures during flood events to reduce the risk of hazardous materials release.   |
| Education and Outreach             | DEP    | <b>Bureau of Public Affairs:</b> DEP's Bureau of Public Affairs is responsible for the agency's communications with the public, public officials, and members of the media. Public Affairs staff distributes valuable information about readiness, hazard mitigation, and response through in-person outreach, mailings, press releases, and events.  | The bureau educates the community about proper preparation for and response to hazards including flooding, drought, coastal storms, extreme weather, air contamination, and hazardous materials release.               |
| Education and Outreach             | FDNY   | <b>Fire Safety Education:</b> Fire safety education programs held by the Fire Safety Education Unit throughout the city are part of FDNY's fundamental mission of protecting the lives and property of New York City residents and visitors. The Fire Safety Education Unit's strategy to reduce fire deaths and injuries is to focus on prevention by identifying and rectifying unsafe behaviors. | Through these outreach programs, the FDNY is able to address fire safety issues and concerns throughout the city.  |
| Education and Outreach             | FDNY   | <b>CPR Training:</b> This training program equips New Yorkers with the skills to act in the event of cardiac arrest by offering free instruction across the five boroughs. The program, taught by certified FDNY EMS personnel, has successfully trained over 50,000 New Yorkers in CPR.  | Community CPR training guarantees public awareness of CPR and moves to increase the survival rate dramatically of those who experience cardiac arrest.   |
| Education and Outreach             | FDNY   | <b>Fire Code Outreach:</b> Contemporaneous with, and as part of the latest Fire Code revision process, the FDNY is hosting information sessions for all affected industries.  | By addressing industries impacted by Fire Code revisions, the FDNY is able to ensure understanding across the board for changes, promoting compliance that ultimately protects lives and property.                     |
| Outreach                           | RPA    | <b>Rebuild by Design Roundtables:</b> The Regional Plan Association (RPA) is partnering with the Municipal Art Society (MAS) and Van Alen Institute (VAI) in Phase III of Rebuild by Design, a competition launched by the President's Hurricane Sandy Task Force to identify and implement locally appropriate but regionally scalable design solutions to the region's resilience challenges.     | This capability promotes capacity building, education, and public outreach on key resiliency, rebuilding, and disaster preparedness issues.  |
| Education and Outreach             | MTA    | <b>Employee Hurricane Training:</b> All employees receive a communication early in hurricane season advising them to develop a hurricane plan with their families. It includes information on how to do this and what should be included.   | Most MTA employees will be expected to work before, during, and/or after a storm; this program ensures they are aware of the need to work out a plan in advance so their families will be safe while they are at work. |

**CAPABILITY ASSESSMENT**

**CHAPTER 4: MITIGATION STRATEGY**

| Capability: Education and Outreach | Agency | Description  | How does this capability address mitigation and risk assessment?   |
|------------------------------------|--------|--|--|
| Outreach                           | DOHMH  | <b>Translation and Interpretation:</b> DOHMH makes critical health information available to non-English-speaking (or less-English-proficient) New Yorkers through translation and interpretation.  | This capability prevents the spread of infectious diseases through education and outreach to vulnerable populations. |
| Education                          | DOHMH  | <b>Community and Government Relations:</b> Assists elected officials in responding to constituent issues/concerns and maintains communications with key external stakeholders during critical public health events.  | This capability promotes education and public outreach on public health matters.                                     |
| Education and Outreach             | DOHMH  | <b>Health Information Campaigns:</b> Raises the public's awareness of personal and community health topics and issues through leaflets, posters, bulletins, billboards, and electronic media.  | This capability promotes education and public outreach on public health matters.                                     |
| Education and Outreach             | DOHMH  | <b>Messaging, Communication, and News Media Relations:</b> DOHMH's External Affairs division communicates internally and externally via email messaging and DOHMH website; disseminates accurate and timely health information to the public through mass media. | This capability promotes education and public outreach on public health matters.                                     |
| Education and Outreach             | OEM    | <b>Ready New York:</b> This campaign encourages New Yorkers to be ready for all types of emergencies, develop a disaster plan, and keep informed about the hazards that may impact New York City.  | This program promotes preparedness for all hazards that may affect the city.   |
| Education                          | OER    | <b>Cleaning up New York City:</b> Educates the public about environmental investigation, environmental cleanup, and community protection and engagement during the cleanup process.  | This capability promotes education on the hazardous waste removal and cleanup process.                               |

**6. Emergency Planning and Operations:**

OEM has developed many plans and protocols that guide New York City's response to emergencies, from extreme weather to power outages. While the HMP focuses on the mitigation phase of emergency management, these other plans and protocols focus on preparedness, response, and recovery phases of a disaster. An understanding of citywide operations related to OEM's emergency plans helps inform the identification and implementation of mitigation strategies.

These operations are laid out in the City's Coastal Storm Plan (CSP), which details the City's response to a coastal storm but can be utilized to direct the response to other hazards. OEM is the overall lead for coordinating the CSP, evacuation operations, health and medical operations, sheltering, and regional coordination. OEM periodically maintains and updates the coastal storm plan to reflect lessons learned from previous events.

**Coastal Storm Plan**

In 2000, New York City first released its citywide plan for hurricanes. In 2006, the Coastal Storm Plan was updated to account for New York City's changing population and the lessons learned from Hurricane Katrina. The plan was re-designed to anticipate a Category 4 hurricane making landfall in Atlantic City, New Jersey—the worst-case scenario for a hurricane affecting New York City—and was activated for Hurricane Irene in 2011 and Hurricane Sandy in 2012. OEM continues to revise and improve the plan based on experience and new information.

The current CSP is New York City's blueprint for responding to coastal storms. It is flexible—readily tailored to the size and impact of any storm—and it is comprehensive. The plan is a series of sub-plans, each focusing on a different component: storm tracking and notification, decision-making, special needs advance warning, evacuation (including procedures used to evacuate at-risk populations such as homebound residents and residents of healthcare facilities), sheltering, commodity distribution, logistics, debris management, public information, recovery and restoration.

*Evacuation Operations*

OEM has a robust evacuation plan within the CSP that

coordinates New York City's many transportation agencies.

OEM has designated a series of coastal evacuation routes on major roadways throughout the Bronx, Brooklyn, Queens, and Staten Island. These routes are clearly signed to direct drivers out of evacuation zones and towards evacuation centers. The New York City Department of Transportation (DOT), in coordination with OEM, erects and maintains evacuation route signage. In an emergency, the New York City Police Department (NYPD) supports movement of traffic along these routes through designated traffic control post locations and pre-positioning of tow trucks to quickly clear obstructions.

OEM also works closely with the Metropolitan Transportation Authority (MTA) to plan for and implement enhanced subway and bus service during evacuations. These efforts are designed to increase capacity along routes serving evacuation zones and modify certain routes to improve subway and bus connections. In addition, MTA disseminates special messaging on buses and trains to direct people to evacuation centers.

OEM's Homebound Evacuation Operation addresses the evacuation of people with special needs who are not able to evacuate on their own. Working with New York City's 311 and 911 services, this effort categorizes people in need of assistance according to their level of mobility; transportation is arranged through either MTA Paratransit or the New York City Fire Department in conjunction with the Department of Education's Office of Pupil Transportation.

A key component of the evacuation operation is planning for shutdown of transit service and transportation facilities, which must be completed in time for the onset of tropical-storm-force winds (39 mph), otherwise known as zero-hour. OEM works with the National Weather Service to establish the zero-hour and use it to plan for shutdowns. To allow sufficient time to secure equipment, MTA subway service must cease hours prior to zero-hour.

The Regional Bridge and Tunnel Closure Protocol provides a framework for coordinated closure of the New York area's bridges and tunnels. This is crucial for en-

asuring the status of the road network and preventing incidents of stranded motorists. The protocol was developed in partnership with the 13 major bridge, tunnel, highway, and law enforcement agencies in New York and New Jersey and establishes a common understanding of closure practices, wind-speed thresholds, and messaging.

### **Healthcare Facility Evacuation Operation**

The healthcare facility evacuation operation is a critical sub-plan of the CSP because New York City has half of the healthcare facilities in New York State. In a worst-case scenario, up to 25 hospitals, 71 nursing homes, 39 adult care facilities, and 6 psychiatric hospitals—representing around 30,000 patients and residents—would be required to evacuate. A successful evacuation requires each facility to expend every effort and available resource. It also requires coordination and support among government agencies and partners.

In the Healthcare Facility Evacuation Plan, the goal is to begin the evacuation of healthcare facilities 72 hours before the onset of tropical-force winds and complete the operation within 48 hours. The evacuation is managed by the Healthcare Facility Evacuation Center (HEC), a tactical communications center that centralizes support for an ordered evacuation of healthcare facilities. Run by the New York State Department of Health with support from city, state, regional, and federal partners, the HEC supports evacuating healthcare facilities with information, resources, and troubleshooting. It finds beds for evacuating facilities when those facilities cannot locate beds through existing relationships, arranges transportation between facilities, provides guidance to receiving facilities on how to maximize their surge capacity, and troubleshoots evacuation issues.

### **Sheltering**

The CSP includes a Shelter Plan, which was designed to activate and manage a safe, accessible, secure, staffed, and supplied emergency shelter system to give refuge from coastal storms to more than 700,000 New Yorkers and visitors who are unable to find alternative shelter outside storm surge areas. The more than 400 shelters, 64 evacuation centers, and eight special medical needs

shelters are grouped into "solar systems" across the five boroughs, each consisting of one evacuation center and 5 to 10 hurricane shelters each.

This sheltering system is intended to be fully integrated and accommodating to the diversity of New Yorkers seeking shelter during an emergency. To that end, OEM has developed a number of plans and procedures that provide people with disabilities the opportunity to meaningfully access the system. This inclusive approach dictates that the City's emergency plans and supporting materials do not segregate the needs of and responses to people with disabilities into any separate and discrete "special needs" plan. Rather, the plans, operational guides and manuals, and accompanying training all contain components that address needs that people with disabilities will likely encounter during an emergency.

#### *Facilities:*

Upon arriving at an evacuation center, individuals complete a triage form used to determine how to best assist persons in need of an accommodation. Hurricane shelters support the needs of the majority of people with disabilities. If a shelter does not provide the level of accessibility a person needs, the individual may choose to be transported to a shelter that provides more suitable support. Accessible transportation is provided to everyone who needs it.

The eight special medical needs shelters are intended to shelter individuals whose needs exceed the capabilities of hurricane shelters but who do not require hospitalization. All are wheelchair-accessible. The New York City Health and Hospitals Corporation is responsible for the medical operations within the special medical needs shelters.

All staff is required to make sure that people with disabilities are able to safely enter the special medical needs shelter and access its services. To confirm the accessibility of their facility, staff is required to complete an accessibility checklist before opening the facility and use it to continually check accessibility during each shift. The checklist also requires that any accessibility issues be immediately addressed by the facility manager.

Signage indicating accessible areas of a shelter is provided to each facility, and specially designed signage encourages shelter residents to ask for any accommodation they may need. "Emergency communications boards" are also distributed to all the facilities in the shelter system. Containing pictures and symbols related to emergency situations and basic needs, these aids are used to help individuals who have difficulty communicating.

#### *Training:*

OEM has created a number of training programs to address issues related to people with disabilities and people with special needs. A suite of online and in-classroom training courses is available to all CSP staff types. Supplemental training and instructional videos can be made available in the event of an incident. These training opportunities address issues related to working with and accommodating people with disabilities and include general and specific communication tips for people with a variety of disabilities.

#### *Logistics:*

Since Hurricane Sandy there has been a doubling of supplies at special medical needs shelters, including wheelchairs, special medical needs cots, crutches, airway kits, bandage compress kits, diabetic testing kits, electrolytes kits, spill kits, first aid kits, and sphygmometer kits. Items to accommodate people with disabilities at general shelters include durable medical equipment such as wheelchairs and raised toilet seats with grab bars.

#### *Emergency Communication:*

New York City uses the Advance Warning System (AWS), a communication tool that sends emergency messages to agencies providing services to people with disabilities, seniors, and people with health vulnerabilities. The agencies then convey the information to their clients and contracted agencies. Through the AWS, emergency information is provided to individuals specific to their needs through trusted, pre-existing relationships. Often, the contact agency will play a role in an individual's emergency plan, providing an essential service that supports continued independence in

the community.

Although the AWS is extensive, some individuals who live independently in the community and are not affiliated with a service provider may not receive AWS communications. They are encouraged to sign up for Notify NYC to receive specialized emergency alerts and updates. Notify NYC messages can be received via text message, phone call, Twitter, Facebook, nyc.gov, and mayoral press releases.

#### *Animal Sheltering:*

The CSP provides for the co-location of companion and service animals (for example, guide dogs) with their owners in all hurricane shelters. Therefore, individuals with pets who do not have any other shelter options are allowed to bring their pets with them to hurricane shelters.

### **Regional Evacuation Coordination**

To address coordination with neighboring communities, OEM co-manages the NY-NJ-CT-PA Regional Catastrophic Planning Team (RCPT). The Team is part of the Regional Catastrophic Preparedness Grant Program (RCPGP), a U.S. Department of Homeland Security-funded initiative, which enhances regional catastrophic preparedness and continuity of operations in high-risk urban areas and their surrounding jurisdictions.

The goal of this program is to allow jurisdictions to determine how to improve their security and resilience by improving existing plans, building regional planning processes and planning communities, and linking operational needs to resources.

The RCPT has developed the *Regional Evacuation Coordination Plan*, which is designed to help improve the decision-making process for an evacuation by creating timelines and a framework for regional coordination during both forewarned and no-notice scenarios. The RCPT consists of subject matter experts, evacuation planners, and transportation coordinators throughout the NY-NJ-CT-PA region and is led by advisors from the Northern New Jersey Urban Areas Security Initiative (UASI) and New York City Urban Area Working Group



(UAWG). This regional planning process began in 2008 and was used as a model for more than 20 separate regional planning initiatives through the RCPGP. At the onset of and throughout a regional emergency, these multi-agency teams will coordinate their agencies to expedite response operations and avoid duplication of effort.

The RCPT has also developed the *Waterways Transit Database Model Tool*, a software-based planning tool designed to assist emergency managers in better understanding the passenger capacity of water-based transportation assets in the region during an emergency. It allows users to view data on landings and vessels, selecting origin and destination points and calculating maximum passenger throughput.

## 7. Post-Disaster Interim Housing for New York City

Housing loss is one of the biggest challenges that cities can face after a large-scale disaster. This is especially true for New York City, which, even under normal circumstances, has a critically short supply of housing. A catastrophic event in New York City could result in a demand for safe, affordable housing that far outstrips supply.

The federal government often deploys interim housing after disasters, but its current building types are not suitable for a dense, urban environment like New York City. To meet the need for interim housing that enables

OEM's first step in developing this prototype was to solicit the best ideas for interim urban housing—and also to publicize the need for such housing. In 2007 OEM held the "What If New York City..." Design Competition, challenging architects, designers, engineers, and planners to offer creative solutions for the design, manufacture, and delivery of multi-story, multi-family housing that could be removed after it was no longer needed or remain in place as permanent housing. Designs teams from around the world responded to the call, submitting hundreds of entries encompassing a wide range of proposals.

Drawing lessons from the best "What if" entries, OEM

**Figure 4.5: Rendering of Interim Housing Prototype by Garrison Architects**



city residents to stay close to home while long-term recovery begins, OEM created the Urban Post-Disaster Housing Prototype Program ([www.nyc.gov/what-ifnyc](http://www.nyc.gov/what-ifnyc)). The signature feature of the program is the construction of a prototype (see Figure 4.5) developed by OEM and the Department of Design and Construction (DDC) in collaboration with many other agencies and with funding from FEMA. This three-story multi-family interim housing prototype—to be assembled, tested, and demobilized in 2014—will demonstrate how post-disaster housing could successfully be used not only in New York but in cities across the country that might suffer disasters.

began working with innovative modular housing companies to explore how existing factories could produce housing designed for urban conditions. Since no single manufacturer can generate housing at the speed and scale that might be needed after a disaster in New York City, the agency sought to develop a way for the entire industry to supply units. Moreover, because different companies employ different designs and building systems, the agency opted for a flexible approach to design and production, rather than a single, standardized solution. In 2011, OEM and DDC developed the Urban Interim Housing Unit Performance Specification, which outlines requirements for post-disaster housing—en-

sure that all units meet the same high standards for safety, environmental quality, durability, and universal design—but does not stipulate what buildings should look like. In the event of a disaster, New York City, FEMA, and the United States Army Corps of Engineers (USACE) can use this Performance Specification to solicit housing from manufacturers. Because the Performance Specification is flexible, a great number of manufacturers will be able to produce housing that meets urban needs by working with the designs and systems they know best.

To test the Performance Specification and identify the main challenges of producing factory-built housing quickly, OEM worked with the Department of Buildings to create an expedited permitting procedure and engaged USACE as project manager for the construction of the prototype next to OEM headquarters. The structure that will be assembled and tested through 2014 is designed to use off-the-shelf parts and be easily replicable. Once the prototype is built, OEM will evaluate living conditions in the units through a study done with environmental psychology students in NYU-Poly's Sustainable Urban Environments program.

While the prototype will provide crucial information about design, manufacture, delivery, installation, operation, and demobilization of interim housing, it is critical to quickly identify specific sites where interim housing could go and how units will be arranged to restore neighborhoods. Of course, it is not possible to determine in advance all sites that would be available after a disaster. Therefore, OEM has developed several resources to identify sites both before an event and at the time of an event as well as facilitate collaborations between government and neighborhood residents. Together these resources contain the information needed to plan for, site, and construct interim housing:

- **Disaster Housing Recovery Plan.** This plan lays out early operations for an interim housing mission and includes a leadership structure and step-by-step process for initiating site selection.
- **Urban Interim Neighborhood Design Guidelines:** These guidelines analyze various site

types that might be available after a disaster and identify physical and regulatory factors that would allow housing to be placed quickly in New York City.

- **Neighborhood Recovery Study:** Developed with Pratt School of Architecture's Resiliency Adaptation Mitigation and Planning Studio, this study shows how the prototype being tested at OEM could be put in place to expedite recovery of 12 neighborhood types.
- **Participatory Urban Planning Toolkit:** The toolkit is designed to help government and community-based organizations plan collaboratively before and after hazard events.

Just as construction of the prototype will facilitate the implementation of deployable interim housing, so, too, will collaborative planning with communities. Since the goal is to use this housing to support neighborhood rebuilding after a disaster, OEM is engaging residents and communities in site selection. In 2014, OEM will conduct participatory workshops during which communities will consider suitable locations for temporary housing. The results of these workshops will be incorporated in future updates of the Hazard Mitigation Plan.

### Website Links:

#### FEMA Local Mitigation Plan Review Guide:

[http://www.fema.gov/media-library-data/20130726-1809-25045-7498/plan\\_review\\_guide\\_final\\_9\\_30\\_11.pdf](http://www.fema.gov/media-library-data/20130726-1809-25045-7498/plan_review_guide_final_9_30_11.pdf)

#### NYS DHSES Hazard Mitigation Standards:

<http://www.dhSES.ny.gov/oem/mitigation/documents/hazard-mit-plan-standards2012.pdf>

#### Public Assistance Grant Program (PA):

<http://www.fema.gov/public-assistance-local-state-tribal-and-non-profit>

#### Section 406:

<http://www.fema.gov/public-assistance-local-state-tribal-and-non-profit/hazard-mitigation-funding-under-section-406-0>

#### Hazard Mitigation Grant Program (HMGP):

<http://www.fema.gov/hazard-mitigation-grant-program>

#### Pre-Disaster Mitigation (PDM):

<http://www.fema.gov/pre-disaster-mitigation-grant-program>

#### Flood Mitigation Assistance (FMA):

<http://www.fema.gov/flood-mitigation-assistance-program>

#### Community Development Block Grant - Disaster Recovery Assistance (CDBG-DR):

[http://portal.hud.gov/hudportal/HUD?src=/program\\_offices/comm\\_planning/communitydevelopment/programs/drsi](http://portal.hud.gov/hudportal/HUD?src=/program_offices/comm_planning/communitydevelopment/programs/drsi)

#### Urban Area Initiative Security Grant (UASI):

<https://www.fema.gov/fy-2013-homeland-security-grant-program-hsgp-0#3>

#### MTA Capital Program:

<http://web.mta.info/capital/>

#### DPR Capital Projects Division:

<http://www.nycgovparks.org/opportunities/capital-projects>

#### DEP Green Infrastructure Program:

[http://www.nyc.gov/html/dep/html/stormwater/nyc\\_green\\_infrastructure\\_grant\\_program.shtml](http://www.nyc.gov/html/dep/html/stormwater/nyc_green_infrastructure_grant_program.shtml)

#### NYC Brownfield Incentive Grant:

<http://www.nyc.gov/html/oer/html/brownfield-incentive-grants/big.shtml>



# CHAPTER 5: PLAN ADOPTION



## 1. Overview

Formal plan adoption is a required part of the planning process and demonstrates New York City's commitment to fulfilling the mitigation goals and objectives outlined in the Plan. In addition to fulfilling the requirements of the Disaster Mitigation Act of 2000, the Mayoral adoption of the Hazard Mitigation Plan (HMP) establishes it as a policy for New York City that defines the actions agencies should take to comply with or implement the HMP.

### A. Plan Adoption Process

- Obtain "Approval Pending Adoption" status from New York State Division of Homeland Security and Emergency Services (DHSES) and the Federal Emergency Management Agency (FEMA).
- Draft an adoption resolution to meet plan requirements and demonstrate New York City's commitment to protect its residents and built environment from the effects of natural hazards.
- Adopt HMP through Mayoral Executive Order.

### B. FEMA Requirements Addressed in this Section

The OEM Hazard Mitigation Planning Team created a plan adoption strategy consistent with the process and steps presented in FEMA's [Local Mitigation Plan Review Guide](#) (2011) (website link provided at the end of chapter 4). This section satisfies the following FEMA requirement:

- **Requirement §201.6(c)(5):** [The local hazard mitigation plan *shall* include] documentation that the plan has been formally adopted by the governing body of the jurisdiction requesting approval of the plan.



FEMA

April 17, 2014

Ms. Susan A. Picarillo  
Deputy Director  
New York State Office of Emergency Management  
Building 22, Suite 101  
1220 Washington Avenue  
Albany, NY 12226-2251

Re: Approval of the City of New York, NY Hazard Mitigation Plan Update

Dear Ms. Picarillo:

I am pleased to inform you that Federal Emergency Management Agency (FEMA) Region II has approved the City of New York, NY Local Multi-jurisdictional Hazard Mitigation Plan. FEMA received the County adoption resolution on April 17, 2014 and has approved this plan for a period of five years from that date. This plan expires on April 17, 2019.

Our office conducted a review of the referenced plan in conformance with Title 44 Code of Federal Regulations (CFR) Part 201, *Mitigation Planning* and FEMA's *Local Mitigation Plan Review Guide*, the official guidance to develop and review new and updated mitigation plans. The Region's review is documented in the Local Hazard Mitigation Plan Review Tool dated March 30, 2014. The jurisdiction can use the information in this Review Tool to refine and update its plan.

With an approved and adopted plan, the jurisdiction is now eligible as a sub-grantee for project grants under FEMA's Hazard Mitigation Assistance programs, including the Hazard Mitigation Grant Program, the Pre-Disaster Mitigation and Flood Mitigation Assistance programs. It is important to note that mitigation activities are not automatically approved for grant funding but are simply eligible and must complete the grant application process.

Please inform The City of this approval. Also, note that jurisdictions that have approved mitigation plans are eligible for points under the National Flood Insurance Program's Community Rating System (CRS). Additional information regarding the CRS can be found at [www.fema.gov/business/nfip/crs.shtm](http://www.fema.gov/business/nfip/crs.shtm) or by contacting the local floodplain manager.

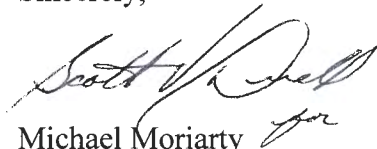
Ms. Susan A. Picarillo

April 17, 2014

Page 2 of 2

We commend the City of New York for taking this important step toward disaster resilience. If you have any questions, contact Scott Duell, Risk Analysis Branch Chief, at (212) 680-3630.

Sincerely,

A handwritten signature in cursive script, appearing to read "Scott Duell".

Michael Moriarty  
Director  
Mitigation Division

cc: Richard Lord, NY State Hazard Mitigation Officer  
New York State Office of Emergency Management





THE CITY OF NEW YORK  
OFFICE OF THE MAYOR  
NEW YORK, N.Y. 10007

EXECUTIVE ORDER No. 3

NEW YORK CITY HAZARD MITIGATION PLAN

April 15, 2014

WHEREAS, the Disaster Mitigation Act of 2000, Public Law 106-390 ("the Act"), establishes a national disaster hazard mitigation program to reduce the loss of life and property, human suffering, economic disruption, and disaster assistance costs resulting from natural disasters, and to assist state, local and Indian tribal governments in implementing effective hazard mitigation measures designed to ensure the continuation of critical services and facilities after a natural disaster; and

WHEREAS, the Act requires such governments to develop hazard mitigation plans to identify the natural hazards that could impact their jurisdictions, identify actions and activities to mitigate the effects of those hazards, and establish a coordinated process to implement such plans; and

WHEREAS, the Act requires local governments to update such plans every five years and submit such updated plans to the Federal Emergency Management Agency for approval; and

WHEREAS, the City of New York (the "City") has been and continues to be committed to reducing the loss of life and property, alleviating human suffering and economic disruption, and controlling disaster assistance costs resulting from all hazards and accelerating the City's recovery after the occurrence of any such hazard; and

WHEREAS, a Natural Hazard Mitigation Plan for the City of New York approved by the Federal Emergency Management Agency ("FEMA") was adopted pursuant to Executive Order No. 126, dated March 4, 2009; and

WHEREAS, the New York City Office of Emergency Management ("OEM"), in coordination with governmental and non-governmental stakeholders having an interest in reducing the impact of natural hazards throughout the City and with input from the private sector and other members of the public, has updated the Hazard Mitigation Plan for the City of New York, and

WHEREAS, such updated Hazard Mitigation Plan has been approved by FEMA subject to adoption by the City;

NOW, THEREFORE, by the power vested in me as the Mayor of the City of New York, it is hereby ordered:

Section 1. The updated 2014 Hazard Mitigation Plan developed by OEM and approved by FEMA is hereby adopted as the City's hazard mitigation plan pursuant to the Disaster Mitigation Act.

§ 2. OEM shall continue to be the agency responsible for monitoring, evaluating and updating the Hazard Mitigation Plan in accordance with the Disaster Mitigation Act.

§ 3. All agencies shall provide such assistance and cooperation as may be necessary or appropriate to implement the provisions of the Hazard Mitigation Plan and carry out the City's responsibilities under the Disaster Mitigation Act.

§ 4. This Order shall take effect immediately.

  
\_\_\_\_\_  
Bill de Blasio  
Mayor



# CHAPTER 6: PLAN MAINTENANCE



## 1. Introduction

This chapter describes the formal process that will ensure the Hazard Mitigation Plan (HMP) remains an effective and relevant document. It establishes the method and schedule for monitoring, evaluating, and revising the HMP during the five-year period leading to the release of an updated HMP in 2019. It also establishes how New York City will maintain community involvement in mitigation planning and the development of the HMP.

New York City's plan maintenance strategy is consistent with the process and steps presented in the Federal Emergency Management Agency (FEMA) [Local Mitigation Plan Review Guide](#) (2011) (website provided at the end of chapter 4). The following FEMA requirements are addressed in this chapter:

- **FEMA 44 CFR Requirement §201.6(c)(4)(i):** [The plan maintenance process *shall* include a] section describing the method and schedule of monitoring, evaluating, and updating the mitigation plan within a five-year cycle.
- **FEMA 44 CFR Requirement §201.6(c)(4)(ii):** [The plan *shall* include a] process by which local governments incorporate the requirements of the mitigation plan into other planning mechanisms such as comprehensive or capital improvement plans, where appropriate.
- **FEMA 44 CFR Requirement §201.6(c)(4)(iii):** [The plan maintenance process *shall* include a] discussion on how the community will continue public participation in the plan maintenance process.

## 2. Monitoring of Mitigation Actions in the HMP

The Hazard Mitigation Unit (HMU) at the New York City Office of Emergency Management (OEM) is the point of contact for hazard mitigation-related issues and serves as the lead coordinator for monitoring and updating the HMP. OEM will maintain adequate mitigation planning staff to support the HMU in its work on the HMP. In the first four years of the five-year HMP planning cycle (2014 to 2018), the HMU's work will include the following:

- Collect annual reports from agencies involved in implementing mitigation projects or activities identified in the Mitigation Strategy chapter of the HMP
- Maintain and update the mitigation action tables
- Participate in resiliency- and mitigation-related initiatives
- Conduct site visits and obtain reports of completed or initiated mitigation actions to incorporate into the next plan revision, as needed
- Research and document new disaster information pertaining to New York City and incorporate into a revised Risk Assessment section, as needed
- Organize annual meetings with Mitigation Planning Council (MPC) members to discuss relevant hazard mitigation issues, provide status updates, and discuss grant opportunities
- Conduct ongoing communication and coordination with the Planning Team
- Organize meetings with the Mitigation Planning Council Steering Committee (Steering Committee) to discuss relevant hazard mitigation issues, provide status updates, and discuss grant opportunities
- Coordinate, compile, and disseminate hazard mitigation funding information and applications

- Convene a meeting of the Steering Committee following a natural disaster or when funding is announced to prioritize and submit potential mitigation actions for funding
- Promote awareness of and spread information about hazard mitigation among local, regional, national, and international partners to forge relationships
- How are other citywide initiatives able to complement and support the Mitigation Strategy?
- Are the mitigation actions effective?
- Have funding opportunities influenced the description or analysis of the mitigation actions?
- Are there any changes in land development that affect mitigation priorities?

Beginning in March 2018, the HMU will reconvene the Planning Team and lead a more intensive planning effort to ensure New York City has an updated HMP by 2019. The HMU will be responsible for compiling, documenting, and incorporating all changes derived from the activities listed above in a revised plan document.

The HMU will work closely with the Mayor's Office of Long-Term Planning and Sustainability (OLTPS) to ensure that the maintenance cycle of the HMP is coordinated with the maintenance cycle for *A Stronger, More Resilient New York*, the City's resiliency plan, which will be updated every four years starting in 2015.

### 3. Evaluation of the HMP

The New York City HMP will be evaluated annually to determine the effectiveness of its projects, programs, and policies. The evaluation will result from scheduled meetings and review of materials in coordination with the Planning Team, Steering Committee, and MPC.

Annual meetings with the Steering Committee and MPC will examine any changes in City resources that may influence plan implementation, such as funding or changes in local, state, or federal policy. It is expected that ongoing Sandy recovery efforts will continue to inform and influence the HMP. These efforts, including many resiliency-focused efforts, may introduce planning and grant opportunities that directly relate to components of the HMP.

The Planning Team will work with the Steering Committee to review all sections of the plan and determine if any information should be updated or modified, given any new available data. The Planning Team will evaluate the content of the Plan using the following criteria:

- Are the goals, objectives, and mitigation actions relevant given any changes in New York City?
- Are the goals, objectives, and mitigation actions relevant given any changes to state or federal regulations or policies?
- Is there any new data that affects the Risk Assessment portion of the plan?

### 4. Update of the HMP

The next step for updating the plan includes the development of an abridged version of the 2014 HMP. The abridged plan will consolidate the information from 2014 HMP into a public-facing document that will be completed by fall 2014.

The Planning Team will update the HMP over the next five years in accordance with FEMA requirements (see Table 5.1). At the end of this planning cycle, the Planning Team will submit the updated 2019 HMP to the New York State Department of Homeland Security and Emergency Services (DHSES) and FEMA for review. After FEMA has approved New York City's 2019 HMP, the City will again formally adopt the plan by executive order.

Table 5.1: HMP Update Schedule

| Time Frame          | Participants                           | Outcome   |
|---------------------|--|---|
| September, 2014     | Planning Team                          | <ul style="list-style-type: none"> <li>Abridged HMP</li> </ul>  |
| First quarter 2015  | MPC, Steering Committee                | <ul style="list-style-type: none"> <li>Reconvene MPC to discuss mitigation action progress and possible plan improvements</li> <li>Reconvene Steering Committee to evaluate plan's effectiveness and application to existing planning mechanisms</li> </ul> |
| First quarter 2016  | MPC, HMU                               | <ul style="list-style-type: none"> <li>Reconvene MPC to discuss progress on mitigation actions</li> <li>Reconvene Steering Committee to evaluate plan's effectiveness and application to existing planning mechanisms</li> </ul>                            |
| Second quarter 2016 | OEM                                    | <ul style="list-style-type: none"> <li>Apply for grant funding for plan update</li> </ul>   |
| First quarter 2017  | MPC                                    | <ul style="list-style-type: none"> <li>Reconvene MPC to discuss mitigation action progress and possible plan improvements</li> <li>Reconvene Steering Committee to evaluate plan's effectiveness and application to existing planning mechanisms</li> </ul> |
| Second quarter 2018 | Steering Committee, MPC, Planning Team | <ul style="list-style-type: none"> <li>Reconvene Planning Team and begin plan update</li> <li>Coordinate monthly meetings with Steering Committee</li> <li>Reconvene MPC and schedule meetings with agencies as required</li> </ul>                         |
| Fourth quarter 2018 | NYS DHSES, Planning Team               | <ul style="list-style-type: none"> <li>Submit draft plan update to NYS DHSES for review and comments</li> </ul>   |
| First quarter 2019  | FEMA, Planning Team                    | <ul style="list-style-type: none"> <li>Submit plan to FEMA for final approval</li> </ul>  |
| First quarter 2019  | New York City                          | <ul style="list-style-type: none"> <li>Adopt the FEMA-approved HMP</li> </ul>   |

In addition to the HMP update cycle, the City also participates in a Cooperating Technical Partnership (CTP) with FEMA Region II, managed by the Mayor's Office of Long-Term Planning and Sustainability (OLTPS). The City provided FEMA with LiDAR data in 2010 to assist in the flood map update. The CTP began in 2011, with the goal of collaborating on flood hazard identification and working together to successfully reduce future risk by creating a climate of understanding and ownership of the mapping process at the local level.

### 5. Incorporating Hazard Mitigation into Existing Planning Mechanisms

As part of the local Capability Assessment, the Plan-

ning Team and Steering Committee identified current plans, programs, policies/ordinances, and studies/reports that will augment or help support mitigation planning. The New York City Capability Assessment is included in Section 5 of Chapter 4: Mitigation Strategy. The Steering Committee, which will meet on an annual basis, will ensure the City integrates hazard mitigation into its future planning activities. Following the 2014 HMP approval and adoption, the Steering Committee will work to incorporate, where applicable, the HMP into the planning mechanisms of New York City.

This work can include:

- Updating work plans, policies, or procedures to

include hazard mitigation concepts

- Establishing mitigation funding within capital and operational budgets
- Developing guidance on risk-reduction techniques
- Issuing plans, policies, regulations, or other directives to carry out mitigation actions
- Adding hazard mitigation elements to redevelopment and capital plans

Several examples (listed below) of how the Hazard Mitigation Plan will be incorporated into existing planning mechanisms include public outreach, education, research, policy, and zoning. The capabilities assessment, which identifies the City's planning, regulatory, administrative, technical, financial, and education tools, will ensure these projects are implemented. For further information on these actions and the capability assessment, see Chapter 4 Mitigation Strategy.

- **CS.E.1 (DCP) Urban Waterfront Adaptive Strategies report:** Provide a systematic assessment of the coastal flood hazards that face New York City, a thorough survey of coastal protection and adaptation strategies that may be suitable for different shoreline and neighborhood types, and a framework for evaluating coastal protection alternatives. The report is intended to serve as a resource for planners, policymakers, and communities within New York City, the region, and elsewhere in the coastal United States.
- **DO.E.4 (PSEG) Pandemic plan:** Provide guidance in the event of a pandemic outbreak in PSEG's service territory. This plan addresses prevention, response, and recovery due to a pandemic outbreak.
- **D.E.4 (DEP) Water Demand Management Plan and water shortage rules:** Adopt new plan to conserve water citywide and the rules to impose use restrictions during drought and emergencies.
- **F.E.2 (DCP) Designing for Flood Risk report:** Identify key principles to guide the design of new buildings in flood zones to promote construction that can not only withstand coastal flood events, but also supports the vibrancy of the public realm. Recognizing the distinct character and needs of higher-density urban environments, such as New York City, the report provides recommendations for how regulations and individual project design can incorporate resilient design principles.
- **F.E.63 (OLTPS) Comprehensive flood protection study of New York Harbor:** Continue to work with the USACE to complete its study.
- **MH.E.13 (DCP) Open Industrial Uses Study:** Promote a more sustainable and resilient working waterfront by assessing cost-effective, pollution-prevention controls for unenclosed industrial facilities. The study also recommends stronger safeguards for open activities and the storage of hazardous and non-hazardous materials along the waterfront and in flood zones.
- **MH.E.15 (DCP) Hazard mitigation planning and zoning:** Examine ways to incorporate hazard mitigation goals into City-sponsored rezoning initiatives. A number of rezonings with waterfront and floodplain components have been adopted, including Greenpoint/Williamsburg, Coney Island, and Hunter's Point. These rezonings incorporate goals established in the Waterfront Revitalization Program (WRP), increase open space along the waterfront, and encourage flood resilient construction in new development.
- **MH.E.52 (DOHMH) Public health risk communication for the general public:** Raise public awareness on how to reduce or prevent illness and mortality from extreme weather events and other environmental hazards including air pollution and environmental exposures (such as carbon monoxide releases, mold, toxic spills, and other toxic releases). Use 311, nyc.gov, printed materials, media, and public forums

and presentations.

- **MH.E. 120 (OEM) Public education through Ready New York guides:** Promote Ready New York guides as a tool to educate New Yorkers about natural hazards. This program offers all-hazards guides; hazard-specific guides for hurricanes, floods, and heat; and guides geared specifically for seniors and people with disabilities, children, and businesses. Guides contain information on how to mitigate, prepare for, and respond to an emergency and are offered in up to 14 languages as well as audio tapes and braille. In 2012 and 2013 OEM mailed over 2.2 million hurricane guides to households that lie in the city's hurricane evacuation zones.
- **F.P.2 (DCP) Flood Resilient Building Design Manual:** Provide guidance for planning and design of new construction and retrofit of existing buildings in areas subject to flooding. Guidance will mitigate property damage and life safety dangers posed by structurally and superficially damaged buildings.
- **F.P.3 (DCP) Zoning for flood-resistant construction, Phase I and II:** Make text amendments to modify zoning to encourage flood-resistant construction. The regulations would be consistent with updated flood area construction practices and the need for greater resilience in the larger flood zones established by FEMA.
- **F.P.11 (DOB) Post-disaster code enforcement:** Hire staff to enforce mitigation measures in Sandy rebuilding efforts, specifically in accordance with NFIP standards.
- **F.P.48 (OEM) Public information and guidance:** Disseminate mitigation information and help provide technical assistance to property owners affected by flood events.
- **MH.P.117 (OEM) Educational outreach to private sector:** Coordinate and provide educational outreach on mitigation strategies the private sector can use to reduce or eliminate the impacts of hazards on private-sector services and infrastructure. Opportunities to educate OEM's private-sector partners include conferences, OEM website, and presentations.
- **MH.P.123 (OEM) Natural hazard event database:** Create a natural hazard event database to capture description, severity, location, impact, and potential loss/damage estimates from events. Use data to update the hazard analysis and mitigation actions for New York City.
- **MH.P.126 (OEM) Public/private mitigation initiatives:** Support the resiliency of New York City's private sector through information sharing, partnership building, and education on mitigation principles and the City's HMP.
- **MH.P.130 (OEM) Zoning for hazard-prone areas:** Correlate natural hazard-vulnerable areas with existing zoning districts to identify areas where mitigation actions would be necessary to maintain responsible and sustainable development.
- **MH.P.131 (OEM) Mitigation public outreach:** Develop a mitigation guide and online training course for homeowners and property managers on risk reduction before and after a hazard event, and work with community-based organizations and non-governmental organizations to engage the community in advance of an emergency.
- **MH.P.134 (OEM) New York City mitigation guide and education:** Educate New Yorkers about hazard mitigation techniques that they can use to reduce long-term risks from natural hazards. Include a mitigation guide for homeowners and property managers; online training; flood-risk information; and CBO/NGO outreach—all to be incorporated into OEM's website.
- **MH.P.158 (SBS) SBS outreach:** Update SBS website with information on emergency preparedness and mitigation best practices, and



email-blast business and neighborhood organization customers to inform them of mitigation best practices and how to prepare for an upcoming hazard.

- **MH.P.162 (OEM) Ready New York materials:** Work with OEM to update/create Ready New York materials geared to businesses with information on mitigation actions.
- **MH.P.163 (SBS) Toolkit and training materials for Business Improvement Districts (BID) and Local Development Corporations (LDC) on mitigation best practices:** Partner with OEM to create toolkit and training materials to train BIDs and LDCs on mitigation best practices. BID representatives and AvenueNYC contract managers will partner with OEM to present on mitigation best practices at meetings in the field.
- **MH.P.164 (SBS) Hazard mitigation seminar for BIDs and LDCs:** Partner with OEM to hold annual seminar on hazardous mitigation best practices.

risdictions. Finally, OEM will send a notice to Citizen Corps members informing them of the plan update. This will provide the public with opportunities to express their concerns, opinions, or ideas about any updates/changes that are proposed in the plan.

## 6. Continued Public Involvement

New York City is dedicated to continued public involvement in hazard mitigation planning and in the HMP review process. During all phases of plan maintenance, the public will have the opportunity to provide feedback. The 2014 plan will be maintained and available for review on the OEM website until 2019. Individuals will have an opportunity to submit comments on the plan at any time by email. The HMU will compile all comments and present them at annual Steering Committee meetings, where members will consider them for incorporation into the next revision of the plan.

The City will publicize the draft of the 2019 plan update to encourage community involvement. Six months prior to the formal submission of the updated HMP, OEM will post the draft plan on its website and also post a notice requesting feedback on the draft plan. The Planning Team will hold community involvement meetings with representatives from academic institutions, the private sector, community groups, and neighboring ju-

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# APPENDIX A: MEETING DOCUMENTATION



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**Table A.1: MPC Meeting Invitees**

| <b>MPC Member Invitees</b>   |
|--|
| Amtrak*  |
| Consolidated Edison  |
| City University of New York (CUNY)                                       |
| Department of Cultural Affairs (DCA)*                                    |
| Department of Citywide Administrative Services (DCAS)                    |
| Department of City Planning (DCP)  |
| Department of Design and Construction (DDC)                              |
| Department of Environmental Protection (DEP)                             |
| Department for the Aging (DFTA)  |
| Department of Homeless Services (DHS)                                    |
| Department of Buildings (DOB)  |
| Department of Corrections (DOC)  |
| Department of Education (DOE)  |
| Department of Health and Mental Hygiene (DOHMH)                          |
| Department of Information Technology and Telecommunications (DoITT)      |
| Department of Transportation (DOT)                                       |
| Department of Parks and Recreation (DPR)                                 |
| Department of Sanitation (DSNY)  |
| Economic Development Corporation (EDC)                                   |
| Federal Emergency Management Agency (FEMA)                               |
| New York City Fire Department (FDNY)                                     |
| Health and Hospitals Corporation (HHC)                                   |
| Housing and Preservation Development (HPD)                               |
| Human Resources Administration (HRA)                                     |
| Housing Recovery Office (HRO)  |
| Long Island Power Authority (LIPA)                                       |
| Landmarks Preservation Commission (LPC)                                  |
| Mayor's Office   |
| Metropolitan Transportation Authority (MTA) New York City Transit (NYCT) |
| MTA Bus Company  |
| MTA Long Island Rail Road (LIRR)   |
| MTA Metro-North Railroad (MNR)   |
| MTA Bridges and Tunnels  |
| New York City Housing Authority (NYCHA)                                  |
| New York City Police Department (NYPD)                                   |
| New York State Office of Emergency Management (NYS OEM)                  |
| Office of the Chief Medical Examiner (OCME)                              |

APPENDIX A: MEETING DOCUMENTATION

|   |
|---|
| Office of Emergency Management (OEM)                            |
| Mayor's Office of Environmental Remediation (OER)               |
| Mayor's Office of Long Term Planning and Sustainability (OLTPS) |
| Office of Management and Budget (OMB)                           |
| Port Authority of New York and New Jersey (PANYNJ)              |
| Regional Plan Association (RPA)                                 |
| Small Business Services (SBS)                                   |
| United States Army Corps of Engineers (USACE)                   |

\*Invited but did not participate.

Table A.2: MPCSC Meeting Invitees

| MPCSC Member Invitees   |
|---|
| Department of City Planning (DCP)                               |
| Department of Environmental Protection (DEP)                    |
| Department of Buildings (DOB)                                   |
| Department of Transportation (DOT)                              |
| Department of Health and Mental Hygiene (DOHMH)                 |
| Department of Parks and Recreation (DPR)                        |
| New York City Fire Department (FDNY)                            |
| Housing Recovery Office (HRO)                                   |
| Metropolitan Transportation Authority (MTA)                     |
| New York City Police Department (NYPD)                          |
| Office of Emergency Management (OEM)                            |
| Mayor's Office of Long Term Planning and Sustainability (OLTPS) |
| Regional Plan Association (RPA)                                 |

Table A.3: Academic Meeting Invitees

| Academic Institutions Meeting Invitees Presentation November 18, 2013            |
|--|
| Columbia University - Center for Climate Systems Research                        |
| Columbia University - Graduate School of Architecture, Planning and Preservation |
| Columbia University - Mailman School of Public Health                            |
| Columbia University - Lamont Doherty Observatory*                                |
| City University of New York (CUNY) - Institute for Sustainable Cities*           |

## APPENDIX A: MEETING DOCUMENTATION

|  |
|--|
| Hunter College (CUNY) - Urban Affairs and Planning               |
| East Carolina University - Department of Geography               |
| Harvard University - Department of Urban Planning and Design     |
| Manhattan College - Department of Chemical Engineering Riverdale |
| NASA Goddard Institute for Space Studies                         |
| New York City College of Technology*                             |
| New York University (NYU) Center for Atmosphere Ocean Science*   |
| NYU Center for Urban Science + Progress                          |
| NYU Large Scale Emergency Response Project (LaSER)*              |
| NYU Wagner Graduate School of Public Service                     |
| NYU Polytechnic Institute  |
| Pratt Institute - Department of City and Regional Planning       |
| Stevens Institute of Technology                                  |
| SUNY Stony Brook: School of Marine and Atmospheric Sciences*     |

\*Invited but did not participate.

Table A.4: Private Sector Webinar Invitees

| Partners In Preparedness Invitees to Webinar November 13, 2013         |
|--|
| 500 Fifth Avenue Inc./Cushman & Wakefield*                             |
| ABC News*  |
| Active Health Management*  |
| Advanced Egress Solutions, Inc.*                                       |
| Advanced Teaching Initiative*  |
| The Advertising Council, Inc.*   |
| AMERICAN EAGLE FORCE-SERT*   |
| Allied Rockaway Foundation for Animal Recreation and Fitness (ARF-ARF) |
| American International Group Inc.*                                     |
| American Red Cross in Greater New York                                 |
| Anti-Defamation League*  |
| Association of Black Social Workers Senior Citizens Center*            |
| Association to Benefit Children*                                       |
| Bank of New York Mellon  |
| Bank of Tokyo-Mitsubishi UFJ, Ltd.*                                    |
| Bartolomeo Business Development Solutions Inc.*                        |
| Black Umbrella, LLC*   |
| BNP Paribas  |
| Bronx Council on the Arts*   |
| Bronxwood Home for the Aged, Inc.                                      |
| Brooklyn Bureau of Community Services                                  |
| Building Owners and Managers Association of Greater New York           |
| Caldwell Temple Soup Kitchen Paths*                                    |

| <b>Partners In Preparedness Invitees to Webinar November 13, 2013</b> |
|---|
| Catholic Charities, Archdiocese of New York*                          |
| CB Richard Ellis*   |
| Central Park Conservancy*   |
| Cert Brooklyn 10  |
| CERT Brooklyn 2   |
| Cert Manhattan 4  |
| Cert Manhattan 6  |
| CERT Rockaway Team CB 14*   |
| The Chapin School*  |
| The Church of Jesus Christ of Latter-day Saints*                      |
| CIBC World Markets  |
| City of New York FISA*  |
| The City University of New York-Central Office                        |
| Classic Security*   |
| CME Group   |
| CNA Insurance Company*  |
| Common Cents*   |
| Consolidated Edison Company of NY, Inc*                               |
| Cravath, Swaine & Moore LLP   |
| Croker Fire Drill Corporation*  |
| The Denelisse LHCSA*  |
| Deutsche Bank*  |
| Disney ABC Television   |
| The Doe Fund, Inc.*   |
| Douglas Elliman Property Management*                                  |
| Edison Properties, LLC*   |
| Ernst & Young, LLP*   |
| Experience Safety Training & Consulting*                              |
| The Fashion Institute of Technology*                                  |
| Federal Reserve Bank of New York*                                     |
| Food Bank For New York City*  |
| For My People Empowerment, Inc.*                                      |
| Fordham University  |
| Fort Greene Grant Square Center*                                      |
| Franklin Templeton Investments*                                       |
| Free Synagogue of Flushing*   |
| Grace Agard Hardwood Center*  |
| Hippodrome  |



**Partners In Preparedness Invitees to Webinar November 13, 2013**

|   |
|---|
| Hunton & Williams*  |
| Institute for Business and Safety                                   |
| Israel Discount Bank of New York*                                   |
| JB Solutions*   |
| Jennison Associates*  |
| JetBlue Airways*  |
| Jewish Community Relations Council*                                 |
| Kings Bay YM-YWHA, Inc.*  |
| Lambda Theta Alpha Latin Sorority, Inc. Lambda Eta Alumnae Chapter* |
| Liquidnet Holdings, Inc.*   |
| L'Oreal USA*  |
| Macy's  |
| Manhattan Dental Enterprise, PLLC*                                  |
| Marubeni America Corp   |
| Mass Mutual   |
| Master Plumbers Council*  |
| The McGraw-Hill Companies*  |
| Medical Reserve Corps   |
| Montefiore*   |
| Neighborhood Housing Services of New York City                      |
| New York Botanical Garden   |
| New York Cares*   |
| New York City Amateur Radio Emergency Communications Service        |
| New York Law School   |
| New York Life Insurance Company                                     |
| New York Liquidation Bureau   |
| The New York Naval Cadet Leadership Institute*                      |
| New York Rescue Response Team*                                      |
| New York State Department of Environmental Conservation (DEC)       |
| New York State Psychiatric Institute*                               |
| New York Stock Exchange Euronext*                                   |
| New York University*  |
| Nightwatch Services*  |
| NYC-ARECS   |
| NYC Department of Cultural Affairs (DCA)                            |
| NYC Clothing Bank   |
| NYC Department for the Aging*                                       |
| NYC Department of Education   |
| NYC Department of Transportation                                    |

| <b>Partners In Preparedness Invitees to Webinar November 13, 2013</b> |
|---|
| NYC Department of Youth and Community Development*                    |
| New York City Health and Hospitals Corporation (HHC)                  |
| NYC Taxi and Limousine Commission*                                    |
| NY-Waterway Ferry*  |
| Orrick, Herrington & Sutcliffe  |
| Paul Signs, Inc.*   |
| The Peninsula New York*   |
| Personal Continuity Group*  |
| Proskauer Rose LLP*   |
| PVH Corp.*  |
| RBC Capital Markets*  |
| Red Hook Senior Center*   |
| Remlu, Inc.   |
| Robert Couche Senior Center*  |
| The Rock Volunteer Ambulance Corps*                                   |
| RPM Warehouse & Transportation Co. Inc.*                              |
| RXR Realty  |
| SelectCare*   |
| Selfhelp Benjamin Rosenthal Prince Street Senior Center*              |
| Selfhelp Community Services, Inc.*                                    |
| Seventh-Day Adventist Church*   |
| Shearman & Sterling LLP   |
| Sheepshead Bay Surgery Center*  |
| The Silvercrest Center for Nursing and Rehabilitation*                |
| Skanska USA Civil Northeast*  |
| Sleepy's LLC*   |
| SL Green Realty*  |
| Société Générale*   |
| South Brooklyn Youth Consortium*                                      |
| Southwest Brooklyn Industrial Development Corporation (SBIDC)         |
| Spanish Speaking Elderly Council-RAICES*                              |
| Stanmore Media Group*   |
| State Capitol PD*   |
| St. John's University   |
| Systems Emergency Preparedness Integration Services*                  |
| Time Warner Cable   |
| Touro College*  |
| Trane*  |
| Trinity Real Estate   |

| <b>Partners In Preparedness Invitees to Webinar November 13, 2013</b> |
|---|
| Trump Organization*   |
| UBS AG*   |
| Union Square Partnership*   |
| United Way of New York City*  |
| Unity International Group*  |
| UrbanAmerica Advisors*  |
| U.S. Army Garrison and Fort Hamilton*                                 |
| USAG - Fort Hamilton*   |
| U.S. Commodity Futures Trading Commission*                            |
| U.S. Department of Labor*   |
| U.S. Geological Survey*   |
| Vera Institute of Justice*  |
| Visiting Nurse Service of NY*   |
| Wall Street Languages, Ltd. dba Rennert International*                |
| The Walt Disney Company   |
| Weil Gotshal & Manges LLP*  |
| Weill Cornell Medical College*  |
| WilmerHale*   |
| World Vision*   |
| Wyckoff Gardens Senior Center*  |
| Young Israel of Forest Hills Senior League*                           |
| Ziff*   |

\*Invited but did not participate

Table A.5: Non-Profit Organizations and Regional Partners invitees

| <b>Non-Profit Organizations and Regional Partners Meeting December 11, 2013</b> |
|---|
| Association for the Advancement of Blind and Retarded (AABR)*                   |
| Arch Care (health ministry of the Archdiocese of New York)                      |
| Beth Israel Medical Center  |
| Birch Family Services, Inc.*  |
| Broad Channel Volunteer Fire Department and Ambulance Corps*                    |
| Brookdale Hospital Medical Center   |
| New York CARES Inc.*  |
| Central Family Life Center, Inc.  |
| Cerebral Palsy Association of NYS*  |
| Continuum Health Partners*  |
| Guild for Exceptional Children*   |
| Hamaspik of Kings County  |

| Non-Profit Organizations and Regional Partners Meeting December 11, 2013 |
|--|
| Hebrew Academy for Special Children                                      |
| Intrepid Museum  |
| Jamaica Hospital Medical Center  |
| Jewish Community Council of Greater Coney Island, Inc.                   |
| Jewish Institute of Queens*  |
| Lutheran Medical Center  |
| Mercy Home for Children*   |
| National Society Hebrew Day Schools                                      |
| New York Hospital Queens   |
| New York Presbyterian Hospital   |
| NY eHealth Collaborative*  |
| NY Sandy Hook Pilots*  |
| Ohel Children's Home and Family Services                                 |
| Providence Rest*   |
| Queens Borough Public Library  |
| Regional Catastrophic Planning Grant Team                                |
| Rogosin Institute *  |
| Sea Gate Association*  |
| Services for the Underserved*  |
| Small Business Development Center-Staten Island*                         |
| St John's Univ.  |
| Unique People Services*  |
| Womens League*   |
| Wyckoff Heights Medical Center   |
| YAI Network  |

\*Invited but did not participate

Table A.6: Citizen Corp Council Invitees, September 17, 2013

| Citizen Corp Council Invitees September 17, 2013                  |
|---|
| 1020 Park Avenue Inc.   |
| 9/11 Memorial   |
| American Red Cross  |
| Association for Neighborhood and Housing Development, Inc. (ANHD) |
| BoonCont  |
| Brooklyn LTR  |
| Catholic Charities  |
| Community Dispute Resolution Centers (CDRC)                       |

**Citizen Corp Council Invitees September 17, 2013**

|   |
|---|
| Community Emergency Response Teams (CERT) Bronx 5               |
| CERT Queens 12/13   |
| CERT Brooklyn 7   |
| CERT Bronx 4  |
| CERT Queens 1   |
| CERT Queens 4   |
| CERT Manhattan 4/5  |
| CERT Manhattan 7  |
| CERT Manhattan 4/5  |
| CERT Manhattan 6  |
| CERT Manhattan 8  |
| CERT Port Richmond  |
| CERT Upper West Side  |
| UES CERT CB8  |
| Citi  |
| Citigroup   |
| CUNY  |
| Disaster Distress Helpline                                      |
| DOHMH   |
| Falconworks   |
| FEMA  |
| friends healing ministry, Inc.                                  |
| Friends of Rockaway   |
| Haitian-American Political Action Committee of New York (HAPAC) |
| NYC HRA   |
| IAEMSA-MCNY   |
| Japan Local Gov't Center  |
| Jewish Community Council (JCC) of Greater Coney Island          |
| Kingsboro Psychiatric Center (Canarsie Clinic OPD)              |
| Long Island University Brooklyn                                 |
| Medical Reserve Corps   |
| Metropolitan College of New York                                |
| Mutual of America   |
| Neighborhood Housing Services                                   |
| New York Disaster Interfaith Services (NYDIS)                   |
| NYC Department for the Aging                                    |
| NYC Parks Department  |

| Citizen Corp Council Invitees September 17, 2013                                 |
|--|
| NYC Administration for Children's Services (ACS)                                 |
| NYC Amateur Radio Emergency Communications Service (ARECS)                       |
| New York Presbyterian Hospital (NYP-Columbia)                                    |
| NYSDEC   |
| Pace University  |
| QUA INC  |
| Red Hook Coalition   |
| SCO Family of Services   |
| Securitas  |
| Shorefront YM-YWHA of Brighton-Manhattan Beach, Inc.                             |
| St John's Episcopal Hospital   |
| St. Bernard Project  |
| Tutor Perini Corporation   |
| U.S FDA  |
| Unitarian Universalist Central East Regional Group Disaster Response Coordinator |
| United Way   |
| US FDA   |
| Vocal-NY   |
| WHCR Emergency Broadcast Team (EBT)  |

Table A.7: Hazard Mitigation Planning Team Meeting Tracker

| Meeting # | Date             | Meeting Purpose         | Participants    | Notes   | Relevant Plan Section |
|-----------|------------------|-------------------------|-----------------|---|-----------------------|
| 1         | January 9, 2013  | Bi-weekly Planning Team | DCP, OEM, OLTPS | <ul style="list-style-type: none"> <li>●Discuss new federal and state requirements</li> <li>●Discuss planning for Steering Committee and Mitigation Planning Council (MPC)</li> </ul>   | Planning Process      |
| 2         | February 6, 2013 | Bi-weekly Planning Team | DCP, OEM, OLTPS | <ul style="list-style-type: none"> <li>●Discuss new federal and state requirements</li> <li>●Discuss planning for Steering Committee and MPC</li> <li>●Discuss hazard selection</li> <li>●Discuss work plan</li> </ul>  | All                   |
| 3         | March 13, 2013   | Bi-weekly Planning Team | DCP, OEM, OLTPS | <ul style="list-style-type: none"> <li>●Discuss planning for Steering Committee and MPC</li> <li>●Discuss hazard selection</li> <li>●Discuss work plan</li> </ul>   | All                   |
| 4         | March 20, 2013   | Bi-weekly Planning Team | DCP, OEM, OLTPS | <ul style="list-style-type: none"> <li>●Discuss new federal and state requirements</li> <li>●Discuss planning for Steering Committee and MPC</li> <li>●Discuss hazard selection</li> <li>●Discuss how city resiliency initiatives can be integrated in the HMP</li> </ul> | All                   |
| 5         | May 17, 2013     | Bi-weekly Planning Team | DCP, OEM, OLTPS | <ul style="list-style-type: none"> <li>●Discuss FEMA and NYS DHSES requirements for updating the HMP</li> <li>●Discuss Steering Committee and draft letter from commissioners from OEM and DCP</li> </ul>   | All                   |
| 6         | May 23, 2013     | Bi-weekly Planning Team | DCP, OEM, OLTPS | <ul style="list-style-type: none"> <li>●Discuss work plan schedule</li> <li>●Letter from commissioners and MPC Meeting Logistics</li> <li>●Updates on the <i>Flood Resiliency Design Manual</i></li> </ul>  | All                   |
| 7         | June 5, 2013     | Bi-weekly Planning Team | DCP, OEM, OLTPS | <ul style="list-style-type: none"> <li>●HMP logo/branding</li> <li>●HMP fact sheet</li> <li>●MPC kick off meeting agenda, presentation/messaging/DCP tasks</li> <li>●Discuss Steering Committee kick off meeting</li> </ul>   | Planning Process      |
| 8         | June 12, 2013    | Bi-weekly Planning Team | DCP, OEM, OLTPS | <ul style="list-style-type: none"> <li>●MPC kickoff presentation</li> <li>●HMGP grants</li> <li>●Logo and branding</li> </ul>   | Planning Process      |

APPENDIX B: MEETING DOCUMENTATION

| Meeting # | Date           | Meeting Purpose                                   | Participants                | Notes   | Relevant Plan Section                   |
|-----------|----------------|---|-----------------------------|---|---|
| 9         | June 17, 2013  | Bi-weekly Planning Team                           | DCP, OEM, OLTPS             | ●MPC kickoff presentation   | Planning Process                        |
| 10        | June 18, 2013  | MPC Kickoff                                       | MPC                         | ●SIRR presentation<br>●HMP overview and role of MPC<br>●Mitigation actions worksheet task     | All                                     |
| 11        | June 26, 2013  | Planning Team                                     | DCP and OEM                 | ●MPC mitigation actions task<br>●Steering Committee meeting<br>●Risk profile outline/deadline | All                                     |
| 12        | June 28, 2013  | Planning Team                                     | OEM and OLTPS               | ●OLTPS deliverables<br>●Timeline  | All                                     |
| 13        | July 19, 2013  | Planning Team                                     | OEM, DCP, OLTPS             | ●Steering Committee meeting agenda<br>●Goals & objectives<br>●Capabilities assessment         | Planning Process                        |
| 14        | July 24, 2013  | GIS/Planning Team                                 | OEM & DCP                   | ●Map template design<br>●Data consistency<br>●Hazus methodology                               | Risk Assessment                         |
| 15        | July 25, 2013  | CUNY's Mitigation Actions                         | OEM & CUNY                  | ●Discussion CUNY's mitigation actions<br>●Potential mitigation actions                        | Mitigation Strategy                     |
| 16        | July 26, 2013  | MPC Steering Committee Kick-off Meeting           | Steering Committee          | ●Select hazards<br>●Establish goals and objectives<br>●Discuss current capabilities           | Risk Assessment and Mitigation Strategy |
| 17        | July 26, 2013  | Flood Risk Assessment                             | OEM, DCP, OLTPS             | ●Discuss flooding hazard profile approach<br>●Divide tasks<br>●Review NYS DHSES requirements  | Risk Assessment                         |
| 18        | August 6, 2013 | DOHMH mitigation actions/Risk Assessment          | OEM, DOHMH                  | ●Discuss mitigation actions<br>●Discuss DOHMH resources for Risk Assessment                   | Risk Assessment<br>Mitigation Strategy  |
| 19        | August 8, 2013 | MTA Metro North Railroad (MNR) mitigation actions | OEM, MTA MNR                | ●Discuss mitigation actions   | Mitigation Strategy                     |
| 20        | August 9, 2013 | MTA Bridges and Tunnels mitigation actions        | OEM, MTA Bridge and Tunnels | ●Discuss mitigation actions   | Mitigation Strategy                     |
| 21        | August 9, 2013 | DEP mitigation actions                            | DEP & OEM                   | ●Discuss mitigation actions   | Mitigation Strategy                     |



APPENDIX A: MEETING DOCUMENTATION

| Meeting # | Date            | Meeting Purpose               | Participants    | Notes  | Relevant Plan Section               |
|-----------|-----------------|-------------------------------|-----------------|--|-------------------------------------|
| 22        | August 12, 2013 | RPA public outreach           | OEM, DCP, RPA   | <ul style="list-style-type: none"> <li>●Discuss public outreach strategies</li> <li>●Determine ways to leverage RPA's contacts and initiatives</li> </ul>                                      | Planning Process                    |
| 23        | August 12, 2013 | DPR mitigation actions        | DPR & OEM       | <ul style="list-style-type: none"> <li>●Discuss mitigation actions</li> <li>●Discuss Wild Fires hazard profile (occurrences and location)</li> </ul>   | Risk Assessment Mitigation Strategy |
| 24        | August 16, 2013 | DOC mitigation actions        | DOC & OEM       | <ul style="list-style-type: none"> <li>●Discuss mitigation actions and next steps</li> </ul>   | Mitigation Strategy                 |
| 25        | August 16, 2013 | USACE mitigation actions      | USACE & OEM     | <ul style="list-style-type: none"> <li>●Discuss mitigation actions and next steps</li> </ul>   | Mitigation Strategy                 |
| 26        | August 21, 2013 | DOB mitigation actions        | DOB & OEM       | <ul style="list-style-type: none"> <li>●Discuss mitigation actions and next steps</li> <li>●Discuss Risk Assessment Severe Weather and Earthquakes on the Built Environment</li> </ul>         | Risk Assessment Mitigation Strategy |
| 27        | August 21, 2013 | Bi- weekly Planning Team      | OEM, DCP, OLTPS | <ul style="list-style-type: none"> <li>●Updates on hazard profiles</li> <li>●Public outreach strategy</li> </ul>   | Planning Process<br>Risk Assessment |
| 28        | August 21, 2013 | FDNY mitigation actions       | FDNY & OEM      | <ul style="list-style-type: none"> <li>●Discuss mitigation actions</li> <li>●Discuss Wild Fires hazard profile (occurrences and location)</li> </ul>   | Risk Assessment Mitigation Strategy |
| 29        | August 22, 2013 | DoITT mitigation actions      | DoITT & OEM     | <ul style="list-style-type: none"> <li>●Discuss mitigation actions</li> <li>●Discuss Cyber Threats hazard profile</li> </ul>   | Risk Assessment Mitigation Strategy |
| 30        | August 22, 2013 | NYCHA mitigation actions      | NYCHA & OEM     | <ul style="list-style-type: none"> <li>●Discuss mitigation actions</li> <li>●Discuss vulnerability assessment for the Infrastructure Failures, Coastal Storms, and Flooding profile</li> </ul> | Risk Assessment Mitigation Strategy |
| 31        | August 22, 2013 | NYCEDC mitigation actions     | NYCEDC & OEM    | <ul style="list-style-type: none"> <li>●Discuss mitigation actions and next steps</li> </ul>   | Mitigation Strategy                 |
| 32        | August 26, 2013 | HRA mitigation actions        | HRA & OEM       | <ul style="list-style-type: none"> <li>●Discuss mitigation actions and next steps</li> </ul>   | Mitigation Strategy                 |
| 33        | August 26, 2013 | PANYNJ mitigation actions     | PANYNJ & OEM    | <ul style="list-style-type: none"> <li>●Discuss mitigation actions</li> <li>●Discuss Infrastructure Failures hazard profile</li> </ul>   | Risk Assessment Mitigation Strategy |
| 34        | August 27, 2013 | DOT mitigation actions        | DOT & OEM       | <ul style="list-style-type: none"> <li>●Discuss mitigation actions</li> <li>●Discuss Infrastructure Failures hazard profile</li> </ul>   | Risk Assessment Mitigation Strategy |
| 35        | August 27, 2013 | Con Edison mitigation actions | Con Ed & OEM    | <ul style="list-style-type: none"> <li>●Discuss Mitigation Actions</li> <li>●Discuss Infrastructure Failures hazard profile</li> </ul>   | Risk Assessment Mitigation Strategy |
| 36        | August 28, 2013 | LPC mitigation actions        | LPC & OEM       | <ul style="list-style-type: none"> <li>●Discuss mitigation actions and next steps</li> </ul>   | Mitigation Strategy                 |
| 37        | August 28, 2013 | HHC mitigation actions        | HHC & OEM       | <ul style="list-style-type: none"> <li>●Discuss mitigation actions and next steps</li> </ul>   | Mitigation Strategy                 |

APPENDIX B: MEETING DOCUMENTATION

| Meeting # | Date               | Meeting Purpose                              | Participants                                       | Notes  | Relevant Plan Section                  |
|-----------|--------------------|--|--|--|--|
| 38        | August 28, 2013    | DFTA mitigation actions                      | DFTA & OEM   | ●Discuss mitigation actions and next steps   | Mitigation Strategy                    |
| 39        | August 29, 2013    | DCAS mitigation actions                      | DCAS & OEM   | ●Discuss mitigation actions and next steps   | Mitigation Strategy                    |
| 40        | August 29, 2013    | DDC mitigation actions                       | DDC & OEM  | ●Discuss mitigation actions and next steps   | Mitigation Strategy                    |
| 41        | August 30, 2013    | SBS mitigation actions                       | SBS & OEM  | ●Discuss mitigation actions and next steps   | Mitigation Strategy                    |
| 42        | September 9, 2013  | DHS mitigation actions                       | DHS & OEM  | ●Discuss mitigation actions and next steps   | Mitigation Strategy                    |
| 43        | September 9, 2013  | Public outreach to Community Board           | MN Community Board 2 Environmental Committee & OEM | ●Discuss mitigation and resiliency efforts throughout the city to increase community awareness                                       | Mitigation Strategy                    |
| 44        | September 10, 2013 | Public outreach to private sector            | OEM (T&I) and OEM (Public Private)                 | ●Discuss strategies for public engagement with private sector (webinars and eblasts)   | Planning Process                       |
| 45        | September 10, 2013 | Public outreach to neighborhood groups       | OEM (T&I) and OEM (CERT)                           | ●Discuss strategies for public engagement with CERT Teams (Awareness Training and RNY Events)  | Planning Process                       |
| 46        | September 10, 2013 | OEM (Human Services Unit) mitigation actions | OEM (T&I) and OEM (Human Services)                 | ●Discuss state's requirements and OEM's strategies for evacuation of special needs communities, pets, and sheltering (ADA compliant) | Mitigation Actions                     |
| 47        | September 11, 2013 | OER mitigation actions                       | OER & OEM  | ●Discuss Mitigation Actions<br>●Discuss Risk Assessment for Hazardous Waste Release  | Risk Assessment<br>Mitigation Strategy |
| 48        | September 11, 2013 | Mitigation strategies OEM external affairs   | OEM (T&I) and OEM (External Affairs)               | ●Discuss External Affairs mitigation actions   | Mitigation Strategy                    |
| 49        | September 11, 2013 | Bi-weekly Planning Team                      | OEM, OLTPS, and DCP                                | ●Discuss public outreach<br>●Discuss Risk Assessment<br>●Discuss next Steering Committee meeting                                     | All                                    |
| 50        | September 11, 2013 | OEM (Watch Command) mitigation actions       | OEM (T&I) and OEM (Watch Command)                  | ●Discuss Watch Command mitigation actions<br>●Discuss Hazardous Waste release historic occurrence data                               | Risk Assessment<br>Mitigation Strategy |
| 51        | September 12, 2013 | MTA Buses mitigation actions                 | OEM and MTA (buses)                                | ●Discuss mitigation actions and next steps   | Mitigation Strategy                    |

APPENDIX A: MEETING DOCUMENTATION

| Meeting # | Date               | Meeting Purpose                                  | Participants   | Notes  | Relevant Plan Section |
|-----------|--------------------|--|--|--|-----------------------|
| 52        | September 12, 2013 | OEM (Strategic Data) mitigation actions          | OEM (T&I) and OEM (Strategic Data)                   | ●Discuss mitigation actions and next steps   | Mitigation Strategy   |
| 53        | September 13, 2013 | MTA LIRR mitigation actions                      | OEM and MTA (LIRR)                                   | ●Discuss mitigation actions and next steps   | Mitigation Strategy   |
| 54        | September 13, 2013 | OEM (Technology) mitigation actions              | OEM (T&I) and OEM (Technology)                       | ●Discuss mitigation actions and next steps   | Mitigation Strategy   |
| 55        | September 16, 2013 | DCP mitigation actions                           | OEM and DCP  | ●Discuss mitigation actions and next steps   | Mitigation Strategy   |
| 56        | September 16, 2013 | OEM (Human Services Unit) NYS requirements       | OEM (T&I) and OEM (Human Services Unit)              | ●Discuss NYS Requirement 3a and 3b (identify sites for temporary housing and potential sites for relocating housing) | Mitigation Strategy   |
| 57        | September 17, 2013 | OEM (Operations) mitigation actions              | OEM (T&I) and OEM (Operations)                       | ●Discuss mitigation actions and next steps   | Mitigation Strategy   |
| 58        | September 17, 2013 | OLTPS mitigation actions                         | OEM & OLTPS  | ●Discuss mitigation actions and next steps   | Mitigation Strategy   |
| 59        | September 17, 2013 | HMP status update with FEMA                      | OEM/OLTPS/FEMA                                       | ●Provide updates on the HMP Plan   | All                   |
| 60        | September 17, 2013 | Public outreach to Citizen Corps on Mitigation   | OEM/Citizen Corps                                    | ●Provide an overview of the Hazard Mitigation Plan Process   | All                   |
| 61        | September 18, 2013 | MTA (NYCT) mitigation actions                    | OEM/MTA (Subways) (HQ)                               | ●Discuss mitigation actions and next steps   | Mitigation Strategy   |
| 62        | September 18, 2013 | Interagency check-in with the Commissioner (OEM) | OEM Mitigation Team/T&I Director/ Commissioner Bruno | ●Provide updates on the HMP Plan   | All                   |
| 63        | September 18, 2013 | Bi-weekly Planning Team                          | OEM/DCP  | ●Check in for consistency on content for NYC's Hazard Environment and Flooding risk profile                          | Risk Assessment       |
| 64        | September 18, 2013 | OCME discussion on participating in the HMP      | OCME/OEM   | ●Provide an overview of the plan<br>●Discuss participation<br>●Discuss next steps                                    | All                   |

APPENDIX B: MEETING DOCUMENTATION

| Meeting # | Date               | Meeting Purpose              | Participants                 | Notes  | Relevant Plan Section               |
|-----------|--------------------|------------------------------|------------------------------|--|-------------------------------------|
| 65        | September 19, 2013 | OEM Special Needs Task Force | Special Needs Task Force/OEM | <ul style="list-style-type: none"> <li>● Provided an overview of the plan</li> <li>● Requested any information they may have on the impact of hazards on special needs populations for the risk assessment section</li> </ul>  | All                                 |
| 66        | September 23, 2013 | HPD mitigation actions       | OEM/HPD                      | <ul style="list-style-type: none"> <li>● Discuss mitigation actions and next steps</li> </ul>  | Mitigation Strategy                 |
| 67        | September 24, 2013 | LIPA mitigation actions      | LIPA/OEM                     | <ul style="list-style-type: none"> <li>● Discuss mitigation actions and next steps</li> </ul>  | Mitigation Strategy                 |
| 68        | September 30, 2013 | DSNY mitigation actions      | DSNY/OEM                     | <ul style="list-style-type: none"> <li>● Discuss mitigation actions and next steps</li> </ul>  | Mitigation Strategy                 |
| 69        | October 2, 2013    | Bi-weekly Planning Team      | OLTPS/OEM/DCP                | <ul style="list-style-type: none"> <li>● Go over Steering Committee presentation</li> <li>● Go over Steering Committee Risk Assessment Review Process</li> <li>● Public Outreach</li> </ul>  | Planning Process<br>Risk Assessment |
| 70        | October 3, 2013    | Steering Committee Meeting 2 | MPCSC                        | <ul style="list-style-type: none"> <li>● Review goals and objectives of the Hazard Mitigation Plan</li> <li>● Discuss final hazard selection</li> <li>● Overview of Risk Assessment: highlights of selected hazards</li> <li>● Discuss next steps for reviewing hazard profiles</li> </ul> | Risk Assessment                     |
| 71        | October 16, 2013   | Bi-weekly Planning Team      | OLTPS/OEM/DCP                | <ul style="list-style-type: none"> <li>● Review HMP timeline</li> <li>● Discuss mitigation actions</li> <li>● Overview of STAPLEE</li> <li>● Discuss prioritization of mitigation actions</li> <li>● Discuss upcoming meeting</li> </ul>   | Mitigation Strategy                 |
| 72        | November 1, 2013   | Bi-weekly Planning Team      | OLTPS/OEM/DCP                | <ul style="list-style-type: none"> <li>● Review HMP timeline</li> <li>● Steering Committee meeting prep</li> <li>● Private sector and academic prep</li> </ul>   | All                                 |
| 73        | November 6, 2013   | Steering Committee Meeting 3 | Steering Committee           | <ul style="list-style-type: none"> <li>● Mitigation Strategy</li> <li>● Analyzing and prioritizing mitigation actions</li> </ul>   | Mitigation Strategy                 |
| 74        | November 12, 2013  | Bi-weekly Planning Team      | OLTPS/OEM/DCP                | <ul style="list-style-type: none"> <li>● Review HMP timeline</li> <li>● Private sector and academic prep</li> </ul>  | All                                 |

APPENDIX A: MEETING DOCUMENTATION

| Meeting # | Date              | Meeting Purpose   | Participants  | Notes   | Relevant Plan Section |
|-----------|-------------------|---|---|---|-----------------------|
| 75        | November 13, 2013 | Private sector webinar                                  | OEM Partners in Preparedness                          | <ul style="list-style-type: none"> <li>● Overview of the HMP</li> <li>● Risk profiles - summary of select hazards</li> <li>● Mitigation action types</li> <li>● Timeline - public review</li> </ul> | All                   |
| 76        | November 18, 2013 | Academic outreach                                       | Columbia, Pratt, NYU, Hunter, CUNY etc.               | <ul style="list-style-type: none"> <li>● Overview of the HMP</li> <li>● Risk profiles</li> <li>● Mitigation action types</li> <li>● Timeline - public review</li> </ul>                             | All                   |
| 77        | December 4, 2013  | Bi-weekly Planning Team                                 | OLTPS/OEM/DCP   | <ul style="list-style-type: none"> <li>● Review HMP timeline</li> <li>● MPC closeout prep</li> <li>● PNP closeout prep</li> <li>● Public review</li> </ul>  | All                   |
| 78        | December 9, 2013  | MPC final meeting                                       | MPC   | <ul style="list-style-type: none"> <li>● HMP overview</li> <li>● Hazard profile summary</li> <li>● Mitigation Strategy findings</li> <li>● Public review</li> </ul>                                 | All                   |
| 79        | December 11, 2013 | PNP webinar   | Public - Private Non Profits                          | <ul style="list-style-type: none"> <li>● Overview of the HMP</li> <li>● Risk profiles - summary of select hazards</li> <li>● Mitigation Action types</li> <li>● Timeline - public review</li> </ul> | All                   |
| 80        | December 11, 2013 | Special Needs Sandy Recovery Task Force conference call | Special Needs Sandy Recovery Task Force/ OEM          | <ul style="list-style-type: none"> <li>● Announcement of the public review period</li> </ul>  | Planning Process      |
| 81        | December 19, 2013 | Bi-weekly Planning Team                                 | Planning Team   | <ul style="list-style-type: none"> <li>● Discussion on preparing HMP for NYS OEM preliminary review</li> </ul>  | All                   |
| 82        | January 6, 2014   | Academic outreach                                       | OEM and Klaus Jacob of Lamont-Doherty Earth Institute | <ul style="list-style-type: none"> <li>● Discuss revision of the Earthquakes hazard profile</li> </ul>  | Risk Assessment       |
| 83        | January 8, 2014   | Special Needs Advisory Group                            | Special Needs Advisory Group/OEM                      | <ul style="list-style-type: none"> <li>● HMP overview</li> <li>● Public review announcement</li> </ul>  | All                   |

APPENDIX B: MEETING DOCUMENTATION

| Meeting # | Date             | Meeting Purpose         | Participants                   | Notes  | Relevant Plan Section |
|-----------|------------------|-------------------------|--------------------------------|--|-----------------------|
| 84        | January 8, 2014  | Public outreach         | Long Island University/<br>OEM | <ul style="list-style-type: none"> <li>●HMP overview</li> <li>●Risk assessment</li> <li>●Mitigation strategy</li> <li>●Public review</li> </ul>        | All                   |
| 85        | January 10, 2014 | Bi-weekly Planning Team | OEM/DCP/OLTPS                  | <ul style="list-style-type: none"> <li>●Timeline</li> <li>●NYC's Hazard Environment profile</li> <li>●Flooding profile</li> <li>●Next Steps</li> </ul> | All                   |
| 86        | January 27, 2014 | Bi-weekly Planning Team | OEM/DCP/OLTPS                  | <ul style="list-style-type: none"> <li>●Planning Team review of entire HMP</li> </ul>  | All                   |



# APPENDIX B: INACTIVE MITIGATION ACTIONS



APPENDIX B: INACTIVE MITIGATION ACTIONS

Table B.1 shows actions that are either no longer in effect or incorporated into other projects since 2009. Please see Action Progress Status column for further explanation.

**Table B.1: Inactive Mitigation Actions**

| 2009 HMP Index No     | Mitigation Action Type      | Mitigation Action Description   | Lead                      | Supporting Agencies (new) | Timeline (new)             | Cost Estimate | Possible Funding Sources                       | Action Progress Status  |
|-----------------------|-----------------------------|---|---------------------------|---------------------------|----------------------------|---------------|--|---|
| <b>Coastal Storms</b> |                             |   |                           |                           |                            |               |  |   |
| CS.P.7                | Infrastructure Project      | <b>Bridge and tunnel improvements and study:</b> Design and install floodgates and barriers at Brooklyn-Battery Tunnel and Queens-Manhattan Tunnel (AW-98). Determine the coastal storm vulnerability of the Triborough Bridge. | MTA (Bridges and Tunnels) | N/A                       | See Action Progress Status | TBD           | TBD  | BBT/QMT work has been subsumed into "Mitigation of Hugh L. Carrey Tunnel and Queens Midtown Tunnel," above. Triborough Bridge work is under "Detailed Engineering Flood Studies at Non-Tunnel Facilities," above. |
| <b>Flooding</b>       |                             |   |                           |                           |                            |               |  |   |
| F.E. 15               | Natural Resource Protection | <b>Natural Resource Protection:</b> Purchase (anticipated) 126 acres on Staten Island to construct and recreate wetlands, which will help mitigate the impact of flooding.  | DEP                       | N/A                       | See Action Progress Status | TBD           | TBD  | No longer applicable, merge with Bluebelt Action  |
| F.E.30                | Prevention                  | <b>Facility and Infrastructure Protection Plan:</b> Conduct system-wide flood study to determine locations and impacts of storm-related water infiltration into the NYCT system.  | MTA (NYCT-Subway)         | N/A                       | 2 years                    | \$3,000,000   | MTA  | Closed, incorporated into new plan actions.   |
| F.E.31                | Property Protection         | <b>Facility Protection:</b> Raise identified street entrances above 100-year flood plain, avoid street gratings, and install large sump system.   | MTA (NYCT-Subway)         | None                      | 7 years (Phase 1)          | TBD           | Federal Transit Administration, Capital Budget | Closed, incorporated into new plan actions.   |



APPENDIX B: INACTIVE MITIGATION ACTIONS

| 2009 HMP Index No   | Mitigation Action Type         | Mitigation Action Description   | Lead   | Supporting Agencies (new) | Timeline (new) | Cost Estimate | Possible Funding Sources | Action Progress Status  |
|---------------------|--------------------------------|---|--------|---------------------------|----------------|---------------|--------------------------|---|
| F.P.30              | Prevention & Policy            | <b>Property Protection:</b> Enroll in National Flood Insurance Program's (NFIP) Community Rating System. By implementing floodplain management initiatives and reducing the City's flood risk, residents can receive discounted flood insurance.            | OEM    | DCP/DOB                   | 5 Years        | TBD           | Agency Operating Budget  | Closed, OLTPS is now the lead on this action (see potential action F.P. |
| F.P. 32             | Education & Awareness          | <b>Severe Repetitive Loss Outreach and Education:</b> Compile and map SRL properties throughout the city. Determine SRL funding eligibility and target these properties for outreach.   | OEM    | DEP/FEMA/NYS OEM          | TBD            | TBD           | HMGP, PDM-C, SRL, RFC    | Closed, OLTPS has started this process see Flooding Hazard Profile.     |
| <b>Multi-Hazard</b> |                                |   |        |                           |                |               |                          |   |
| MH.P.1              | Prevention                     | <b>Danger Tree Program:</b> Identify and eliminate right-of-way tree and dead vegetation hazards. This program has evolved and is incorporated into the vegetation management program.  | Con Ed | N/A                       | TBD            | TBD           | Agency Operating Budget  | Incorporated into vegetation management program.                        |
| MH.E.52             | Structural Projects            | <b>Green Roof Installation:</b> Encourage the installation of green roofs through a new incentive program. Green roofs can reduce the volume of stormwater runoff by absorbing or storing water and help reduce the impact of the urban heat island effect. | OLTPS  | DOB, DOF                  | 8 years        | TBD           | TBD                      | Take off didn't work  |
| MH.E.53             | Public Education and Awareness | <b>Public Education:</b> Create a community planning process and "toolkit" to engage all stakeholders in community-specific climate adaptation and flood mitigation strategies.   | OLTPS  | OEM                       | 2 years        | TBD           | TBD                      | Not pursuing  |

APPENDIX B: INACTIVE MITIGATION ACTIONS

| 2009 HMP Index No | Mitigation Action Type | Mitigation Action Description  | Lead | Supporting Agencies (new) | Timeline (new) | Cost Estimate | Possible Funding Sources | Action Progress Status   |
|-------------------|------------------------|--|------|---------------------------|----------------|---------------|--------------------------|--|
| MH.P.57           | Emergency Services     | <b>Critical Facility Protection:</b> Conduct or update natural hazard vulnerability assessments for critical facilities throughout the City. | OEM  | MPC                       | Ongoing        | TBD           | TBD                      | No longer applicable   |
| MH.P.60           | Property Protection    | <b>Facility Protection:</b> Install storm shutters at OEM headquarters designed to protect windows from flying debris.                       | OEM  | N/A                       | 3–5 Years      | \$800,000     | HMGP/PDM-C               | This mitigation action is a duplicate from the 2009 plan. Please see CS.P. 23 in Chapter IV: Mitigation Strategy, Table 4.6. |



# APPENDIX C: HAZARD MITIGATION SURVEY



## **A. Hazard Mitigation Survey Methodology**

The Planning Team created an online hazard mitigation survey to gain a better understanding of the types of hazards that members of the general public feel pose a risk to the city. The survey also contained questions regarding actions that local communities can take to mitigate the impact of hazards as well as strategies that local, state, and federal government can implement to lessen disaster losses. The survey was posted to OEM's website on October 28 until January 22<sup>nd</sup> and sent to the following groups: Citizen Corps, Community Emergency Response Teams (CERT) teams, Partners in Preparedness members, Special Needs Advanced Warning System (AWS) contact list, the Special Needs Task Force, Volunteer Organizations Active in Disasters (VOAD), community board offices, borough presidents' offices, and academic institutions.

**B. Hazard Mitigation Survey**

1. What borough do you live in?

Manhattan  Bronx  Brooklyn

Queens  Staten Island

Neighborhood (optional)

2. Have you ever experienced or been impacted by a disaster?

Yes  No

3. How concerned are you about the possibility of being impacted by a disaster?

Extremely concerned  Somewhat concerned

Not concerned

4. Please select the natural or man-made hazard(s) you feel poses a threat to your neighborhood:

Coastal Erosion  Coastal Storms  Flooding  Drought  Earthquakes

Extreme Temperatures (Hot and Cold)  Winter Storms  Disease Outbreaks

Severe Weather (Thunderstorms, Wind Storms, Tornadoes)  Wild Fires

Utility Disruptions  Hazardous Waste Release  Infrastructure Failures

Building Collapses and Explosions  Cyber Threats  Other

5. Is there another hazard not listed above that you think is a wide-scale threat to your neighborhood?

Yes  No

If yes, please explain:

6. Do you rent or own your home?

Rent  Own

7. Is your home located in a flood zone?\* [\*Flood zones are areas that are vulnerable to flooding and are identified by FEMA through the National Flood Insurance Program (NFIP). Flood zones should not to be confused with hurricane evacuation zones, which were developed by the City of New York, and represent varying threat levels of coastal flooding resulting from storm surge.]

Yes  No  Not Sure

8. If you own your home, do you have flood insurance? (Flood insurance is not included in a standard home-owners policy and must be purchased separately)

- Yes     No     N/A

9. What is the best way for you to receive information about how to make your home and community more resistant to natural and man-made hazards?

- Internet/Social Media     Television/Radio     Brochures     Public workshops/Meetings  
 Mail     Email     Text Message

10. In your opinion, what are some steps that government (local, state, and federal) could take to reduce the risk of future natural and man-made hazard damages in your neighborhood?

11. There are many actions and strategies to reduce the risk from natural and man-made hazards. Overall, these actions fall into one of the following categories. Please tell us how important you think each one is for your neighborhood.

Very Important                      Somewhat Important                      Not Important

**A. Prevention**

Policies to reduce the impact of hazards, such as zoning, planning, and building codes.

**B. Property Protection**

Modifications of existing homes and buildings to protect them from hazards, such as elevation of electrical equipment.

**C. Coastal/Natural Resource Protection**

Actions that not only reduce the impact of hazards but also preserve and restore natural habitats. Examples include parks preservation and wetlands restoration.

Very Important

Somewhat Important

Not Important

D. Emergency Preparedness & Services

Actions that protect people and property during or immediately after a disaster or hazardous event. Examples include advanced Warning systems, emergency response training, etc.




E. Infrastructure Projects

Engineering of structures to reduce the impact of hazards. Examples include seawalls, bulkheads, levees, etc.

### C. Hazard Mitigation Survey Findings

From October 28, 2013 to January 22, 2014 there were 207 responses to the hazard mitigation survey. Although, there were respondents from all five boroughs, Brooklyn had the highest percentage of survey responses while the Bronx had the lowest percentage (see Figure C.1). The survey's preliminary findings are grouped by the following categories: concerns regarding future disasters, hazards that may pose a risk to New York City neighborhoods, individual efforts to reduce risk, government efforts to reduce risk, and ratings of mitigation strategy type. The survey will remain on the OEM website in order to get more responses. In addition, analysis of the results will continue in order to aid in future mitigation initiatives.

Survey responses were voluntary and responses should not be considered scientific or statistically significant.

**Concerns regarding future disasters:** (see Figure C.2 and Figure C.3)

- Sixty-five percent of survey respondents reported to have experienced or to be impacted by a disaster
- A little over 50% were extremely concerned about the possibility of being impacted by a disaster

**Hazards that may pose a threat to New York City neighborhoods:** (see Figure C.4)

- Of the 15 hazards, severe weather and utility failures received the highest response for hazards that posed the greatest risk to their neighborhood
- Drought and wild fires received the lowest response for hazards respondents felt posed the greatest threat to their neighborhood

**Individual mitigation efforts:** (Figure C.5 and Figure C.6)

- A low percentage (27 percent) of respondents live in a FEMA flood zone
- Even fewer respondents (17 percent) who

owned a home in a FEMA flood zone reported to have flood insurance

**Government mitigation efforts:**

- Seventy respondents choose to write in actions that they felt local, state, and federal governments should take to reduce the risk to future hazards. Below are some examples of the types of strategies respondents identified:
  - Enhance advance warning communications for populations who do not speak English
  - Improve communications with special needs populations
  - Build levees, seawalls, and jetties to protect the city from storm surge
  - Supply generators to critical facilities
  - Provide education on climate change
  - Support environmental cleanup
  - Improve waterway maintenance
  - Hold city-wide exercises or drills

**Ratings of mitigation strategy type:**

- Emergency preparedness and infrastructure projects received the highest percentage points for the very important rating
- Property protection received the lowest percentage points for the very important rating



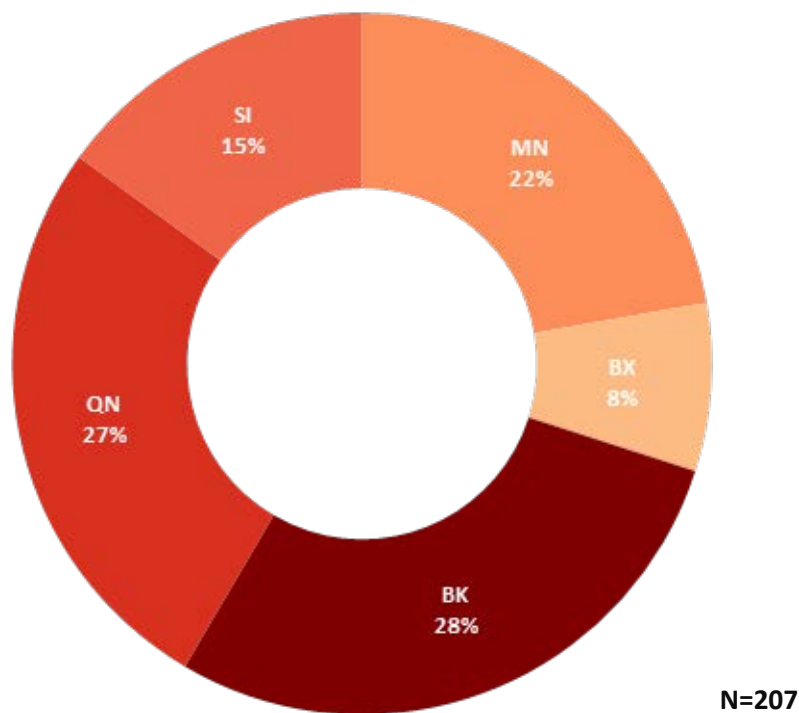


Figure C.1: Percentage survey responses by borough

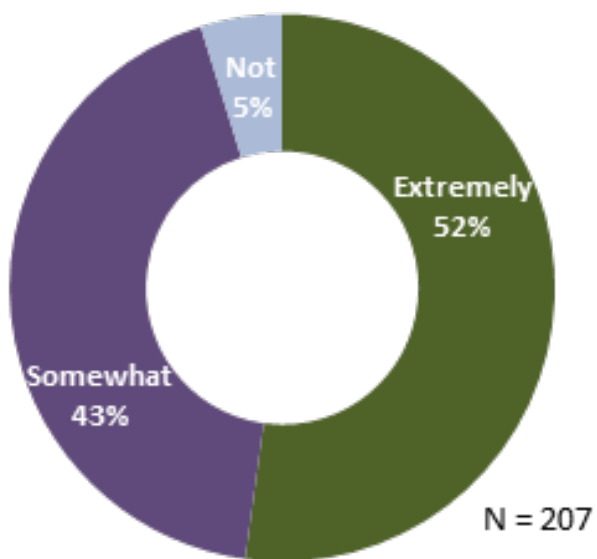


Figure C.2: Percentage of respondents who are concerned about being impacted by a disaster

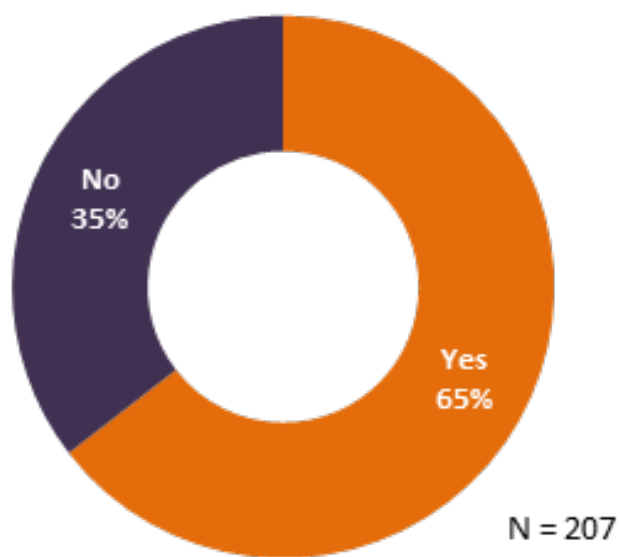
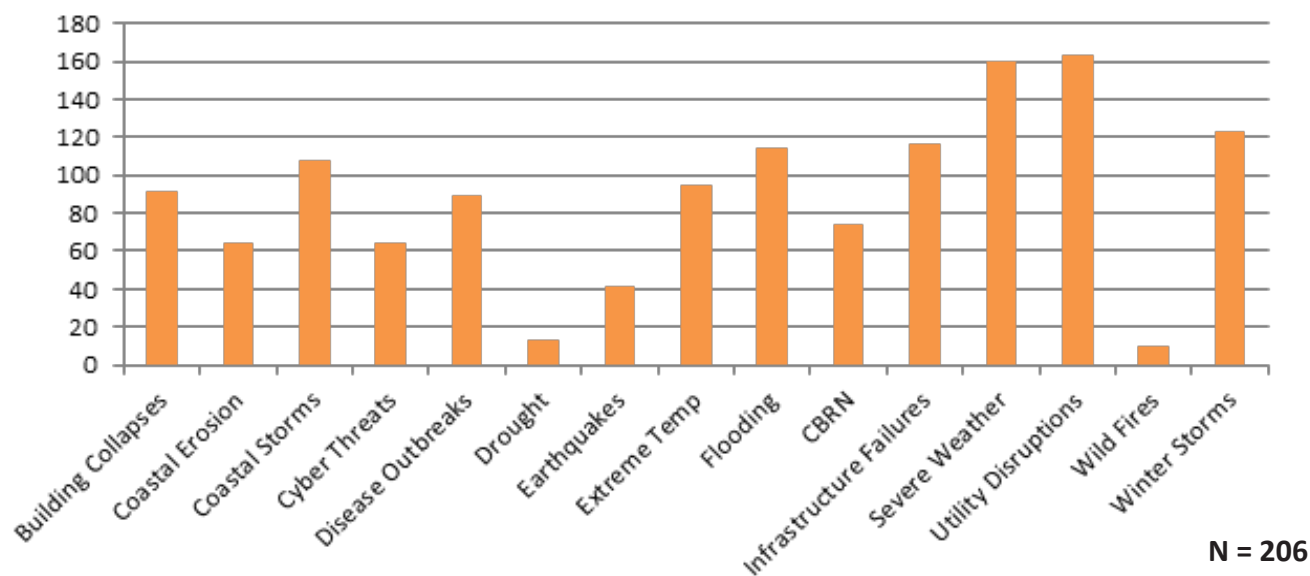


Figure C.3: Percentage of respondents who have experienced or been impacted by a disaster

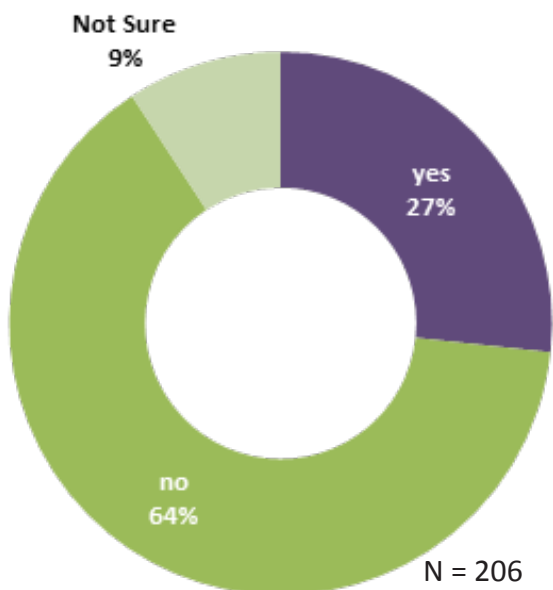


**Figure C.4: Hazards respondents feel poses threat to their neighborhood**

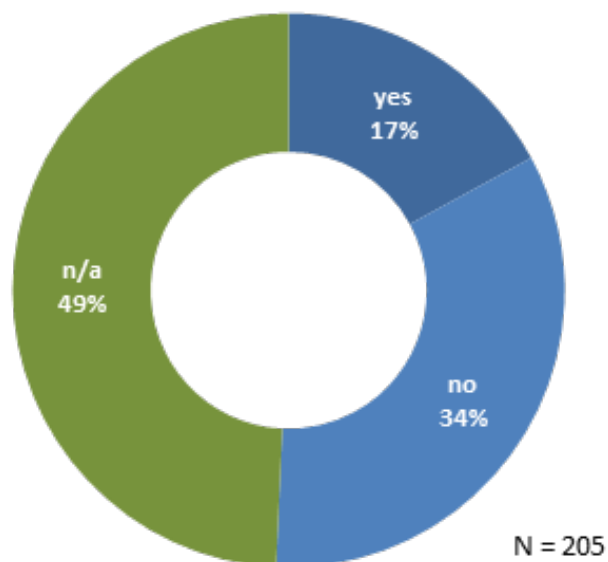
\* respondents could vote for more than one hazard

N = 207 surveys

N = 1,328 total hazard votes



**Figure C.5: Percentage of respondents who have a home located in a flood zone.**



**Figure C.6: Percentage of respondents who own homes in the flood zone and have flood insurance**



# APPENDIX D: ACRONYMS



**Table D.1: Acronyms Table**

| Acronym  | Definition  |
|----------|---|
| ACS      | American Community Survey   |
| ADA      | Americans with Disabilities Act   |
| AOTPS    | Administrative Other-Than-Personal-Services   |
| ARA      | Applied Research Associates   |
| ARC      | American Red Cross  |
| ARF-ARF  | Allied Rockaway Foundation for Animal Recreation and Fitness                              |
| ASCE     | American Civil Engineers  |
| ASOS     | Automated Surface Observing System  |
| AWS      | Special Needs Advanced Warning System   |
| B&T      | Metropolitan Transportation Authority Bridges and Tunnels                                 |
| BCA      | Benefic-Cost Analysis   |
| BID      | Business Improvement District   |
| BIG      | Brownfield Incentive Grant  |
| BIN      | Building Identification Numbers   |
| BFE      | Base Flood Elevation  |
| BMP      | Best Management Practices   |
| BSA      | Board of Standards and Appeals  |
| BWS      | New York City Department of Environmental Protection-Bureau of Water Supply               |
| BWSO     | New York City Department of Environmental Protection-Bureau of Water and Sewer Operations |
| CAU      | New York City Community Affairs Unit  |
| CBRN     | Chemical, Biological, Radiological or Nuclear materials                                   |
| CCC      | New York City Citizen Corps Council   |
| CCTV     | Closed Circuit Television   |
| CD       | Community Districts   |
| CDBG     | Community Development Block Grant   |
| CDBG-DR  | Community Development Grant - Disaster Recovery   |
| CDC      | Centers for Disease Control   |
| CDC PHEP | Public Health Emergency Preparedness  |
| CEHA     | Coastal Erosion Hazard Area   |
| CEQR     | City Environmental Quality Review   |
| CERT     | Community Emergency Response Team   |
| CHASP    | Citywide Health and Safety Plan   |
| CHIP     | Consolidated Highway Improvement Program  |

| Acronym     | Definition  |
|-------------|---|
| CBIDAS      | Coordinated Building Inspection and Data Analysis System  |
| CIMS        | Citywide Incident Management Systems  |
| CITF        | Critical Infrastructure Task Force  |
| CMAQ        | Congestion Mitigation and Air Quality Improvement Program   |
| Con - Ed    | Consolidated Edison   |
| COOP        | Continuity of Operations  |
| CPC         | New York City Planning Commission   |
| CSO         | Combined Sewer Overflow   |
| CSP         | Coastal Storm Plan  |
| CTL         | City Tax Levy   |
| CTP         | Coordinating Technical Partnership  |
| CUNY        | City University of New York   |
| CWPP        | Community Wildfire Protection Plan  |
| DASNY       | Dormitory Authority of the State of New York  |
| DBIR        | Data Breach Investigation Report  |
| DCA         | New York City Department of Cultural Affairs  |
| DCAS        | New York City Department of Citywide Administrative Services  |
| DCAS-DFMC   | New York City Department of Citywide Administration-Division of Facilities and Management Construction (DCAS) |
| DCP         | New York City Department of City Planning   |
| DDC         | New York City Department of Design and Construction   |
| DDoS        | Distributed Denial of Service   |
| DEP         | New York City Department of Environmental Protection  |
| DFIRM       | Digital Flood Insurance Rate Map  |
| DFTA        | New York City Department for the Aging  |
| DG          | Distributed Generation  |
| DHS         | New York City Department of Homeless Services   |
| DMA 2000    | Disaster Mitigation Act of 2000   |
| DMJM Harris | Daniel, Mann, Johnson, & Mendenhall Harris (Consultant)   |
| DMP         | Drainage Master Plan  |
| DOB         | New York City Department of Buildings   |
| DOC         | New York City Department of Corrections   |
| DOE         | New York City Department of Education   |
| DOE-SCA     | New York City Department of Education-School Construction Authority   |
| DOF         | New York City Department of Finance   |

| Acronym   | Definition  |
|-----------|---|
| DOHMH     | New York City Department of Health and Mental Hygiene                     |
| DOITT     | New York City Department of Information Technology and Telecommunications |
| DOT       | New York City Department of Transportation                                |
| DPR       | New York City Department of Parks and Recreation                          |
| DR        | Disaster Declaration Number   |
| DSNY      | New York City Department of Sanitation                                    |
| ECC       | Emergency Command Center  |
| ED        | Emergency Department  |
| EDC       | New York City Economic Development Corporation                            |
| EDR       | Electrical Distribution Room  |
| EF-Scale  | Enhanced Fujita Scale   |
| EM        | Emergency Declaration Number  |
| EMAS      | Engineered Material Arresting System                                      |
| EMS       | Emergency Medical Services  |
| EOC       | Emergency Operations Center   |
| EPA       | United States Environmental Protection Agency                             |
| EPIC      | Environmental Project Information Center                                  |
| FAA       | United States Federal Aviation Administration                             |
| FAST      | Financial Assistance Search Tool  |
| FDNY      | New York City Fire Department   |
| FDOC      | Fire Department Operations Center   |
| FEMA      | United States Federal Emergency Management Agency                         |
| FEMA – PA | Public Assistance   |
| FEMA – IA | Individual Assistance   |
| FHWA      | Federal Highway Administration  |
| FIRM      | Flood Insurance Rate Map  |
| FMA       | Flood Mitigation Assistance   |
| FRA       | United States Federal Railroad Administration                             |
| F-Scale   | Fujita Scale  |
| ft        | Feet  |
| FTA       | United States Federal Transportation Administration                       |
| FTA-ER    | Emergency Relief Program  |
| FY        | Fiscal Year   |
| GBS       | General Building Stock  |
| GCF       | General Capital Funding   |

APPENDIX D: ACRONYMS

| Acronym  | Definition  |
|----------|---|
| GIGP     | Green Infrastructure Grant Program                          |
| GIS      | Geographic Information Systems                              |
| GMATS    | Global Maritime and Transportation School                   |
| GWB      | George Washington Bridge                                    |
| H&H      | Hydrological/Hydraulic                                      |
| HAZMAT   | Hazardous materials   |
| HAZUS-MH | Hazards U.S. Multi-Hazard                                   |
| HHC      | New York City Health and Hospitals Corporation              |
| HI       | Heat Index  |
| HMC      | Hazard Mitigation Coordinator                               |
| HMGP     | Hazard Mitigation Grant Program                             |
| HMP      | New York City Hazard Mitigation Plan                        |
| HMU      | Hazard Mitigation Unit                                      |
| HPD      | New York City Housing and Preservation Development          |
| HQ       | Headquarters  |
| HRA      | New York City Human Resources Administration                |
| HRO      | Mayor's Office of Housing Recovery                          |
| HVAC     | Heating Ventilation and Air Conditioning                    |
| IBM      | International Business Machines                             |
| ICC      | International Code Council                                  |
| ITS      | Intelligent Transportation System                           |
| IVR      | Interactive Voice Response                                  |
| JFK      | John Fitzgerald Kennedy Airport                             |
| LGA      | Fiorello LaGuardia Airport                                  |
| LIRR     | Metropolitan Transportation Authority Long Island Rail Road |
| LDC      | Local Development Corporation                               |
| LPC      | New York City Landmarks Preservation Commission             |
| MapPLUTO | Property Land Use Tax Lot Output                            |
| MDC      | Manhattan Detention Complex                                 |
| MERS     | Middle Eastern Respiratory Syndrome                         |
| MEOW     | Maximum Envelope of Water                                   |
| MLLW     | Mean Lower Low Water  |
| MMI      | Modified Mercalli Intensity                                 |
| MNR      | Metropolitan Transportation Authority Metro-North Railroad  |
| MOM      | Maximum of MEOWs  |
| MOPD     | New York City Mayor's Office for People with Disabilities   |

| Acronym   | Definition  |
|-----------|---|
| MOTF      | FEMA Modeling Task Force  |
| MPC       | Mitigation Planning Council   |
| MPCSC     | Mitigation Planning Council Steering Committee                      |
| mph       | Miles Per Hour  |
| MTA       | Metropolitan Transportation Authority                               |
| N/A       | Not Applicable  |
| NEHRP     | National Earthquake Hazards Reduction Program                       |
| NESIS     | Northeast Snowfall Impact Scale                                     |
| NFPA      | National Fire Protection Association                                |
| NFIP      | National Flood Insurance Program                                    |
| NHC       | National Hurricane Center   |
| NJT       | New Jersey Transit  |
| NOAA      | United States National Oceanic and Atmospheric Administration       |
| NPFA      | National Protective Feature Areas                                   |
| NPCC      | New York City Panel on Climate Change                               |
| NPS       | National Park Service   |
| NRDC      | Natural Resources Defense Council                                   |
| NRE       | Natural Resource Enhancement  |
| NWS       | National Weather Service  |
| NYC       | New York City   |
| NYCCAS    | NYC Community Air Survey  |
| NYCEM     | NYC Area Consortium for Earthquake Loss Mitigation                  |
| NYCHA     | New York City Housing Authority                                     |
| NYCT      | Metropolitan Transportation Authority New York City Transit         |
| NYCWIn    | New York City Wireless Network                                      |
| NYLB      | New York Liquidation Bureau   |
| NYPA      | New York Power Authority  |
| NYPD      | New York City Police Department                                     |
| NYS       | New York State  |
| NYSDEC    | New York State Department of Environmental Conservation             |
| NYSDHCR   | New York State Department of Housing and Community Renewal          |
| NYS DHSES | New York State Division of Homeland Security and Emergency Services |
| NYSDOH    | New York State Department of Health                                 |



APPENDIX D: ACRONYMS

| Acronym | Definition   |
|---------|--|
| NYS DOT | NYS Department of Transportation                                 |
| NYSOHS  | New York State Office of Homeland Security                       |
| NYS GS  | New York State Geological Survey                                 |
| NYS HMP | New York State Hazard Mitigation Plan                            |
| NYSOTDA | New York State Department of Temporary and Disability Assistance |
| OCME    | New York City Office of the Chief Medical Examiner               |
| OEM     | New York City Office of Emergency Management                     |
| OER     | Mayor's Office of Environmental Remediation                      |
| OLTPS   | New York City Office of Long-Term Planning and Sustainability    |
| OMB     | New York City Office of Management and Budget                    |
| PANYNJ  | Port Authority of New York and New Jersey                        |
| PATH    | Port Authority Trans-Hudson                                      |
| PDM-C   | Pre-Disaster Mitigation-Competitive                              |
| PFA     | Psychological First Aid  |
| PGA     | Peak Ground Acceleration   |
| PHL     | Public Health Laboratory   |
| PlaNYC  | PlaNYC: A Greener, Greater New York                              |
| PPE     | Personal Protective Equipment                                    |
| PSC     | New York State Public Service Commission                         |
| PSEG    | Public Service Electric and Gas Company                          |
| RBIS    | Risk Based Inspection System                                     |
| RCPGP   | Regional Catastrophic Preparedness Grant Program                 |
| RCPT    | Regional Catastrophic Planning Team                              |
| RDD     | Radiological Dispersal Device                                    |
| RED     | Radiological Exposure Device                                     |
| REDC    | Regional Economic Development Corporation                        |
| RFC     | Repetitive Flood Claims  |
| ROW     | Right-of-way   |
| RPA     | Regional Plan Association  |
| SA      | Spectral Acceleration  |
| SARS    | Severe Acute Respiratory Syndrome                                |
| SBS     | New York City Small Business Services                            |
| SFHA    | Special Flood Hazard Area  |
| SHA     | Structural Hazard Areas  |
| SIP     | Session Initiation Protocol                                      |
| SIRR    | Special Initiative for Rebuilding and Resiliency                 |

APPENDIX D: ACRONYMS

| Acronym   | Definition  |
|-----------|---|
| SLOSH     | Sea, Lake, and Overland Surges from Hurricanes Model                            |
| SNAG      | Special Needs Advisory Group  |
| SRL       | Severe Repetitive Loss  |
| SSBG      | Sandy Social Services Block Grant   |
| StarLIMS  | State-of-the-art Laboratory Information Management System                       |
| STEP      | Sheltering and Temporary Essential Power  |
| STAPLEE   | Social, Technical, Administrative, Political, Legal, Economical , Environmental |
| TAP       | Transportation Alternatives Program   |
| TB        | Tuberculosis  |
| TBD       | To Be Determined  |
| TEP       | Transportation Enhancement Program  |
| TIC       | Toxic Industrial Chemicals  |
| TSGP      | Transit Security Grant Program  |
| UASI      | Urban Area Security Initiative  |
| ULURP     | Uniform Land Use Review Procedure   |
| USACE     | United States Army Corps of Engineers   |
| USAR      | Urban Search and Rescue   |
| USCG      | United States Coast Guard   |
| USDA EWPP | U.S. Department of Agriculture Emergency Watershed Protection Program           |
| USDHS     | United States Department of Homeland Security                                   |
| USDOE     | United States Department of Energy  |
| USGS      | United States Geological Survey   |
| USPS      | United States Postal Service  |
| UAWG      | New York City Urban Area Working Group  |
| UWAS      | Urban Waterfront Adaptive Strategies  |
| VCBC      | Vernon C. Bain Center   |
| VOIP      | Voice Over Internet Protocol  |
| VOAD      | Volunteer Organizations Active in Disasters                                     |
| WAVES     | Waterfront Vision and Enhancement Strategy                                      |
| WRP       | Waterfront Revitalization Program   |
| WTC       | World Trade Center  |
| WUI       | Wildland-urban interface  |



# APPENDIX E: GLOSSARY



Table E.1: Glossary Table

| Term                                | Definition  |
|-------------------------------------|---|
| 100-Year Flood                      | The flood that has a 1 % chance of being equaled or exceeded in any given year. Thus, the 100-year flood could occur more than once in a relatively short period of time. The Federal Emergency Management Agency (FEMA) defines it as the 1 % annual chance flood, which is now the standard definition used by most federal and state agencies and by the National Flood Insurance Program (NFIP).  |
| A Stronger, More Resilient New York | A comprehensive plan, developed as part of the Special Initiative for Rebuilding and Resiliency (SIRR), with actionable recommendations for rebuilding the communities impacted by Sandy and increasing the resiliency of buildings and infrastructure citywide.  |
| Agricultural Drought                | Links the various characteristics of meteorological drought to agricultural impacts due to precipitation shortages and soil-water deficits.   |
| Air Contamination                   | Poor air quality resulting from a high concentration of primarily industrial pollutants (including particulate matter and ozone) near the ground  |
| Aviation Incidents                  | Accidents involving aircraft departing from or arriving at Kennedy or LaGuardia Airports that cause or have the potential to cause injury or loss of life.  |
| Barrier Islands                     | A long offshore deposit of sand parallel to the coastline which act as a buffer against storms by absorbing the most severe impacts of waves and storm surge.   |
| Bearing                             | A storm's direction and angle of approach.  |
| Beaufort Wind Scale                 | A simplified scale to aid in the estimation of wind speed and corresponding typical effects.  |
| Benefit-Cost Analysis (BCA)         | A systematic, quantitative method of comparing projected benefits to projected costs of a project or policy. It is used as a measure of cost effectiveness.   |
| Biological Hazard                   | Include disease-causing microorganisms and pathogens, such as bacteria and viruses. These substances have the ability to multiply within a host and cause an infection.   |
| Boroughs                            | The five geographic and political divisions of New York City, each classified as an individual county. The five Boroughs of New York City are the Bronx, Brooklyn (Kings), Manhattan (New York), Queens, and Staten Island (Richmond).  |
| Building Collapses/Fires/Explosions | Damage to or destruction of a building resulting from collapse, fire, or explosion  |
| Building Value                      | Value of the physical building.   |
| Capability Assessment               | Provides a description and analysis of a community's current capacity to address threats associated with hazards. The assessment includes two components: an inventory of an agency's mission, programs, and policies, and an analysis of its capacity to carry them out. A capability assessment is an integral part of the planning process in which a community's actions to reduce losses are identified, reviewed, and analyzed, and the framework for implementation is identified. |
| Chemical Hazard                     | A substance with the potential to cause harm, primarily to humans, through toxicity, reactivity, corrosivity, or flammability.  |
| Civil Unrest                        | A public crisis that occurs without warning and may adversely impact a significant portion of the population  |
| Coastal Erosion                     | Loss or displacement of land along the coastline due to the action of wind, waves, currents, tides, wind-driven water, waterborne ice, runoff of surface waters groundwater seepage, or human activities.   |

APPENDIX E: GLOSSARY

| Term  | Definition   |
|---|--|
| Coastal Erosion Hazard Area (CEHA)                            | Coastal locations that are particularly vulnerable to erosion requiring written approval of regulated activities or land disturbance to properties within these areas.   |
| Coastal Flooding  | Floods affect areas along the ocean, bays, rivers, streams, or estuaries of tidal influence. Coastal floods are most commonly caused by storm surge from a strong coastal storm, such as a hurricane or other tropical storm or a nor'easter.  |
| Coastal/Natural Resource Protection (for Mitigation Strategy) | Actions that, in addition to minimizing hazard losses, also preserve or restore the functions of natural or coastal systems.   |
| Coastal Storms  | Include tropical cyclones formed in the atmosphere over warm ocean areas, and nor'easters which form at higher latitudes during the colder months of the year. Circulation is counterclockwise around a center of low pressure. Depending on the exact storm type, coastal storms can affect the area with heavy rain, winds, storm surge, tornadoes, or wintry precipitation.                             |
| Coastal Storm Plan (CSP)                                      | New York City's blueprint for responding to coastal storms. Originally developed in 2000, the CSP continues to be revised and improved upon based on experience and new information.   |
| Community District  | 59 distinct geographical boundaries within New York City that have an important advisory role in dealing with land use and zoning matters, the City budget, municipal service delivery, and many other matters relating to their communities' welfare.   |
| Community Rating System (CRS)                                 | A voluntary program under the NFIP that rewards participating communities (provides incentives) for exceeding the minimum requirements of the NFIP and completing activities that reduce flood hazard risk by providing flood insurance premium discounts.   |
| Critical Facilities   | A critical facility is vital to the City's ability to provide essential services and protect life and property. Loss of a critical facility would result in a severe economic or catastrophic impact.  |
| Cyber Attack  | An cyber incident that is intentional or malicious in nature.  |
| Cyber Crime   | A cyber attack that is primarily motivated by financial gain.  |
| Cyber Threat  | An adverse event in an information system or network in which the digital infrastructure of a person or organization is compromised.   |
| Debris  | The scattered remains of assets broken or destroyed during the occurrence of a hazard. Debris caused by wind or water hazards can cause additional damage to other assets.   |
| Deterministic (for HAZUS-MH)                                  | Estimates of hazard-related damage to a city or a region from a hypothetical "hazard event" of a fixed severity and location.  |
| Disaster Mitigation Act of 2000 (DMA 2000)                    | Federal legislation enacted to encourage and promote proactive, pre-disaster planning as a condition of receiving financial assistance under the Robert T. Stafford Act. The DMA emphasizes planning for disasters before they occur. Under the DMA, a pre-disaster hazard mitigation program and new requirements for the national post-disaster hazard mitigation grant program (HMGP) were established. |
| Disease Outbreaks   | When disease cases exceed what would normally be expected in a defined community, geographic area, or season   |

| Term  | Definition  |
|---|---|
| Dose (radiation)                                  | Amount of energy absorbed by the body.  |
| Dose Equivalent (radiation)                       | Considers dose absorbed and the type of radiation to which one is exposed.  |
| Drought   | A prolonged period with significantly below average precipitation. Limited winter precipitation accompanied by moderately dry periods during the spring and summer months can also lead to drought conditions.  |
| Drought Emergency                                 | Declared by the New York City Department of Environmental Protection when there is a reasonable probability that, without the implementation of stringent measures to reduce consumption, a protracted dry period would cause the City's reservoirs to drop to levels that would threaten public health and safety. |
| Drought Warning                                   | Declared by the New York City Department of Environmental Protection when there is less than a 33% probability that either of the two largest reservoir systems, the Delaware or the Catskill, will fill by the following June 1, the start of the water-year.  |
| Drought Watch                                     | Declared by the New York City Department of Environmental Protection when there is less than a 50% probability that either of the two largest reservoir systems, the Delaware or the Catskill, will fill by the following June 1, the start of the water-year.  |
| Earthquakes                                       | A sudden, rapid shaking of the earth caused by the breaking and shifting of rock beneath the surface, usually within the upper 10–20 miles of the earth's surface.  |
| Education and Awareness (for Mitigation Strategy) | Actions to inform and educate citizens, elected officials, businesses, and property owners about the hazards they face and protective measures they can take to best prepare for or respond to hazards.   |
| Emergency Services (for Mitigation Strategy)      | Actions that protect people and property, or increase the capacity of emergency response during and immediately following a disaster event.   |
| Endemic (disease)                                 | Refers to the usual presence of a disease within a specific population or area.   |
| Endogenous Hazards                                | Include construction or maintenance flaws in the built environment.   |
| Enhanced Fujita Scale                             | National Weather Service's revised Fujita-scale, which is a complex, systematic approach to measuring the strength of a tornado.  |
| Epicenter   | Point on the surface directly above the source of an earthquake.  |
| Epidemic  | The sometimes-sudden increase in the number of cases of a disease that exceeds what is normally expected.   |
| Excessive Heat Warning                            | Issued within 24 hours of onset of the following condition: Heat index of at least 105°F for at least two consecutive hours   |
| Excessive Heat Watch                              | Issued 24-48 hours prior to onset of the following condition: Heat index of at least 105°F for at least two consecutive hours   |
| Existing Mitigation Action                        | A project, plan, policy, or program the City has already taken or has begun to implement that addresses natural hazard mitigation.  |
| Exogenous Hazards                                 | Natural hazards.  |
| Exposure (economic)                               | The number and dollar value of assets considered to be at risk during the occurrence of a specific hazard.  |

APPENDIX E: GLOSSARY

| Term                                       | Definition  |
|--|---|
| Exposure (human health)                    | Contact with a substance which has the potential to cause adverse health impacts.   |
| Extreme Cold                               | Temperatures that drop well below normal in an area. Whenever temperatures drop well below normal and wind speed increases, heat can leave your body more rapidly (known as the wind-chill effect).   |
| Extreme Heat                               | Temperatures that hover 10° F or more above the average high temperature for the region and last for several weeks. Humid or muggy conditions, which add to the discomfort of high temperatures, occur when a "dome" of high atmospheric pressure traps hazy, damp air near the ground. |
| Federal Emergency Management Agency (FEMA) | An independent federal agency (now part of the Department of Homeland Security) created in 1978 to provide a single point of accountability for all federal activities related to disaster mitigation and emergency preparedness, response, and recovery.                               |
| Flash Flooding                             | Caused by short-term, high-intensity rainfall that occurs as waters rise rapidly in areas with poor drainage  |
| Flood Insurance Rate Map (FIRM)            | The official map of a community for which FEMA has designated flood zones – geographic areas classified according to levels of flood risk, with each zone reflecting a different severity and/or type of flooding – and the insurance risk premium zones applicable to the community.   |
| Floodplain                                 | Any land area that becomes inundated with water during a flood or from any other source. Floodplain can be defined in different ways but is commonly defined as the area that is also called the 100-year floodplain.   |
| Flood                                      | A general and temporary condition of partial or complete inundation on normally dry land. Flooding can be categorized as coastal, riverine, tidal, or inland.   |
| Focus (earthquakes)                        | An earthquake's location of origin beneath the surface.   |
| Freezing Rain                              | Precipitation that falls as rain, but freezes on contact with the surface, forming a glaze of ice.  |
| Frostbite                                  | Freezing of the body's outer tissue as a result of prolonged exposure to extreme cold. Most commonly occurs in the outer extremities like the nose, ears, cheeks, chin, fingers, and toes. Symptoms include numbness, tingling or stinging, aching, and discoloration of the skin.      |
| Fujita Scale (F-Scale)                     | Standard measurement for rating the strength of a tornado.  |
| Geographic Information Systems (GIS)       | A computer software application that relates data regarding physical and other features on the earth to a database for mapping and analysis.  |
| Geomorphology                              | The study of geographic features and landforms and the processes that shape them over time  |
| Gibson Index                               | An open-source ranking system created in February 2013, widely used in cyber threat analysis. The scale ranges from 0 to 7.   |
| Goal                                       | A general guideline that explains what is to be achieved. Goals are usually broad-based, long-term, policy-type statements and represent global visions. Goals help define the benefits that a plan is trying to achieve.   |
| Go-Outside-the-Home Disability             | Conditions lasting six or more months that make going outside the home alone to shop or visit a doctor's office difficult.  |
| Ground Acceleration                        | Shaking of the ground resulting from seismic waves caused by an earthquake.   |
| Hacktivism                                 | The act of hacking, or breaking into a computer system, for a politically or socially motivated purpose.  |
| Hail                                       | Precipitation in the form of irregular pellets, or balls of ice more than five millimeters in diameter, falling from thunderstorm.  |

APPENDIX E: GLOSSARY

| Term                                   | Definition   |
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| Hazard                                 | A source of potential danger or adverse condition that could harm people and/or cause property damage.   |
| Hazardous Materials (HAZMAT) Incidents | A situation in which hazardous materials are released into the environment, causing a threat to human health and safety. Such incidents are often classified as chemical, biological, radiological, and nuclear (CBRN).  |
| Hazard Mitigation                      | Reduction or alleviation of the loss of life, personal injury, and property damage that could result from a disaster through long- and short-term strategies. Hazard mitigation involves strategies such as planning, policy changes, programs, projects, and other activities that could mitigate the impacts of hazards.   |
| Hazard Mitigation Grant Program (HMGP) | Authorized under Section 202 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act, the HMGP is administered by FEMA and provides grants to states, tribes, and local governments to implement hazard mitigation actions after a major disaster declaration. The purpose of the program is to reduce the loss of life and property due to disasters and to enable mitigation activities to be implemented as a community recovers from a disaster.    |
| Hazard Mitigation Plan (HMP)           | A collaborative document that identifies hazards that could affect a community, assesses vulnerability to hazards, and presents existing and potential actions that the community is undertaking or intends to undertake in order to minimize or eliminate the effects of hazards.   |
| Hazards U.S. Multi-Hazard (HAZUS-MH)   | A nationally applicable standardized methodology and software program, developed by FEMA, which is under contract with the National Institute of Building Sciences. The program estimates potential losses from earthquakes, hurricane winds, and floods. In HAZUS-MH, current scientific and engineering knowledge is coupled with Geographic Information Systems (GIS) technology to produce estimates of hazard-related damage before, or after, a disaster occurs. |
| Heat Advisory                          | Issued within 24 hours prior to onset of any of the following conditions: 1) Heat index of 100°F-104°F for any period 2) Heat index of 95°F-99°F or greater for two consecutive days   |
| Heat Exhaustion                        | A health condition brought on by prolonged exposure to extreme heat, with symptoms including confusion, dizziness, fatigue, nausea, headaches, and muscle cramps.  |
| Heat Index                             | The temperature the body feels when heat and humidity are combined. Higher humidity reduces the body's ability to cool itself and makes the temperature feel hotter.   |
| Heat Stroke                            | Occurs when the body is no longer able to regulate its internal temperature, resulting in a body temperature of greater than 105°F. Common symptoms include seizures, disorientation, loss of consciousness, and complications involving the central nervous system.   |
| Health Risk Assessment                 | Process of evaluating the existence and/or magnitude of health problems resulting from exposure to a hazardous substance. The four steps in this process are health problem identification, toxicology (dose response), exposure assessment, and health risk characterization.   |
| Hurricane                              | A tropical cyclone with winds that have reached a constant speed of 74 miles per hour or greater.  |
| Hurricane Sandy After Action Report    | Report with recommendations on how the City's response capacity and performance can be strengthened in the wake of Hurricane Sandy.  |
| Hydrological Drought                   | Involve deficiencies in surface and subsurface water supplies. These droughts usually lag behind meteorological and agricultural droughts.   |



APPENDIX E: GLOSSARY

| Term   | Definition   |
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| Hypothermia  | A significant lowering of internal body temperature which occurs due to prolonged exposure to extreme cold. Early symptoms of hypothermia include shivering, fatigue, loss of coordination, and disorientation. If continued untreated, this condition becomes more serious, with recognizable symptoms including blue skin, dilated pupils, slow pulse and breathing, or loss of consciousness. |
| Ice Storms   | Occur when freezing rain results in dangerous accumulations of ice, usually 1/4 inch or greater.   |
| Infrastructure failure                                 | Failure of infrastructure systems—including transportation, water, and wastewater—to perform their intended functions.   |
| Infrastructure Projects (for Mitigation Strategy)      | Actions that involve the engineering of infrastructure systems to be more resistant to the impacts of hazards.   |
| Inland Flooding  | Can be caused by short-term, high-intensity rainfall, often associated with sudden small-scale thunderstorms or hurricanes and other large-scale storms (see "Flash Flooding").  |
| Intensity (earthquakes)                                | Used to describe the overall felt severity of shaking during an earthquake at a particular location, measured in terms of the Modified Mercalli scale.   |
| Landslides   | The downward and outward movement of slope-forming materials reacting to the force of gravity. Slide materials may be composed of natural rock, soil, artificial fill, or combinations of these materials. The term landslide includes rock falls, rockslides, block glide, debris slide, earth flow, mudflow, slump, and other such terms.  |
| Land Subsidence  | Depressions, cracks, and sinkholes in the earth's surface, which can threaten people and property. Subsidence depressions, which normally occur over many days to a few years, may damage structures with low strain tolerances such as dams, factories, nuclear reactors, and utility lines.  |
| Linguistically Isolated                                | People who speak English less than "very well".  |
| Liquefaction   | Occurs when unconsolidated, water-saturated soils exhibit fluid-like or significantly softened properties due to the intense shaking and vibrations during an earthquake.  |
| Magnitude (earthquakes)                                | A measurement of the energy released at the source of the earthquake expressed by ratings on the Richter or more recent magnitude scales.  |
| Mean Lower Low Water (MLLW)                            | The average height of the lowest tide recorded at a tide station each day during a recording period.   |
| Maximum Envelope of Water (MEOW)                       | SLOSH output showing the maximum surge inundation from a set of hypothetical storms with fixed intensity and bearing but varied size, forward speed, and landfall locations.   |
| Maximum of MEOWs (MOMs)                                | SLOSH output which represents the worst-case scenario storm surge.   |
| Meteorological Drought                                 | Below average precipitation sustained over a significant period of time. This type of drought has a slow onset and usually takes at least three months to develop, but may last for several seasons or years.  |
| Mitigation Actions                                     | Specific projects, plans, or policies that achieve goals and objectives that minimize the effects from a disaster and reduce the loss of life and property.  |
| Mitigation Planning Council (MPC)                      | Composed of 41 essential governmental and non-governmental stakeholders that have an interest in reducing the impact of natural hazards throughout New York City.  |
| Mitigation Planning Council Steering Committee (MPCSC) | A core group of 13 agencies and organizations that own or manage some of the City's largest infrastructure networks and/or engage in planning for or regulating these systems.   |
| Mitigation Strategy                                    | A systematic process for analyzing, prioritizing, and implementing the identified mitigation actions in the Hazard Mitigation Plan.  |

APPENDIX E: GLOSSARY

| Term                                    | Definition  |
|---|---|
| Modified Mercalli Intensity (MMI)       | A scale used for measuring the intensity of an earthquake. The scale quantifies the effects of an earthquake on the Earth's surface, humans, objects of nature, and man-made structures on a scale of I through XII, with I denoting a weak earthquake and XII one that causes almost complete destruction.   |
| National Flood Insurance Program (NFIP) | Program through which FEMA sets insurance premiums and minimum building standards for properties in the 100-year floodplain. The three components of the NFIP are flood insurance, floodplain management, and flood hazard mapping. Nearly 20,000 communities across the United States and its territories participate in the NFIP by adopting and enforcing floodplain management ordinances to reduce future flood damage. In exchange, the NFIP makes Federally backed flood insurance available to homeowners, renters, and business owners in these communities. Community participation in the NFIP is voluntary. |
| Natural Hazard                          | Hazard which results from conditions in the natural environment. Humans may contribute to or exacerbate the hazard, but are not the direct source of the hazard.  |
| Natural Protective Feature Area (NPFA)  | Portion of Coastal Erosion Hazard Area (CEHA) which contains natural protective features that protect natural habitats, infrastructure, and built structures from wind and water erosion and storm-induced high water.  |
| New York Bight                          | A bight is a curve in the shoreline of an open coast that funnels and increases the speed and intensity of storm surge. The New York Bight is located at the point where New York and New Jersey meet, creating nearly a right angle in the coastline.  |
| New York City Construction Code         | The City's comprehensive building code managed by the New York City Department of Buildings, last updated in 2008. The next update is scheduled for fall, 2014.   |
| Non-Natural Hazard                      | Hazard which results from human-induced processes.  |
| Nor'easter                              | A strong low-pressure system that affects the Mid-Atlantic and New England states. Nor'easters can form over land or coastal waters, generally between October and April. These events are notorious for producing heavy snow, rain, and tremendous waves that crash onto Atlantic beaches, often causing beach erosion and structural damage.  |
| Nuclear Hazard                          | Incidents that result directly from the detonation of a nuclear device or at a nuclear reactor site when accompanied by the release of large amounts of energy in the form of intense light, heat, pressure, and radiation.   |
| Objective                               | A short-term aim that, when combined with other objectives, forms a strategy or course of action to meet a goal. Unlike goals, objectives are specific and measurable.  |
| Outwash Plains                          | Deposits of sand, silt and clay deposited by glaciers which comprise the low-lying areas of eastern Staten Island, and southern Brooklyn and Queens.  |
| Pandemic                                | An epidemic that has spread across a region or over several countries.  |
| Peak Ground Acceleration (PGA)          | The maximum acceleration experienced by the ground during the course of an earthquake motion, described by its changing velocity as a function of time. It is expressed as a percent of the established rate of acceleration due to gravity (9.8 m/sec <sup>2</sup> ).  |
| Phragmites                              | Tall perennial grasses, typically found in temperate wetland areas, which burn easily and significantly contribute to the risk of wildfires.  |

| Term  | Definition   |
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| Physical Disability                             | Long-lasting conditions that substantially limit one or more basic physical activity, such as walking, climbing stairs, reaching, lifting, or carrying.  |
| Planning Team                                   | The coordinators for the HMP. The Planning Team was comprised of four planners from the OEM Planning and Preparedness Division, one specialist from OEM's Geographic Information Systems (GIS) Unit, five planners from the Department of City Planning (DCP), and a Senior Policy Advisor and GIS Specialist from the Mayor's Office of Long Term Planning and Sustainability (OLTPS). The Planning Team facilitated overall plan development to ensure the HMP met the requirements of DMA 2000 and executed hazard models to create maps and data tables that support the Plan. |
| PlaNYC  | Outlines a detailed strategy for how the City will address the challenges of population growth, aging infrastructure, and climate change. PlaNYC contains initiatives designed to achieve sustainability goals for land, water, transportation, energy, air quality, and climate change.   |
| Potential Mitigation Action                     | A project, plan, policy or program that the City would like to take to address hazard mitigation, but currently does not have the funds and/or resources to implement.   |
| Preparedness                                    | Actions that strengthen the capability of government, citizens, and communities to respond to disasters.   |
| Presidential Disaster Declaration               | Typically made for events that cause more damage than state and local governments and resources can handle without federal government assistance. Generally, no specific dollar loss threshold has been established for such declarations. A Presidential Disaster Declaration puts into motion long-term federal recovery programs, some of which are matched by state programs, designed to help disaster victims, businesses, and public entities.  |
| Prevention and Policy (for Mitigation Strategy) | Government, administrative, or regulatory actions and processes that influence the way land and buildings are developed and built. These actions also include public activities that reduce hazard losses. Examples of this category include building and construction code revisions, zoning regulation changes, and hazard computer modeling.  |
| Probabilistic (for HAZUS-MH)                    | Events modeled by looking at the damage caused by an event that is likely to occur over a given period of time, known as a return period.  |
| Property Protection (for Mitigation Strategy)   | Actions that involve the modification of existing buildings or structures to protect them from a hazard, or removal from the hazard area.  |
| Radiological Hazard                             | When harmful doses of radiation come into contact with humans. Can occur when external radiation comes into contact with a person's skin, hair, or clothing, or through inhalation or ingestion.   |
| Recovery  | Recovery refers to actions taken by an individual or community after a catastrophic event to restore order and community lifelines.  |
| Repetitive Loss Property                        | Any NFIP-insured property that, since 1978 and regardless of any change(s) of ownership during that period, has experienced any of the following:1) Four or more paid flood losses exceeding \$1,000 each 2) Two paid flood losses exceeding \$1,000 each within any 10-year period since 1978 3)Three or more paid losses that equal or exceed the current value of the insured property.   |
| Resiliency                                      | The capacity of the social, built or natural environment to bounce back and return to normalcy following a disaster.   |
| Return Period                                   | Average period of time in years between occurrences of a particular hazard (equal to the inverse of the annual frequency of occurrence).   |

| Term  | Definition   |
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| Richter Scale   | A logarithmic scale used to express the total amount of energy released by an earthquake. Its values typically fall between 0 and 9, with each increase of 1 representing a 10-fold increase in energy.  |
| Risk  | The estimated impact that a hazard would have on people, services, facilities, and structures in a community. Risk measures the likelihood of a hazard occurring and resulting in an adverse condition that causes injury or damage. Risk is often expressed in relative terms such as a high, moderate, or low hazard. Risk also can be expressed in terms of potential monetary losses associated with the intensity of likelihood of sustaining damage above a particular threshold due to occurrence of a specific type of the hazard. |
| Risk Assessment   | The process of measuring potential loss of life, personal injury, economic injury, and property damage resulting from hazards. This process assesses the vulnerability of people, buildings, and infrastructure to hazards and focuses on 1) hazard description 2) severity 3) probability 4) location 5) historic occurrences 6) impact to the social environment 7) impact to the built environment 8) impact to the natural environment, and 9) impact to the future environment  |
| Riverine Flooding                                       | Occurs when freshwater rivers and streams exceed local flow capacity and water spills over their banks.  |
| Saffir-Simpson Hurricane Wind Scale                     | Primary scale used by the National Weather Service (NWS) to measure the strength of a hurricane. The scale uses wind speed to determine the category strength of a hurricane on a scale of 1 to 5.   |
| Sea, Lake, and Overland Surges from Hurricanes (SLOSH)  | Computer model which calculates surge based on storms moving in different directions and with varying strengths.   |
| Self-Care Disability                                    | Conditions lasting six or more months that make dressing, bathing, or getting around inside the home difficult.  |
| Sensory Disability                                      | Blindness, deafness, or a severe vision or hearing impairment.   |
| Severe Thunderstorm                                     | Thunderstorms consisting of winds of 58 mph or higher, and/or large hail measuring at least 1 inch in diameter, and/or a tornado. About 10% of thunderstorms are classified as severe.   |
| Sleet   | Sleet is defined as pellets of ice composed of frozen or mostly frozen raindrops or refrozen partially melted snowflakes.  |
| Snow  | Precipitation in the form of ice crystals, mainly of intricately branched, hexagonal form and often agglomerated into snowflakes, formed directly from the freezing of the water vapor in the air.   |
| Snow Showers  | Brief, intense periods of snowfall resulting in accumulations of one inch or less.   |
| Snowsquall  | Moderate to heavy snowfall accompanied by strong, gusty winds and, sometimes, lightning.   |
| Socioeconomic Drought                                   | Occurs when a water shortage impacts health, well-being, and quality of life or starts to have an adverse impact on a region.  |
| Special Initiative for Rebuilding and Resiliency (SIRR) | Initiated by Mayor Bloomberg in December 2012 to explore what happened during Hurricane Sandy and how to prepare for and reduce New York City's risk from the impacts of climate change.   |
| Spectral Acceleration (SA)                              | Measures what is experienced by a building during an earthquake, by referencing a particle mass on a mass-less vertical rod having the same natural period of vibration as the building.   |

| Term                     | Definition   |
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| STAPLEE                  | A set of criteria used to examine the Social, Technical, Administrative, Political, Legal, Economic, and Environmental (STAPLEE) opportunities and constraints of implementing a particular mitigation measure using a consistent framework.   |
| Stillwater Flooding      | A rise in water levels without significant waves.  |
| Storm Surge              | An abnormal rise in water level above the normal astronomical tide level as it is pushed towards the shore by the force of the winds and low pressure of a storm. It is measured as the difference between normal astronomical tide levels and observed storm water levels, or storm tide. |
| Storm Surge Inundation   | The storm surge height above ground level, calculated by subtracting the total land elevation from the total storm surge height.   |
| Storm Tide               | When storm surge combines with the astronomical high tide, raising mean water level and causing severe inundation of coastal areas.  |
| Structural Hazard Areas  | Section of the Coastal Erosion Hazard Area located landward of natural protective features and having shorelines receding at a long-term average recession rate of one foot or more per year.  |
| Susceptibility           | Factors which make certain populations more at-risk to a hazard, including predisposition, stress, environmental factors, and behavioral factors.  |
| Terminal Moraine         | Rock debris deposited by glaciers. In the city this represents the hilly area which stretches through Staten Island and central Brooklyn/Queens.   |
| Thundersnow              | Snow accompanied by thunder and lightning.   |
| Tidal Flooding           | Flooding of low-lying coastal areas that occurs due to astronomical high tides combined with sea level rise.   |
| Tornadoes                | A local atmospheric storm, generally of short duration, formed by winds rotating at very high speeds, usually in a counterclockwise direction. The vortex is visible to the observer as a whirlpool-like column of winds rotating about a hollow cavity or funnel.                         |
| Tropical Cyclone         | Organized areas of precipitation and thunderstorms that form over warm, tropical ocean waters. Rotation is counterclockwise around a low pressure center.  |
| Tropical Depression      | A tropical cyclone consisting of an organized system of clouds and thunderstorms, with a defined surface circulation, and maximum sustained winds of 38 miles per hour or less.  |
| Tropical Storm           | A tropical cyclone consisting of an organized system of strong thunderstorms, with a defined surface circulation, and maximum sustained winds of 39 to 73 miles per hour.  |
| Urban Heat Island Effect | Develop when built surfaces replace a large portion of natural land. Incoming solar radiation is trapped during the day and is then re-radiated at night. This slows the cooling process, keeping nighttime air temperatures high, relative to temperatures in less urbanized areas.       |
| Utility Disruptions      | Disruptions to essential utilities, including energy (electric, gas and steam) and communications.   |
| Virulence                | The relative severity of a disease caused by a microorganism (the ratio of clinical cases to the number of infected hosts)   |
| Vulnerability            | Refers to a reduced capacity of the social, built, or natural environment to cope with, resist, or recover from the impact of a hazard.  |
| Wildfires                | Uncontrolled fires that are ignited in woodland, brush, or grassland areas with minimal development.   |

| Term                           | Definition  |
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| Wildland-Urban Interface (WUI) | The area, or zone, where structures and other human developments come into contact with undeveloped areas or vegetative fire fuels.   |
| Wind-Chill Effect              | Measures apparent temperature felt on exposed skin due to the combination of air temperature and wind speed. This occurs because wind causes heat to leave the body more rapidly.   |
| Windstorms                     | Short-duration events involving strong straight-line sustained winds or gusts of sufficient strength to cause property damage. Windstorms are especially dangerous in areas with significant tree stands, exposed property, poorly constructed buildings, mobile homes (manufactured housing units), major infrastructure, and aboveground utility lines. A windstorm can topple trees and power lines; cause damage to residential, commercial, critical facilities; and leave tons of debris in its wake. |
| Winter Storms                  | Ice storms, heavy snow, and blizzards, often accompanied by extreme cold. Heavy snow generally means snowfall accumulating to 6 inches or more in 12 hours or less, or snowfall accumulating to 8 inches or more in 24 hours or less. A blizzard has winds of 35 miles per hour or more with snow and blowing snow, reducing visibility to less than 1/4 mile for at least three hours.   |