NYS 2100 COMMISSION

Recommendations to Improve the Strength and Resilience of the Empire State's Infrastructure

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Foreword by

NYS 2100 Co-Chairs
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Superstorm Sandy produced countless stories of heartbreak, but also of hope and resilience. First responders and emergency service personnel focused on rescue operations, even as their own properties faced certain peril. New Yorkers opened their homes to friends and neighbors who were without heat and electricity long after the floodwaters receded. Families who lost nearly everything in the initial impacts and the blazes that broke out after the storm chose to look forward, vowing to pick up the pieces and return stronger than before.

As New York continues to recover, we must also turn our attention to the future. We live in a world of increasing volatility, where natural disasters that were once anticipated to occur every century now strike with alarming regularity. Our response capabilities to this new level of instability and the ability to bounce back stronger must be developed and strengthened. Our efforts must be rooted in robust structural underpinnings as well as expanded operational capacities. Superstorm Sandy made the urgency of this undertaking painfully clear. We also now possess a vastly deeper understanding of our current vulnerabilities. We cannot just restore what was there before – we have to build back better and smarter. As Governor Cuomo said, "It's not going to be about tinkering on the edges. Many of these systems we know have not worked for many, many years."

While the response to Sandy continues, work needs to begin now on how we build back better – in a way that increases New York's agility when responding to future storms and other shocks. Building back better demands a focus on increased resilience: the ability of individuals, organizations, systems, and communities to bounce back more strongly from stresses and shocks. Resilience means creating diversity and redundancy in our systems and rewiring their interconnections, which enables their functioning even when individual parts fail.

There is no doubt that building resilience will require investment, but it will also reduce the economic damage and costs of responding to future storms and events, while improving the everyday operations of our critical systems. In a time of fiscal constraints, the positive sign is that inexpensive policy changes will be as critical as the financial investments we make. Hard infrastructure improvements must be complemented by soft infrastructure and other resilience measures, for example, improving our institutional coordination, public communication, and rapid decision making abilities will make us better able to recover from the catastrophic effects of natural disasters. In many respects, New York is ahead of the game in this regard. In recent storms, including Irene and Sandy, we have successfully embraced the notion of "failing safely," accepting the inevitability of widespread disruptions and tucking in to protect our assets to the extent possible.

We cannot prevent all future disasters from occurring, but we can prevent failing catastrophically by embracing, practicing, and improving a comprehensive resilience strategy. As New York and our neighboring states continue to recover from the devastating impacts of Superstorm Sandy, we have a narrow but distinct window of opportunity to leverage the groundswell of consciousness.

Building a 21st century resilience strategy comes with significant economic opportunities. Newly conceived infrastructure investments will be rooted in rebuilding smarter while also creating the jobs of tomorrow, including green jobs. The spirit of New Yorkers is never more evident than when faced with crisis and the attendant challenges. Now is no different. The recommendations outlined in the following report provide the framework, but this is only the beginning. Resilience requires frequent testing and evaluation. Together, we can make a more vibrant and crisis-ready New York State.


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Executive Summary

Introduction

On November 15, 2012, Governor Andrew Cuomo convened the NYS2100 Commission in response to the recent, and unprecedented, severe weather events experienced by New York State and the surrounding region: most recently, Superstorm Sandy, Hurricane Irene, and Tropical Storm Lee. The Governor asked the Commission to examine and evaluate key vulnerabilities in the State's critical infrastructure systems, and to recommend actions that should be taken to strengthen and improve the resilience of those systems. If done right, we have a tremendous opportunity not only to mitigate future damage and subsequent economic losses, but to invigorate New York's economy with a robust green technology sector and to enhance quality-of-life for all New Yorkers.

The next century will be defined by the extent to which our communities are resilient to the direct and indirect impacts of a rapidly changing climate and other long-term accelerators of change. We will never be able to predict or prevent all extreme events. But we must not waste the lessons learned and opportunities afforded by these recent storms to chart a course for the State that truly prepares our communities for future eventualities. Planning for a more resilient tomorrow enables the State and its residents to take cost-effective actions and to make investments that will benefit our communities today and far into the future.

Governor Cuomo convened a diverse group of experts from academia, business, the not-for-profit community, engineering, finance, real estate, and the federal government to advise him and the people of New York on what investments were needed to enhance the state's resilience to 21st century hazards and support a thriving economy throughout the coming decades.

The challenges facing the State are not to be underestimated. There are significant climate change risks including sea level rise, changing patterns of precipitation, temperature change and increasingly frequent extreme weather events. There are demographic pressures, with significant population growth predicted for New York state, and structural changes within the population, including further urbanization, the growth of suburban poverty, as well as the continuing needs of those living below the poverty level and a growing aging population.

We will never be able to perfectly predict or prevent all extreme events or eventualities. Therefore, we must conserve and develop those systems that can most quickly respond to, and most effectively rebound from, severe weather events and other emergencies. Building resilience will enable us to avoid unmanageable impacts, while managing the risks that the future will no doubt present. Our capacity to deal with known risks, while establishing countermeasures to contend with unknowns, will be critical in this century.

The Commission reviewed the vulnerabilities faced by the State's infrastructure systems, and developed specific recommendations that can be implemented to increase New York's resilience in five main areas: transportation, energy, land use, insurance, and infrastructure finance. These recommendations are aimed to:

- Identify immediate actions that should be taken to mitigate or strengthen existing infrastructure systems – some of which suffered damage in the recent storms – to improve normal functioning and to withstand extreme weather more effectively in the future;
- Identify infrastructure projects that would, if realized over a longer term, help to bring not only greater climate resilience but also other significant economic and quality of life benefits to New York State's communities;
- Assess long-term options for the use of "hard" barriers and natural systems to protect coastal communities;
- Create opportunities to integrate resilience planning, protection and development approaches into New York's economic development decisions and strategies; and
- Shape reforms in the area of investment, insurance and risk management related to natural disasters and other emergencies.

In addition to numerous recommendations related to specific infrastructure systems, the Commission identified nine cross-cutting recommendations to improve New York State's overall resilience. These recommendations include steps to improve the State's built (hard) and natural (soft) infrastructure, institutions, and information systems. Based on a broad resilience framework, these recommendations aim to improve the day-to-day functioning of critical systems and enhance the efficiency of normal operations, doubling the benefit of the recommended investments.

These cross-cutting and sector-specific recommendations are outlined below and described in depth in the Commission's full report, along with numerous case examples of where similar resilience measures have been applied effectively elsewhere in the United States and around the world. These examples all point to core characteristics that resilient systems share in good times and in times of stress. These include having spare capacity, staying flexible, managing failure adaptively, rebounding quickly, and improving frequently through effective feedback loops, not just when disaster strikes. The Commission's recommendations aim to provide the elements of a blueprint for Governor Cuomo to rely upon in preparing New York State's infrastructure and its communities for the increasing challenges of this century

Cross-cutting Recommendations

All resilient systems share and demonstrate certain core characteristics in good times and in times of stress. Many of these recommendations are relevant to multiple sectors, create improvements across systems, and enhance these essential resilience characteristics. The nine major recommendations highlighted below are elaborated in the full report.

Protect, upgrade, and strengthen existing systems
State agencies and authorities can take specific short-term action to significantly improve the long-term resilience of New York State's critical infrastructure systems. These include returning aging and damaged transportation, energy, drinking water and wastewater systems to a state of good repair; replacing irreparably damaged infrastructure with more resilient alternatives; and providing services and protections through new measures, such as natural infrastructure projects and coastal ecosystem restoration, to create additional lines of storm defenses.

Rebuild smarter: ensure replacement with better options and alternatives
As the rapid recovery and response continue to move forward, it is essential to identify where one-to-one replacement is not the best option for long-term resilience building. This recommendation focuses on transitioning from short-term solutions to long-term resilience measures. The State should develop scenario-planning capability to explore policy options for guiding where to build, what to build, and how to strengthen communities in areas of greatest risk. Scenario planning exercises should be held with communities across the state to inform and guide decisions about long-term rebuilding efforts, future investment plans, and the level to which we rely upon "soft" solutions or harden and upgrade our infrastructure.

Encourage the use of green and natural infrastructure
The Commission recommends that New York State adopt measures that promote the use of green and natural infrastructure through direct investment, new incentive programs, and education. A green infrastructure approach emphasizes the use of solutions that maintain and support services provided by natural systems, such as wetlands and dunes that can serve as natural buffers against storm surges and complement efforts to build new traditional infrastructure to protect communities. There have been many severe weather events where a broader adoption of green infrastructure could have minimized local problems with flooding, contamination or erosion.

Create shared equipment and resource reserves
The Commission recommends creating statewide and regional pools or banks of critical infrastructure that allow for continuous improvement and modernization in the face of disruptions or failures. One of the major barriers to effective system upgrading and maintenance is weak links or limiting factors in critical supply chains. Creating regional pools of hard-to-procure equipment can facilitate rapid recovery from component failures and support more cost-effective regular system upgrades as newer parts are cycled through a system.

Promote integrated planning and develop criteria for integrated decision-making for capital investments
New York State has a variety of planning processes. Ensuring that resilience is effectively incorporated into the State's many complex systems and plans requires new approaches to both planning and implementation. Responsibility for the State's infrastructure is shared, with no single institution in charge. Transportation, energy, and utility infrastructure are networked systems such that delays, failures, or catastrophic failures in one system can disrupt other systems. In several areas, the Commission recommends a more integrated planning function or process across agencies and authorities. For example, integrated planning is an essential first step to creating a comprehensive coastal management strategy and inventory that ensures multiple lines of defense for vulnerable communities. Additionally, the Commission strongly recommends that other decision criteria, such as the New York Works capital investment criteria, be aligned with relevant and practical resilience assessments in future institutional decision-making, planning and investment processes across the State.

Enhance institutional coordination
The Commission recommends several key actions to streamline New York State's approach to planning for and implementing resilient development strategies. Recommendations include the creation of a new Chief Risk Officer or unit to provide a platform for coordination between different State agencies and neighboring municipalities and create the basis for an "all hazards" approach to planning, investment, and decision-making. Improving coordination within and between levels of government also offers opportunities to minimize duplication and conflict among agencies, find areas of cooperation to make better use of tax-payer dollars, and improve outcomes for citizens and communities.

Improve data, mapping, visualization, communication systems
Information systems include both the hard data that need to be found, processed, updated, secured and stored in ways that can by effectively used and also the wide range of institutions and individuals who make up the user community of these data. The hard data inform decision-making, interactions between systems, and coordinated management. They also serve as a tool to inform State decision-makers and others so that they can better understand how best to support the general well-being and welfare of the State. One example of this type of infrastructure is the State's Critical Infrastructure Response Information System (CIRIS), which uses Geographic Information Systems (GIS) technology to support analysis, visualization, and decision-making. Further improving the State's information systems can enhance the governance and management of the State's infrastructure during normal operations and also create essential feedback loops to support real-time decision-making and response during and after emergencies.

Create new incentive programs to encourage resilient behaviors and reduce vulnerabilities
In several areas, the Commission recommends the use of incentive programs to influence regional, municipal, and individual decisions and behaviors to encourage more resilient development. For example, various land use programs are identified to support longer-term smart growth patterns that avoid areas of high and increasing vulnerability. The Commission recommends programs designed to expand green storm-water infrastructure; promote energy efficiency and alternative fuels; and reinforce or mitigate vulnerable assets, equipment, or buildings, or homes.

Expand education, job training and workforce development opportunities
New York State should expand investment in education and workforce development programs to ensure the availability of skilled professionals in critical recovery and resilience building activities, including restoring ecosystems, creating and maintaining green infrastructure, repairing damaged equipment and upgrading services. Growing the pool of available skilled workers is essential to handle the current and future needs of critical infrastructure systems, such as electric power and environmental engineering. Infrastructure jobs often require highly skilled workers with years of training; investment in training programs should begin immediately to account for future needs. Creating a larger network of training programs will help form a foundation for the continued development of New York State's workforce for years to come.

Sector-specific Recommendations

These recommendations are grouped into broad headings, and details on specific actions are presented fully in each sector-specific chapter. Additionally, numerous case examples of effective implementation of similar measures can be found in the corresponding chapters of this report.

Transportation

Develop a risk assessment of the State's transportation infrastructure
Identify those assets that are vulnerable to extreme weather events, storm surge, sea level rise and seismic events, and to prioritize future investment through the use of a lifeline network that defines critical facilities, corridors, systems, or routes that must remain functional during a crisis or be restored most rapidly.

Strengthen existing transportation networks
Improve the State's existing infrastructure with an emphasis on key bridges, roads, tunnels, transit, rail, airports, marine facilities, and transportation communication infrastructure. Focus on improved repair, as well as protecting against multiple hazards including flooding, seismic impact and extreme weather.

- Protect transit systems and tunnels against severe flooding
- Invest in upgrades to bridges, tunnels, roads, transit and railroads for all hazards
- Strengthen vulnerable highway and rail bridges
- Protect waterway movements
- Safeguard airport operations

Strategically expand transportation networks in order to create redundancies
Make the system more flexible and adaptive. Encourage alternate modes of transportation.

- Modernize signal and communications systems
- Build a bus rapid transit network
- Expand rail access to/from Manhattan
- Create new trans-Hudson tunnel connection
- Expand rail Access to/from Manhattan with Metro-North Penn Station access
- Expand capacity on the LIRR's Main Line
- Develop alternative modes of transportation

Build for a resilient future with enhanced guidelines, standards, policies, and procedures

Change the way we plan, design, build, manage, maintain and pay for our transportation network in light of increased occurrences of severe events.

- Review design guidelines
- Improve long-term planning and fund allocation
- Improve interagency and interstate planning
- Seek expedited environmental review and permitting on major mitigation investments

Energy

Strengthen critical energy infrastructure
Securing critical infrastructure should be a primary focus. Strategies of protection, include among other things, selective undergrounding of electric lines, elevating susceptible infrastructure such as substations, securing locations of future power plants, hardening key fuel distribution terminals, and reexamination of critical component locations to identify those most prone to damage by shocks or stresses. Creating a long-term capital stock of critical equipment throughout the region provides an efficient system of distribution to streamline the delivery and recovery processes.

- Facilitate process of securing critical systems
- Protect and selectively underground key electrical transmission and distribution lines
- Strengthen marine terminals and relocate key fuel-related infrastructure to higher elevations
- Reinforce pipelines and electrical supply to critical fuel infrastructure
- Waterproof and improve pump-out ability of steam tunnels
- Create a long-term capital stock of critical utility equipment

Accelerate the modernization of the electrical system and improve flexibility
As utilities replace aging parts of the power system, the State should ensure new technologies are deployed. It is important to immediately invest in new construction, replacement, and upgrades to transition the grid to a flexible system that can respond to future technologies, support clean energy integration, and minimize outages during major storms and events. The grid for the 21st century should seamlessly incorporate distributed generation, microgrids, and plug-in electric vehicles (PEVs).

- Re-design electric grid to be more flexible, dynamic and responsive
- Increase distributed generation statewide
- Make the grid electric vehicle ready

Design rate structures and create incentives to encourage distributed generation and smart grid investments
The State should implement new technologies and system improvements to provide effective backup power, flexibility, distributed generation, and solutions for "islanding" vulnerable parts of the system. In addition to improving the resilience and stability of energy, electricity, and fuel supply systems, these solutions promote energy conservation, efficiency, and consumer demand response.

Diversify fuel supply, reduce demand for energy, and create redundancies
Lowering GHG emissions in the power sector through the Regional Greenhouse Gas Initiative (RGGI) will contribute to reducing the impacts of climate change over the very long term. To build on the success of RGGI, the State should encourage alternative fuel sources such as biogas, liquefied natural gas (LNG), and solar heating in transportation and other sectors. PEVs, energy storage systems, and on-site fuel storage where feasible, should also be used to provide new energy storage mechanisms. Incentive programs to promote energy efficiency and renewable energy deployment should be strengthened to increase the level of private sector investment in this space.

- Facilitate greater investments in energy efficiency and renewable energy
- Diversify fuels in the transportation sector
- Support alternative fuels across all sectors
- Lower the greenhouse gas emissions cap through RGGI

Develop long-term career training and a skilled energy workforce
The utility workforce is aging and tremendous expertise will be lost in the next several years. Workforce development strategies should ensure the availability of skilled professionals to maintain a state of good repair, effectively prepare for and respond to emergencies, and deploy and maintain advanced technologies.

- Create a workforce development center
- Expand career training and placement programs
- Build awareness of the need for skilled workers
- Coordinate workforce development among all stakeholders within the energy sector

Land Use

Protect coastal and Great Lakes communities
Our coastlines, one of our most vulnerable assets, are home to a vast majority of the State's population. Because of the significant risk of coastal problems resulting from climate change, this category of recommendations focuses specifically on immediate actions to restore and mitigate coastal infrastructure to protect communities, and on strategies for using natural as well as engineered measures to improve resilience.

- Restore dunes, beaches, and barrier islands
- Repair hard infrastructure along the coast
- Repair and protect wastewater infrastructure
- Repair important public recreational areas
- Dredge inlets and address beach breaches on Long Island and the Great Lakes
- Restore coastal wetlands
- Develop a Great Lakes resilience strategy
- Develop a comprehensive resilience strategy, including a restoration plan and storm surge barrier assessment, for New York Harbor

Reduce inland vulnerability to extreme weather events
Climate change poses a risk not only to coastal communities, but to the inland communities of New York State as well. An increase in extreme weather can damage buildings and infrastructure, cripple economies, and create public health hazards. This category of recommendations identifies measures to manage the effects of freshwater flooding and drought, and reduce their impact.

- Protect and restore statewide freshwater wetlands
- Expand wetlands protection in flood prone areas
- Create a wetlands and natural systems mitigation banking program to offset damage or loss
- Protect minor streams across the state
- Expand green infrastructure and urban forests
- Manage at-risk drinking water supplies
- Strengthen dams and levees to protect the public from inland flooding
- Protect and secure petroleum, chemical, and hazardous waste tanks located on waterways

Strengthen wastewater infrastructure
Critical wastewater infrastructure in the State is highly vulnerable to storms and serves a growing population. This category of recommendations focuses on updating the design, planning, and operation of New York's treatment facilities, pump stations, and pipes to reflect new risks.

- Require installation of disinfection systems
- Update design standards for wastewater systems
- Improve long-term maintenance and planning

Develop probabilistic hazards mapping and risk mapping
Superstorm Sandy exposed major weaknesses in our capacity to predict flood events and determine affected areas. Identifying risks is critical to preparing for, and reacting to, weather events and other disasters. This category of recommendations identifies problems and solutions for current methods of hazard and risk assessment.

Strengthen land use programs, standards, policies, guidelines, and procedures
To fully prepare for the effects of climate change, we must encourage sound uses of land to minimize vulnerabilities and preserve communities. This category of recommendations outlines how New York can use programs, incentives, policies, and procedures to shape better land use and building practices.

- Develop regional resilience strategies
- Update the State Environmental Quality Review Act (SEQRA) to incorporate resilience
- Establish new land use policies to account for climate change effects

Insurance

Protect New York State
The resilience of a state and its ability to rebound from devastation not only depend on the severity of any catastrophic event, but also on available funding for relief, recovery, and reconstruction. These include actions the State can take to manage risk holistically and protect itself against financial shocks arising from large losses from disaster.

- Promote state-level risk management
- Consider options to pre-fund disaster recovery and transfer catastrophic risk to capital markets

Protect consumers and businesses
Superstorm Sandy demonstrated the strengths and limitations of the insurance system in New York State and the surrounding region. This section provides a description of the recommendations designed to protect and mitigate risk to individual policyholders, both businesses and residential, including actions the State could take to reduce underinsurance and promote coverage in normal times, as well as actions that would help to protect consumers in post-disaster circumstances.

- Promote investment in risk mitigation
- Improve consumer awareness and education
- Prevent underinsurance for flood risk and certain covered perils
- Expand coverage for business interruption
- Promote a Comprehensive Insurance Emergency Measures Act (CIEMA)
- Provide catastrophe response services

Infrastructure Finance

Establish an "Infrastructure Bank" to coordinate, allocate, and maximize investment
The Commission recommends the establishment of a new Infrastructure Bank with a broad mandate to coordinate financing and directly finance the construction, rehabilitation, replacement, and expansion of infrastructure.

- Assist the State in making more efficient and effective use of public infrastructure funding
- Mobilize private sector resources to meet critical infrastructure needs

Adopt a standard set of criteria for project selection and prioritization
Infrastructure planning and investment decisions, when made in isolation and without the benefit of appropriate analysis, are likely to result in an inefficient allocation of resources. The Commission recommends the State build on the existing criteria from New York Works to develop and apply a standard set of criteria to the selection and prioritization of projects statewide, in accordance with State and regional resilience and economic development strategies.

Develop a range of sources of revenue and cash flow
As projects are identified, prioritized, and financed, it will be necessary to identify appropriate and adequate sources of revenue to pay for them. The Commission recommends identifying the widest possible range of revenue sources.

- Identify revenue sources, including grants, taxes, user fees, and targeted regional programs
- Capture cost savings and avoided losses to generate additional cash flow

Continue to improve the enabling environment
A strong enabling environment can facilitate the identification, financing, funding, and efficient use of the State's infrastructure. The State should evaluate and improve the overall policy and regulatory environment for infrastructure investment.

- Enhance State procurement processes
- Use public-private partnerships
- Expedite permitting
- Provide tax abatements
- Expand the participant pool in financial guarantee protection


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Background

Challenges Facing The Empire State

Climate Change Risks

After the damage inflicted by recent extreme storms, it is clear that New York State must prepare for a new normal. Planning for the future will never again mean the same thing. The recent storms are not anomalies. They represent further evidence in a developing pattern: an increased frequency and intensity of severe weather attributable to climate change.

Climate change can threaten the basic aspects of well-being such as food, shelter, water, energy supply, health and safety. New York State's recent ClimAID projections show that higher temperatures and sea level rise are extremely likely for New York State through the end of the century.[1] Mitigating these climate change risks will require an assessment of broad systemic vulnerabilities, including sea level rise, changing precipitation, changing temperature, and extreme weather events.

Sea Level Rise: Global sea levels continue to rise steadily due to the melting of the polar glaciers and ocean expansion due to warming. By 2100, experts project sea level to rise in New York City and Long Island by as many as six feet under certain scenarios.[2] Rising sea levels will have major consequences for New York's coastal communities including but not limited to:

- Dangerous storm surges caused by high winds and tides, which increase the risk of flooding, beach erosion, and damage to infrastructure in low-lying areas;
- Increased areas of coastal inundation during regular tidal cycles;
- Regular inundation of coastal wastewater infrastructure and the direct transmission of pathogen and nitrogen pollution to ground and surface waters;
- Increased salinity of the drinking water supply in communities along the Hudson due to saltwater intrusion.

Changing precipitation: Over the past 100 years, the pattern of precipitation has changed with increased precipitation in the winter and decreased precipitation in the summer. The latter raises the risk of drought while adversely affecting drinking water supply. Total annual precipitation amounts in the Northeast have increased by approximately 3.3 inches over the last 100 years.

Changing temperature: New Yorkers can expect an increase in average temperature ranging from 4 to 10°F by 2100, primarily in the form of warmer winters. Consequences of this warming include, among other things, northward expansion of certain invasive species and parasites that threaten native plants, ecosystems, and human beings. The impact also potentially creates significant adverse effects on key New York regional economic activities, including winter sports, and maple syrup, apple, and dairy production.

Extreme Weather Events: Extreme weather events, ranging from heat waves to extreme precipitation events, are forecast to increase in both frequency and intensity. Sustained heavy downpours of rain heighten the risk of localized flash flooding and erosion. Heat waves, defined as three consecutive days with maximum temperatures above 90°F, are associated with heat-related illnesses, which disproportionately affect the elderly and children.

The following is a summary of projected changes from the New York ClimAID report[3] as well as the latest climate projections[4]

Climate change risk	2020s	2050s	2080s
Sea Level Rise			
Low	1-5 inches	5-12 inches	8-23 inches
High	5-10 inches	17-29 inches	37-55 inches
Change in precipitation	0-5% increase	0-10% increase	5-15% increase
Change in temperature	1.5-3.0°F	3.0-5.5°F	4.0-9.0°F

Temperature and Precipitation Projections for 2100[5]

Region	Temperature Change	Precipitation Change
1 – Western New York and the Great Lakes Plain	+4.5 to 10.0°F	0 to +15%
2 – Catskill Mountains and the West Hudson River Valley	+4.0 to 9.5°F	0 to +10%
3 – Southern Tier	+4.5 to 9.5°F	0 to +10%
4 – New York City and Long Island	+4.0 to 9.0°F	0 to +10%
5 – East Hudson and Mohawk River Valleys	+4.5 to 9.5°F	0 to +10%
6 – Tug Hill Plateau	+4.5 to 10.0°F	0 to +15%
7 – Adirondack Mountains	+4.5 to 9.5°F	0 to +15%

Sea Level Rise Projections for 2100[6]

Region 4 – New York City and Long Island	
GCM-based	+ 15 to 30 inches
Rapid ice-melt scenario	+ 56 to 72 inches
Region 5- East Hudson and Mohawk River Valleys	
GCM-based	+ 11 to 26 inches
Rapid ice-melt scenario	+ 52 to 68 inches

Demographic Shifts

Demographic and societal changes will have an impact on New York State's expanding population in the decades to come. Between 2011 and 2040, New York State's overall population is expected to grow by 12.5%, from 19.6 million residents to 22 million.[7] Within the population itself are significant structural changes such as the continuing trend of urbanization, the growth of suburban poverty, and the continuing needs of those living below the poverty level, as well as an aging population. New York is the third most populous state in the nation with 87.5% of the population residing in "urban" areas.[8]

Any planning must be cognizant of the more than 2.7 million New York residents who live below the poverty level and face particular challenges in dealing with long-term disruptions.[9] Those who live above the poverty line are often not much better off; many families are just one emergency away from poverty. In New York State, individuals living below the poverty line are often completely reliant on a well-performing public transportation system to get to work, school, and hospitals. Without fully resilient transportation and energy systems, people may be stranded in potentially dangerous situations.

Additionally, the senior segment (65-plus) of the population is forecasted to grow by 75% in the next 30 years in New York State, due to an increase in life expectancy.[10] By 2040, 1 in 5 New York State residents (20.9%) will be above the age of 65. Nationally, over 9 million retirees cannot afford their basic living costs. In the event of a catastrophe, large-scale evacuation of an elderly population is not just about the challenges of a major physical relocation for seniors with impaired mobility, but also careful consideration of refrigeration of medicines; battery backup power for critical life support systems; and effective transportation to ensure adequate staffing, nursing and support.

Infrastructure Vulnerabilities and Impacts

The Commission worked extensively with relevant State agencies' staffs to analyze the experience of recent storms, as well as projected climate change impacts. Based on this analysis, the Commission identified the following key vulnerabilities. In addition to these sector-specific vulnerabilities, the Commission also identified a general lack of redundancy in services and systems that, in the event of a natural disaster, can mean the difference between a complete outage or stop in service and continued operation.

Energy

- New York State's electric transmission and distribution lines and substations are aging and vulnerable to damage and outages, as a result of being mostly above ground and insufficiently protected against severe weather events such as flooding, ice storms and high winds. Utilities are largely unable to identify specific outages in real-time without manual inspections. Too often, utilities also face harmful personnel and equipment shortages in the event of natural disasters that affect large regions. More fundamentally, the "grid" does not sufficiently allow, and certain regulatory requirements discourage, power sources and customers to be "islanded" or run as a micro-grid to allow outages to be confined and enable more rapid recovery.
- With respect to liquid fuels, the pipeline system lacks redundancy and sufficient pumping capacity to avoid widespread impacts in the event that terminals are damaged or must be shut down. Distribution terminals and retail fuel suppliers in most cases either lack, or have insufficiently protected, back-up power sources. Additionally, marine terminals for bulk fuel distribution are often vulnerable to flooding because of their placement and design.
- The State's natural gas pipeline system is aging and prone to leaks. The system lacks remotely operated valves to limit the impact of damage or leaking pipes.
- A large number of Manhattan buildings and universities and hospitals around the State use steam for heat, air conditioning and other processes. Steam tunnels are prone to flooding, and even if undamaged, must often be shut down to avoid safety threats.

Land Use

- Hard infrastructure (sea walls, berms, etc.) are increasingly insufficient to protect against rising tides, storm surge and high winds from severe storms like Sandy, which threaten coastal communities (New York City and Long Island), riverine communities (Hudson Valley, Capital District), Great Lakes communities, and natural ecosystems (dunes, beaches, barrier islands, wetlands).
- With respect to inland communities, many dams and levees must be strengthened to withstand flooding. Inland wetlands and streams that help to reduce flooding are also vulnerable to destruction in the absence of protection.
- Wastewater treatment plants and related stormwater collection systems are vulnerable to flooding, especially in urban areas with large amounts of impervious surfaces. In many cases, these systems lack the technologies to disinfect large volumes of sewage that overflow during and after severe storms to protect public health.
- Drinking water supplies are threatened by increasing droughts, and watersheds and aquifers serving New York City, Long Island, and other communities are increasingly vulnerable to salt water intrusion.
- Critical planning tools, such as hazard maps used for flooding and storm surge predictions, are out of date and not currently based on advanced predictive technologies. These tools and data are used by FEMA to warn the public of risks and used by various state and local agencies to design and locate critical infrastructure, such as storm and waste water collection and discharge systems.
- The natural systems – wetlands, floodplains, forests, and dunes – that provide protection from storms, mitigate climate impacts, retain water to prevent floods, and cool our cities, are vulnerable to development and other land use pressures in addition to the impact of storms. Those systems are often not considered infrastructure in the traditional sense, but they are critical for the future of the State's resilience and its economy

Transportation

- Subway tunnels and depots for both subway cars and buses in New York City lack sufficient protections against flooding and capacity to pump out water that not only stops mass transit service but also damages communications and other aging systems.
- Bridges, culverts, roads, and certain rail infrastructure are all susceptible to the threat of "scour," caused by flooding that erodes the foundations of structures and, if not addressed, undermines the structural integrity of critical transportation links.
- Flooding poses a major threat to airport runways, terminals, and other systems, especially at airports like LaGuardia and JFK that are adjacent to water.
- Vulnerabilities to marine transportation (ports, rivers, canals) vary in nature, but include insufficient tidal gates, electrical power lines vulnerable to damage, and insufficient embankments to protect against flooding and severe winds.

Insurance

- In the event of a disaster, many consumers are unaware of what damage their property insurance covers or, in many cases, they have little or no insurance. This problem is exacerbated by various lawful but complicated deductible and policy exclusions that leave damage from flooding uncovered or damage from multiple events subject to separate deductibles.
- The State's various agencies and authorities manage risks separately and lack a unified risk management operation across all agencies and covering all hazards.

A Resilient New York and Resilient New Yorkers

What is Resilience?

Resilience is the ability of a system to withstand shocks and stresses while still maintaining its essential functions. Therefore systems that are more vulnerable – i.e., those that are brittle, at stretched capacity, or with very low diversity – are more at risk of catastrophic consequences when the next shock event happens. Resilient systems are also better able to repair and recover afterwards.

Taken together, there are several features that are common to most resilient systems, including having spare or latent capacity (redundancy); ensuring flexibility and responsiveness; managing for safe failure (building resistance to domino effects); and having the capacity to recover quickly and evolve over time – to thrive, not just survive major disruptions. These characteristics form the basis for the Commission's ideas about which measures will help to make New York more resilient.

Resilience dynamics operate at every level and on all scales – from individuals and families up to State and Federal entities – and for any type of system, such as local communities, markets, utility networks and ecosystems. For the State to become more resilient, we must look at virtually every aspect of our society to identify potential improvements. We will all need to become resilient New Yorkers.

The recommendations of the Commission reflect the breadth and complexity of this challenge, with some aimed at modernizing our physical infrastructure, some designed to improve the quality and availability of information – both for planning and in times of crisis – and still others directed towards the policy and regulatory reforms needed to encourage and empower institutions and individuals to act in ways that reduce vulnerability.

Avoiding the Unmanageable and Managing the Unavoidable

Resilience thinking is useful because it allows us to develop effective strategies to reduce risk from events even when we cannot control the events themselves. It also helps to ensure that our strategies are holistic and take into account all the different elements and the possible interactions between them when we try to make changes to any one part. This is especially important when we are looking at the challenges New York faces from climate change risk, social shifts, and infrastructure vulnerabilities.

Resilience is not just a topic for times of crisis. We will never be able to perfectly predict or prevent all extreme events and eventualities. We must conserve the natural systems that protect us, and plan and develop systems that can quickly respond to, and rebound more effectively from, severe weather events and other emergencies. Building resilience will enable us to avoid unmanageable impacts, while managing the unavoidable risks that the future no doubt will present. Our capacity to deal with known risks, while establishing countermeasures to contend with unknowns, will be critical in the coming century.

A resilience-planning framework provides a clear guide to the regular process of planning, assessment and re-evaluation. Through this framework, knowledge and feedback from past events can be applied to understand and prepare for future impacts. Flexible, long-term options must be favored over short-term fixes.

Because resilient systems are defined by a set of shared characteristics, rather than by particular projects, the use of a resilience framework encourages flexibility and creativity in decision-making and implementation. These features are necessary for a system's ability to withstand and recover from shocks and stresses and thrive

Building Blocks of Resilience: How Will These Recommendations Make New York More Resilient?

There are some core characteristics that all resilient systems share and demonstrate in good times and in times of stress.[11] These include having spare capacity, staying flexible, managing failures, rebounding quickly, and improving continuously, not just when disaster strikes. These building blocks of resilience have been developed through research, practice, and hard experience with disasters around the world. Programs such as the Rockefeller Foundation's Asian Cities Climate Change Resilience Network have demonstrated that by reducing the vulnerabilities or weak links in one area resilience can be enhanced more broadly in a large urban area or across an entire region.

All of the Commission's recommendations in this report are intended to improve New York's resilience and capacity to rebound. The five characteristics below are well-described in the emerging, empirical research on what makes some places and some

systems more resilient than others. They are used here to provide a consistent framework for considering all of the proposed actions described in this report, and highlight how individual projects or actions might enhance the resilience of New York State overall.

Spare capacity or redundancy: Spare capacity or redundancy provides a measure of security when a system is under stress by making sure that there are adequate and effective back-ups, alternatives, or reserves to respond to sudden or severe events. This spare or latent capacity in a system depends on up-front planning to ensure diversity and to build alternative strategies, pathways and options for maintaining core services and safety nets. At the individual or household level, redundancy describes simple actions like having extra batteries for flashlights in the event of power failures, canned food and water in the pantry, or a spare tire in the trunk of a car. At the State and regional levels, this characteristic encompasses having spare parts for the electric grid and back-up generators (at hospitals and apartment buildings) with fuel supplies that are unlikely to be disrupted by whatever might take down the electric supply or redundant means for transportation. Redundancy needs to be a part of New York's planning and investment strategies across all of the State's critical infrastructure and services.

Flexibility or Responsiveness: Flexibility in the face of disaster is the ability to change, evolve and adopt alternative strategies (in either the short or longer term) in response to changing conditions. Flexibility implies recognizing when it is not possible to return to the previous way things worked and evolving or finding new solutions and strategies to short and long-term problems. This favors "soft" rather than "hard" solutions, such as having coastal hazard maps and flood maps that are regularly updated with real-time data to inform planners and decision makers for many purposes, but including to support evacuation plans as conditions change and to build additional lines of defense in the longer-term to reduce the need for emergency measures.

Limited failure: Systems can be made more or less resilient depending on surrounding decisions, requirements, and actions. Decisions cannot be made in isolation. Each piece of the puzzle has the ability to either derail or reinforce how we respond to calamities in whatever form they come. Resilient network infrastructures are designed to prevent cascading failures and allow for "safe failure" that is limited in scope. When one domino falls it should not take down a whole system. This is related to a system's ability to absorb shocks and manage the cumulative effects of slow-onset challenges in ways that avoid catastrophic failure. When part of a resilient system fails it does so progressively rather than suddenly, and limits ripples across other systems.

Rapid rebound: The capacity to rebound is part of a system's ability to re-establish function to contain losses and avoid further disruption. This ability requires feedback loops that facilitate effective reorganization to reestablish function quickly. Rapidity is a key part of responsiveness in order to contain losses and prevent cascading failures or long-term disruption. A major part of rebounding quickly is making sure that rapid response measures do not limit pathways for learning, long-term response, and growth. The MTA shut down in advance of Superstorm Sandy was a good example of both limiting failure and rapid rebound. The MTA reduced the danger and damage by closing in an orderly way and getting all the trains and buses to higher ground before the floodwaters arrived. As the water receded the MTA was able to immediately restart service, slowly bringing the system back up to normal over hours, days, and weeks that followed.

Constant learning: Building resilience is a process not an outcome. As the future evolves and unfolds, how we plan for, approach and face new challenges requires constant adaption and reinterpretation. Every critical experience – both failures and successes – must get folded into the calculus of how we safeguard the future. Each occurrence tests our resilience measures in unique ways and each system reaction provides the opportunity to tailor and fine-tune our approach. This capacity is related to the ability to mobilize assets (financial, physical, social, environmental, technology, data and information) and human resources in flexible ways to find new solutions as conditions change.[12]

The Commission recognizes the critical importance of having clear assessment criteria that can apply to the wide range of activities and investment decisions necessary to improve the State's infrastructure, institutions, and information systems over time. The Commission notes that resilience assessment criteria are as important as other decision criteria, such as New York's capital investment criteria, and should be used in future institutional decision-making, planning and investment processes across the State.

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Recommendations


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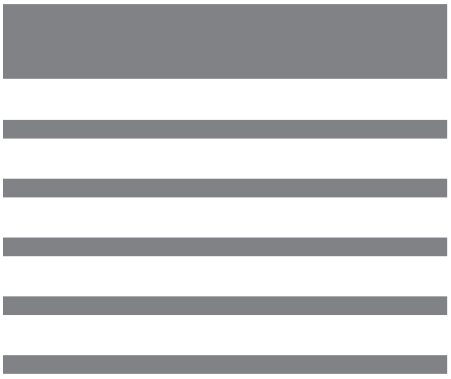
Cross-Cutting



Overview

The cross-cutting recommendations of the Commission are based on actions that affect multiple aspects of New York State's overall resilience. Many of these recommendations build on one another for the purposes of achieving a truly robust regional network of built and natural infrastructure, local and state institutions, and information and communication systems.

Based on an initial vulnerability assessment, the Commission recommends the following nine major actions to address multiple vulnerabilities and priorities in the State of New York:

- Protect, Upgrade, and Strengthen Existing Systems
- Rebuild Smarter: Ensure Replacement with Better Options and Alternatives
- Create Shared Equipment and Resource Reserves
- Encourage the Use of Green and Natural Infrastructure
- Promote Integrated Planning and Develop Criteria for Integrated Decision-making for Capital Investments
- Enhance Institutional Coordination
- Improve Data, Mapping, Visualization, and Communication Systems
- Create New Incentive Programs to Encourage Resilient Behaviors and Reduce Vulnerabilities
- Expand Education, Job Training and Workforce Development Opportunities

Collectively, these recommendations represent a foundation for the broad-based changes that are essential to building the long-term resilience of the State and its citizens.

Protect, upgrade and strengthen existing systems

Specific actions that State agencies and authorities can take in the short-term to significantly improve long-term resilience, include: returning aging and damaged transportation, energy, drinking water and wastewater systems to a state of good repair; replacing irreparably damaged infrastructure with more resilient alternatives; and providing services and protections through new or expanded measures, such as coastal ecosystem restoration and natural infrastructure projects that would create additional storm defenses. These actions and others are described in detail in the chapters that follow, and below are a few cross-cutting actions that should be the focus of planning, construction, and policy making processes to ensure resilient system-wide upgrading:

- Waterproof low-lying infrastructure, such as road and rail tunnels, transit depots and yards, airports, hospitals, water and wastewater treatment plants, energy plants, and solid waste facilities. Flood-proofing critical transportation tunnels, such as the major transit points to and from Manhattan, and upgrading the electricity delivery system to use submersible switches and smart grid technologies are important measures that can improve normal operations, prevent long-term damage, and ensure quick recovery from disruptions.
- Safeguard the State's coastline through a comprehensive package of short- and long-term solutions to address baseline sea-level rise and tidal changes and extreme storm surges. This includes protecting urban shorelines with carefully designed measures, such as surge barriers, levees, bulkheads, natural defenses, and green infrastructure to better manage stormwater.
- Strengthen or replace scour-prone bridges and culverts to protect against future storms and flooding.
- Fortify wastewater infrastructure and require disinfection of stormwater discharges in flood-prone plants to protect public health.
- Protect future supplies of drinking water through a comprehensive set of measures to reduce threats to existing sources, improve efficiency and reduce the demand for new infrastructure, and reform drought management procedures.
- Prioritize energy system upgrades to improve the efficiency and reliability of existing aging power plants and transmission lines, while adding flexibility to the system to accommodate future technologies, allow clean energy integration, and minimize sustained outages and cascading failures during major disruptions. Hardening or elevating substations, selective underground placement of power lines, and better distribution management systems to limit widespread outages are critical. These steps should be complemented by identifying and reinforcing critical elements most prone to damage, and diversifying the fuel supply for electricity, transportation and heating. Accommodating smart grid technologies to assess and manage system performance in real time can also minimize the impacts of future disasters and create pockets of power when central power plants or parts of the grid are down.

Rebuild Smarter: ensure replacement with better options and alternatives

In many cases, one-to-one replacement is not the best option for long-term resilience. Transitioning from short-term recovery to long-term resilience measures means taking steps to support system expansions and to avoid locking-in technologies or approaches that are less effective over time. Creating new network access points and alternatives -- including new transportation links, back-up power systems, nodes for telecommunications systems, and multi-fuel source power generation systems -- can help ensure that immediate and reliable work-around options become available as systems are disrupted. Below are a few examples of cross-cutting actions that should be the focus of smart rebuilding efforts.

- Expand and create critical transportation redundancies and alternatives both to improve day-to-day operations and to keep people and materials moving safely through inevitable failures that occur in the event of a disaster. Redundancy measures may include intercity rail, additional surface transit systems (rail and bus), expansion of ferry services, and the addition of infrastructure that encourages the use of alternative modes of transit. Specific recommendations highlighted by the Commission include the expansion of the Metro North transit line, construction of new train tunnels into Manhattan, and expansion of the Bus Rapid Transit network to decrease dependence on lower Manhattan subway lines and improve mobility for outer boroughs residents.
- Smart rebuilding will require a case-by-case assessment to ensure that specific projects enhance long-term security for the communities and assets they are designed to protect. In areas where inlets are stable or closing slightly, such as the Fire Island Wilderness breach, the better option might involve allowing for growth of new grasses and wetlands that can reduce flooding.
- Prioritize repairs, upgrades, replacement, and construction of new energy infrastructure designed to reduce risk of climate change and disruption to other energy-dependent systems. This includes improving system efficiency and diversifying fuels and supply pathways to build resilience and support the State's goals for reducing carbon emissions and limiting future climate-related impacts. As noted, hardening vulnerable systems (selective undergrounding, relocating, or upgrading of components) can also reduce disruptions.
- Update potentially harmful existing rules and incentives. In numerous areas discussed in this report, the Commission recommends that the State review existing laws and regulations to integrate benchmarks or consideration of resilience into planning for development, capital spending and other processes. For example, the Stafford Act is federal legislation that governs public funding to repair, restore, reconstruct, or replace public facilities destroyed in a major disaster. In general, governments can only recover eligible costs based upon a structure's pre-disaster design, which may limit their ability to recoup extra costs needed to improve an asset so that it is more resilient. This legislation and other similar rules were put in place in a time before shifting demand, technology innovation, and climate change accelerated the pace of change in our infrastructure systems. The Commission recommends that New York lead the charge to encourage FEMA to approve modifications that increase the resilience of an asset and develop clear guidelines for seeking a modification for these purposes.

Encourage the use of green and natural infrastructure

The Commission recommends that New York State expand investment in green and natural infrastructure systems and adopt measures that promote the use of green infrastructure through incentive programs and education. Using green infrastructure where appropriate to mimic natural processes to infiltrate, evaporate, retain, or reuse storm water can help safeguard communities against serious flood damage. Considering "soft" infrastructure solutions as part of a package with traditional infrastructure can help mitigate system risk, among other benefits. Building New York's resilience to coastal flooding through the following measures can also enhance ecosystem health, provide additional parkland and recreational opportunities, increase public access to the shore front, improve water quality, and reduce urban heat island effects:

- Expand green infrastructure incentive programs and encourage existing State Environmental Protection Fund grant and loan programs to provide dedicated funding for planning and implementing natural infrastructure projects across sectors, such as repaving roads with porous materials and promoting water efficiency in the energy and transportation sectors.
- Assess changes to the Environmental Conservation Law to encourage green infrastructure as part of mitigation actions taken to promote resilience; provide incentives for creation of soft shorelines and wetlands; and require consideration of sea level rise scenarios. Identify revisions to existing laws and programs to streamline soft infrastructure projects, particularly where such infrastructure will provide additional defenses against future storms. As part of this process, New York State should also consider pay-for performance policy options that could incentivize private investment.
- Develop a comprehensive package of soft infrastructure investments to protect New York Harbor communities, including building living shorelines, new wetlands, oyster reefs, and small island archipelagos in shallow offshore areas and flood zones, where appropriate.

Create shared equipment and resource reserves

The Commission recommends creating statewide and regional pools or banks of critical equipment that allow for regular improvement and modernization in the face of disruptions or failures. One of the major barriers to effective system upgrading and maintenance is weak links or limiting factors in critical supply chains. Creating regional pools of hard-to-procure equipment can facilitate rapid recovery from component failures and support more cost-effective continuous system upgrades as newer parts are cycled through a system.

Many utilities are highly constrained by the small number of equipment suppliers for critical capital-intensive, specialized equipment, such as extra-high-voltage transformers, which can take months to manufacture and transport. A large event has the potential to trigger a shortage of available equipment. A resource pool that spreads the costs to create a long-term stock of critical equipment across a region can leave utility companies less exposed to supply bottlenecks.

In efforts to restore services following Superstorm Sandy, the MTA used over 80% of their inventory of equipment, nearly exhausting replacement supplies. Similarly, the PANYNJ relied on partners including the US Department of Transportation and the Federal Transit Authority, as well as companies from as far as Louisville, KY, Pearl, MS, and Pittsburgh, PA for PATH replacement parts. Ensuring adequate and appropriate component supply in critical systems, such as the electrical switches and signals in transit networks, is not only essential for recovery of the transit system but also for other transportation dependent systems.

- Standardize equipment across transportation agencies to improve redundancy and efficiency. While this may require long-term actions for larger equipment such as vehicles and rolling stock, establishing a uniform selection of critical equipment for signals and communications in the short-term would minimize storage area, increase the availability of replacement parts, and streamline delivery.
- Optimize surplus inventory maintained by transportation agencies to make more efficient use of capital budgets and available space for storage. The State government should work with regional utilities to establish a program that helps agencies share inventory, and provide capital investment to purchase and maintain reserves. A shared inventory provides redundancy across systems in the event of a failure in one area, and ensures that necessary equipment will be readily available and easily accessed. These inventories should not be located in proximity to the components that are intended to be replaced to avoid damage in the case of an extreme event.
- Create resource pools for critical services. New York should, as part of its comprehensive emergency planning process, designate critical facilities such as schools, hospitals and municipal buildings to serve as safe havens during storms by supporting the deployment of clean on-site generation at those facilities capable of operating when the grid goes down. Private facilities, such as big box stores and shopping malls, willing to commit to serve as "energy sanctuaries," should receive incentives and support.
- Develop a fleet of clean portable generators – including solar PV coupled with batteries and fuel cells – for temporary emergency dispatch and back-up power.

Promote integrated planning and develop criteria for integrated decision-making for capital investments

The Commission strongly recommends that the State create a mechanism to streamline and enhance coordination among State agencies, authorities and municipalities over where to build, what to build, and how to strengthen communities in areas of greatest risk. The planning process should guide decisions about rebuilding efforts, future investment plans, and the level to which we rely upon "soft" solutions or harden and upgrade our infrastructure over the long-term.

Planning is a major part of the capital improvement, prioritization, financing, operations, and maintenance of infrastructure. Long-term resilience planning should be coordinated across sectors, especially to incorporate climate data and projections into existing scenario planning and decision-making processes, manage risk, prioritize investments, and assess the range of potential options to build resilience.

- Establish a State-level Risk Officer or unit to assess risks across agencies and systems to manage risks more effectively. The existing agency-by-agency approach to risk management misses an opportunity to make integrated risk management decisions and achieve greater efficiencies and lower costs.
- Integrate Long Term Scenario Planning into both state and regional planning processes to assess anticipated climate change impacts and other long-range changes. Using tools such as the State's GIS system CIRIS, scenarios can help set policy over where to build, where not to build, where to strengthen and protect systems and where to avoid investment due to increased risks. Use existing plans and mapping tools to ensure that the most vulnerable areas can be targeted for coordinated development and support.

- Building on New York Works, the State should plan its agencies' capital investments holistically and against common benchmarks to ensure the most effective prioritization process and allow resilience to be fully considered in that planning process.
- Identify critical cross-sector interdependencies, such as transportation switching, signaling, and communications infrastructure to develop integrated plans to mitigate against cascading failures across multiple sectors. State agencies should periodically assess critical linkages and risks across transportation, water, communications, electricity, and fuel systems.
- Develop resilience assessment criteria. The Commission notes that resilience assessment criteria are as important as other decision criteria, such as New York's capital investment criteria. The Commission strongly recommends that existing criteria, such as the New York Works capital investment criteria, be aligned with relevant and practical resilience assessments in future institutional decision-making, planning and investment processes across the State.

Enhance institutional coordination

- Ensuring resilience within the State's infrastructure system requires knowledge that crosses disciplines and agency jurisdictions. As a home-rule state, New York's municipal governments hold powers to determine how land development, land management and infrastructure investments are addressed. Cooperation between neighboring states is essential where critical infrastructure systems cross state boundaries. Infrastructure financing in many states and across levels of government is often carried out in a "siloed approach," which can compromises the efficient use of funds. Agencies and authorities should be coordinated not only across sectors but regionally, across the state and, where applicable, across the Tri-State area to better understand the impact that certain upgrades or new developments might have on the wider system.
- The Commission recommends several key actions to streamline New York State's institutional structure to promote resilient development. Recommendations to improve both integrated planning and cross-agency coordination include a unit to provide a platform for aligning different State agencies and neighboring municipalities and creating the basis for an "all hazards" approach to planning, investment, and decision-making. Improving coordination within and between levels of government also offers opportunities to minimize duplication and conflict among agencies, find areas of cooperation to make better use of tax-payer dollars, and improve outcomes for citizens and communities.
- Create a regional coastal resiliency program under the Department of State to assist local governments, in collaboration with state agencies and external institutions, to develop regional resilience strategies. The program must combine infrastructural and governance solutions to achieve multiple benefits, and identify the expected time frame and planning required for its recommendations. This provides the opportunity for immediate actions to be initiated without an adverse effect on long-term initiatives.
- Expand coastal community partnerships. The DEC, US Army Corps of Engineers and communities currently work together on a number of projects along the State's coasts. Several additional partnerships exist between federal, state, and local institutions. These collaborations are critical to successfully implementing numerous recommendations of the Commission.
- Establish a Tri-state effort to expand coordination among existing, federally mandated Metropolitan Planning Organizations (MPOs) that play an integral role in transportation investment coordination in their respective jurisdictions. New York, New Jersey and Connecticut benefit from one of the world's largest metropolitan economies, and rely upon shared transportation infrastructure. Superstorm Sandy highlighted how integrated and fragile this economy is. This kind of multistate coordination will improve the region's ability to respond to long-term risks, such as climate change.

Improve data, mapping, visualization and communication systems

Superstorm Sandy exposed weaknesses in our capacity to predict flood events and their impacts. Many of New York's most important mapping products need to be upgraded and modernized to enable their effective use. The Commission recommends that the State enhance its short, medium and long-term mapping efforts to support resilience-focused planning, analysis, and coordination around critical infrastructure and vulnerable areas. Most importantly, these systems should allow for real-time assessment, feedback and course-correction during and following crises.

Information systems include both hard data that need to be found, processed, updated, secured and stored in ways that can by effectively used and the wide range of institutions and individuals who make up the user communities. An example of this type of infrastructure is the State's Critical Infrastructure Response Information System (CIRIS), which uses Geographic Information Systems (GIS) technology to support analysis, visualization, and real-time decision making. Specific cross-cutting recommendations include:

- Develop "cloud" storage and back-up systems for critical data to ensure efficient recovery and avoid data loss. It is important that information systems are available during emergency so the Commission recommends that essential systems are fully backed-up in multiple and/or remote server locations to allow full operation even in the event of regional disruptions.
- Support social media and mobile technology platforms and tools that allow citizens to report local issues and serve as first-line reporters and damage assessors. During recent severe weather events, citizens across the State were using cell phone cameras and platforms like Facebook and Twitter to document where power lines were down and streets were blocked, which helped utilities identify problems and respond more quickly and effectively.
- Create spaces for residents and communities to provide ongoing feedback on successes and failures, and develop tools to help utilities work with one another and government officials and citizens to find and use critical information. For example, during Superstorm Sandy, cable providers were able to help electric utilities identify and target power outages.
- Update flood maps to include marine coastal risk zones and probabilistic flood hazards to inform land use plans and strengthen or relocate critical facilities. New York should create a statewide review to ensure that public and critical information are updated in a timely manner.

Create new incentive programs to encourage resilient behaviors and reduce vulnerabilities

New York State should expand the use of incentive programs to influence regional, municipal, sectoral and individual decisions and behaviors associated with more resilient development pathways.

- The Commission recommends a series of insurance-related measures to promote actions by individuals and businesses to mitigate their properties and assets against threats and to ensure that they are not left under-insured in the event of a disaster. For example, a mitigation fund should be considered that would support private sector loans for property improvements that could then be repaid in part through resulting reductions in insurance premiums. Such improvements should also be exempted from property value assessments by local governments to encourage owners to invest in protections. Further, the State should consider requiring flood insurance in flood plains even for those property owners without a mortgage.
- Develop incentives, such as rate based cost recovery, to aid microgrid development. The state has a long history of supporting energy efficiency and renewable energy deployment through the Renewable Portfolio Standard and the Energy Efficiency Portfolio Standard, both currently approved by the PSC through 2015. These programs provide rebates and other incentives to overcome barriers to individuals making investments in energy efficiency and renewable energy. The PSC should review and extend these programs to provide great market certainty.
- Leverage additional private sector investment in energy efficiency through public-private financing mechanisms. In 2011 New York adopted a state-wide on-bill financing program, administered by NYSERDA, that allows electricity and natural gas customers to make substation energy efficiency improvements through a loan from NYSERDA that is paid back through energy savings and a surcharge on a utility bill. To grow this program, the State should encourage the private sector to participate in the financing of these loans.
- Incorporate increased green infrastructure incentives into the State clean water infrastructure funding programs operated by DEC, including the Water Quality Improvement Program grants, Green Innovation Grant Program and the Agricultural Environmental Management Program.
- Pursue climate resilience land use policies to incentivize proper development and smart growth, and in certain areas, to provide voluntary opportunities for property owners to avoid development in highly vulnerable areas. In some highly vulnerable areas, creating the proper opportunities, programs, and incentives to help communities and individuals, who are interested in realigning and relocating buildings and infrastructure to reduce vulnerability, is an important step to make New York more resilient. There are a number of federal, state and local land acquisition programs that can be used to facilitate voluntary acquisition of vulnerable coastal property in appropriate cases.
- The Department of Financial Services should work closely with the insurance industry to develop a consumer education and disclosure initiative focused on homeowner and business owner insurance policies to ensure that consumers are making the choices they actually intend to make. In part, that initiative should focus on presenting the deductible options and coverage gaps at the point-of-sale, including clear and conspicuous disclosures that, at a minimum, use plain language comprehensible to consumers; contain a clear format and design, such as an easily readable type font; and succinctly explain the information that must be communicated to the consumer when purchasing an insurance policy.

Expand education, job training, and workforce development opportunities

Education and workforce development strategies should ensure the availability of skilled professionals in critical infrastructure work. Growing the pool of available skilled workers is essential to handle the current and future needs of critical infrastructure systems. Infrastructure jobs often require highly skilled workers with years of training, so the investment in training programs should begin immediately to account for future needs. Focusing training on these systems will help form a foundation for the continued development of New York State's workforce for years to come. These programs should be continually reviewed and updated to remain relevant with changing technologies.

- Create a new long-term energy workforce development strategy within New York State which will make the State's energy infrastructure system more self-reliant and robust by addressing impending and long-term labor shortages. The State University of New York (SUNY) and the City University of New York (CUNY), the Regional Economic Development Councils, the New York State Department of Labor, NYSERDA, and utilities should develop a comprehensive plan that will be continuously updated to reflect sector trends in regular cycles.
- Support local level education, training and workforce development through the New York State Association of Regional Councils and the nine New York State regional planning boards by developing guidance on land use planning for climate resilience and deploying enhanced information services, such as regional data centers, to promote public education and awareness.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Transportation

Overview

New York State's transportation infrastructure encompasses a vast network of Interstates, state highways, local roads, public transit systems, waterways, bike networks, and walking facilities (Figure T-07 and T-08). Our transportation systems link to airports and marine ports that connect New York to the rest of the country and the world. Downstate, New York City boasts the most comprehensive and complex transportation network in the country that supports a region of national and global significance. Overall, the State's transportation infrastructure is vital to the health of our economy, environment, and well-being.

Recent severe events, such as Superstorm Sandy, Tropical Storm Lee, Hurricane Irene and the 2010 snowstorm, have revealed vulnerabilities in our transportation infrastructure. Much of it is aging and susceptible to damage from extreme weather events or seismic threats, and many facilities, such as tunnels and airports, have been built in locations that are increasingly at risk of flooding. Steps must be taken to make the State's transportation infrastructure more resilient to future severe events.

To protect and maintain our economy, mobility and public safety, the State must invest in a diverse and redundant transportation system. This is particularly important during unexpected events. In considering recommendations that foster resiliency, the Commission focused on four key principles:

1) Moving people safely by ensuring maintenance of access and egress during crises.

2) Maintaining the integrity of the physical system and supply chain.

3) Providing flexibility through alternate routes, modes and transit options.

4) Ensuring efficient recovery from severe events to allow for optimal performance in times of need.

The Commission has grouped its transportation recommendations into four areas:

1. **Develop a risk assessment of the State's transportation infrastructure** to identify those assets that are vulnerable to extreme weather events, storm surge, sea level rise and seismic events, and to prioritize future investment through the use of a lifeline network that defines critical facilities, corridors, systems, or routes that must remain functional during a crisis or be restored most rapidly.

2. **Strengthen existing transportation networks** by improving the State's existing infrastructure with an emphasis on key bridges, roads, tunnels, transit, rail, airports, marine facilities, and transportation communication infrastructure. Initiatives focus on improved repair, as well as protecting against multiple hazards including flooding, seismic impact and extreme weather.

3. **Strategically expand transportation networks in order to create redundancies** that make the system more flexible and adaptive. Encourage alternate modes of transportation.

4. **Build for a resilient future with enhanced guidelines, standards, policies, and procedures.** Change the way we plan, design, build, manage, maintain and pay for our transportation network in light of increased occurrences of severe events.

Within each of the areas, recommendations include short-term steps based on lessons learned from recent events; medium-term projects that require more extensive planning and development; and long-term solutions that require systemic planning, process refinement, capital budgeting, and large-scale project implementation.

The transportation system response to Superstorm Sandy

Recovery efforts began immediately. From October 29 through October 30, the New York State Department of Transportation (NYSDOT) deployed approximately 1,000 crew members and 800 pieces of equipment each day. More than 2,200 maintenance staff were deployed for "boots on the ground" repair work, with 64 percent of staff and equipment coming from outside of the New York metro area, including Albany, Utica, Buffalo, Rochester, Hornell, Syracuse, Watertown, and Binghamton. Limited bus service was restored hours after the storm, and normal, weekday service resumed by October 31. John F. Kennedy International Airport (JFK) and Newark-Liberty International Airport (EWR) also opened on the 31st, while flights to and from LaGuardia Airport (LGA) were restored on November 1. Limited service on Metro-North and the Long Island Railroad (LIRR) began the same day. Only days later, Metro-North was operating at full service and LIRR was operating on its four main branches. By November 1, limited subway service was restored, and a "bus bridge" was introduced by the Metropolitan Transportation Authority (MTA) to transport customers between Manhattan and Brooklyn via the Manhattan and Williamsburg Bridges. Buses also played a critical role in trans-Hudson connections, making up for extended outages at key Port Authority Trans-Hudson (PATH) stations and commuter rail tunnels to Penn Station. Special bus service was provided by NJ Transit and Academy Bus, a private operator, to the Port Authority Bus Terminal, which accommodated record bus movements of up to 250 additional daily departures and an estimated 30,000 to 40,000 additional customers each day for two weeks following the storm. By the following weekend, more than 80 percent of subway service had been restored (measured in track miles). All but one of the MTA's bridges reopened the day after the storm, and emergency assistance was procured to pump out and repair the Queens-Midtown and Hugh L. Carey Tunnels. All Port Authority of New York and New Jersey (PANYNJ) bridges were reopened within 18 hours of closure, while the Lincoln Tunnel remained open throughout the entire storm. By November 2, the Holland Tunnel reopened to buses after PANYNJ crews had pumped out an estimated 20 million gallons of water. The first oil tanker entered the Port of New York and New Jersey on November 2, with container vessels arriving at PANYNJ facilities two days later. All port facilities reopened by November 5. On November 6, PATH service from 33rd Street to Journal Square in Jersey City was restored with limited service, providing relief for some of its 260,000 daily passengers. An estimated 100 million gallons of water was pumped from the World Trade Center site and another 10 to 15 million gallons from two PATH tunnels and the World Trade Center PATH station. Throughout the recovery, communication between agencies was key. See "Improve interagency and interstate planning coordination" for more information on interagency communication throughout the Superstorm Sandy recovery effort.

Figure T-01: Damage on the New York City Subway Rockaway Line (A train). (MTA New York City Transit, Leonard Wiggins, 2012)

Figure T-02: Superstorm Sandy flood waters run to the ceiling of the Hugh L. Carey Tunnel. (MTA, Patrick Cashin, 2012)

Figure T-03: Escalators under water at the South Ferry subway station. (MTA, 2012)

Figure T-04: Governor Cuomo inspecting the World Trade Center PATH station. (PANYNJ, 2012)

Figure T-05: MTA employees using a pump train to pump seawater out of the L train tunnel under the East River. (MTA, Patrick Cashin, 2012)

Figure T-06: With subway tunnels flooded, MTA's "bus bridge" provided needed transit service between Brooklyn and Manhattan immediately following Superstorm Sandy. (MTA, Patrick Cashin, 2012)

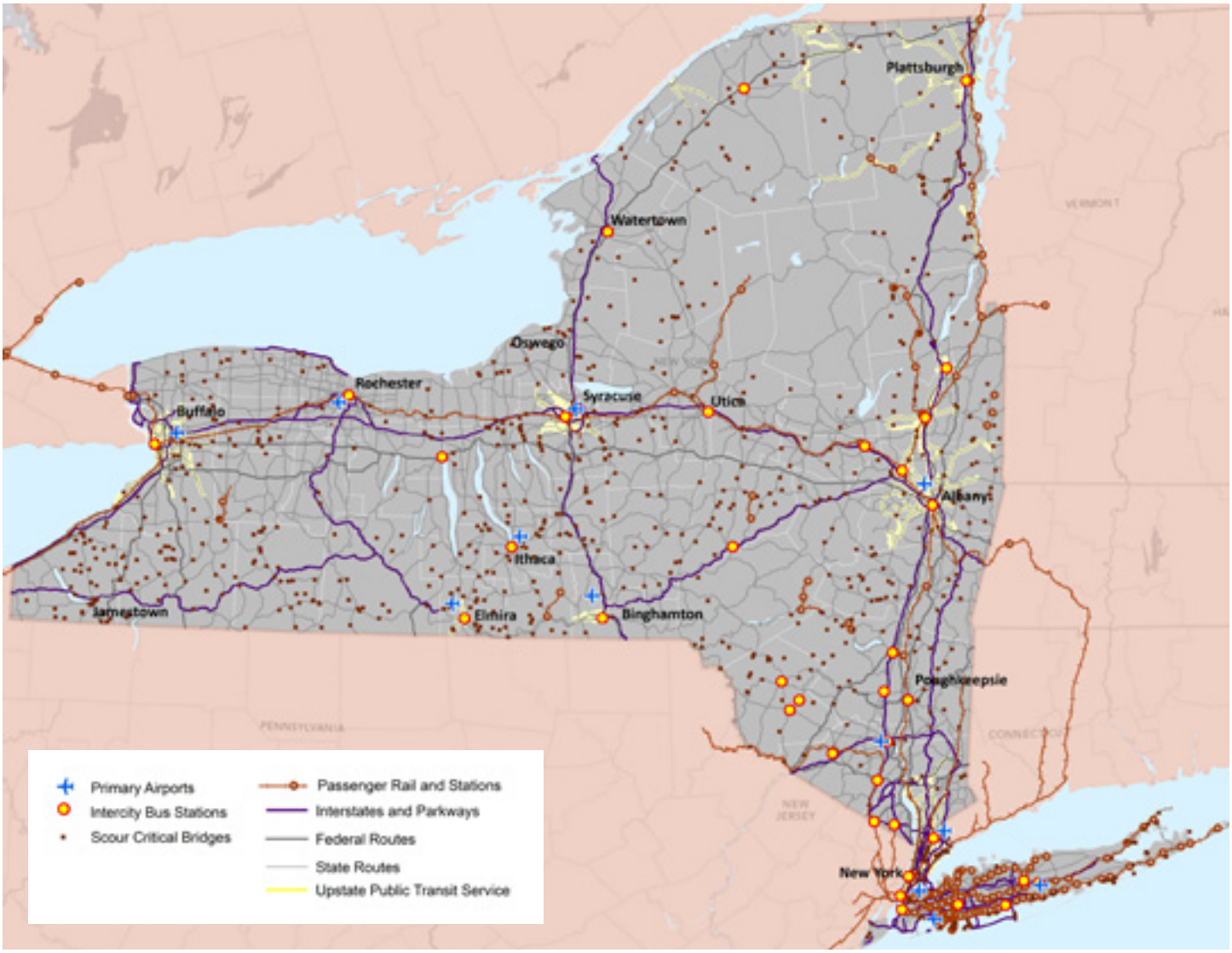

Figure T-07: New York Transportation Network (State of New York, 2012)

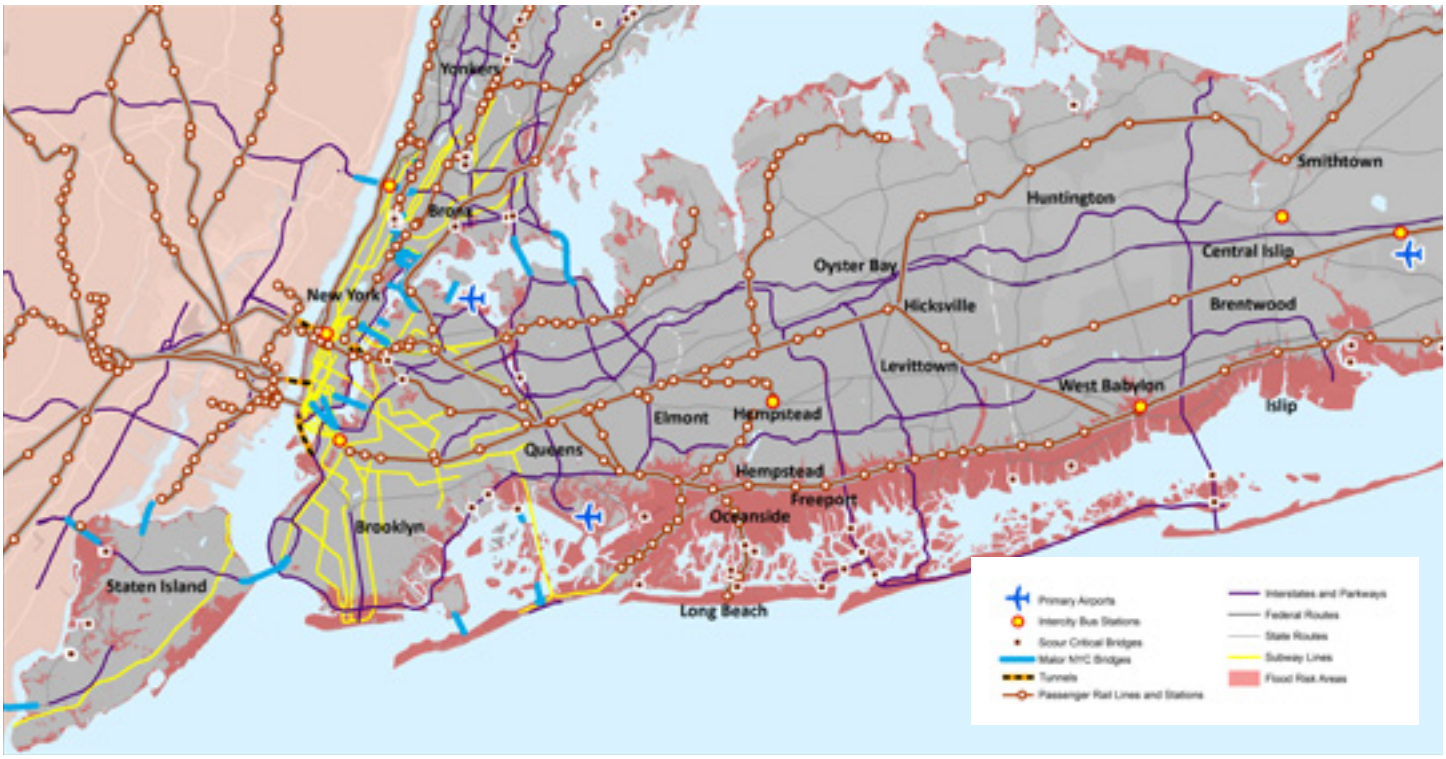

Figure T-08: New York Transportation Network (State of New York, 2012)

Develop a risk assessment of the State's transportation infrastructure

Identifying risks is critical to preparing for and reacting to severe events. This section identifies immediate actions to categorize components of the State's transportation infrastructure at risk. This inventory and assessment of existing infrastructure will provide the framework for prioritizing future investments, guidelines, standards, planning, and policies that will lead New York State to a more secure future. Systems cannot be crisis-proofed immediately; strategies must account for time, funding, and feasibility and balance risk against return. State transportation agencies and authorities need to prioritize a list of projects and establish a lifeline network of transportation systems that will ensure a minimum level of performance during and after any event or crisis.

The Commission has laid out the following recommendations, detailed in the sections that follow:

- Undertake a comprehensive risk assessment/inventory.
- Prioritize a transportation lifeline network.

Undertake a comprehensive risk assessment/inventory

To understand which transportation assets need to be upgraded or replaced, transportation agencies, in conjunction with owners and operators of infrastructure, should undertake a comprehensive inventory and risk assessment to identify vulnerable assets. This risk register will help shape investments and infrastructure upgrades based on the associated risk.

While many agencies and operators currently conduct risk assessments to identify areas where upgrades to infrastructure are required, a focus on climate change vulnerabilities will ensure that more resilient upgrades are made.

The inventory and risk assessment of transportation assets, along with other factors such as cost, redundancy, value, and likelihood of hazards, should help to prioritize investments in the repair, rehabilitation or replacement of infrastructure for the entire transportation network.

Prioritize a transportation lifeline network

New York State should identify a transportation lifeline network which comprises infrastructure essential to State and regional mobility. The purpose of the lifeline network would be to maintain regional mobility and speed recovery operations and revenue service following events. At the very least, the network should aid in evacuations, and maintain basic transportation services, such as the movement of goods, commodities and emergency or relief services.[1]

Individual components – tunnels, bridges, highways, rail facilities, airports, etc. – must be physically able to withstand the impacts of severe events. If specific facilities currently lack adequate hardening, but are essential to the network, then they should be prioritized for retrofitting.

In a New York State lifeline network, infrastructure elements could be classified in one of two ways.

- **Lifeline Facility Class 1 (LFC1), "Primary"** – These are facilities that are designed, built/renovated, maintained, and operated to withstand multiple types of severe events (seismic, wind, flooding, etc.). Their operation is critical for the safe movement of people and goods immediately before and after events. If closed for any duration during an event, they should reopen as quickly as conditions permit. A specific timeframe for safely reopening these facilities following an event should be applied, with the understanding that it can be difficult to determine when, exactly, an event is "over."
- **LFC2, "Secondary"** – These facilities may not be hardened to the extent that Primary facilities are, but they should be able to withstand all but the worst types of conditions. When events do prevent them from functioning, they should be brought back online as quickly as possible. Secondary facilities provide redundancy to the Primary facilities and support local and regional movements of people and goods.

By categorizing transportation infrastructure this way, lifeline components can be communicated in advance of severe events (when possible) to various user groups, such as the general public, agencies, utilities, and emergency service providers. Categorization will also help transportation agencies identify the strategic infrastructure investments needed to ensure that facilities maintain a certain level of performance.

The development of a State-wide transportation lifeline network would require a risk assessment based on established criteria, regional coordination among various agencies and operators, and a qualitative consideration of important economic, social, and environmental impacts. Development of the network would also require input from transportation agency operations and planning staff, as well as outreach to local communities.

In determining the lifeline network, criteria could include the following:

- The facility provides a vital link for the movement of people from one core area to another (city to city, central business district (CBD) to an airport, etc.)
- The facility provides regional movements along a key corridor.
- The facility acts as a critical link for the movement of essential goods, first responders, and operational equipment.
- The facility carries multiple transportation modes.

- The facility has been designed to withstand extreme conditions.
- The facility is part of an established evacuation route.

Long Island is a prime example of a place that would benefit from a lifeline network. Many Long Island communities, including and especially Long Beach and Lindenhurst, were heavily damaged during Superstorm Sandy. If included in a lifeline network, key facilities such as the Cross Island Parkway, Long Island Expressway, Grand Central Parkway, and the Robert F. Kennedy (RFK) Triborough, Bronx-Whitestone and Throgs Neck Bridges, would ensure that Long Islanders could safely navigate and evacuate the Island if necessary. It would also ensure delivery of the goods and services needed to aid recovery efforts.

However, specific vulnerabilities associated with such infrastructure risk their viability and reliability as network components. For instance, both the Cross Island and Grand Central run along waterfront that is extremely susceptible to storm surge and flooding; the Grand Central had to be closed in late July 2012 due to a torrential downpour.[2] In developing the lifeline network, it is important to evaluate vulnerabilities inherent to proposed network facilities and determine what upgrades could be made to ensure operations are not interrupted.

London Road Resilience Network (London, United Kingdom)

A successful precedent to the creation of a potential New York State lifeline network could be the London Road Resilience Network, which describes the minimum roads within the Greater London area that are required to be continuously kept open in severe winter weather to allow essential services to operate reliably and safely and to 'Keep London Moving.' The network includes the roads to be treated in exceptional weather, when salt storage supplies are scarce, including those for which either Transport for London or the Borough is responsible, together with those in private ownership. It ensures continuity across jurisdictional boundaries, access to the strategic road network, and allows London Buses to operate at a minimum service. The London Road Resilience Network includes all A classified roads, roads required to access essential services and bus routes with frequent bus services. Essential services include hospitals with accident and emergency departments; police, fire and ambulance stations; bus and railway stations; bus garages and depots; and salt storage depots.

Figure T-09: The London Road Resilience Network. (London Councils, Crown Copyright, 2010)

Regional Transportation Emergency Management Plan (RTEMP) (San Francisco Bay Area, United States)

The San Francisco Bay Area Regional Transportation Emergency Management Plan (RTEMP) provides guidance for the coordination of emergency response capabilities of transportation agencies throughout the nine-county San Francisco Bay Area. The purpose of the RTEMP is to enhance the ability of Bay Area public transportation agencies to recover operations and deliver basic transportation services after a significant regional disaster. The RTEMP builds upon the framework of the Trans Response Plan and provides detailed definitions of the roles, responsibilities, interagency coordination, and decision-making mechanisms between state and regional emergency management agencies and multi-jurisdictional transportation agencies. It also provides reference materials applicable to specific emergency scenarios, such as earthquakes on the San Andreas and Hayward faults and acts of terrorism[3]. The RTEMP could serve as a framework for regional emergency management plans and interagency coordination throughout New York State.

Strengthen existing transportation networks

Stronger and more resilient transportation infrastructure will allow better performance during and after severe events. It will limit damage, and enhance the network's ability to rebound. A network in a state of good repair will be better equipped to handle everyday wear-and-tear, thereby reducing maintenance and operation costs, while also creating a more robust system for use during times of need. Building resilience into transportation infrastructure as it is repaired, rehabilitated, or replaced is a cost-effective strategy for preserving critical linkages.

The recommendations in this section focus upon immediate and medium-term actions that should be taken to repair and improve specific vulnerabilities in the State's transportation systems after Superstorm Sandy caused widespread flooding and other damage. Through such short-term mitigation measures, the deeper resilience of those systems will be created.

The Commission has laid out the following recommendations, detailed in the sections that follow:

- Protect transit systems and tunnels against severe flooding.
- Invest in upgrades to bridges, tunnels, roads, transit, and railroads for all hazards.
- Strengthen highway and rail bridges vulnerable to scour.
- Protect waterway movements.
- Safeguard airport operations.

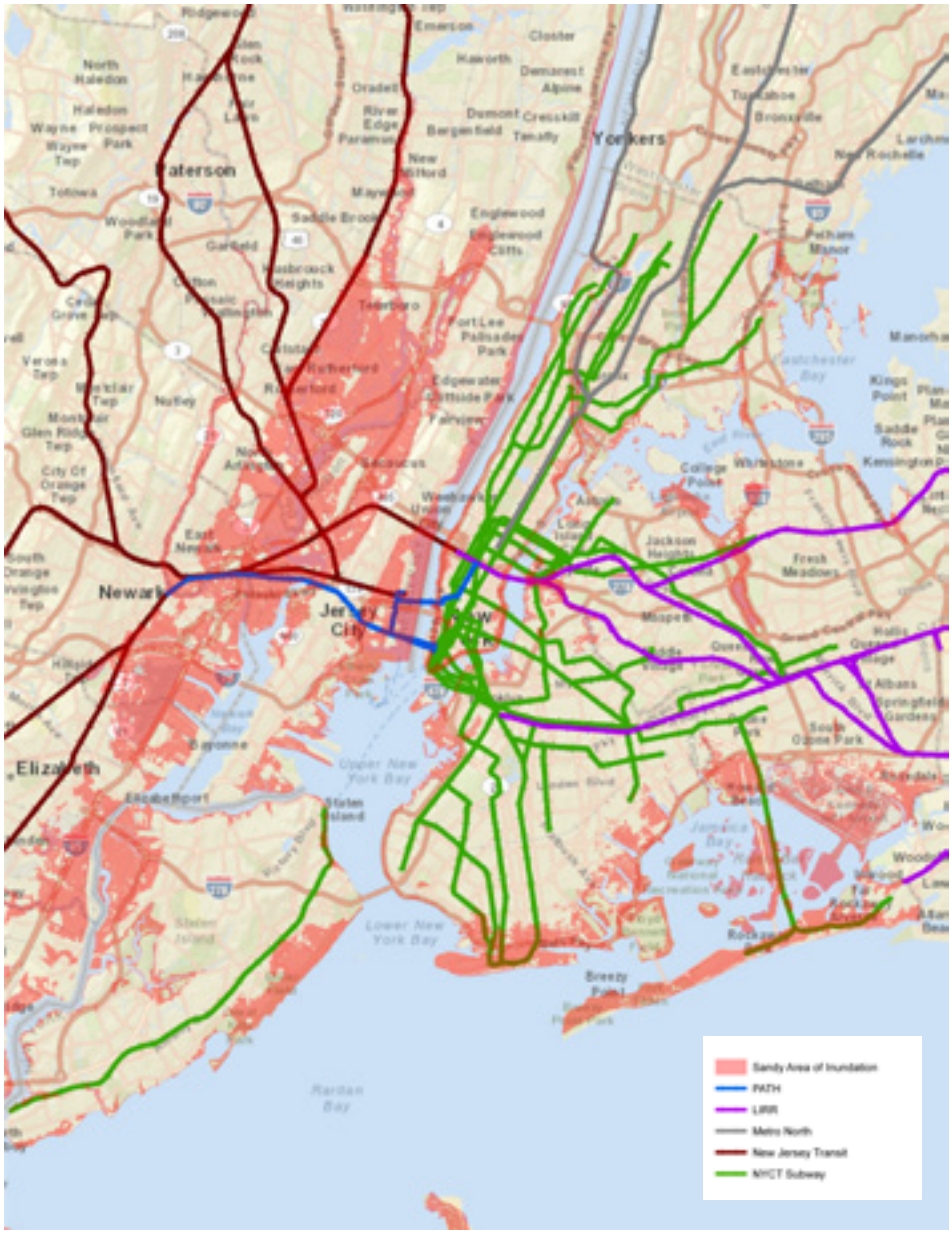

Figure T-10: Rail transit infrastructure in New York City metro area at risk of flooding. (FEMA, MTA, NJ DEP GIS, NYSDOT, NYCDOT, PANYNJ, 2012)

Protect transit systems and tunnels against severe flooding

The regional public transit system is the backbone of the New York City economy. Considering the impacts of the recent flooding of the New York City subway, East River tunnels (used by LIRR), PATH, and vehicular tunnels, as well as the flooding of commuter rail facilities during Hurricane Irene, the State should adopt strategies that mitigate or prevent severe flooding of transit tunnels, terminals, depots, yards, and electrical and signal systems.

Protect underground transit systems and tunnels

To prevent severe flooding of underground transit infrastructure, including subway and vehicular tunnels, stations and associated electronic systems (e.g., signaling systems, communications systems, and track switches), the Commission recommends mitigation measures to protect underground transit systems including:

- Installing waterproof, vertical roll-down doors at the foot of subway stair entrances.
- Installing mechanical below-grade vent closures to prevent water from entering through ventilation shafts.
- Using inflatable plugs/bladders to keep flood waters out of tunnel entrances.
- Sealing electrical equipment against water infiltration.

Elevation data and records of post-Superstorm Sandy flood conditions should be examined to identify locations where these barricades are needed most. These kinds of investments should be planned in conjunction with an integrated drainage and floodwater management strategy to avoid the redirection of floodwaters to other areas. The implementation strategy should consider the entire transit system so as not to focus on particular vulnerabilities at the expense of others.

Protect aboveground transit systems

Both Hurricane Irene and Superstorm Sandy demonstrated how commuter rail service on Long Island and low-lying segments of the Metro-North system are vulnerable to severe events. Key facilities like yards, signal system components, and substations near major bodies of water were shown to be particularly vulnerable to flooding and associated corrosive damage from prolonged salt water exposure. In some cases, railways were washed away.

Extensive flood mitigation measures should be undertaken to protect aboveground transit systems including:

- Constructing drainage improvements along railroad rights-of-way and at rail/bus depots, including culverts which channel water underneath the railway. Retaining walls should also be constructed, where appropriate, to protect the railway.

Figure T-11: Flooding at Metro-North's Harmon Yard in Croton-on-Hudson exemplified the challenges faced by Metro-North employees in restoring service after Superstorm Sandy. (MTA Metro-North Railroad, 2012)

Figure T-12: Damage and debris in the South Ferry subway station following Superstorm Sandy. (MTA, Patrick Cashin, 2012)

- Installing aluminum dam doors at depots that house buses and trains in low-lying areas prone to flooding (e.g., Zones A, B and C).
- Relocating sensitive equipment from the basement and first floor to higher floors or to the roof.
- Installing new, permanent, high-capacity pump equipment.
- Reinforcing water-penetration points in depots and stations, such as windows, doors or cracks in walls.

Upgrade pumps in flood prone areas

In addition to pursuing new flood mitigation measures, improvements to existing pumping capacity at tunnels and other below-grade facilities should be implemented. This is essential to limiting water exposure and ensuring rapid restoration of service. Improvements should include:

Installing new, higher-capacity discharge lines at points of water accumulation.

- Installing new, higher-capacity discharge lines at points of water accumulation.
- Upsizing existing fixed pumps.
- Installing adequate back-up power sources to ensure that pumps continue to operate even in the event of a localized power outage.
- Ensuring the availability of high-capacity mobile pumps to respond to unpredictable flooding situations in a variety of locations.

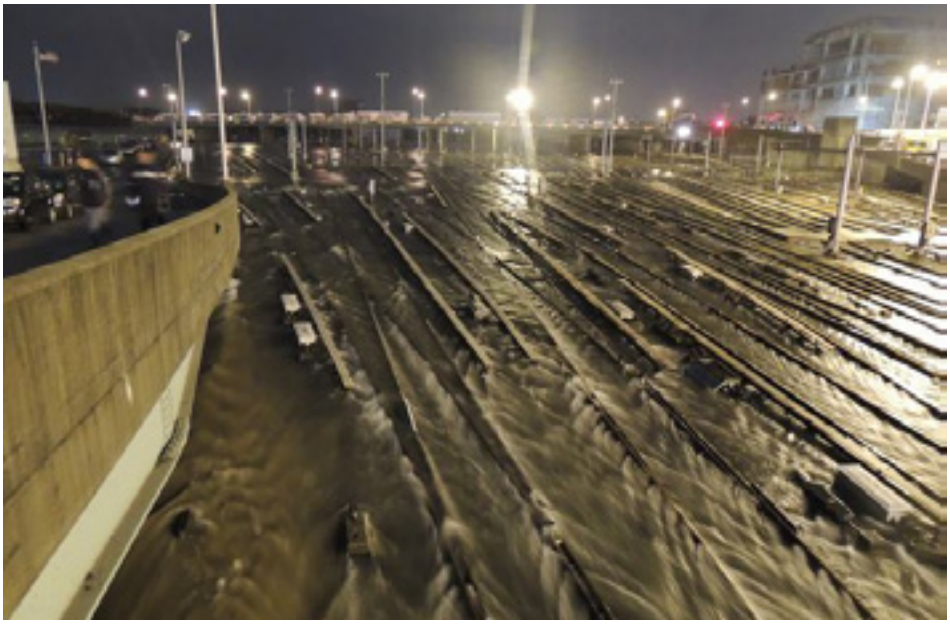

Figure T-13: Floodwater inundating LIRR's West Side Yard. All trains had been removed prior to the arrival of the storm. (MTA Long Island Rail Road, 2012)

Supporting American companies with Buy America provisions

Buy America provisions are used by agencies or for certain programs to construct, alter, maintain or repair public buildings or public works using domestically-produced parts and equipment, such as iron, steel or various manufactured goods.[4] For instance, the United States Department of Transportation uses the provisions to ensure that the nation's transportation infrastructure projects are built with American-made products.[5]

Ultimately, the provisions are intended to support an entire supply chain of American companies and their employees.[6] As part of present and future recovery efforts, Buy America language should be applied to public rebuilding projects using Federal Emergency Management Agency (FEMA) and/or Department of Housing and Urban Development (HUD) funding. Such language could be similar to that laid out in the American Recovery and Reinvestment Act (ARRA) of 2009.

The Buy American provision in the American Recovery and Reinvestment Act of 2009 (section 1605 of Title XVI), provides that, unless one of three listed exceptions applies (nonavailability, unreasonable cost, and inconsistent with the public interest), and a waiver is granted, none of the funds appropriated or otherwise made available by the Act may be used for a project for the construction, alteration, maintenance, or repair of a public building or public work unless all the iron, steel, and manufactured goods used are produced in the United States.[7]

Not only are Buy America provisions sound national policy, but they help businesses in New York. For instance, manufacturers throughout the State like Bombardier in Plattsburgh, Alstom in Hornell and Kawasaki in Yonkers produce integral parts and equipment for transit agencies across the country. These businesses can support recovery efforts, while keeping jobs in New York and bolstering the State's economy.[8]

Protect transit systems and tunnels against severe flooding

Even with extensive pre-Sandy preparations, the MTA estimates it will cost nearly $5 billion to restore the transit system back to its state prior to Superstorm Sandy. While flooding will never be completely prevented in underground transit systems, measures can be taken to protect infrastructure as much as possible.

Superstorm Sandy severely disrupted people's travel patterns. Even with commuters adapting to other modes of transportation, an estimated 15 percent of surveyed New Yorkers[9] did not travel to work on November 1 and 2. Nearly half a million MTA customers either had no or reduced service or had to find alternative travel routes. This is equivalent to the population of Miami, Cleveland, Atlanta, or Pittsburgh having no transportation or having their commutes become significantly longer.[10]

The Commission recommends mitigation to prevent the severe flooding of underground tunnels and stations including:

- Retrofitting subway stairways with waterproof, vertical roll-down doors.
- Installing mechanical below-grade vent closures to prevent water front entering ventilation shafts.
- Using inflatable plugs/bladders to keep floodwater out of tunnel entrances.

Floodwater, particularly corrosive salt water, severely damaged electrical systems such as signals and communications. Measures to protect these assets should include:

- Below-ground: sealing equipment against water infiltration.
- Above-ground: raising selected structures (e.g., signal boxes) above flood plains and out of flood-prone areas.

The ability to pump water from tunnels, terminals and other transit infrastructure when they do flood is critical. Improvements should include:

- Installing new discharge lines at points of water accumulation.
- Upsizing critical fixed pumps.
- Installing adequate back-up power sources to ensure that pumps continue to operate even in the event of a localized power outage.
- Acquiring high-capacity mobile pumps to respond to unpredictable flooding situations in a variety of locations.

For transit stations and depots in low-lying areas prone to flooding, waterproof doors should be installed at vulnerable entry points. Longer-term measures include the permanent relocation of depots out of flood-prone areas and building or retrofitting certain facilities with components that can sustain exposure to water.

While further protection from flooding is needed, we will never be able to make underground transit systems fully flood-proof. Through its recommendations, the Commission seeks to minimize disruption to systems and protect the State's residents and consumers through other actions such as improved business interruption insurance. (See the Insurance chapter of this report for more information.)

Resilient Tunnel project (United States)

The Department of Homeland Security Science and Technology Directorate recently tested a new technology for preventing and containing flooding in transit tunnels. The project, known as the Resilient Tunnel Project, consists of an inflatable cylinder that can inflate within minutes, acting as a plug to protect tunnels from flooding. The shape and material of the plug is flexible enough to account for the irregular cross-section of tunnels created by platforms, lights, tracks and other equipment.

The inflatable cylinder could provide a more cost-effective solution to flood prevention in existing tunnels, negating the need for costly retrofits. When deflated, the plug can be stored in a small space in the tunnel, similar to a car airbag ready for inflation.

The plug is being developed by the Pacific Northwest National Laboratory, West Virginia University, and ILC Dover (maker of NASA space suits).[11]

Protecting the New York City subway from flash flooding (New York City, United States)

Flooding has forced the MTA to shut down New York City's subway system a number of times in the past decade.

In 2004, heavy rain caused the closure of the subway when more than two inches of rain fell within an hour. In August 2007, a flash flood dropped 3.5 inches of water in New York, overwhelming pumps and shutting down the subway during morning rush hour. Following this event, the MTA carried out $30 million worth of flood mitigation projects between 2007 and 2009. Specific projects included installing valves to keep discharged water from re-entering the subway system, raising entrances at 30 subway stations, modernizing and replacing pumps, and improving sewer capacity.[12] While these measures could not prevent the severe flooding from Superstorm Sandy, they do represent important steps in addressing subway flooding vulnerabilities.

Invest in upgrades to bridges, tunnels, roads, transit, and railroads for all hazards

The State's highways, bridges, tunnels, rail corridors and transit systems have proven to be largely structurally resilient. The agencies that own and maintain these facilities are continually refining their design processes to address the impacts of severe events. Nevertheless, given the age and utilization of the system, the State should assess all of its infrastructure in light of severe events, including flooding, seismic impacts, fire, and extreme weather.

Bridges, tunnels and roads are vital for the movement of people and goods and provide key connections across state and international borders. Rail also provides a prime means of intercity and long-distance mobility for people and goods and is pivotal in the transport of raw materials, supplies, finished products and waste. Key freight rail connections in the upstate region provide important links to and from Canada and adjoining states and to and from PANYNJ ports and other marine facilities.

Strategic investments should be made to enhance the resilience of transportation infrastructure. These investments include:

- Installing flood gates to protect critical tunnels in the lifeline network. (More information on lifeline networks can be found in Section 1.2.2.)
- Performing rigorous maintenance on railroads, roads, bridges, tunnels and culverts, including joint and drainage cleaning, debris removal and crack sealing.
- Replacing metal pipe culverts with concrete box culverts and/or bridges in flood-prone areas.
- Retrofitting bridges (including elevated and viaduct subway and rail structures) and tunnels to withstand seismic activity, wind and fire events, according to risk.

Figure T-14: New York City tunnels and bridges at risk of flooding. (FEMA, MTA, NJ DEP GIS, NYSDOT, NYCDOT, PANYNJ, 2012)

- Systematically stabilizing slide-prone areas, slopes, embankments and rock walls.
- Raising roadway and railway grades and/or constructing floodwater control measures to protect roadways, railways and embankments from immersion and scour.
- Installing generators and battery back-ups at key locations and considering other measures to protect and restore signs, signals and communication.

As with mass transit operations, maintaining power to electronic systems is essential, especially during the response and recovery phases following

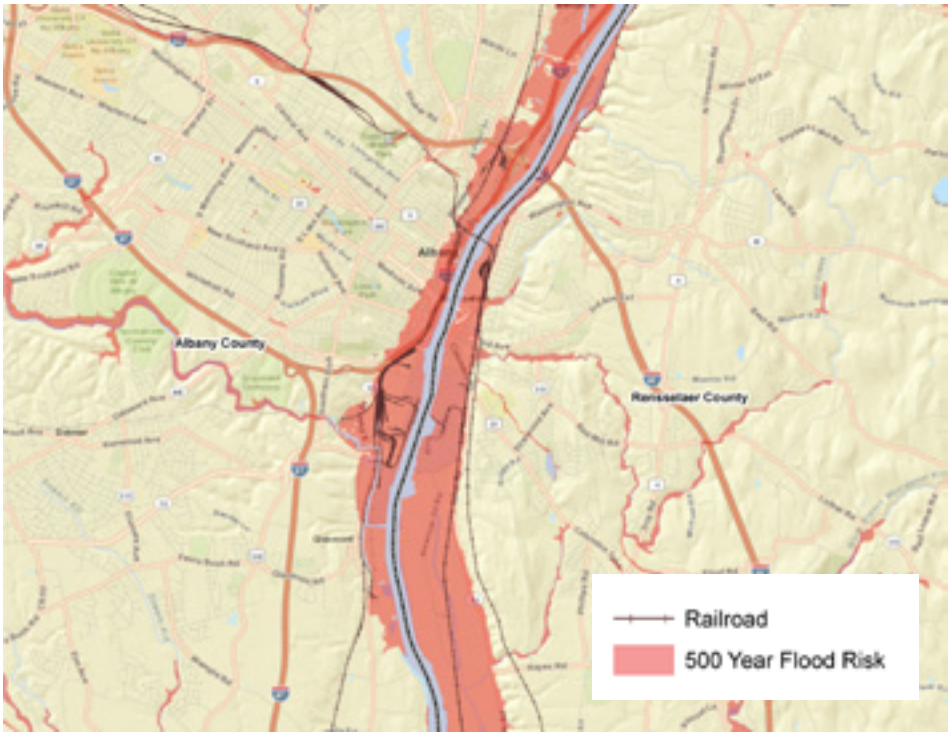

Figure T-15: Railroads in Albany and Rensselaer Counties at risk of flooding. (DEC, FEMA, NYSDOT, 2012)

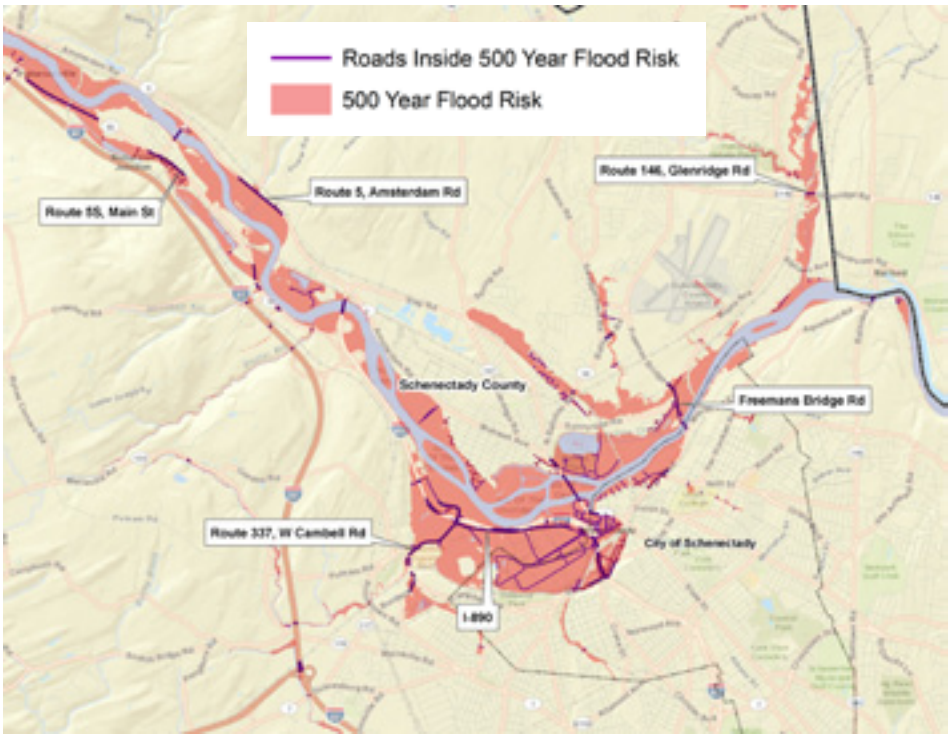

Figure T-16: Schenectady County roads at risk of flooding. (DEC, FEMA, NYSDOT, 2012)

a severe natural event. Information and communications technologies are valuable for providing information, monitoring the ongoing function of the roadway and railway systems, and ensuring future resilience. Information can be used to manage demand during and after incidents and emergencies and provide information on alternatives to driving. The Commission recommends upgrades to information and communications technologies to ensure that appropriate operations are maintained in times of severe events. An example of this type of operational improvement would be continued development of intelligent transportation systems (ITS), including the 511NY system, which facilitates real-time communication with the travelling public and the State's regional transportation partners.

Strengthen highway and rail bridges vulnerable to scour

Road and rail bridges are prime examples of aging assets creating risk for the State's infrastructure system. For example, the Livingston Avenue Rail Bridge, which crosses the Hudson River in Rensselaer, New York, was originally built in 1866 and had its steel superstructure replaced in 1901.[16] It is still in service today. Since New York led the nation in building new highway bridges more than 50 years ago during the Interstate era, its bridges have been among the first in the nation to decline. These structures have now reached a state at which repair, rehabilitation, or replacement is needed to withstand the frequency and severity of recurring severe events.

One of the most significant vulnerabilities of road and rail bridges is scour caused by rapidly-flowing water against bridge foundation elements: abutments, piers, and embankments. Bridge scour is a destructive and erosive action which carries away sand and rocks from around and beneath bridge foundations. The intensity and velocity of water can quickly compromise the structural integrity of bridges and is one of three main

Figure T-17: Bridge scour at the south abutment of the Marine Parkway / Gil Hodges Memorial Bridge in the Rockaways. (MTA, Bridges and Tunnels, Adrian Moshe, 2012)

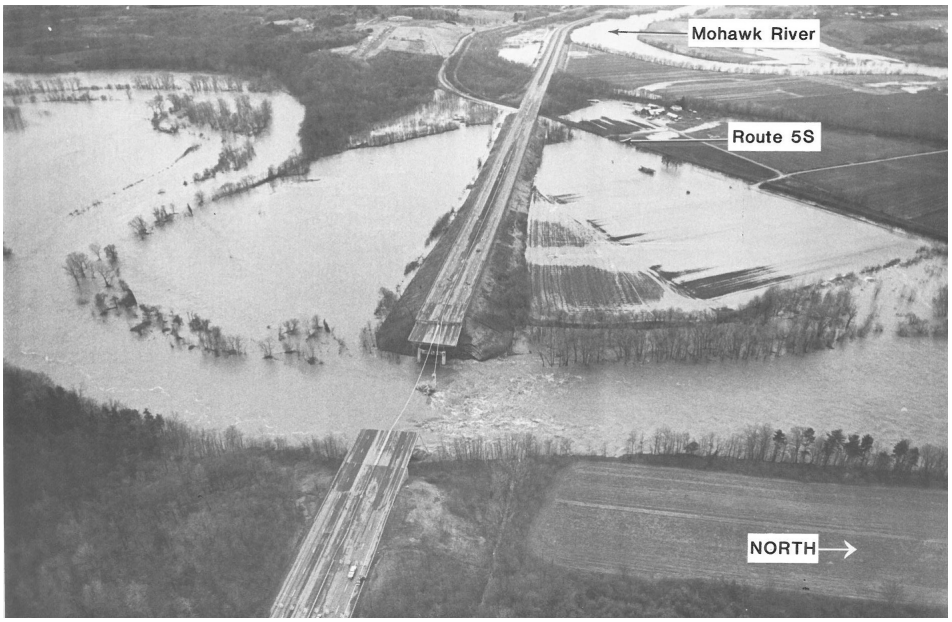

Figure T-18: The Schoharie Creek Bridge collapsed on April 5, 1987 due to severe foundation scour after a record rainfall. (NYSTA, 1987)

causes of bridge failures (the others being collision and overloading).

To mitigate the destructive impacts of scour on road and rail bridges, the State should:

- Install appropriate countermeasures which may include:
  - Strategically placing riprap to absorb, deflect or redirect flowing water energy to a preferred location.
  - Extending footing/pile structures to support slopes or protect them from erosion.
  - Constructing spur dikes, barbs, groins, vanes, or other river-training devices that alter stream hydraulics to mitigate undesirable erosion and/or depositional conditions.
  - Constructing flow-deflecting plates connected to piers.
- Continue the rigorous flood watch program to ensure the safety of scour-vulnerable bridges until funding becomes available to retrofit or replace them.
- Perform routine, rigorous maintenance on road and rail bridges, including debris removal, foundation and slope maintenance, and drainage cleaning to preserve these facilities.

As scour-critical bridges are repaired or replaced, opportunities will arise to address other bridge vulnerabilities.

Protect waterway movements

New York's maritime transportation network consists of all navigable water-based facilities, both natural and man-made, that accommodate the movement of people and freight to, from and through the State. These facilities generally fall into three basic areas:

- Port facilities, including, but not limited to, 190 marine terminals in the Port of New York and New

Figure T-19: The Hudson and Mohawk Rivers and other secondary waterways crested Monday, August 29, 2011. The storm impact in the Hudson Valley, Mohawk Valley, Catskills and Adirondacks was severe. (NYSDOT, 2011)

Figure T-20: Emergency repairs at the Erie Canal embankment in Albion, NY. (New York State Canal Corporation, 2012)

Jersey, numerous small and medium-size ports on the Long Island Sound, and approximately 50 facilities on the Great Lakes and St. Lawrence Seaway in cities like Buffalo, Oswego, Massena and Ogdensburg.

- Rivers/Seaways, including, but not limited to, the Hudson River, Mohawk River, and St. Lawrence Seaway.
- Canals, including the Erie, Oswego, Cayuga-Seneca and Champlain Canals.

More than 90 percent of global trade moves by ship, and the maritime industry in New York serves a central role as an international hub of commerce.[17] The Port of New York and New Jersey, for example, is the gateway to one of the most concentrated and affluent consumer markets in the world. It is the largest port on the east coast, moving over 33.3 million metric tons of general cargo and 48.2 million metric tons of bulk cargo in 2011. 53 percent of all the international waterborne cargo entering the North Atlantic (from Halifax, Nova Scotia to Norfolk, Virginia) enters through the Port of New York and New Jersey.[18] Farther north, the Great Lakes-St. Lawrence Seaway system moves more than 160 million metric tons of cargo directly between New York, the other Great Lakes states, and Canada.[19]

As critical as the maritime transportation network is to the people and economy of New York and the nation, it is also vulnerable to severe events, in large part because the locations of most facilities are prone to flooding, wind, and storm surges. The State should undertake an extensive facility-based risk assessment, covering all potential risks to maritime infrastructure, to prioritize improvements based on cost (including the initial capital improvement and operational costs) and schedule (construction and operation). Without this assessment, it is not possible to identify specific recommendations because the State's maritime transportation system is so expansive, diverse and geographically dispersed. For instance, at ports highly susceptible to storm surge (including those in the St. Lawrence Seaway), adapting

A regional approach to freight mobility (New York and New Jersey, United States)

Each year, gateway facilities in the New York metropolitan area – namely, ports and airports – move billions of dollars' worth of goods to, from and through our region. Ports move 3.4 million cargo containers annually, and the area's five airports handle more than 2.1 million tons of cargo.[13] At the same time, the nation's largest consumer market and thousands of diverse businesses depend on goods carried via densely-trafficked regional roadways and railways that must accommodate expanding commuter and Amtrak demands.

The movement of freight often gets overlooked. It is simply assumed that goods and commodities will be available when and where they're needed. Following Superstorm Sandy, ports in the New York metropolitan area suffered heavy damage. Facilities were inundated with salt water; cargo containers toppled from stacks; access roads and rail track were washed out; and barges and debris were tossed about, damaging piers. Less visible, but perhaps more serious, was damage to the ports' electrical infrastructure. Superstorm Sandy brought the freight network to a standstill, disrupting the region's supply chain for weeks.[14] For example, deliveries of heating fuel for Long Island residents had to be re-routed upstate and back downstate, east of the Hudson River, to access the Island.

What happens to New York-area ports affects the nation. The region's airports facilitate the transport of passengers and freight throughout the United States and abroad, and port facilities serve as gateways for cargo that is shipped to and from destinations around the country.[15]

To plan for more efficient and resilient freight movements, PANYNJ, NYSDOT, and the New Jersey Department of Transportation (NJDOT) are nearing completion of a comprehensive Goods Movement Plan for the bi-state metropolitan area and its connections to upstate and inland markets. The plan includes a systems-level assessment of supply chain needs and current deficiencies, as well as a shared vision for creating a modern multi-modal freight transportation system to serve cargo gateways, commercial centers, and consumer markets. The plan takes a phased approach with "early-action" operational and regulatory initiatives and major infrastructure investments over a 20-year span. Capital investments are both corridor-based (e.g., Interstate-95) and functional (e.g., innovative technologies), advancing a unified, regional approach to improve freight reliability and attract both Federal aid and private investment.

Figure T-21: Toppled containers at Port Newark following Superstorm Sandy. (PANYNJ, 2012)

individual facilities to withstand flooding, rather than prevent it, may be most appropriate. At other facilities, protecting terminals, freight rail and roadway connections would be more prudent.

The Commission recommends the following investments to the maritime transportation system, where possible:

- Installation of storm surge barriers and reverse flow-tide gates to prevent flooding of docks, berths, terminal facilities, and connecting road and rail freight systems.
- Protection of communication and power infrastructure that services port facilities.
- Relocation of select power lines underground, elevation of substations and pump houses above flood levels, and waterproofing mechanical and electrical rooms. (See "Strengthen critical energy infrastructure" in the Energy chapter on undergrounding.)

Maintaining and utilizing existing upstate canals for commercial freight and goods movement could provide enhanced system redundancy and offer significant economic benefits. A series of improvements to the canal system's water management infrastructure would allow the canals to be reestablished as a viable commercial artery. Improvements should include

- Upgrades to aged locks and movable dams to allow for reliable management of water levels.
- Restoration and maintenance of design depths to allow for vessel movement.
- Maintenance of embankments to protect surrounding communities from flooding.

Figure T-22: New York and New Jersey ports at risk of flooding. (FEMA, NJ DEP GIS, PANYNJ, 2012)

Figure T-23: The New York State Canal System. (NYS Canal Corporation, 2012)

The return of bulk transportation to the canal system in 2012 and the congestion of traditional land-based transportation systems make it important to enhance the river and Seaway systems, and reestablish canals as viable transportation arteries.[a] This could provide alternate and redundant transportation routes for fuel and other commodities.

Safeguard airport operations

Just as New York's other modes of transportation play key roles as hubs of commerce, the State's airports are important gateways for national and international passenger and freight movements. New York's public-use aviation system includes 18 commercial service facilities and 119 general aviation facilities.

The downstate metropolitan region constitutes the largest air travel market in the world. Its three main airports, John F. Kennedy International Airport (airport code: JFK), Newark-Liberty International Airport (EWR), and LaGuardia Airport (LGA), handle more than 109 million passengers each year. In 2011, the combined passenger traffic at these three airports exceeded the number one ranked U.S. airport by almost 20 million more passengers.[20] JFK, EWR and LGA are ranked 6th, 14th, and 20th, respectively, in terms of U.S. passenger traffic.[21] With respect to international passenger traffic, JFK and EWR ranked 17th and 37th, respectively, in 2011.

In addition to passengers, JFK and EWR handled 1.4 million and 812,000 tons of cargo, respectively, in 2011, ranking them 7th and 9th in the nation.[22]

Because of their close proximity and overlapping service area, the impact of a closure of any one of these airports ripples throughout the region.

[a] The Canal System is only open to cargo traffic from early April through mid-December, and the St. Lawrence Seaway from early March through December, as conditions allow.

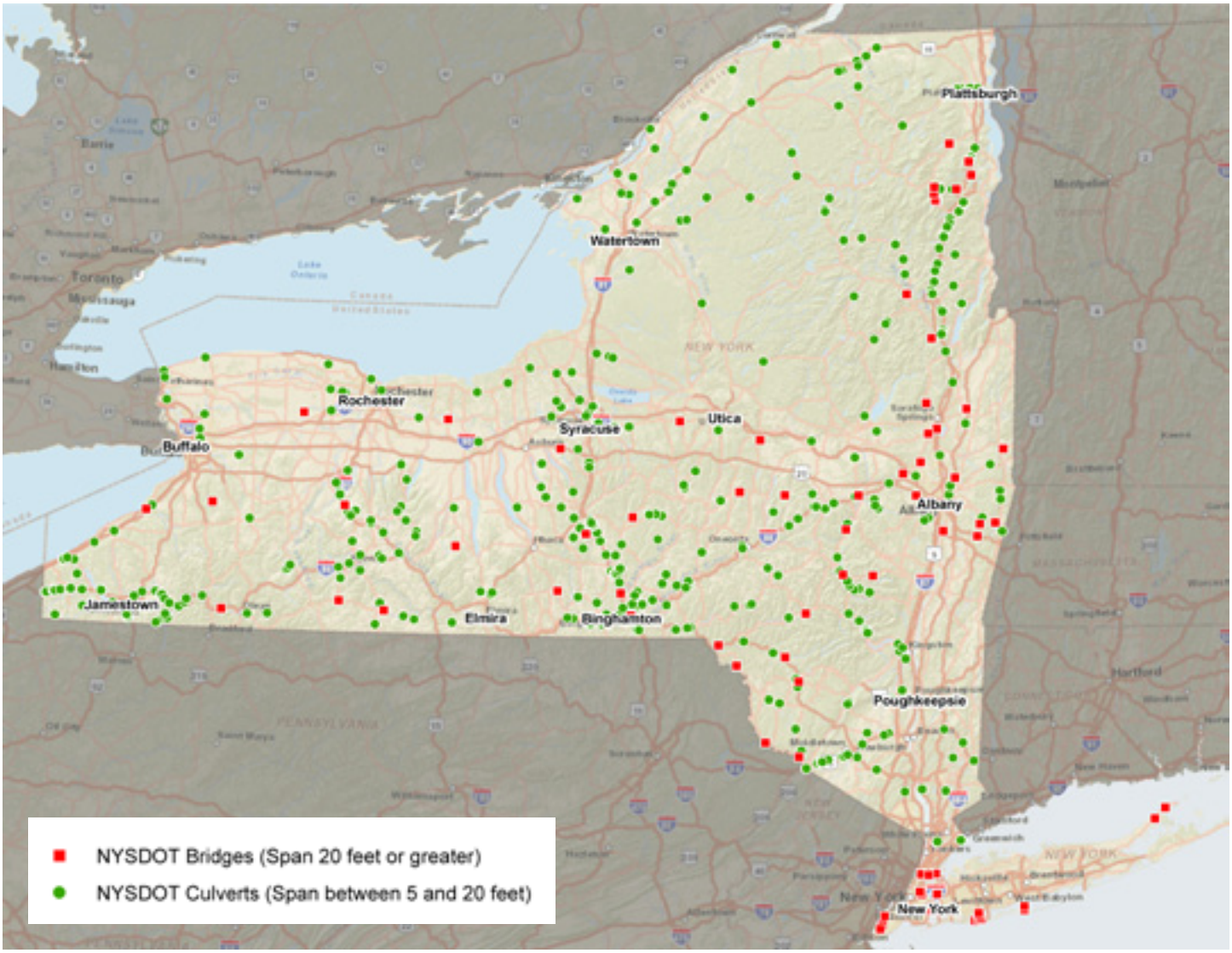

Figure T-24: New York State bridges and culverts at risk of scour. There are 20,000 bridges in the state, of this amount there are 91 state bridges, 731 local bridges at risk to scour as well as 431 culverts at risk to scour. (NYSDOT, 2012)

Upstate airports serve an additional 18 million passengers yearly. The five key upstate airports – Buffalo Niagara International (BUF), Greater Rochester International (ROC), Syracuse Hancock International (SYR), Albany International (ALB), and Stewart International (SWF) – are key economic drivers for the upstate region. These airports provide critical links to major population centers in and outside of the New York City metropolitan area, through a combination of commercial, corporate, and freight cargo aviation services.

Airports not only serve as gateways for commerce and tourism, but, in times of emergency, both commercial and general aviation facilities are used to support evacuation and disaster relief efforts. In recent events, airports were used by Federal, state, and local agencies to store and distribute food, water, medicine, and other commodities. When disasters compromise ground transportation routes – as happened on Long Island following Superstorm Sandy – air access becomes a vital means of providing necessary search, rescue, and recovery efforts. MacArthur Airport, located in Ronkonkoma, could provide a vital link on Long Island for emergency operations requiring air support.

Given the importance of New York's aviation facilities for passenger travel, cargo movements, and emergency access,

Figure T-25: Flooding at LaGuardia Airport from Superstorm Sandy. (PANYNJ, 2012)

the State should invest in infrastructure improvements to maintain operational capacity during times of stress. Returning airports to full or near-full operational status after a severe event is a critical step to regional recovery.

The following recommendations will contribute to more resilient airport operations:

- Raising runway elevations, providing elevated or submersible pump control panels, adding tide gates and/or drainage check valves on drainage outfalls are all strategies that should be assessed on a facility-by-facility basis in the medium-term. In the long-term, install emergency generators and dedicated pump feeders, where appropriate.
- Maintain all electrical power systems, including sub-stations, in a state of good repair. Obsolete substations should be replaced with new, higher-standard substations. Existing substations should be expanded. Long-term investments include the installation of backup power systems, such as a cogeneration plant, and increasing the resilience of electric distribution systems to prevent salt water seepage and corrosion. Coordination with public utility companies (e.g., Con Edison, National Grid, etc.) is recommended.
- Actions like these that address airport power will ensure the continued operation of airfield lighting, air traffic facilities, and critical navigational aids. These systems control operations at individual airports and are necessary for controlling aircraft. Actions that address the operational impacts of the loss of power (and possibly heating and cooling) in terminal and support facilities must also be considered.
- Expand additional fuel storage facilities. An uninterrupted fuel supply must be ensured for both aircraft and landside vehicles and equipment.
- Maintain piers in a state of good repair. Piers should be built to a standard that adequately protects navigational aids and allows for repairs following a severe event. Coordination with the Federal Aviation Administration (FAA) and agencies that regulate adjacent bodies of water will be required for planning, modification, and construction.

Strategically expand transportation networks in order to create redundancies

The previous section focused on making existing transportation infrastructure more resilient. The recommendations in this section are guided by longer-term system expansions, based on need, to ensure improved resilience and redundancy by the end of the century. In considering the expansion of our transportation infrastructure, key questions include:

- Over the next several decades, what should New York do to ensure a transportation network that is resilient enough to withstand and operate effectively through events like Hurricane Irene, Tropical Storm Lee or Superstorm Sandy?
- Equally importantly, how should New York plan for major, new investments recognizing that the region and its economy will grow and change significantly in that time?

As New York State's population grows, the State's mass transit ridership will evolve, population centers will shift, and new commercial development will require changes in how people move within, around and between major metropolitan areas. Even now, the State's transportation network in certain areas is being pushed to the limits of its capacity.

This is especially evident in New York City. Between 1975 and 2011, annual subway ridership increased 38 percent, from 1.05 billion to 1.64 billion passengers.[24,25] During that time, LIRR and Metro-North have also seen significant increases in ridership, at 22 percent and 105 percent, respectively.[26,27] Additionally, the population within the New York Metropolitan Statistical Area (MSA) increased 11 percent, with a 4 percent increase in New York City alone.[28,29,30,31] To address increased demand, MTA has undertaken significant repairs and capacity upgrades and committed resources to current capital projects, including the 7 line extension, the Second Avenue subway, and LIRR East Side Access (ESA) to Grand Central Terminal. However, these are the first substantial expansions of the MTA network in 60 years, and, due to budget constraints, other services have been reduced or eliminated (e.g., the W line), adding additional strain to the system.[32]

For this reason, the recommendations in this chapter focus strongly on building new redundancies and resiliencies that enhance the overall transportation network. The infrastructure we invest in today will serve generations of New Yorkers to come.

Our transportation network requires changes that address the loss of major transportation assets during severe events. As we learned from Superstorm Sandy, with the flooding of eight subway tunnels, no single transportation mode can completely withstand every type of severe event. There is a need for system-wide redundancy to accommodate interruptions and maintain the safe and effective movement of people and goods.

Redundancies should be planned for the long-term. They should include intercity rail, additional surface transit systems, stronger bridge and highway infrastructure, expansion to ferry services to support land-based mobility, and facilities that accommodate and promote non-motorized modes of transit. New York State should make investments in new transportation systems that provide multiple modes of travel and route options and minimize disruptions to the overall transportation network should individual systems shutdown. Investments should be realized in cities as well as the peripheral reaches of metro areas.

The Commission has laid out the following recommendations, detailed in the sections that follow:

- Modernize signal systems: communication-based train control.
- Build a bus rapid transit network.
- Expand rail access to/from Manhattan.
- Expand capacity on the LIRR's Main Line.
- Encourage alternative modes of transportation.

Modernize signal systems: communication-based train control

New York State should modernize the signal systems of all of its rail operations. Modern signal systems, like communication-based train control (CBTC) for subway systems and modernized signal systems for commuter railroads, better assure the safe and efficient movement of trains by continuously monitoring the location and speed of trains using equipment installed in rail cars and along the wayside.

CBTC provides many benefits including greater safety through continuous overspeed protection and automatic train operation; system redundancy in the event of component failure; and additional capacity for less cost than new systems. Under CBTC, trains can proceed at closer spacing, allowing more trains and, in turn, greater passenger capacity along a line. CBTC supports enhanced train service flexibility when parts of the line are shut down, either for scheduled work or other unplanned disruptions. This flexibility includes demarcating slow-speed work zones where workers could be encountered on the track, as well as "all stop" commands and reverse-running of trains to avoid hazardous track areas.

The Commission recommends a modern signal system like CBTC to provide resilience and redundancy in the event of a natural disaster. CBTC signal systems prevent conflict with event-driven hazards along track and allow additional throughput, which provides greater passenger capacity. CBTC also requires less wayside equipment (e.g., signals, switches, and other devices located along the railroad) that could be susceptible to flooding than existing fixed-block signals, thereby reducing the risk to service during and after severe events. In addition, if the system is damaged by flood or other events, CBTC relies on

Figure T-26: M15 SBS articulated bus. (MTA, 2011)

Figure T-27: M15 SBS traveling in bus lane in New York City. (MTA, 2011)

modern microprocessors and other standard electronic systems which are more readily available than 1950s-era electro-mechanical relays.

Build a bus rapid transit network

The State should support an ambitious expansion of the New York City regional transit system by planning, designing and constructing a bus rapid transit (BRT) network along viable routes. BRT is a high performance transit system that combines the speed, reliability and amenities of rail-based transit systems with the flexibility of buses. To meet high performance standards, BRT incorporates certain features, including dedicated and/or physically separated lanes (where space allows), priority signaling at traffic lights, off-board fare collection, level boarding at multiple doors, real-time bus arrival information, and distinctive branding. In effect, BRT acts as a train on rubber wheels. Given the cost and time required to expand rail-based transit, BRT offers a quality alternative at a lower cost and quicker timeframe.

A BRT network would enhance the resiliency and redundancy of the overall transit system by supplementing existing rail transit and providing a complementary service for people who lack direct access to the subway system. Following Superstorm Sandy, when New York City subway tunnels were flooded, the MTA "bus bridge" improvised BRT-like service between Brooklyn and Manhattan, underscoring the need for redundant surface transportation options. BRT corridors should become integrated components of the overall transit system, providing connections to other modes. For example, a BRT route that runs through southern Brooklyn could connect Bay Ridge commuters who rely on the R train to the D, F, B and Q in Coney Island and Brighton Beach. Another east-west corridor through central Brooklyn could provide riders of the above trains to connections to the 2, 5, 3, L, A and C.

The State's and City's economies and patterns of development are changing in ways that require greater redundancy. Over the past few decades, job centers outside Manhattan, like Hunts Point in the Bronx, JFK in Queens, and the State University of New York (SUNY) Downstate Medical Center in Brooklyn, have grown dramatically, leading to profound changes in travel demand that the current, Manhattan-centric subway system was not designed to handle. For example, between 1990 and 2008, the number of Bronx residents who travel to work in Queens or Westchester has increased by 38 percent, compared to the 13 percent growth of those traveling to Manhattan. The number of Brooklyn residents traveling to Queens for work has increased 32 percent, with nearly 160,000 crossing the border on a daily basis.[33]

While the very best examples of high-performing BRT are outside the United States (e.g., Curitiba, Brazil), American cities like Chicago, Los Angeles, Las Vegas and Cleveland have embarked on ambitious BRT expansions. New York has some experience it can build on. The MTA's successful Select Bus Service (SBS) – initiated in 2008 on Fordham Road in the Bronx and expanded to two routes in Manhattan and one on Staten Island – can serve as the foundation.

SBS, while not true BRT, possesses some of its characteristics, such as pre-board fare payment, limited stops, and dedicated (although not physically separated) bus lanes on some routes.[34] Vehicles feature low-floors for easier boarding and are visually branded to distinguish themselves from regular MTA buses.

SBS has produced increases in ridership and decreases in travel time. The expansion of SBS into a full-fledged BRT system would provide a viable and cost-effective transit

Build a bus rapid transit network in New York City

A BRT network would enhance the resiliency and redundancy of the overall transit system in New York City by supplementing surface transit options. Transit ridership in New York City has increased almost 60 percent since 1990, but increasing congestion has reduced average bus speeds by 11 percent, among the slowest in the country. Furthermore, the majority of the City's transit infrastructure was built prior to the institution of seismic and flood design standards.

Dedicated BRT lanes have been proven to reduce corridor transportation energy consumption and related pollution emissions by 29 percent in the short run and 45 percent over the long run, compared with general purpose lanes.[35] BRT can serve neighborhoods and job centers beyond the reach of the subway network as well as reduce trip times on heavily travelled bus routes.

Given fiscal constraints, low-cost, high-impact solutions are needed to provide additional transit service. BRT can leverage existing roadway and bridge infrastructure with new transit technology to expand and improve bus services at relatively low cost. SBS has proven to be an effective use of transit funds, producing increases in ridership of up to 10 percent and decreases in travel time of up to 20 percent.[36]

RTA HealthLine (Cleveland, United States)

The possible economic and job-creation benefits of BRT systems for New York can be seen in the positive effects of Cleveland's RTA HealthLine seen along the Euclid Avenue corridor. The City and the Greater Cleveland Regional Transit Authority (RTA) examined several alternative transportation solutions to improve access to its two largest employment centers. With input from the public, BRT was selected over rail, as it was estimated to be half the cost of the least expensive rail alternative while still achieving many of the same transit benefits.

The RTA HealthLine opened in 2008 and consists of a 9.2-mile BRT corridor that connects downtown Cleveland, University Circle, and East Cleveland, passing through several areas which were previously underserved by transit. The project's cost of $168.4 million was funded by several institutions, including the Federal Transit Administration (FTA), State of Ohio, City of Cleveland, and RTA, among others. Within a year of service, ridership had expanded 47 percent compared to the former local transit service along the corridor. It is also estimated that $4.3 billion in development has already been generated along the route, including the rehabilitation of older buildings into housing and retail, new construction for business startups, and major expansions of universities, museums and hospitals. The corridor now leads the state in job creation and research.[39]

The Commission offers the following recommendations:

- Where appropriate, incorporate additional BRT technologies along existing and developing SBS routes, including (where not present) real-time bus arrival information, dedicated or physically separated lanes (where feasible), transit priority signaling, pre-board ticketing, and limited stops.
- Establish a process to evaluate potential BRT routes. One such option may be the creation of a BRT task force, including MTA, NYCDOT, NYMTC, and business and industry experts, to develop, by the end of 2013, recommendations for an integrated BRT network. The task force should review demographic data and current travel patterns, identify underserved neighborhoods, current difficult transit trips (those that are slow or require multiple transfers), crowded subway routes, and expected growth areas. It should prioritize corridors to optimize economic development, system redundancy and improvement of service in communities that currently lack robust transit. Particular attention should be paid to inter-borough routes. An integrated BRT network should also plan for the incorporation of pedestrian and bicycle connections.

Transitway (Ottawa, Canada)

Since 1983, the City of Ottawa, Ontario, has been operating one of the largest BRT systems in North America. The Ottawa Transitway features seven routes that transport 200,000 daily riders, achieving peak capacities of 10,000 passengers per hour per direction and a bus frequency of one to two minutes.[37]

The Transitway employs a variety of innovative features. Two dedicated lanes, or "busways," are physically separated from vehicular traffic along most routes. Busways widen to four lanes at each station to allow passing, keeping buses moving efficiently. In downtown, the BRT system runs in dedicated lanes that share the same rights-of-way as private vehicles and local buses. Outside of the downtown, grade-separated crossings help buses avoid delays at intersections. Station platforms flank the busway, with right-side boarding/alighting and pre-board fare payment. Low-floor, articulated buses allow easier boarding and alighting and access for all abilities.

The Transitway also enhances system-wide transit connectivity to the O-Train (light rail transit) and local bus service. Many other bus routes use parts of the Transitway and connect to Transitway stations, which serve as convenient passenger transfer points, often near shopping or employment areas. Pedestrian bridges facilitate access and transfers at most stations, and park-and-ride lots provide access to the system for those who live in suburban areas.[38]

When considering BRT in New York, the Transitway offers an appropriate case study of a flexible system that connects suburban residential communities to job centers and provides context-sensitive station design to meet access needs.

option, particularly in the outer boroughs. The system could utilize existing rights-of-way and foster long-term, sustainable growth along the corridors through which it operates. However, as seen along existing SBS routes, the use of existing rights-of-way for dedicated travel lanes involves the reallocation of road space. This requires advance planning, input and acceptance from the community, and policy choices to implement along select corridors.

Developing a regional BRT system would involve expansion of the existing SBS Phase I routes and the introduction of possible Phase II corridors. More detail on planning a regional BRT network can be found in the section entitled "Build a bus rapid transit network in New York City."

Figure T-28: RTA Healthline. Modern, articulated bus stopped in dedicated bus lane at the East 6th Street Station in downtown Cleveland. (Flickr Creative Commons, itdp, 2011)

Expand rail access to/from Manhattan

New York State should pursue enhancements to Manhattan rail access. For the first time in their 100-year history, two Hudson River tunnels and two East River tunnels, that together serve more than 1,000 daily trains to/from Manhattan, were flooded as a result of the storm surge from Superstorm Sandy. These closures, along with those of subway and auto tunnels, cut Manhattan from the region, impacting the regional and national economy.

Expanding rail access to and from Manhattan would offer increased redundancy along with broad regional benefits. Overall regional mobility would be improved by providing additional connections to Manhattan, as would regional evacuation and recovery efforts.

Two project options, if realized, would expand rail access and connectivity and provide a new layer of redundancy to the regional transportation network:

- Two new, dedicated, multi-user rail tunnels under the Hudson River. (See "Create a new trans-Hudson tunnel connection.")
- Connecting Metro-North to Penn Station on Manhattan's west side. (See "Expand rail access to/from Manhattan with Metro-North Penn Station Access.")

Expand capacity on the LIRR's Main Line

The LIRR's Main Line, an 18-mile segment that extends through central Suffolk County was electrified to Ronkonkoma in the late 1980s, providing single-seat service to Penn Station in New York. The service was immediately successful, attracting passengers throughout Suffolk County. However, increased residential development and ridership growth have led to overcrowded conditions. Additionally, the Main Line has single points of failure, including the point at which trains enter and exit the storage yard at Ronkonkoma. Disruptions caused at these locations have ripple effects on the entire LIRR network. As a result of these challenges, the Main Line is the least reliable within the LIRR system.

A second track on the Main Line between Farmingdale and Ronkonkoma would provide a variety of service benefits. It would allow half-hourly off-peak service in both directions, relieve crowding with more trains, provide greater on-time service reliability, and allow faster recovery time following service disruptions.

Double-tracking would provide a vital redundancy by allowing alternative routing in the event of service disruptions or track blockages. With a second track, trains could bypass problem areas, and ensure the delivery of essential cargo and materials to Suffolk County if the region's roadways were damaged during a severe event.

Double-tracking is a key component in the promotion of economic development in central Suffolk County. It would support other corridor improvement initiatives including Connect Long Island, Wyandanch Rising, Ronkonkoma Hub, and Heartland Town Square in Deer Park. Double tracking would also enhance access to Long Island MacArthur Airport by providing frequent rail access to Ronkonkoma, and pave

the way for the future re-opening of the Republic Station near the airport in East Farmingdale (closed in 1986).[42] It would also support planned BRT and smart growth development along the Route 110 business corridor.

The MTA 2010-2014 Capital Program has allocated $138 million for the project's first phase, from Ronkonkoma to Central Islip. An additional $350 million is required to complete double tracking from Central Islip to Farmingdale. Phase 1 will be complete by 2016, while Phase 2 could be completed by 2018, assuming continued funding.[43] The double tracking project will provide needed construction jobs and support local and regional material suppliers.

The State should work with the MTA and LIRR to ensure funding is in place to complete double track work along the Main Line.

Encourage alternative modes of transportation

The effects of Superstorm Sandy highlighted the importance of planning for and encouraging the use of alternative modes of transportation to supplement commonly-used modes such as private vehicles and mass transit.

As described earlier, the MTA and the New York City Department of Transportation (NYCDOT) responded to impaired subway service by improvising a "bus bridge,"[44] with temporary, exclusive bus lanes carrying buses through city streets. Emergency ferry services provided a transportation option for those in particularly hard-hit areas of Staten Island and the Rockaways. Non-emergency trans-Hudson ferries also saw heavier usage than usual, given disruptions to PATH service. Some ferries saw average weekday ridership increase by over 335 percent, and ferry facilities, such as the PANYNJ's World Financial Center terminal, saw an increase in usage of over 310 percent .[45] Similarly, the number of bike commuters in New York City tripled.

Figure T-29: NY Waterway ferry on the Hudson River. (Arup, Anthony Durante, 2011)

Figure T-30: 9th Avenue bike lane in Manhattan. (Arup, Allison Davis, 2009)

Alternative transportation options like these can be utilized to relieve demand on overtaxed facilities and systems to facilitate mobility and provide a layer of redundancy when roads are damaged, transit lines are out of service, or fuel is scarce. This is especially important in places that are heavily reliant on private automobiles and lack transportation alternatives.

The State should:

- Study the role and use of alternative transportation modes immediately following Superstorm Sandy to determine whether any of the impromptu, post-event strategies should be made permanent. These strategies include:
  - Exclusive bus lanes at key bridges and tunnels connecting Manhattan to the outer boroughs and New Jersey.
  - High-occupancy vehicle (HOV) lanes to/from Manhattan (with enforcement).
  - Maximizing the capacity and flexibility of taxis and other vehicles (e.g., Access-A-Ride vans) during times of need.
- Institutionalize a protocol between public agencies in New York and New Jersey for cross-honoring tickets and expanding ferry services during times of need; ensure that funding is available to private ferry operators if they are requested to respond in an emergency.
- Enhance system redundancies by investing in active transportation infrastructure, including sidewalks, crossing improvements at intersections, bike lanes, bike storage amenities (parking and lockers), and wayfinding systems.

Create a new trans-Hudson tunnel connection

The construction of two new tunnels under the Hudson River, along with associated track, bridge and station improvements, would provide system redundancy through the addition of new connections to New York's Penn Station. The tunnels would help to manage demand by doubling capacity for rail passengers between New Jersey and New York. Connecting to New Jersey via new Hudson River tunnels would provide valuable new linkages to Newark, New Jersey, Newark-Liberty International Airport, and beyond via the Northeast Corridor rail line. Additional trans-Hudson capacity would also minimize conflict by allowing all regional rail operators – Amtrak, LIRR, NJ Transit, and, in the future, Metro-North – more flexibility to maximize daily service to and from Manhattan.

The tunnels would be built to modern standards that will better prevent flooding and ensure rapid recovery following a seismic, fire or other severe event. Once built, the tunnels could also be used to temporarily accommodate all trans-Hudson rail traffic while the existing century-old rail tunnels are upgraded to modern standards.

An associated expansion of Penn Station south of 31st Street is key to accommodating increased rail traffic. This expansion would benefit Amtrak and NJ Transit with increased capacity. Also, by allowing greater flexibility in programming track space, the expansion benefits other current and future users of Penn Station, LIRR and Metro-North.

New Hudson River tunnels provide ancillary benefit as well. They are a prerequisite to bringing true high speed rail to New York. In addition, the tunnels support the revitalization of Manhattan's west side, currently underway. It would create jobs in engineering, construction, and related trades during construction years and would also serve commuters in the knowledge and service industries who work in Manhattan's growing midtown-west business district.[40]

Durchmesserlinie Rail Tunnel (Zurich, Switzerland)

The Durchmesserlinie (DML) is a major rail infrastructure project that will add capacity, relieve congestion and build redundancy into the city's currently congested rail network. The 5-mile line will include: two single-track viaducts; a four-track underground station with two platforms; a double-track tunnel between Zurich's main station and Oerlikon (with a parallel escape and rescue tunnel); and widening of the cutting between the tunnel portal and Oerlikon station to accommodate two additional tracks and station expansion.

The line will not only relieve congestion in the city but will enhance Switzerland's east-west axis by cutting journey times for services on the Geneva – St. Gallen corridor. At present, most trains crossing Zürich from east to west, including many long-distance and S-Bahn (suburban commuter rail) lines, must reverse at Hauptbahnhof, a station that has reached its capacity limit.

Construction began in September 2007 and is expected to open to S-Bahn traffic in 2013 and to intercity trains in 2015. The total estimated cost of the project is approximately $2.1 billion, half of which can be attributed to the new station and tunnel.[41]

London Crossrail (London, United Kingdom)

Crossrail is a major new rail tunnel project through Greater London. It has been planned in an innovative and forward-thinking manner, by designing system components in response to anticipated impacts from climate change.

Crossrail will be the largest addition to the Greater London regional transportation network in more than 50 years, providing high-frequency rail service starting in 2017. The Crossrail route will run for 118 km from Maidenhead in the west (with a spur to Heathrow Airport), through two new 21-km tunnels under Central London, to Shenfield in the east. Once complete, Crossrail will facilitate east-west travel in South East England and reduce crowding on London's existing rail lines. The project will handle 500,000 weekday passenger trips, increasing London's tube and rail capacity by 10 percent. The estimated financial benefit to the UK economy is approximately £36 billion.

Crossrail's infrastructure includes ten major integrated systems, from station construction to tunnel ventilation. In reviewing system vulnerabilities, it was determined that all systems and related components would be affected by any combination of three climate change impacts: flooding, high temperatures, and water scarcity.

Flooding was a particular concern to project planners for three reasons: 1) much of the Crossrail tunnel network is being constructed in floodplains of the River Thames[b] and the River Lee; 2) many of the stations are located in areas at risk of flooding; and 3) the 120-year design life of the project requires consideration of future flood risk. Floodwater entering the tunnels would not only impact the Crossrail network, but also the London Underground, to which Crossrail is connected.

To assess flood risk, planners looked at a variety of vulnerable project components, including construction sites, stations, tunnel portals, and shafts. Flood design levels and flood mitigation strategies were developed for the specific locational/situational context of each component. Where possible, "passive" flood protection measures, such as raising entry or egress levels, raising track levels, or extending portal walls were preferred, but other "active" measures, such as watertight doors or temporary floodgates, were proposed as necessary.

[b]As a tidal river, the Thames, like the Hudson River, is particularly vulnerable to the future impacts of sea level rise.

Expand rail access to/from Manhattan with Metro-North Penn Station Access

The Metro-North Penn Station Access project proposes new links to Manhattan's West Side using two existing rail corridors: the western Long Island Sound/Interstate-95 corridor via the Metro-North New Haven line/Amtrak Hell Gate line and the Hudson River corridor via the Metro-North Hudson line / Amtrak High Line.

This project would create system redundancies by avoiding two single points where disruptions can debilitate the overall Metro-North system: the Mott Haven Junction and the Harlem River Lift Bridge. The project would establish new links for the New Haven and Hudson lines in the east Bronx and west Bronx that bypass both the Mott Haven Junction and the Harlem River Lift Bridge. Since both facilities are currently used by the entire Metro-North network, they represent points of failure that would cripple the railroad if disrupted. In fact, the Harlem River Lift Bridge was almost lost in a fire two years ago that would have effectively shut down the railroad. This project isolates the risk created by these points of failure. It would also involve the addition of four new Bronx stations (proposed for Co-op City, Morris Park, Parkchester and Hunts Point), which will provide extended service to residents of the Bronx, some of whom are not currently served by commuter rail; and to up to two new stations on the West Side of Manhattan.

Metro-North Penn Station Access represents a cost-effective means of providing enhanced regional rail connectivity by upgrading and utilizing existing infrastructure. It would provide enhanced access to jobs by improving connections to Manhattan's west side via Penn Station and other regional destinations in the Bronx, the lower Hudson Valley and Connecticut.

Figure T-31: Future Metro-North Penn Station Access via the Hudson (green) and New Haven (red) lines. (MTA Metro-North Railroad, 2009)

Expanding commuter access along the MBTA's Providence/Stoughton Line (Massachusetts and Rhode Island, United States)

In October 2010, the Massachusetts Bay Commuter Railroad Company (MBCR), the Massachusetts Bay Transportation Authority's (MBTA) commuter rail operator, introduced new commuter rail service along the Providence branch of the Providence/Stoughton Line. The service expanded regional connectivity for commuters between metropolitan Boston and Providence.

Key to MBCR's strategy has been to expand service with minimal system expansion. In this vein, the agency leveraged existing track along the Northeast Corridor between Providence and Boston; the track in Rhode Island is owned by Amtrak, while the track from the Rhode Island border to Boston is owned by the MBTA. MBCR further enhanced service through the purchase and introduction of bi-level coaches and an upgraded maintenance regime.

The new service was made possible through a 1988 partnership agreement between the MBTA and The Rhode Island Department of Transportation (RIDOT). The agreement benefited both agencies. A regional transportation link was provided in Rhode Island, while the MBTA was able to conduct needed capital improvements along the Providence/Stoughton Line.

Today, the Providence branch runs 15 round trips per day, provides weekend service, and serves approximately 2,000 riders per day from Providence.

Sources: Massachusetts Bay Transportation Authority, 2010; Massachusetts Bay Commuter Railroad Company, 2011

Build for a resilient future with enhanced guidelines, standards, policies, and procedures

A combination of changes to transportation planning processes and new tools may better address the range of potential climate futures and resulting implications.[45] These improvements will assist with incorporating climate data and projections into existing scenario planning and decision-making processes, risk assessment, investment prioritization, and mitigation measures.

Building for the future is less about developing newer ways of planning for and managing the State's transportation infrastructure, and more about considering ways of incorporating new thinking into existing planning processes. Existing risk assessment inventories can be adjusted to account for all-hazard vulnerabilities. Design guidelines and standards can be updated so that new and rehabilitated infrastructure can withstand future threats. The framework governing the design and operation of infrastructure can be expanded to include the impacts of climate change. Perhaps, most importantly, within and across agencies and organizations that manage infrastructure, adaptation strategies should draw from a broad range of responses, including adjustments in operations and management, capital investments in infrastructure, and development of policies that promote flexibility.[46]

The Commission has laid out the following recommendations, detailed in the sections that follow:

- Review design guidelines
- Improve long-term planning and funding allocation
- Improve interagency and interstate planning coordination
- Seek expedited environmental review and permitting on major mitigation/ repair investments

Review design guidelines

New York State should review design guidelines that govern transportation infrastructure. Resilient infrastructure is better equipped to withstand physical, environmental and property damage and can limit human casualties and the social ramifications of extreme events. These facilities are physically more robust, and therefore better positioned to recover from events.

While organizations such as the American Association of State Highway and Transportation Officials (AASHTO) and the American Society of Civil Engineers (ASCE) have developed standards to safeguard against natural events (including wind, seismic, stream current, thermal, ice flow and scour), the State should revisit how it applies these standards in light of severe events. The lead organizations for establishing and revising national standards – AASHTO, ASCE – should continue to be at the forefront of engineering practice, informed by empirical data provided by research organizations, such as the National Science Foundation.[47]

Technology in the form of infrared cameras, thermocouples, weather monitors, and other "smart" instrumentation can also be used to better understand the impacts of severe events by assessing the structural integrity and behavior of specific transportation facilities during events and inform design guidelines going forward.[48]

Guidelines for resilient infrastructure should:

- Be clear and consistent across agencies and regions.
- Incorporate State-endorsed climate predictions.
- Be risk-oriented, based on probabilistic climate change projections.
- Include requirements for life-cycle costing and return on investment.
- Be considered by all agencies for use in the development and design of capital projects.

Key to the development of any resilient infrastructure guidelines is input from the design and engineering community. Practitioners should play a significant role in developing new design philosophies and guidelines that will strengthen and protect transportation assets and ensure the long-term viability of the State's transportation network in both emergency and everyday conditions.

Improve long-term planning and funding allocation

Planning is a major part of capital improvement, prioritization, financing, operations and maintenance. A recent study found that, nationally, improvements in planning policy are needed in accessing and incorporating climate data and projections into existing scenario planning and decision-making processes, assessing risk, prioritizing investments, and assessing the range of potential options to build resilience.[49]

States are required to develop transportation plans in order to be eligible for Federal highway and transit funding. It is through these plans that state transportation agencies prioritize projects and identify which to fund using Federal monies. The current planning process, however, does not require consideration beyond a 20-year time horizon.[50]

By incorporating longer-term climate change effects into visioning and scenario planning processes that inform their long-range plans, transportation agencies and planning organizations will be better placed to address the range of potential climate futures and resulting implications.

New York State should work with its regional planning partners to ensure that resilience to climate change impacts and extreme weather is considered in all capital funding programs. This process will help direct limited Federal funds to projects that minimize vulnerabilities to the State's transportation system.

The planning process should guide decisions about rebuilding efforts, future investment plans, and the hardening and upgrade of infrastructure. The plans should also be linked to the State's lifeline network to ensure that funding for upgrades to Lifeline Facility Class 1 and Class 2 infrastructure are prioritized.

Improve interagency and interstate planning coordination

Creating resilience within the State's transportation system requires knowledge that crosses disciplines and policies that cross jurisdictions. Responsibility for the State's transportation infrastructure is shared, with no one institution in charge. Some institutions report to the Governor, others to mayors, and some to the President. Further, parts of the transportation system are operated privately. Since the system is networked and integrated, delays and failures in one area can affect component parts.

The ability to respond to change – climatic or otherwise – depends on the regulatory context, organizational capacity, and decision-making authority of the organizations involved. In dealing with new challenges, institutions can benefit from practical, continuing education and regular training to nimbly evaluate and respond to changing conditions, adjust procedures, and adopt best practices.

New York, New Jersey and Connecticut benefit from one of the world's largest metropolitan economies, and rely upon shared transportation infrastructure. Superstorm Sandy revealed how integrated and fragile this economy is. The three states can build on existing efforts to improve coordination among the five Metropolitan Planning Organizations (MPOs) in the metropolitan tri-state area. These MPOs are Federally-mandated, cooperative agencies that plan and coordinate transportation investment decisions within their respective jurisdictions. The New York Metropolitan Transportation Council (NYMTC) is the MPO for New York City, Long Island, and the lower Hudson Valley. NYMTC along with the North Jersey Transportation Planning Authority (NJTPA), the South Western Region Metropolitan Planning Organization (SWRMPO), the Greater Bridgeport/Valley MPO (GB/VMPO), and the Housatonic Valley Council of Elected Officials (HVCEO) have signed a memorandum of understanding (MOU) that commits the five MPOs to increased coordination in their planning and programming. This can provide a ready foundation for the creation of a tri-state, interagency working group that can add a stronger focus on resiliency and adaptation within the transportation sector.

The transportation sector has some models for cross-jurisdictional arrangements, such as regional authorities for specific facilities (e.g., the Alameda Corridor in California). Regional and multistate emergency response operations that include transportation are beginning to emerge in the wake of other disasters. These could serve as the nucleus for multistate regional agreements to address other issues, such as the impacts of climate change. State-mandated regional coordination for addressing air quality issues provides another model.[52]

Interstate and interagency coordination should consider the following opportunities:

- **Develop ways of sharing best practices** across the tri-state area for climate change adaptation. A repository for local and state research and best practice solutions could be catalogued and disseminated to all agencies and jurisdictions.[53]
- **Create a tri-state risk assessment framework** to assess potential impacts of climate change on transportation infrastructure and prioritize resiliency investments. State and local governments and private infrastructure providers could adopt an approach similar to California's seismic retrofit program for bridges for identifying and screening critical infrastructure relative to projected climate changes. Key to adopting such an approach is establishing a performance standard for a particular facility that reflects a tolerable level of risk, along with a screening process that takes into consideration such factors as the degree of risk, the vulnerability of the facility, and how essential the facility is to the system so priorities for rehabilitation or retrofit can be determined. Risk assessment tools and adaptive management approaches, will facilitate the planning process.[54]
- **Continue to foster partnerships** that could involve closer collaboration between transportation agencies and other entities, including private operators and emergency responders. Transportation agencies and service providers should work closely with the National Oceanic and Atmospheric

Planning for sea-level rise in California (California, United States)

The California Department of Transportation recently issued guidance to its staff on how to incorporate consideration of the risks of sea-level rise when planning and developing transportation projects. The guidance directs staff to consider the project's design life; the availability of alternative routes; how critical the route is to travel, commerce and safety; the amount of investment; the added cost of incorporating adaptations to sea-level rise; and environmental constraints. Staff are directed to evaluate projects given interim sea-level rise projections adopted by the state Ocean Protection Council in March 2011.[51] Similar guidelines using state-endorsed projections could be developed for NYSDOT as well as local transportation agencies and authorities.

Administration (NOAA) and emergency response planners to convey their own lead-time requirements so they can provide the personnel and equipment necessary for evacuation and protect their own assets. Other relevant partnerships could include private transportation operators (such as NY Waterway) as well as university climate scientists and local and regional transportation and land use planners.

- **Coordinate to pursue new funding streams** for regional transportation services which connect multiple jurisdictions and systems. Regional consortia in downstate New York/ southwestern Connecticut and in northern New Jersey have recently been created to secure Federal Sustainable Community grants, thereby enhancing the competitive position of these regions and spurring new planning efforts.

Seek expedited federal and state environmental review and permitting on major mitigation/repair investments

All major Federal actions, including projects financed and/or permitted by Federal agencies, must comply with the National Environmental Policy Act (NEPA) and environmental review requirements.[56] Similarly, state agencies are typically bound by the State Environmental Quality Review Act (SEQRA), which has similar requirements. While some emergency relief projects are categorically excluded from Federal and/or state environmental review requirements (and can proceed quickly, with less expense), this exclusion does not always apply if a project is rebuilt to extend beyond the pre-disaster footprint of the asset. Furthermore, this exclusion does not automatically apply to projects aimed at improving or enhancing future resilience. This is of particular importance given the time delays that are often associated with permits and other approvals that are part of this process.

Transportation Management Centers (United States)

Improving the efficiency of the existing highway network involves the application of technologies, such as ITS, and control strategies, transit signal priority, variable message signs, and incident management. In many large metropolitan areas, these developments have been accompanied by the establishment of regional transportation management centers (TMCs), which act as nerve centers for monitoring traffic, providing rapid police response, multi-agency/multi-modal operational coordination, and travel advisories. New York State currently has several TMCs.

Many TMCs are manned by staff from multiple agencies and jurisdictions working as a team. An example of this is the Houston TranStar TMC, which is a consortium of transportation and emergency management agencies in the greater Houston area, housing engineers, law enforcement personnel, information technology specialists, and emergency managers. In addition to traffic and incident monitoring, emergency management personnel monitor potential emergencies due to severe weather to provide the public with real-time information.[55]

Effective communication of transportation updates across the largest metropolitan area in the nation involves an extraordinary degree of coordination among dozens of independent agencies. During natural disasters such as Hurricane Irene and Superstorm Sandy, the need for accurate information across agency lines intensifies dramatically. TRANSCOM, the coalition of 16 major highway, transit and public safety agencies in New York, New Jersey and Connecticut, fulfills this need through a network of strong working relationships, supplemented by technical systems which provide accurate and timely data. Beginning the weekend before Superstorm Sandy, TRANSCOM led a series of regional conference calls which, at their peak, included over 100 officials from transportation facilities, police and emergency management agencies, and the Governor's office. As the need for situational awareness during the storm expanded, participants from beyond the TRANSCOM membership in Pennsylvania and Delaware also joined the calls. Not only did each agency provide up-to-date information, but issues were addressed on a real-time basis.

The United States Department of Transportation (USDOT) has stated that TRANSCOM is a national model "which has adhered to the principles of regional operations collaboration and coordination since it began and continues to evolve to improve one of the most complicated transportation systems in the Nation." Both State and local transportation agencies should continue to invest in ITS and other technologies to monitor storm events and improve real-time communication with drivers.

Figure T-32: PANYNJ Emergency Operations Center. (PANYNJ, 2012)

California seismic retrofit program for bridges (California, United States)

Large-scale planning and coordination benefits from a clear framework for making decisions. Following the Loma Prieta earthquake in 1989, the California Department of Transportation (Caltrans) had to evaluate and prioritize its inventory of about 25,000 state and local highway structures throughout the State for seismic retrofit. Due to the large number of bridges, a simple prioritization methodology was devised to identify and rank the most seismically vulnerable bridges in the State so that available resources could be used in the most efficient manner possible.

The process began with establishing a required performance standard. For most bridges, the minimum standard was "no collapse" during a major seismic event to prevent loss of life. Some damage was acceptable provided that the structure itself remained intact and could be reopened for service soon after the event.

A risk algorithm was developed for screening non-toll bridges, based on four major evaluation criteria: seismic activity, seismic hazard, impact, and vulnerability. The score on each criterion was multiplied by a weighting factor and summed with those on the other criteria to arrive at a final score.

All 12,600 state highway bridges were processed using this screening procedure and prioritized by score. Additional screening was required for 7,000 bridges that failed to meet the minimum performance standard.

A second screening was used to determine whether the bridge was in the program or retrofit could be deferred. A final in-depth field inspection was then performed, through which some bridges were found to meet the "no collapse" requirement and removed from the list. A similar procedure was followed for the 12,400 local roadway bridges, resulting in 4,500 structures that required further evaluation and analysis.

Since the program was initiated, 2,194 bridges on the state highway system have been retrofit at a cost of $3 billion. The program is considered 99 percent complete.

For New York, a clear decision framework could allow the evaluation and prioritization of statewide infrastructure repair and retrofit projects, whether preventative and reactive to a storm or other incident.

Improving performance of Federal permitting and review of infrastructure projects

Recognizing the need to improve efficiency and effectiveness of the Federal permitting process, the Obama Administration has taken a number of steps to make environmental review under the NEPA process more efficient. On October 11, 2011, the Administration announced the selection of 14 infrastructure projects around the country that would be expedited through the permitting and environmental review process. Among these projects was the Tappan Zee Bridge.[57]

Several months later, on March 22, 2012, President Obama signed an Executive Order on Improving Performance of Federal Permitting and Review of Infrastructure Projects. Citing the need to have a "fast, reliable, resilient, and environmentally sound means of moving people, goods, energy, and information" as the basis for maintaining a competitive edge and an enduring economy, the Order calls for Federal agencies to move infrastructure permitting "with maximum efficiency and effectiveness."[58] In particular, the Order notes the need for clear timelines and schedules for completion of reviews, clear goals, and tracking of progress against them.

Three more projects with direct benefit for New York State are now moving through this expedited process, and status and results can be easily seen on the Federal Infrastructure Dashboard that was launched as part of the overall initiative as a means for increasing transparency and tracking progress. Still in its pilot phase, ultimately the dashboard will also highlight best practices in making Federal permitting and review decisions more efficient.

While it is important to recognize the value of Federal and state oversight, as well as stakeholder input during these reviews, the Commission recommends modifying processes and procedures so that projects can advance as quickly as possible in order to create resilience within an expedited timeframe. The Obama Administration has recently instituted a process aimed at streamlining projects of national or regional significance. The same focus should be applied to rebuilding vital infrastructure and for major mitigation projects related to key transportation facilities.

The State should work with FEMA, the Federal Highway Administration (FHWA), Federal Transit Administration (FTA), Federal Railroad Administration (FRA) and other Federal agencies to explore mechanisms to expedite review public asset reconstruction after a disaster. Recently, the FHWA solicited comments on amending the agency's categorical exclusion for emergency repairs, specifically on whether FHWA should extend the categorical exclusion to include "construction of engineering and design changes to a damaged facility to deal with future severe events and sea level rise."[59] Other potential changes to the review process include:

- Expanding the categorical exclusion list to include more transit projects and the rehabilitation of transit stations and other facilities that do not require additional property.[60] Categorical exclusions are projects that, based on past experience, do not individually or cumulatively have significant environmental impacts. These projects require neither an environmental assessment (EA) nor an environmental impact statement (EIS) and should move ahead more quickly.
- Emergency exemptions should be clearly defined in applicable Federal and state regulations. Where such definitions do not exist currently, they should be developed; where they do exist, they should be reviewed for clarity and consistency across all regulations and related agencies.
- Develop a single regulatory and approval process for the FTA, FHWA and other Federal transportation agencies for use on multi-modal projects. A single process could expedite such projects that accommodate multiple transportation options to the benefit multiple user groups.
  - Develop and implement methods for expediting projects under SEQRA review, similar to the federal process for expediting projects under NEPA review.

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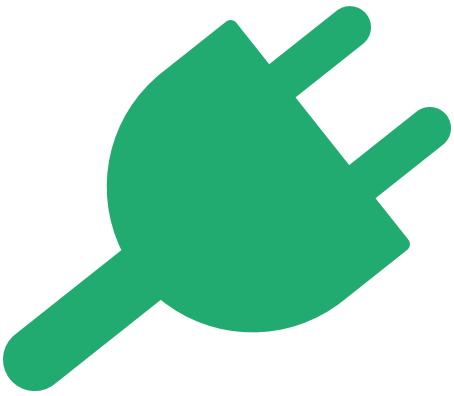
Energy



Overview

Unlike many of the capital assets that sustain civic life, energy infrastructure is not one that most people notice. Catastrophes like Superstorm Sandy confront citizens with the importance of these assets by way of their absence. New Yorkers witnessed the result of operational assets strained past their breaking point. New York State must enhance and protect its energy infrastructure to prevent such devastating effects in the future.

New York's electric system is primarily composed of central power generation, transmission, and distribution facilities (Figures E-01 and E-02). Energy is delivered from generators to customers through transmission lines running overhead, underground, and underwater to electric substations. From the substations, distribution lines run to pad- and pole-mounted transformers, and to distribution substations where electricity is finally converted to usable lower voltages. There are also large industrial and commercial building users, and some residential customers who generate electricity on-site.

New York's natural gas is delivered to customers (residential, commercial, industrial, and municipal) utilizing an extensive pipeline network that extends beyond New York through the United States and Canada. Gas that is brought in

The following recommendations will help the State achieve its goal of a more resilient and future-ready energy system:

1. **Strengthen critical energy infrastructure.** Securing critical infrastructure should be a primary focus. Strategies of protection, include among other things, selective undergrounding of electric lines, elevation of susceptible infrastructure such as substations, secure locations of future power plants, hardening key fuel distribution terminals, and reexamination of critical component locations to identify those most prone to damage by shocks or stresses. Creating a long-term capital stock of critical equipment throughout the region provides an efficient system of distribution to streamline the delivery and recovery processes.

2. **Accelerate the modernization of the electrical system and improve flexibility.** As utilities replace aging parts of the power system, the State should ensure new technologies are deployed. It is important to immediately invest in new construction, replacement, and upgrades to transition the grid to a flexible system that can respond to future technologies, support clean energy integration, and minimize outages during major storms and events. The grid for the 21st century should seamlessly incorporate distributed generation, microgrids, and plug-in electric vehicles (PEVs).

3. **Design rate structures and create incentives to encourage distributed generation and smart grid investments.** The State should implement new technologies and system improvements to provide effective backup power, flexibility, distributed generation, and solutions for "islanding" vulnerable parts of the system. In addition to improving the resilience and stability of energy, electricity, and fuel supply systems, these solutions promote energy conservation, efficiency, and consumer demand response.

4. **Diversify fuel supply, reduce demand for energy, and create redundancies.** Lowering GHG emissions in the power sector through the Regional Greenhouse Gas Initiative (RGGI) will contribute to reducing the impacts of climate change over the very long term. To build on the success of RGGI, the State should encourage alternative fuel sources such as biogas, liquefied natural gas (LNG), and solar heating in transportation and other sectors. PEVs, energy storage systems, and on-site fuel storage where feasible, should also be used to provide new energy storage mechanisms. Incentive programs to promote energy efficiency and renewable energy deployment should be strengthened to increase the level of private sector investment in this space.

5. **Develop long-term career training and a skilled energy workforce.** The utility workforce is aging and tremendous expertise will be lost in the next several years. Workforce development strategies should ensure the availability of skilled professionals to maintain a state of good repair, effectively prepare for and respond to emergencies, and deploy and maintain advanced technologies.

Superstorm Sandy

The destructive forces of Superstorm Sandy exposed vulnerabilities in New York's energy infrastructure, including the electric, natural gas, steam, and fuel distribution systems. Sandy severely affected the electric system in New York, leaving 2.1 million residents and businesses without power statewide. In some regions of the state, power was not restored for two weeks or more. Long Island's electrical system experienced widespread devastation and outages of record number and duration — 90% of Long Island's electric customers experienced outages.[2] Superstorm Sandy led to the loss of power for over 1 million of Con Edison's 3.3 million customers. The storm was five times more destructive than any storm Con Edison has endured in recent history (including Hurricane Irene in 2011).[3] Many of the power plants, substations, and other electric system infrastructure in the downstate region of New York are clustered in or near coastal areas, making them vulnerable to the type of flooding encountered during this most recent disaster. The steam distribution system also experienced outages and damage from flooding, as the underground pipes and tunnels were not equipped to manage the large volume of water associated with major storm events.

In Manhattan, a power outage lasting five days below 39th Street caused some to proclaim an entirely new neighborhood: "SoPo," or "South of Power." There was tremendous frustration as the power restorations did not come quickly. This lag created an added danger as the temperatures dropped. Many businesses were unable to resume operations for weeks. Backup diesel generators rolled in as reports indicated that power restoration would take weeks for some of the most affected buildings in downtown Manhattan. The loss of heat and electricity in this area caused many commercial and residential tenants to break leases in their buildings and relocate permanently.[4]

The impacts of Sandy also exposed the fact that the natural gas and fuel distribution systems require improvement in order to better survive natural disasters. Though the natural gas system is considered to be more resilient to disasters because it tends to continue to function during outages in the electric grid, the system is still vulnerable to uprooted trees damaging underground pipes and flooding compressor stations. Sandy significantly affected the fuel distribution network in New York, which includes fuel for transportation, power generation, and heating. The fuel distribution supply chain comprises an interconnected collection of pipelines, hubs, terminals, refineries, marine supply, and service stations. As a result of the storm, a breakdown in this supply chain created gasoline shortages across the region and resulted in widespread impacts both on those responding to the emergency and residents attempting to recover from it.

For the first time since the 1970s, gasoline rationing took place in New York City and Long Island. New Yorkers were left waiting for hours to fill up their cars and gas cans. New York was ill-prepared for such massive destruction to energy and infrastructure, and the State has much work to do to prepare for the next major event.

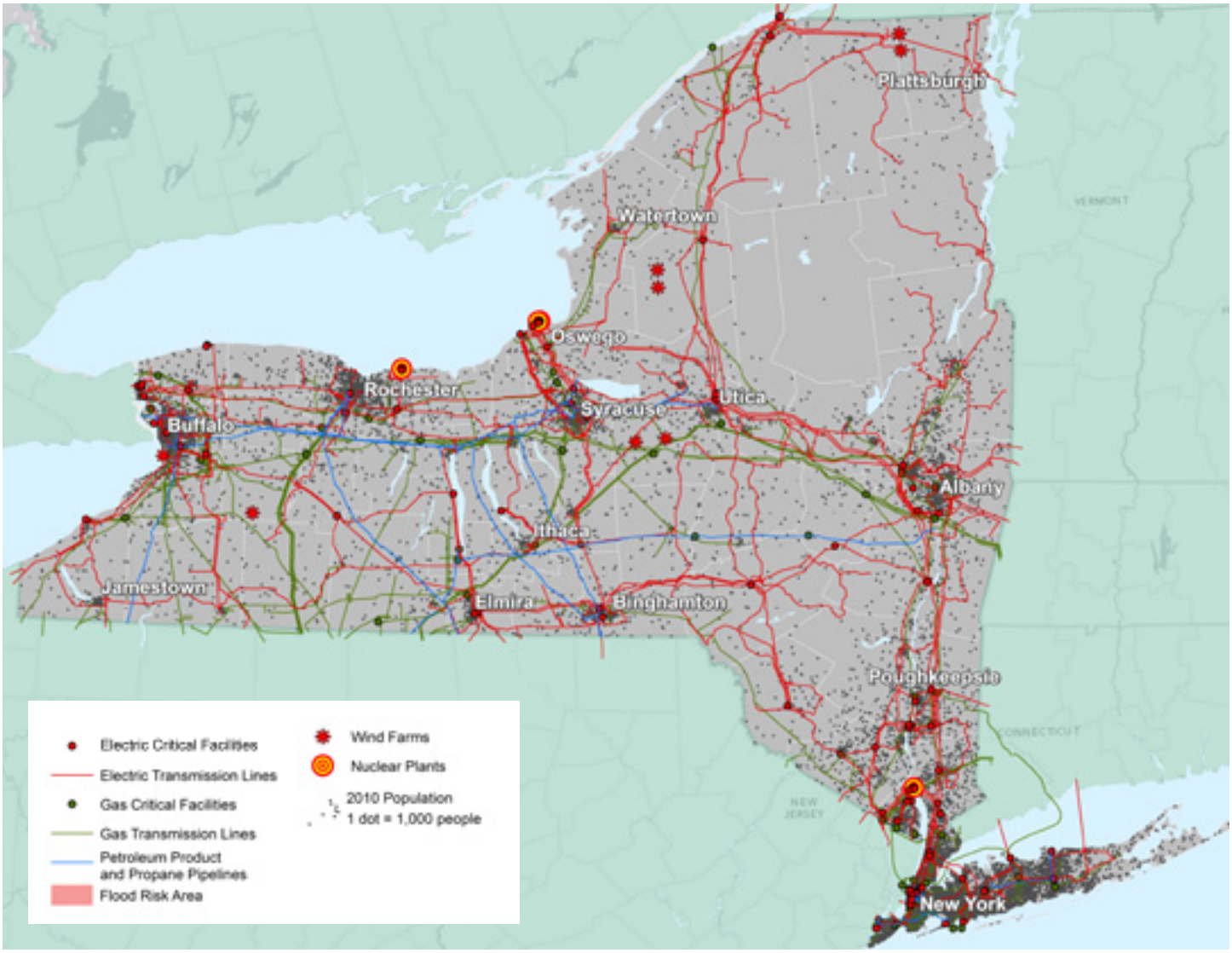


Figure E-01: New York Energy Network (State of New York, 2012)

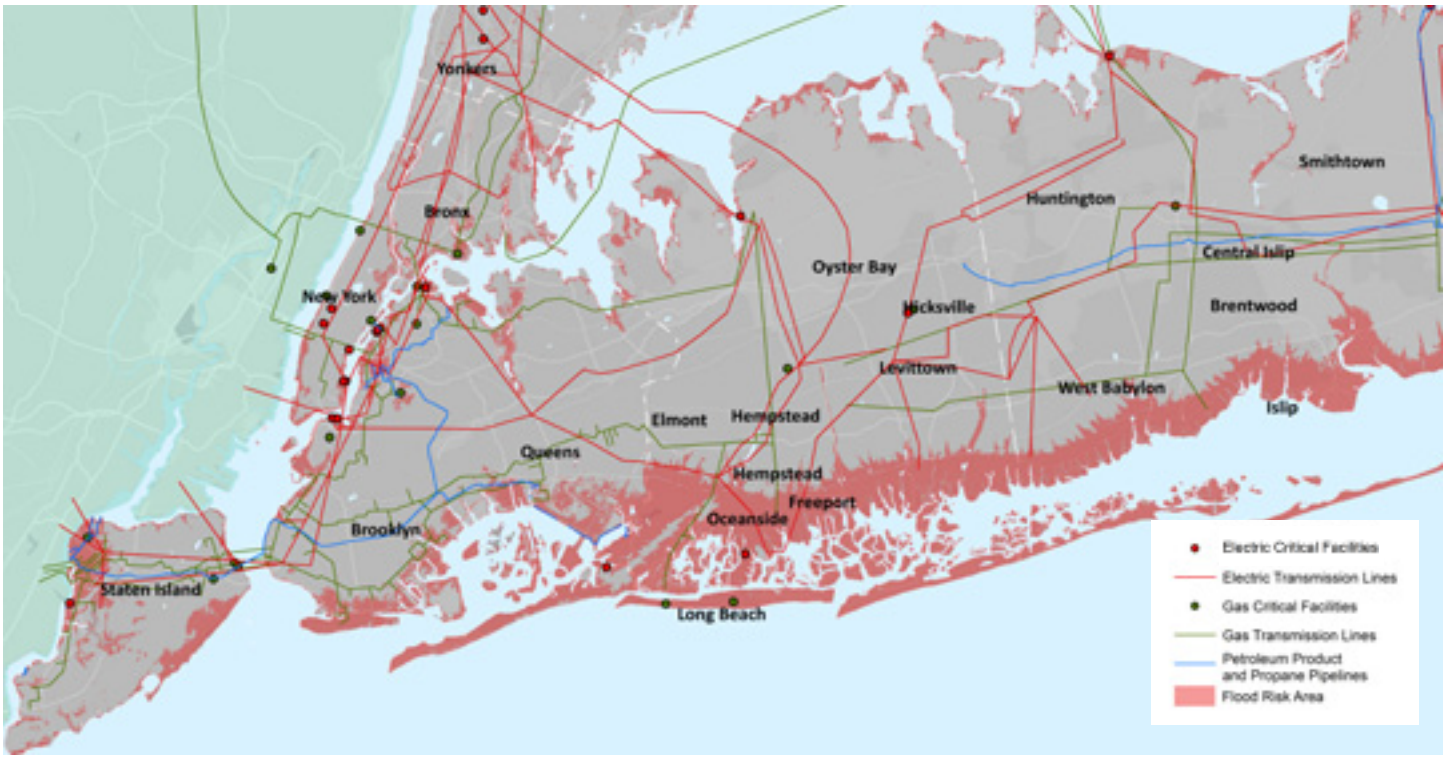


Figure E-02: New York Energy Network (State of New York, 2012)

from out of state is delivered directly from the interstate pipeline to large industrial and electric power generation stations, or routed to local distribution companies serving residential, commercial, and midsize industrial customers. Fuels like gasoline, diesel, and heating oil are delivered via interstate pipelines, ship, rail, and truck to be stored in terminals, typically located along the coast. Refineries in New Jersey receive crude oil by ocean tanker, barge, and railcar. The manufactured petroleum fuel products then make their way into the region's supply distribution.

New York City relies on steam that comes from a distributed system managed by Consolidated Edison Company of New York (Con Edison) in Manhattan. The steam is generated in central plants and distributed through portions of Manhattan in insulated underground pipes. Campuses and research facilities across the state also rely on local steam infrastructure.

While the state's energy infrastructure was built to withstand 100-year weather events, Superstorm Sandy, Hurricane Irene (2011), and Tropical Storm Lee (2011) demonstrated that the system was improperly prepared for the increasing number and degree of extreme weather events.

In order to make today's energy infrastructure more resilient, New York State must rebuild and plan for the demands of the coming century. There is an emerging scientific consensus that storms like Superstorm Sandy will become more frequent in the near future. A more resilient energy infrastructure is more critical than ever. The Commission envisions a profound transition for New York State over the next century to an energy system that is at once affordable, efficient, resilient to natural and man-made disasters, responsive to the needs of its stakeholders, and largely decarbonized. Our technologically advanced society is ever more dependent on a reliable and resilient energy system to ensure public safety and to power our economy.

The energy system in place today, which is heavily dependent on fossil fuels, contributes to worldwide emissions of carbon dioxide and methane, two major greenhouse gases (GHGs) in our atmosphere that are contributing to climate change. According to the United Nations Intergovernmental Panel on Climate Change, substantial reductions in GHG emissions by midcentury have the potential to minimize the most severe climate change impacts currently predicted. The strategies we employ to reduce GHG emissions will also provide an opportunity to strengthen infrastructure against future storms.

New York State set a goal to reduce GHG emissions to 80% below the 1990 baseline by the year 2050.[1] Since energy use (in the form of fossil power and gasoline/diesel vehicles) accounts for a majority of GHG emissions in the state, a drastic system transition must take place. As the state shifts away from fossil fuel usage, it should focus on the goals of improving reliability, availability, and resilience.

New York's transition to a new energy system will not happen overnight. Major changes to the energy system can be expensive and disruptive to the economy. Because of this, changes will require a firm commitment to continuous improvement through sustained planning, informed by changing conditions, available technology and data, and robust public engagement and education. Over the short-term, the State should make public investments and induce private-sector support for a stronger, smarter, and more efficient electric grid and more resilient natural gas, steam, and fuel distribution systems. These investments will reduce the negative impacts of extreme weather events like Superstorm Sandy, while laying the foundation for an energy system that in the long-term will mitigate, rather than exacerbate, the threat of climate change.

The Commission has identified a number of recommendations that build on the Governor's Energy Highway Blueprint that will enable New York to develop a resilient energy ecosystem, strengthening critical energy infrastructure; creating alternatives, backups, and redundancies in vulnerable parts of the system; and setting the foundation upon which the energy infrastructure of the future will be built.[a]

Within each of the areas, recommendations include short-term steps based on lessons learned from recent events; medium-term projects that require more extensive planning and development; and long-term solutions that require systemic planning, process refinement, capital budgeting, and large-scale project implementation.

[a] In October 2012, Governor Cuomo's Energy Highway Task Force released the Energy Highway Blueprint with 13 specific recommendations to transform New York's aging, congested energy infrastructure. The recommendations shape a new energy infrastructure that is equipped to support economic growth and to supply reliable, lower cost, and clean power for New York's residents and businesses into the future, including expanding the transmission system to reduce congestion, accelerating investment in the electric and natural gas distribution infrastructure, and investing in new technologies and smart grid programs.

Strengthen critical energy infrastructure

The physical location of critical energy infrastructure should be reexamined to identify installations that are most prone to stress damage. Repairs, upgrades, replacement, and new infrastructure should mitigate the risks associated with climate change. New York State is seeking federal funding assistance for a portfolio of hardening, or strengthening projects. These investments are recommended to prevent future damage that would otherwise be incurred.

For example, New York has identified specific storm hardening projects for which it is seeking federal funding, including the following:

- strengthen substations against flood damage
- reconfigure network boundaries to separate flood areas from non-flood areas
- elevate critical distribution transformer installations
- replace critical distribution wood poles with steel poles or upgrade and harden existing poles (e.g., by installing guy wires)
- install excess flow control valves on the natural gas system
- install remotely operated natural gas control valves
- protect natural gas regulators from floods
- strengthen electric and steam production facilities
- strengthen steam tunnels

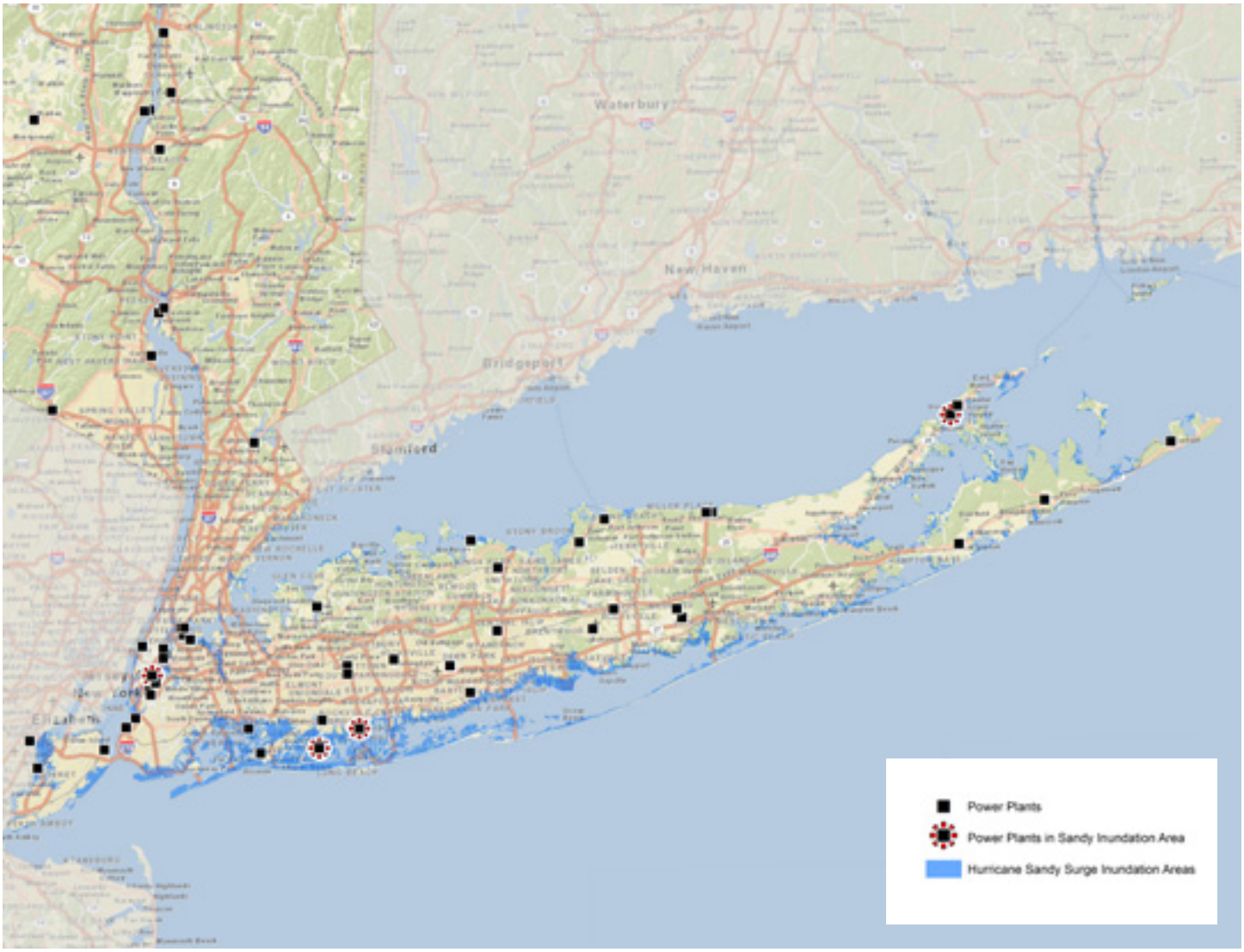


Figure E-03: Downstate power plants in and not in Superstorm Sandy inundation zone (NYSDPS, 2011; FEMA, 2012)

Strengthening these systems will reduce outages and fuel shortages and preserve the everyday quality of life for New Yorkers. While this will come at a considerable cost, and appropriate financing (including federal funding as available) will be needed to make these changes, not acting may be even more expensive due to the potential damage and extensive outages caused by recurring natural disasters. The Public Service Commission (PSC) should continue to work with utilities to coordinate the assessment and cost estimates of, and plans to address, these critical infrastructure improvements. In addition, the State should work with owners of the fuel supply and distribution system to identify opportunities for fuel system infrastructure improvements.

Require Plans to strengthen critical infrastructure

In 2013, the State should require public- and investor-owned utilities to provide detailed plans for strengthening existing infrastructure over the next one to three years and longer-term capital plans to continue building a strengthened system. Those plans should include the elements discussed below for the specific service areas covered.

Protect underground equipment and substations

Underground structures that house electric equipment and utility vaults are susceptible to sea water flooding. Saltwater can be more damaging than fresh water because of its corrosive effects. Many substations are located in flood zones (Figure E-05) including those flooded by Superstorm Sandy. Disruption of service to even one substation can affect thousands of customers. Expanced use of submersible switches and transformers should be considered in flood-prone areas and relocation of transformers considered in areas at risk for saltwater intrusion.

Figure E-04: Flooded substation (Flickr, FirstEnergy Corp, 2012)

Identify best underground locations for electrical transmission and distribution lines

Installing electric distribution lines and equipment underground can reduce the potential for damage caused by high winds, debris, impact, and lightning strikes. Placing equipment underground can also improve land use aesthetics and free up land for additional use. Because undergrounding can be cost-prohibitive, it may be more effective to employ it only for portions of a circuit that are difficult to access or particularly vulnerable. The PSC should require utilities to identify the best locations for undergrounding within the next six to twelve months, and work with utilities to devise workable plans to implement undergrounding in such areas.

Critical distribution lines that service areas affected by natural disasters should be considered a top priority for selective undergrounding.

Experience and best practices from other countries should be used as a reference when developing the policy and regulatory measures necessary to implement these recommendations. For example, Germany, Denmark, and France have each passed legislation or regulations to increase the proportion of undergrounded power lines on their systems. Western Australia has been implementing a comprehensive undergrounding program over the past 15 years. A recent review by the Economic Regulation Authority of Western Australia demonstrates the benefits achieved have outweighed the costs in that country.[5]

Protect transmission and distribution lines

To mitigate against damage to transmission and distribution power lines from snow and ice, hydrophobic coatings should be applied to appropriate components of the electric system as lines are replaced, installed new, or upgraded. By helping components shed precipitation these coatings mitigate water damage on non-ceramic insulators and can facilitate ice removal, thereby preventing outages from occurring.

Reconfigure electric system for critical infrastructure customers

Following Superstorm Sandy, the interconnectedness of our electric, telecom, natural gas, transportation, health care, and fuel delivery systems was made apparent. Marine terminals, telecom services, hospitals, and mass transit were all affected by the power outages. Loss of power to these critical assets disrupts other critical services to society. For example, following Superstorm Sandy, fuel terminals in the New York metro region were without grid power for days and in some cases more than one week. Delays in interconnecting back-up power at these sites, and in some cases technical problems with the back-up generators, significantly disrupted gasoline and other fuel deliveries. This led to a temporary fuel shortage and the imposition of fuel rationing for the first time since the 1970s. Damage to transformers and substations can cause power outages to thousands of customers, and take significant time to repair. In these instances, mobile

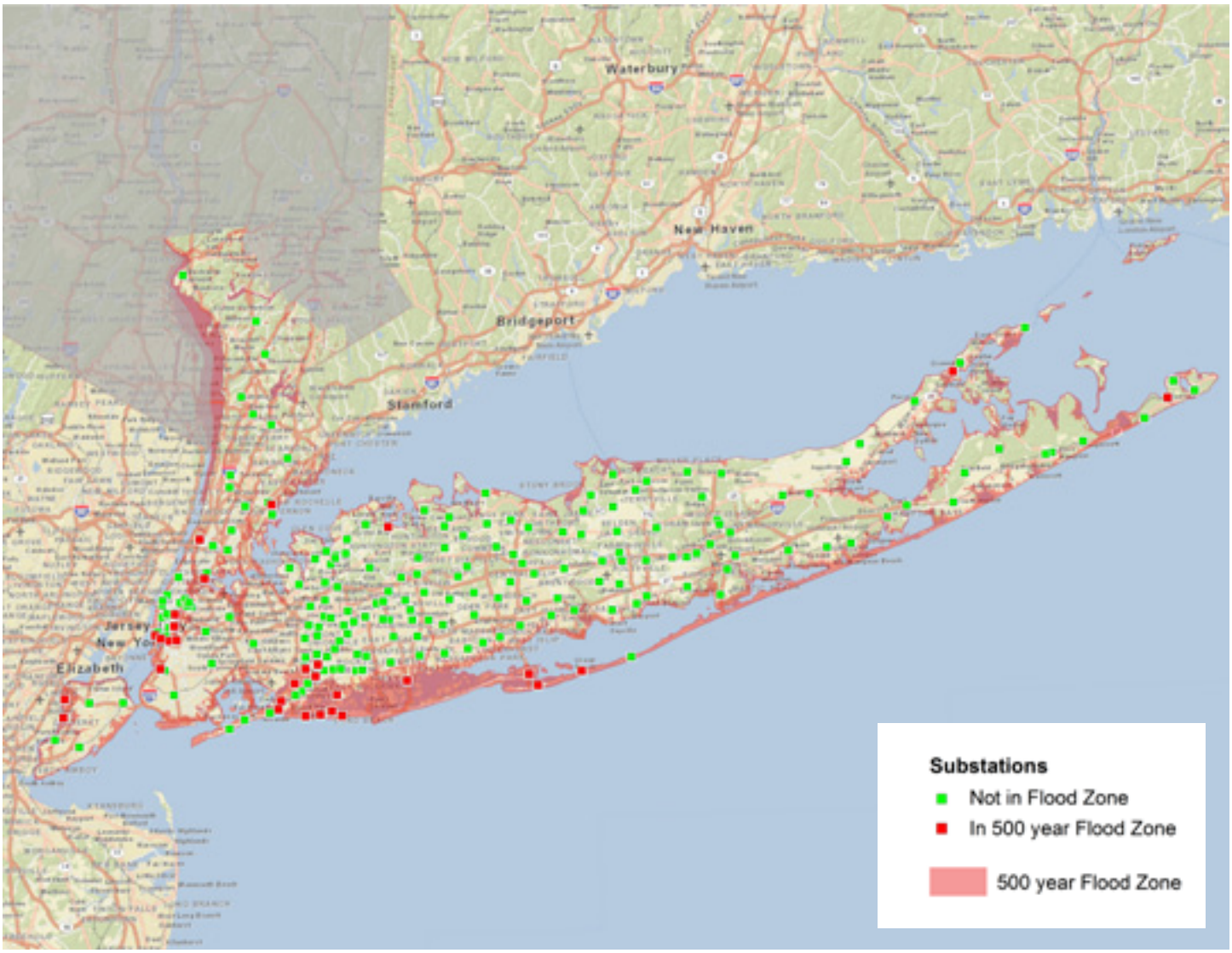


Figure E-05: Downstate substations in 500 year flood zone (NYSDPS, 2012; NYSDEC, 2012)

Figure E-06: A hard-to-reach distribution circuit that could be a candidate for selective undergrounding (NYPA, 2012)

Figure E-07: A Seattle City Light project as an example of selective undergrounding of a power line with frequent outages (City of Seattle, 2012)

transformers and substations could be rapidly deployed to replace the damaged equipment and provide temporary power to the affected customers. In many cases, however, such mobile solutions cannot be used because the grid has not been configured to allow it. Utilities should work to reconfigure their distribution systems to the extent feasible to maximize their ability to isolate and provide redundant (and mobile) power sources to critical infrastructure customers to minimize the impact of such outages.

Strengthen marine terminals and relocate key fuel-related infrastructure to higher elevations

In many areas of the State including New York Harbor, the Hudson River, and the Great Lakes, fuels are transported by barge to marine terminals (Figure E-09) and then distributed by truck to customers. Marine terminals are particularly vulnerable because of their location to storm surges and flooding. Dock supports and structures, moorings, loading and off-loading equipment, and leak containment equipment all require flood protection. In 2013, New York State Energy Research and Development Authority (NYSERDA) should lead an assessment of these structures in collaboration with asset owners, government authorities (e.g., port authorities, Coast Guard), and other experts to document existing risks and help prioritize mitigation strategies.

Refineries and distribution/delivery terminals also must be hardened or otherwise protected. Installing, upgrading, or raising existing floodwalls could help protect such facilities from corrosive saltwater. Control stations, crucial electronic equipment and instruments, and communication equipment may need to be elevated or relocated in these facilities to reduce the risk of service interruption. In certain cases, elevating or relocating key facilities serving critical loads for petroleum assets may be necessary

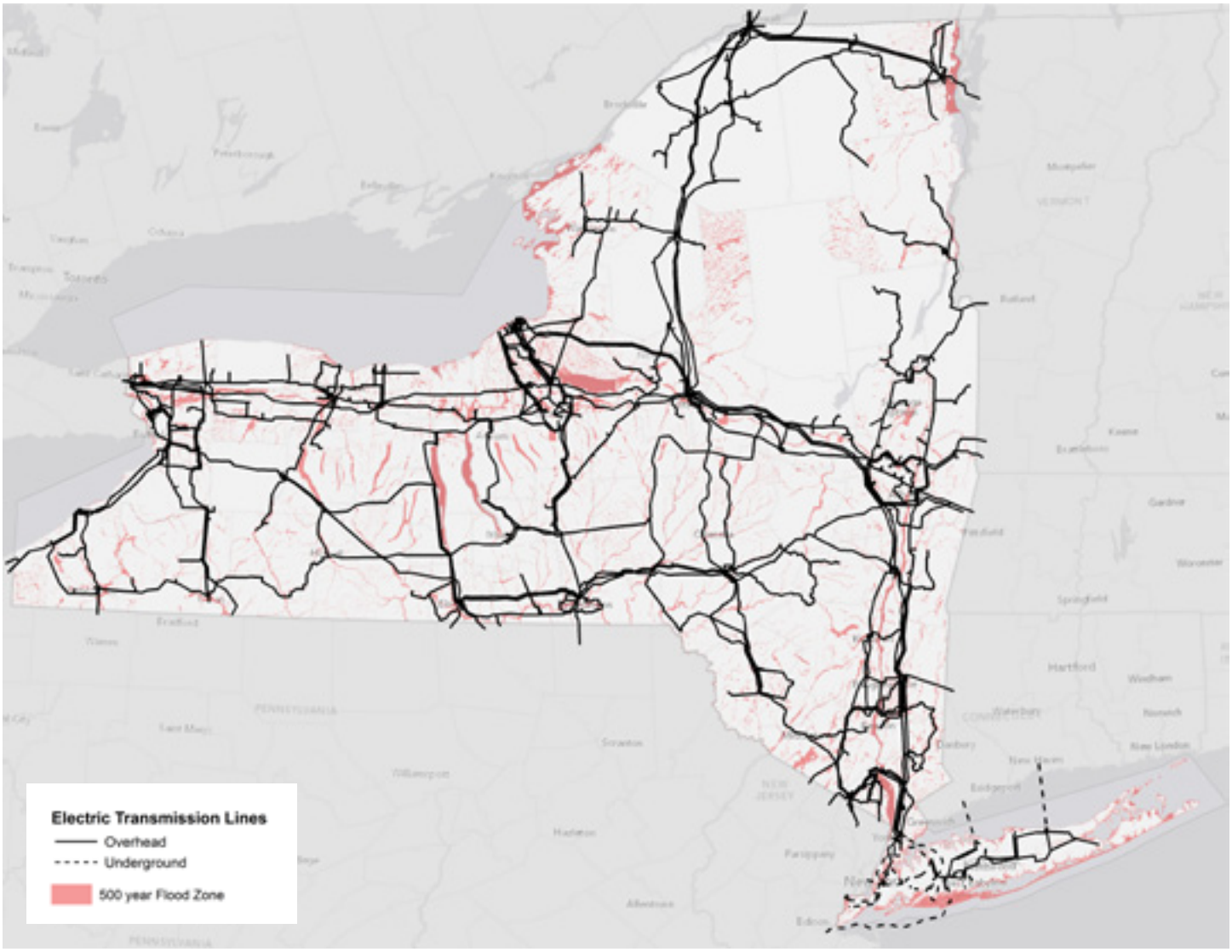


Figure E-08: New York State transmission lines and 500 year flood zone (NYISO, NYSDPS 2010; NYSDEC, 2012)

to minimize disaster impacts and accelerate restoration of fuel asset operations.

Reinforce natural gas distribution infrastructure

Many parts of New York's natural gas infrastructure (Figure E-08) have been in use for nearly two centuries. Miles of aging pipeline are prone to leakage and vulnerable to storm damage (and ground movement). Natural gas utilities have established programs to replace older, cast-iron portions of their systems that are prone to leakage (Figure E-09), but the programs cannot keep pace with the need. The State should accelerate pipeline replacement programs in flood prone areas. Further, the installation of remotely operated valves would enhance network resilience by allowing the rapid isolation of leaks and, consequently, service restoration. This is consistent with recent actions recommended in the Energy Highway Blueprint to accelerate improvements to the natural gas distribution system.

Natural gas compressor stations are another vulnerable asset. Compressor stations require gas turbines, reciprocating engines or electric motors to compress natural gas and move it through the pipeline. Importantly, these components of the natural gas distribution infrastructure enable the system to continue functioning during electric power outages, but all of these components can fail if inundated by flood waters. Reinforcing natural gas driven compressors can help to ensure continued natural gas delivery during power outages

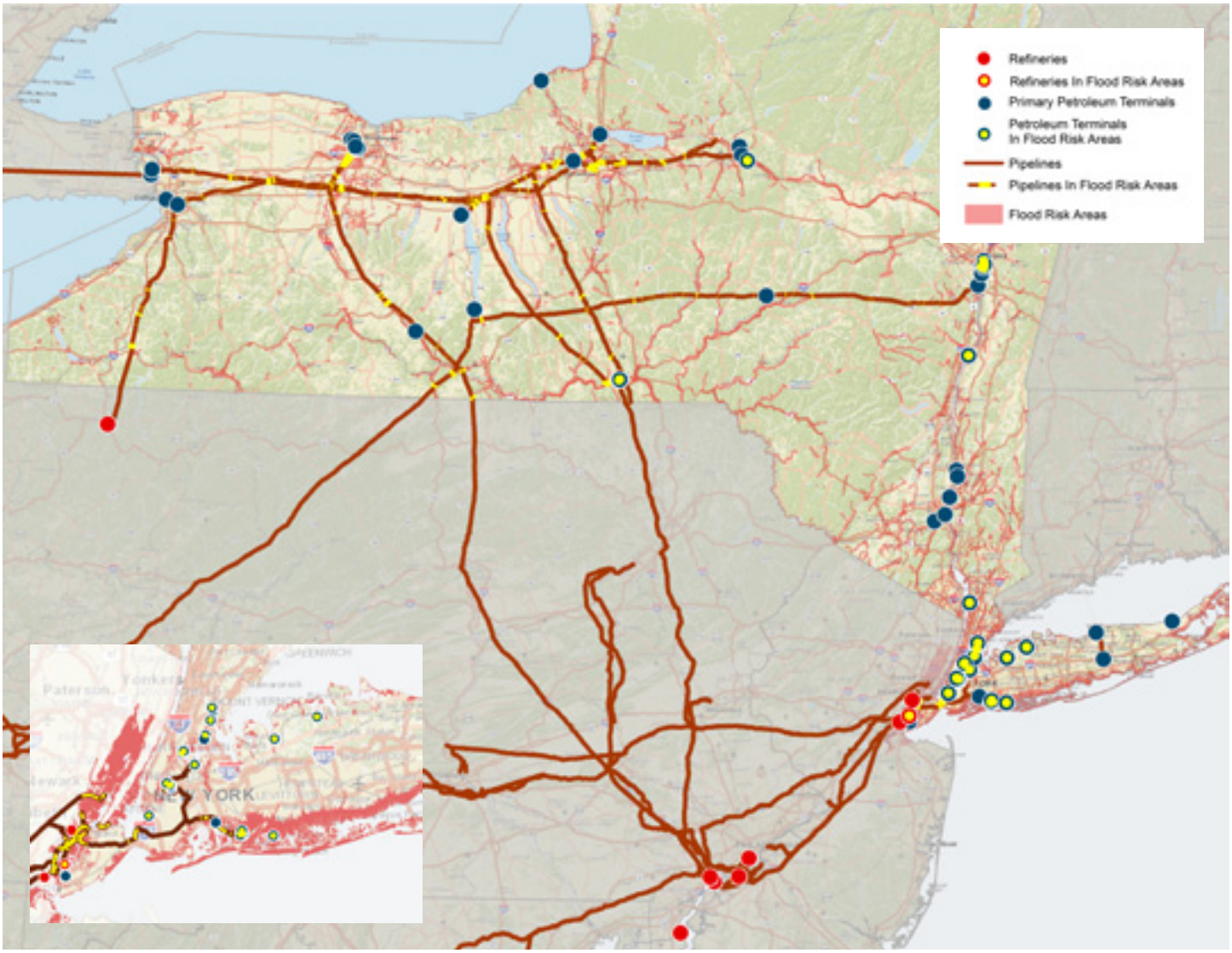


Figure E-09: Map of regional liquid fuel terminals and refineries and 500 year flood zones (NYSERDA, DOS, NYSDEC & FEMA, 2012)

and reduce fugitive methane leaks during normal operations. The PSC should require natural gas utilities to evaluate their infrastructure and prepare plans for strengthening these critical systems. This should involve annual review and development of design criteria for the natural gas network, including analysis of incidents, progress and priorities of gas supply providers.

Reinforce electrical supply to fuel infrastructure and pursue additional booster stations for the Buckeye pipeline

Petroleum products arrive into New York City and Long Island by barge, truck, and pipeline. The Buckeye Pipeline is the primary petroleum pipeline directly serving New York City and Long Island. Sustained delivery of power to key fuel supply and delivery assets is imperative to operation of the Buckeye Linden Hub (Figure E-10) and other critical assets that serve New York State with petroleum products. Because these critical assets are located across the New York Harbor, the Commission recommends that utilities such as Public Service Electric and Gas (PSE&G), Long Island Power Authority (LIPA), Con Edison, and other providers collaborate with petroleum supply chain asset owners, and New York and New Jersey agencies (e.g. New York Power Authority (NYPA), New York State Department of Transportation (NYSDOT), the New York

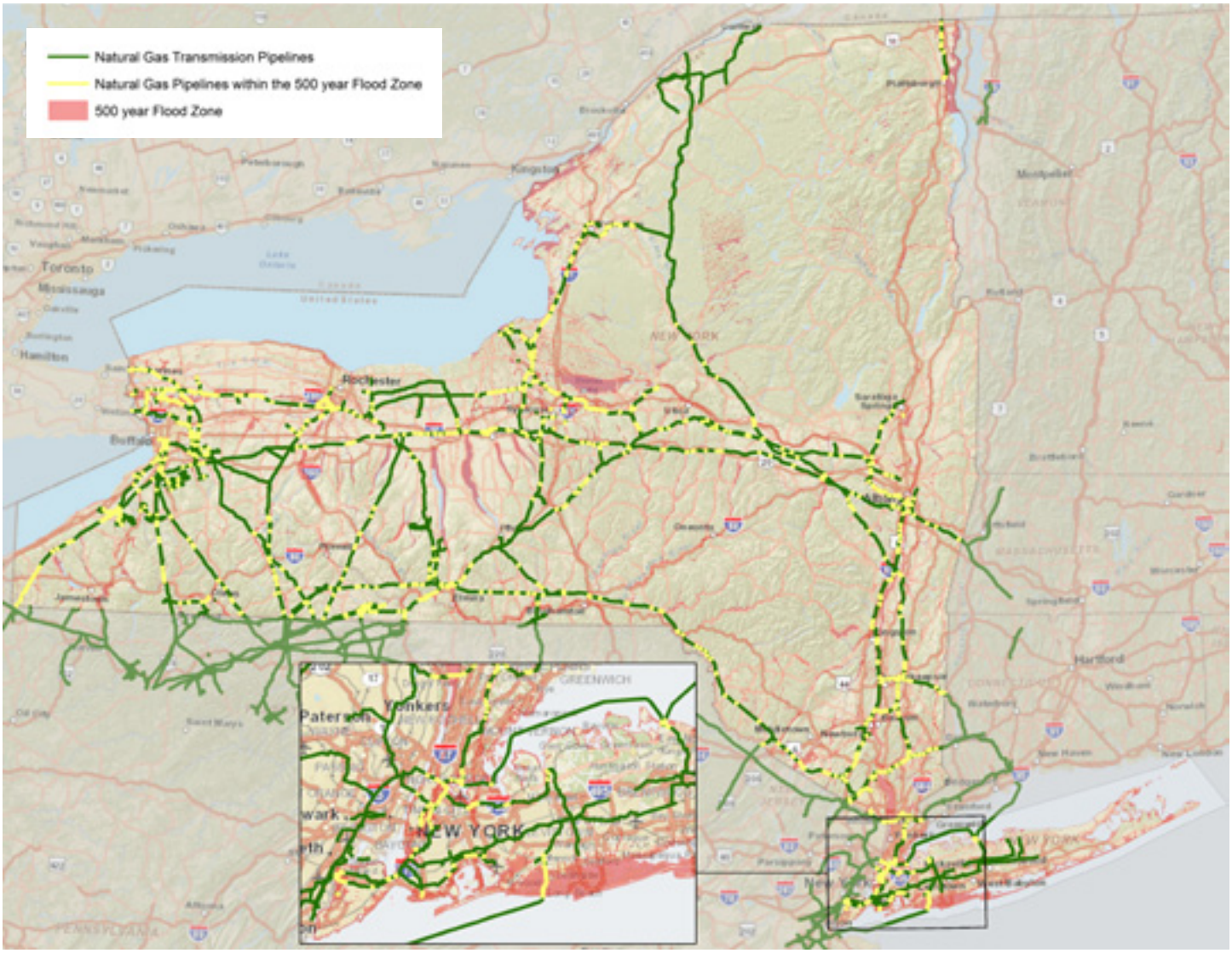


Figure E-10: New York State natural gas transmission pipelines and 500 year flood zone (National Pipeline Mapping System, 2010; NYSDEC, 2012)

Department of Homeland Security, and NYSERDA to assess vulnerable substations and transmission lines supporting New York State fuel infrastructure by the end of 2013. The Buckeye Linden Hub (and other fuel hubs) could be potential locations for distributed generation which could be used to maintain supply. Any assessment should focus on identification of potential locations for distributed generation and/or micro-grid opportunities to keep the power systems operating and maintaining fuel flows through the system.

Fuel supplies following a major event are critical, especially for emergency operations and first responders. As discussed in the NYS Ready Commission Report, New York should pursue procurement of additional fuel supplies into congested areas, and install the necessary infrastructure to ensure fuel shortages can be alleviated. While pipeline capacity is typically the most efficient method to deliver fuel following a major storm – Buckeye's pipelines are utilized at near full capacity to serve New York City and Long Island demand. When delivery of fuel over this pipeline network is disrupted as was the case following Superstorm Sandy, there is no additional capacity on the pipeline to help replenish supplies while keeping up with continuing demand. Buckeye has proposed to install a booster station that would increase the capacity of the lines servicing New York City and Long Island.

New York should support the addition of booster stations in New York City on the Buckeye pipeline, which would significantly increase capacity during

emergency events and reduce impacts of fuel delivery disruptions.

Waterproof and improve pump-out ability of steam tunnels

Steam systems provide energy to campuses and buildings that is used for heat, hot water, air conditioning (running steam-driven compressors), and other industrial processes. Steam systems are typically installed in underground pipes that are especially vulnerable to flooding, which can cause the steam to condense to water and create a dangerous condition known as water hammer. Major steam systems such as the Con Edison steam system, must be protected from disaster events to provide necessary heating and cooling. Flood protection measures could include water-proofing tunnels, improving pump-out ability, building higher flood walls around steam generating stations, relocating critical equipment to higher elevations, installing flood pumps, and installing or improving protective barriers around facilities. The

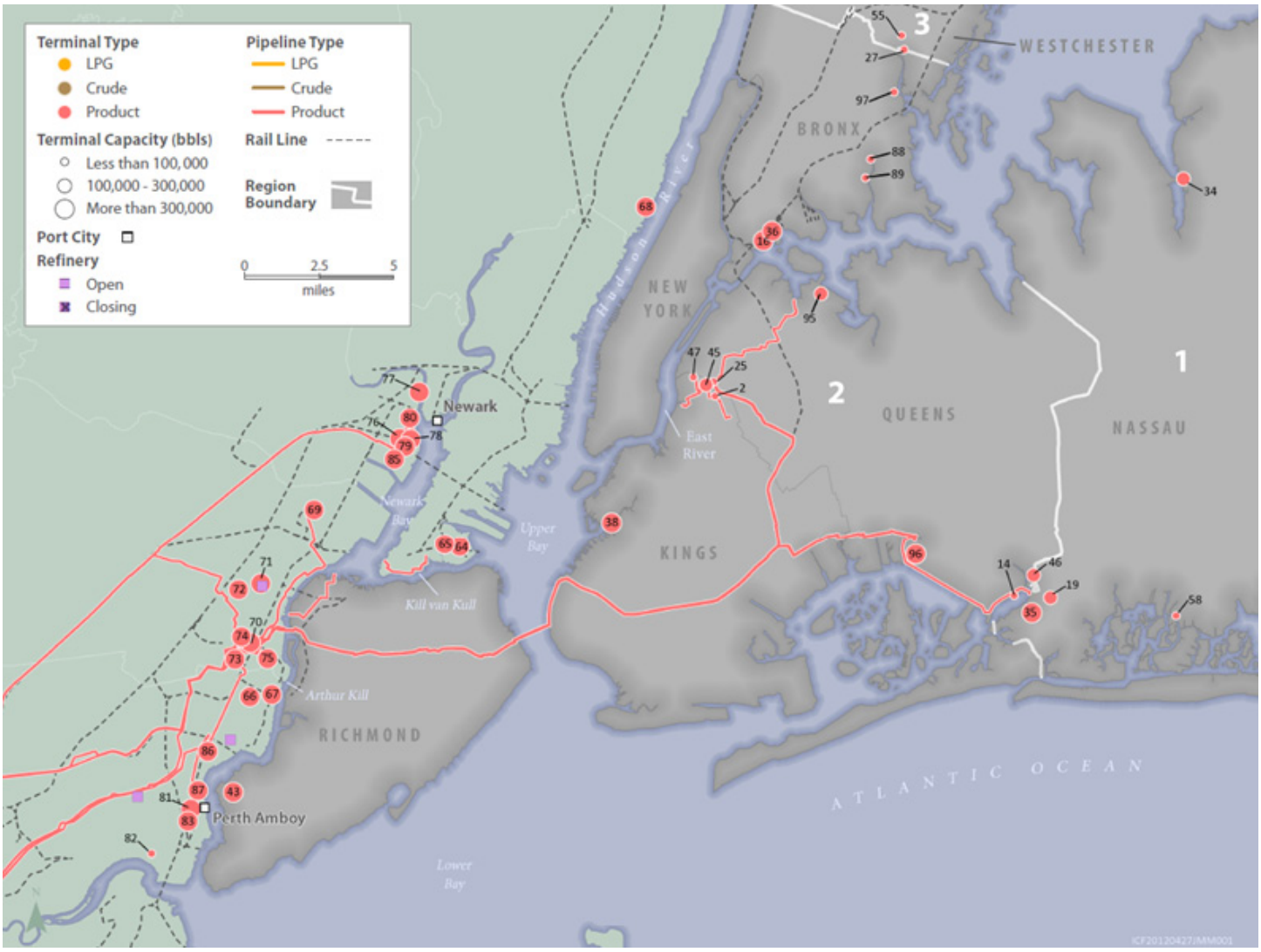
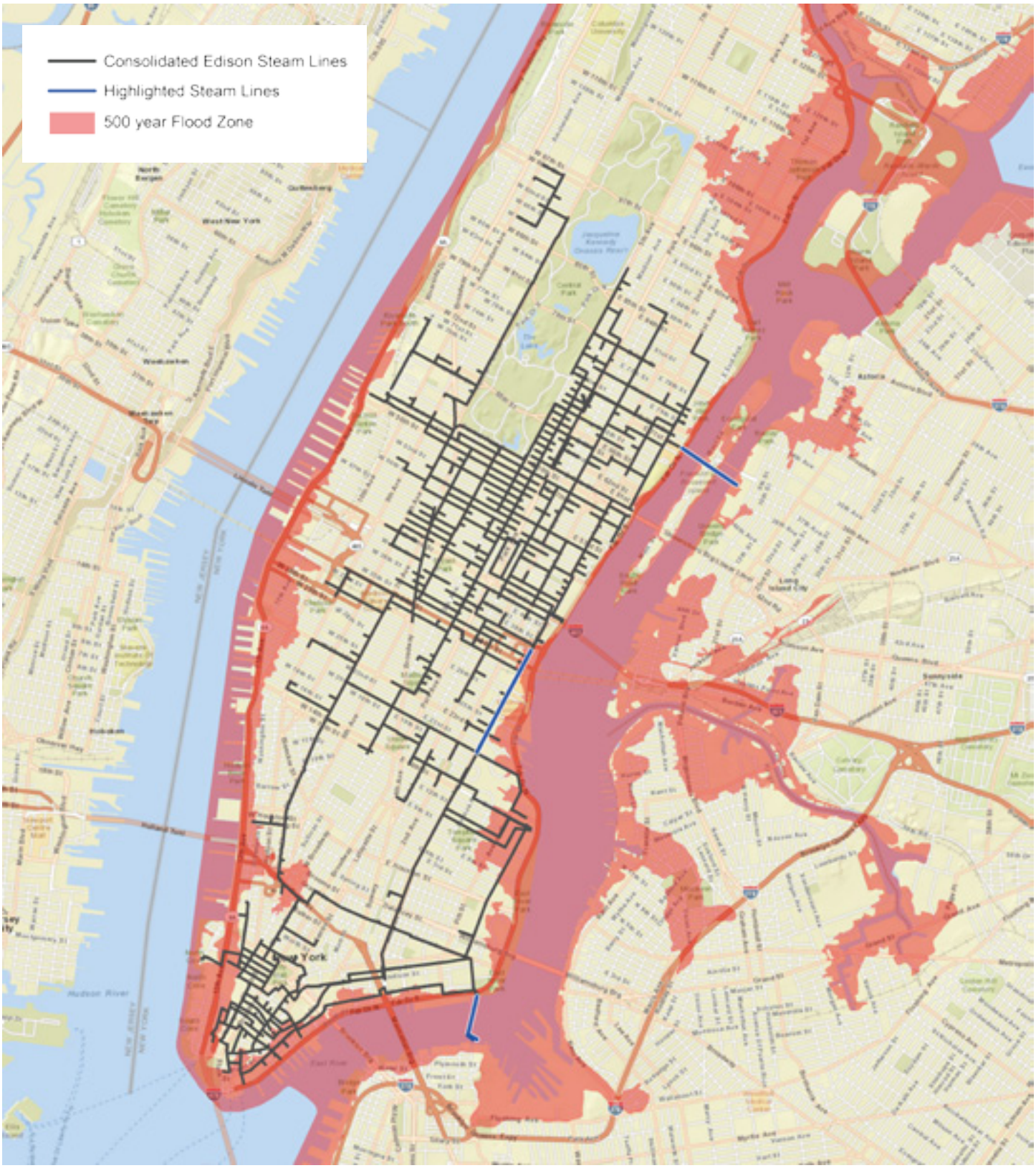


Figure E-11: Buckeye pipeline and fuel terminal which serves New York State with petroleum products (NYSERDA/ICF International, 2012; OPIS/Stalsby Petroleum Terminal Encyclopedia 2012, U.S. IRS xStars Database, 2012)

Figure E-12 (following page): Map of New York City Con Edison steam lines and 500 year flood zones (critical tunnels highlighted in blue) (Consolidated Edison, 2009)


Consolidated Edison Steam Lines
Highlighted Steam Lines
500 year Flood Zone

PSC should require Con Edison to submit a detailed plan to improve flood protection in critical steam tunnels (Figure E-11).

Create a long-term capital stock of critical equipment among utilities

Many utilities rely on a relatively small number of equipment suppliers for critical parts. Individual utilities are capable of managing equipment inventories and supply chains, but highly specialized equipment, such as extra-high-voltage transformers, require months to manufacture and are difficult to transport. This limits the ability of utilities to maintain spares which, if purchased, are often located in vulnerable areas.[6] A large event may introduce outages across multiple regions, causing supply chain or transportation interruptions. These interdependencies can lead to cascading failures that indefinitely extend recovery efforts.[7]

Following a disaster, the need for rapid response may result in regional or local shortages of critical equipment.[8] In addition, a robust stock of critical equipment will also reduce the potential for misalignment of available equipment among utilities and streamline the delivery process.

The PSC, New York Independent System Operator (NYISO), and utilities should establish this inventory and coordinated distribution plan by the end of 2013, as well as set-up periodic training sessions for employees for its use.

Surplus inventory maintained by individual utilities depends on capital budgets and available storage space. A shared stock of spare equipment, managed by a universally accessible database, spreads investment across the Region's utility providers, and creates access that would otherwise be unavailable or vulnerable to damage.

As improvements are made to local systems, spare components can be used to upgrade outdated equipment in vulnerable areas. These inventories should be protected in place, and never be located in proximity to the components they are intended to replace to avoid extending exposure during an event.

Accelerate the modernization of the electric system and improve flexibility

Today's power system relies heavily on central power generation plants, primarily powered by fossil fuels, nuclear, and hydroelectric sources based in New York (Figure E-12). Power flows almost exclusively in one direction, from power plant to customer. Beyond this, small distributed generators are used in limited applications, primarily for emergency power during grid outages. Much of the distribution grid today employs a system design developed decades ago, and does not incorporate recent technological advances. The system is largely static and not designed to allow for quick reconfiguration to redirect power along alternate routes when damage occurs to the primary sources of power supply in the distribution system.

New York's grid is aging — 59% of the state's generating capacity and 84% of transmission facilities were put into operation before 1980, and over 40% of the state's transmission lines will require replacement within the next 30 years, at an estimated cost of $25 billion.[9] This need represents an opportunity to upgrade the transmission system to a more distributed smart grid network.

Investments should be made to transition the electric grid to a dynamic and flexible system that allows for future technologies, additional clean energy integration, and minimal outages during major storms and events. New designs should not be dependent on specific technologies and should instead be flexible to be able to incorporate new devices as products are developed.

The PSC has previously ordered the electric utilities in New York to make smart grid investments starting at the transmission system level, pursuing investments with an incremental approach. The rationale for this relatively conservative approach is to minimize ratepayer costs and to ensure large investments are not made in technologies that may become obsolete. However, in light of recent extreme weather events, the PSC should review whether readily available smart grid technology could have reduced outages or improved power restoration and communications with customers, and reevaluate and prioritize utility investments in smart grid technology accordingly. The State should build on the existing PSC order and accelerate investments that offer the dual benefit of storm-strengthening and improved outage management while also implementing a smarter, more flexible system that better integrates distributed generation and improves communication flow between the utility and their customers.

Vision of the electric system operation

The modern electric power system must be a dynamic and flexible network that draws from constantly changing sources of electric energy. A smart grid is a dynamic electrical grid consisting of generation and consumption equipment interacting together to meet the loads on the grid efficiently. Enhanced sensors and controls give grid operators more visibility into the behaviors of electricity consumers, provide consumers a level of understanding of their energy usage, and enable the deployment of distributed generation, energy storage, and demand response. For instance, during times of peak load, a smart grid can automatically shut-down or temper high energy use appliances in homes and businesses. If utilities charge prices that vary by time-of-use, reflecting the actual cost of energy production in real-time, coupled with advanced metering, the system efficiency will increase by reducing peak demand (thereby reducing the need to build costly infrastructure to meet peak demand). Under such a rate design, consumers can shift loads to periods of low demand and pay a lower price for electricity which, in turn, will have a system-wide effect of leveling total demand on the system over time. To increase customer acceptance of these options, the choice of several alternative tariff structures can be offered.

Numerous jobs will also be created through the implementation, operation, and maintenance of smart grid technologies. In addition, the technologies involved in building a smart grid are the focus of extensive research in laboratories such as the Energy Power Research Institute (EPRI).

Operation and control of this increasingly complex and interconnected grid, along with the associated financial transactions of a competitive energy marketplace, will require significant changes to the static nature of today's power system. Smart grids will minimize the impacts of future natural disasters on consumers, by helping to enable individual premises and microgrid "islanding" to provide power to pockets of consumers when central power plants or portions of the transmission and distribution system are inoperable. Robust and highly integrated communications and distributed computing infrastructures utilizing a network of sensors will give utilities greater control over grid operations and customers greater control over their own electricity use. The central power plant's role will be diminished and clean microgrids[b] will become more prevalent, allowing small distributed plants to supply homes, buildings, and neighborhoods with power.

Enhanced sensors and controls also enable utilization of distributed generation networks.[c] Utilizing distributed generation resources, or on-site power generation, reduces dependence on the electric distribution system that is susceptible to damage during a natural disaster. To maximize the storm-resiliency benefits of on-site generation, it must be located appropriately and protected against damage during major weather events. Distributed generation resources, such as solar and wind, can also contribute to a cleaner electricity supply. Central power plants should still play a role in meeting energy demand, but proliferation of microgrids

[b] "Microgrids" refers to clusters of homes and buildings that share a local electric power generation and/or energy storage device while disconnected from the utility grid.

[c] "Distributed generation" refers to small electrical power generators installed in homes, businesses, and office buildings that can supply power to a location when grid power is not available.

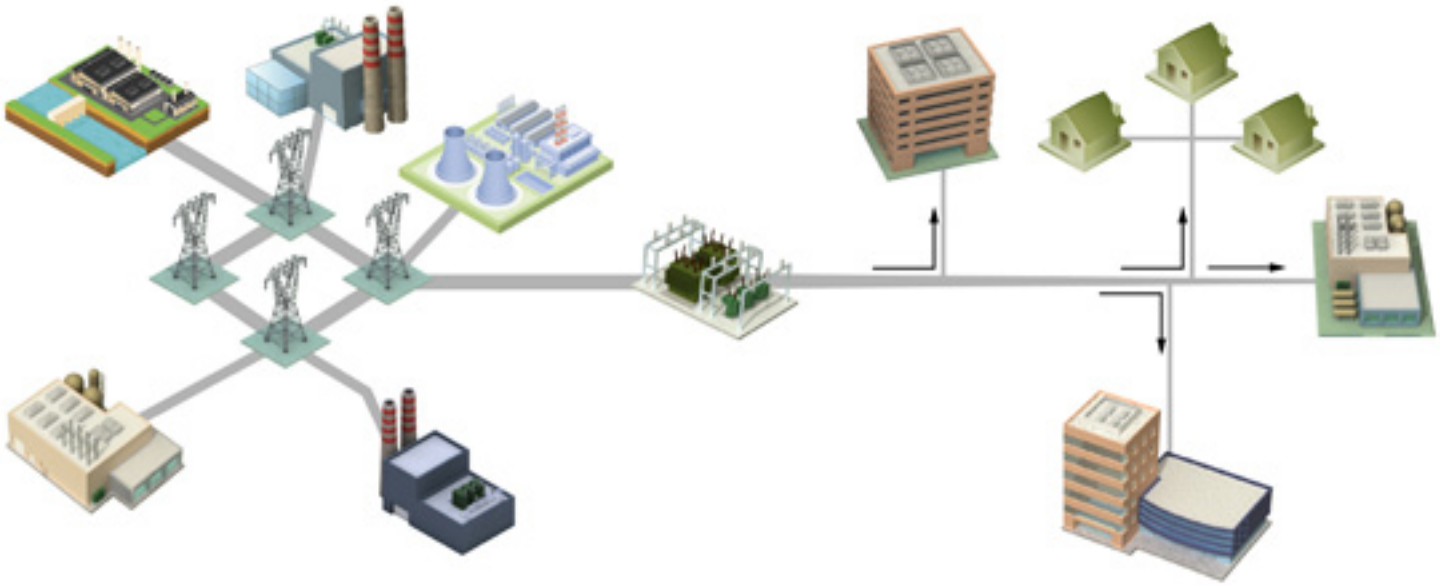


Figure E-13: Today's power system comprised of large central station power generation connected by a high-voltage network or grid to local distributions systems which serve homes, businesses and industry. Electricity flows predominantly in one direction using mechanical controls (EPRI, 2012)[10]

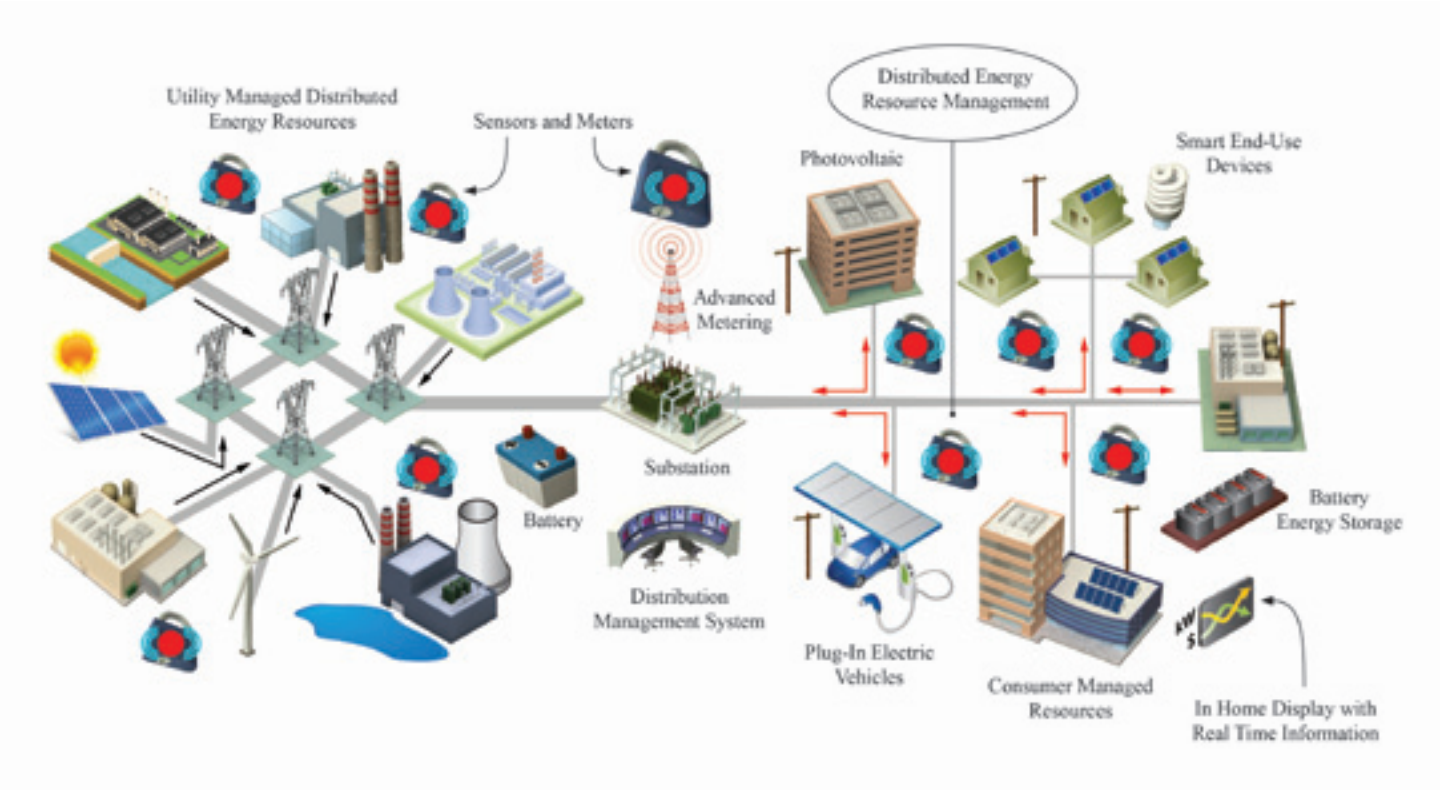


Figure E-14: Tomorrow's power system — the grid of tomorrow enables additional customer-sited clean energy generation and storage, and also provides for two-way communication between customer locations and the utility (EPRI, 2012)[10]

can provide resilience through redundancy within the power supply system.

Design a more flexible electric grid to be dynamic and responsive during normal operations and emergencies

The smart grid makes the power system more flexible by employing automatic switching and sectionalizing equipment to reduce the extent and duration of power outages. Such equipment has the capability to automatically redirect power over in-service lines and isolate faulted areas. During Superstorm Sandy, entire neighborhoods were without power. A smart grid with sectionalizing switches and connections to multiple substation supplies would make it possible to restore portions of the neighborhood by using the switches to change power sources. The PSC and utilities should work to incorporate additional automatic switching and sectionalizing of equipment across the grid.

Smart grid technologies should also be used to enable better intelligence regarding the status and availability of electric system equipment, which would improve utility response to equipment and customer outages.

The smart grid includes the following major components:

1. **Distribution Management System (DMS)** – a decision support system for utilities to assist control room and field operating personnel to monitor, control, and optimize the electric distribution system without compromising safety and assets. For example, a modern DMS would enable the utility to identify the precise location of a faulted piece of equipment and mobilize a repair team more quickly to restore service. With many of the DMSs in place today the utility is unable to determine if individual customers are without service unless the outages are caused by a large-scale failure. A modern DMS can be used to provide the utility improved awareness of customer outages, facilitating faster response and restoration.

2. **Distribution Supervisory Control and Data Acquisition (D-SCADA)** – collects and reports voltage levels, current demand, equipment state, operational state, and event logging allowing operators to remotely control capacitor banks, breakers and voltage regulation. For example, the utility can control power flow over its system to prevent overloads before occurring, and in some case remotely correct issues to maintain service.

3. **Automated Metering Infrastructure (AMI) and Meter Data Management** – allows two way communication with smart meters, customer and operational data-bases, and provides customers with the ability to reduce electricity bills by using electricity more efficiently and at selected times when it is cheaper by participating in Demand Response Programs. This will facilitate customers who choose appliances, heating systems, and other technologies that can be programmed to operate based on electricity prices. Additionally, coupled with a Distribution Management System, the increased deployment of smart meters will assist utilities in determining which customers have lost service and inform restoration strategies.

4. **Distributed Energy Resource Management (DERM)** – coordinates with the dispatch of central power stations and the distribution management system to schedule more efficiently demand response and distributed energy resources (distribution-side generation, energy storage, and demand response technologies). Coordinating the timing and need for distributed generation and demand response resources (e.g., during peak demand periods or system outages) increases the value of these resources for end users.

Certain New York utilities are already implementing variations of these systems in their service territories. For example, utilities have been and continue to incorporate distribution automation devices (reclosers, sectionalizers, looping schemes, etc.) on their electrical system to help make the system smarter and responsive to issues and failures, but barriers including cost and customer acceptance of new technologies have been barriers to woider deployment. Each utility will have unique needs and opportunities to deploy smart grid technologies. To encourage greater deployment of these technologies, the PSC should factor in resiliency benefits in cost justifications.

In addition, the PSC, NYPA, NYSERDA, and others should continue to support investments in smart grid technologies such as those called for in the Energy Highway Blueprint. These include the following:

- advancing the Smart Grid in New York by funding demonstration projects, developing an Advanced Energy Management System Control Center and pursuing federal energy research grants;
- ensuring electric utility capital expenditure plans that include cost-effective smart grid technologies; and
- evaluating polices to encourage technological and commercial innovation in New York State to accelerate deployment of new technologies and capitalize on economic development opportunities.

Increase the deployment of distributed generation and microgrids throughout New York

As noted, distributed generation is customer or neighborhood-scale energy generation, which provides power locally to an individual customer or region in a distributed manner. Distributed generation can defer the need for additional utility transmission and distribution system upgrades while improving owner quality

Con Edison CoolNYC Program (New York City, United States)

This project involves working with building owners and tenants in large apartment buildings throughout New York City to install smart air conditioning controls. The goal of the program is to help residential customers use less energy for air conditioning and provide Con Edison a resource to help maintain high reliability during peak load periods. Con Edison plans to install controls through "modlets" on 10,000 air conditioners. This will result in a 5-MW demand reduction, which is enough to power 5,000 homes. Partnering with ThinkEco, a New York City company, Con Edison installed the modlets in the summer of 2012 on window air conditioning units. There are over six million air conditioning units of this type in New York City, and some of them run unnecessarily when residents are not at home. The modlet is a plug-in smart outlet that a smart air conditioning thermostat can control. Customers are able to remotely turn on or off their air conditioning, set its temperature, and set the schedule, from a smart phone or browser. When needed during peak load periods, Con Edison will alert these customers and adjust the unit's temperature to reduce usage.

National Deployment of Smart Meters (United Kingdom)

The United Kingdom has a two-stage national plan for smart meter deployment.[11] The first stage, which is currently in progress, involves collaboration between the government, the energy industry and the public to determine the best method of installing a smart meter in every home by 2020. This first stage allows all relevant stakeholders to be a part of the decision making process before smart meters are deployed across the entire country. The second stage of the plan encompasses the actual roll-out of the meters after all necessary customer engagement has been completed. The UK's two-stage approach is expected to help improve customer acceptance of smart meters while promoting a better understanding of the technology's benefits.

and reliability. Distributed generation can be based on several technologies, including: solar photovoltaic (PV), small wind, small-scale biomass generation, fuel cell, small hydro or small- to medium-sized gas generation providing both electricity and steam or hot water [referred to as combined heat and power (CHP)]. Energy storage (e.g., batteries) can supplement distributed generation networks to ensure continuous delivery of electricity.

Estimates indicate that developing new power generation facilities closer to high-demand areas can save New York in costs associated with constructing new transmission infrastructure as well as transmission congestion costs. Low-end estimates represent avoided fuel, operation and maintenance costs while high-end estimates also include avoided costs from constructing new power plants and upgrading transmission and distribution systems. Switching from central generation to distributed generation lowers operating costs (and potentially eliminates fuel costs) by providing more efficient energy generation. Generally, there is a trade-off between higher capital expenditures with reduced operating expenditures over time compared to paying for energy over time from a centralized grid.

Although distributed generation systems provide a wide range of benefits, all of these benefits are not captured by existing financial models.[12] Therefore, the avoided costs and added value of these systems are likely to be much higher than current estimates.

Expanding use of natural gas for distributed generation and combined heat and power applications will also improve storm resiliency since the natural gas system often continues to operate during major weather events. Notably, such applications will increase demand on the natural gas system, so the interdependency of these systems needs to be considered and system investments should be planned accordingly.

Microgrids are small-scale distribution systems that link and coordinate multiple distributed energy resources (DERs) into a network serving some or all of the energy needs of users located in close proximity. DERs include distributed generation resources, energy storage technologies, and power system control devices. In a microgrid, such DERs are linked together with multiple local energy users by separate distribution facilities (i.e., wires and pipes) and managed with advanced metering infrastructure, communications, and automated control systems.[13] Microgrids can be configured to operate in tandem with the bulk supply system during normal conditions, but also disconnect and operate as an independent island (i.e., "islanding") in the event of a bulk supply failure or emergency.[14] The microgrid is the natural evolution of distributed resources for areas where conventional power systems do not reliably serve customers or where critical customers need uninterrupted power supply during emergencies. Microgrids can also provide support to conventional power systems that are constrained in meeting demand.

To adopt and integrate microgrids and increase deployment of distributed generation into the current electric system, New York needs to create regulatory and statutory clarity and appropriate incentives. Current regulatory frameworks, laws, and compensation systems do not encourage the widespread deployment of such components

(and limit them almost exclusively to campus settings). For example, regulations currently require electricity marketer or public utility status in order to be able to sell electricity to others. Appropriate policy and regulatory mechanisms should be developed by the State and the PSC to incentivize the microgrid investments that will allow expedited development and integration of microgrids. Incentives, such as rate-based cost recovery, should be explored to aid microgrid development. The PSC should create straight-forward protocols for interconnection and cost allocation for microgrids and their components.

Determination of responsible parties for microgrid maintenance and upkeep is also necessary to aid adoption and success of microgrid implementation. Accordingly, the PSC should work with utilities to develop protocols for establishing microgrid ownership to ensure the installations are well maintained.[15]

NYSERDA issued a report in 2010 ("Microgrids: An Assessment of the Value, Opportunities, and Barriers to Deployment in New York State"), which included a roadmap for facilitating microgrids in New York State. The recommendations found in that roadmap should be considered when developing statutory and regulatory changes necessary to integrate microgrids into the State's electric system. The PSC should identify and work to reform local utility policies and practices that hinder the development of clean distributed resources, such as requirements that shut down interconnected distributed resources during outages to prevent back-feeding into the grid. Such requirements are meant to protect utility workers when restoring power, but technology exists to allow the system to continue powering the customer during outages without back-feeding to the grid.

NYSERDA should expand its incentive programs for distributed generation resources, including solar and Combined Heat and Power programs. These programs should give preference to critical facilities

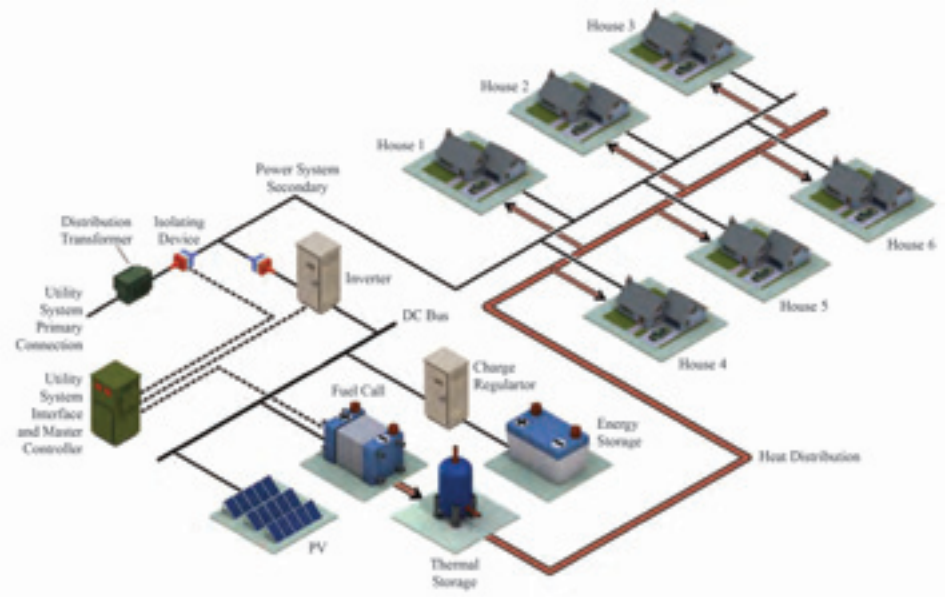


Figure E-15: Community-level microgrid with distributed energy resources (EPRI, 2010)[16]

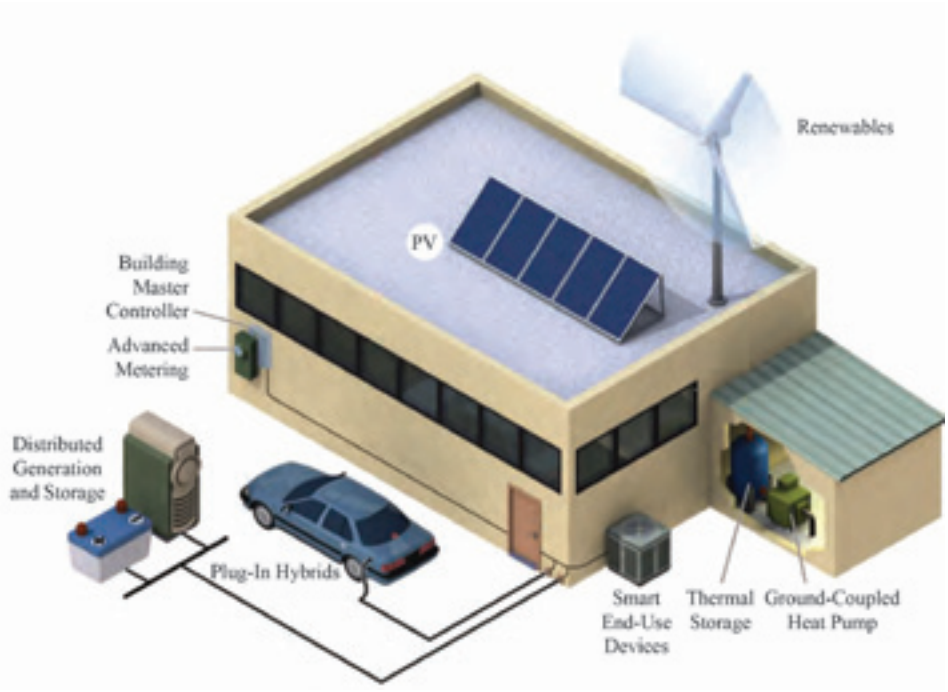


Figure E-16: Building-level microgrid with distributed energy resources (EPRI, 2010)[16]

Drake Landing Solar Community – Solar Hot Water District Energy (Okotoks, Canada)

A new housing development in Okotoks, Alberta, Canada, which started operation in 2007, incorporated a localized district energy system to provide heat to 52 single family homes almost entirely from solar energy. The innovative system stores heat energy captured during the summer in tanks and boreholes underground for use during the winter. A network of underground tubes transfers the captured heat into the surrounding rock and soil, which act as a natural heat storage reservoir. The underground boreholes and tubes are covered with sand, a waterproof membrane and high-density insulation to prevent heat from escaping. The stored heat is then transferred back to the tubes when heat is needed during the cold winter months. Over 90% of the energy used throughout the year comes from solar panels on the houses and garages of the development, decreasing dependence on fossil fuels.[17] Since the system is distributed, with the many components contributing to energy generation, and most of the pipework and tanks underground, it is resilient against weather-related disasters. Although the Drake Landing system is the first in the world to achieve a solar fraction of heating of over 90%, similar community-scale solar energy systems exist in Northern Europe.[18]

Figure E-17: Aerial view of the 52-home Drake Landing Solar Community, 2007 (Natural Resources Canada, 2007. Reproduced with the permission of the Minister of Natural Resources of Canada, 2012)

such as schools, hospitals and municipal buildings that are designated as safe havens during storms. Such facilities should have clean on-site generation designed to operate when the grid goes down. Private facilities, such as big box stores and shopping malls, willing to serve as such sanctuaries, should receive expedited permitting for installing distributed generation systems.

Make the grid electric vehicle ready

Plug-in electric vehicles (PEVs) are battery-powered vehicles that are charged via the electricity grid. According to a recent study by the Rocky Mountain Institute and a number of other partners including the International Energy Agency and C40 cities, New York City is one of the leading cities pursuing electric vehicle integration.[22]

The State (via agencies including the DOT, PSC, NYPA and NYSERDA) and local governments should continue to aid PEV deployment through the promotion of PEV charging installations, consumer incentives and education, and regulatory reform. Electric vehicles provide a benefit to the utility grid when they charge during off-peak times, providing a balancing service. Studies suggest that the integration of smart grid management and electric vehicle energy storage can limit increases in peak electricity loads.[23]

Electric vehicle readiness involves supporting PEV purchases, use, and education through a wide variety of channels. New York State, through NYSERDA, the DOT, and the private sector, should increase its electric vehicle

readiness by installing more public and workplace charging stations statewide in areas where PEV users drive. This includes municipal and private parking lots, transit stations and park-and-ride lots, retail and tourist destinations, major travel corridors,

New York University Natural Gas Combined Heat and Power Plant (New York City, United States)

Distributed generation can function well even in the heart of bustling Manhattan. During Superstorm Sandy, when the electricity from Con Edison's distribution network failed, the cogeneration plant installed at New York University (NYU) in 2010 began running full-throttle in "island-mode". Although normally connected to the grid to export and import electricity when needed, the plant switched to microgrid operation. The plant burns natural gas in combined cycle gas turbines to produce both electricity (13.4 MW) and heat. The entire process operates at almost 90% efficiency, compared to 30% to 60% for traditional centralized fossil fuel power plants. Steam is even used to drive a chiller to produce cold air in the summer. Although the system does not cover the entire campus, it was able to keep the larger buildings and core of the Washington Square campus heated and powered throughout the storm and in the weeks that followed, while surrounding buildings were cold and dark. Since the natural gas infrastructure was well-protected during the storm, this system didn't suffer the same fate as Con Edison's steam and electricity distribution networks. As an additional benefit, the carbon dioxide output of the system is 23% smaller than that of NYU's previous system. The cost of the system was $125 million, with utility savings of $5-8 million per year. The cost-benefit analysis favored this system compared with decommissioning the existing district energy plant and using electricity and steam from Con Edison.[19,20,21]

Other cogeneration facilities were also able to keep the lights on during the hurricane using microgrids, such as Co-Op City (the largest cooperative housing development in the world), Princeton University, and One Penn Plaza.

and workplaces of all sizes, including state government lots.

Operational costs can be stabilized by transitioning drivers and fleet owners away from the volatile and escalating price of gasoline and diesel toward the relatively more stable costs of grid electricity. With time-of-use rates, PEVs can charge using lower cost off-peak electricity. In addition, if power is lost, distributed generation (recommended above) could help fuel PEVs. Fleet owners, who put many miles on their vehicles and can afford higher upfront costs in exchange for lower operating costs, will find the technology attractive today. This is especially true for state government agencies and local municipalities with long-term outlooks on operational costs

Electric vehicle deployment could be accelerated with expanded public charging stations, including fast charging capabilities (current technology can provide an 80% charge within 30 minutes). In addition, some fleets of government or commercial vehicles could benefit from technologies such as battery "swapping", which is a business model to replace the battery rather than recharging it, which can significantly reduce "recharging" time (such a model has been embraced by Renault in some European markets).

The Commission recommends prompting electric vehicle readiness by:

- Promoting PEV deployment by conducting a PSC proceeding to address PEV barriers to more rapid consumer and government agency adoption. Electricity distribution investments needed to support increased use of vehicles should also be addressed.
- Promoting State-sponsored investments (NYPA, NYSDOT, NYSERDA, etc.) in public charging stations. Deployment of charging stations powered by distributed generation with pricing that incentivizes the use of clean and off-peak energy should also be considered.[d]
- Requiring NYSDOT, utilities and vendors to collaborate and map PEV charging stations, and centrally track perational status in 2013.
- At the local level, streamlining permitting for charging stations and introducing updates to zoning and parking ordinances and building codes that encourage charging station installations and use in 2013.
- Developing State-led general public education campaign, supported by utilities and auto manufacturers, to increase consumer understanding of PEVs and the benefits they provide.
- Investing in vehicle-to-grid technology R&D to accelerate deployment.[e]
- Leveraging Public Private Partnerships (PPP) that expand state incentives for charging stations.

[d] Solar array covered parking lots could provide the electricity for the vehicles and provide shading to the vehicles during summer months, increasing vehicle efficiency from reduced cooling loads

[e] PEV applications can also provide a reverse flow power capability such as vehicle-to-grid (dis), however there are elements of these systems such as battery durability, utility/automotive/consumer acceptance, and economics that have yet to be demonstrated. V2G, therefore, remains an R&D and pilot project agenda.

FedEx Delivery Vehicle Pilot (New York City, United States)

A FedEx package distribution center in lower Manhattan started operating a pilot using ten electric delivery vehicles in Spring of 2012.[24] The pilot is a collaboration between Columbia University, General Electric and FedEx to explore convenient and cost-effective mechanisms to charge the vehicles. Putting a large amount of electric vehicles on the grid at once generates a fundamental shift in transport energy from liquid fuels to electricity. FedEx has a 500-vehicle fleet in New York City, and shifting one-third of its fleet to electric trucks would require a megawatt of generating capacity.[25] The pilot project is developing software to prevent the peak load draw during charging from spiking by providing each vehicle with the appropriate amount of energy in the evening to run the delivery route the next morning.

Electric vehicles are good workhorses for the urban delivery industry since they make frequent stops allowing for recapturing braking energy, cover short, predictable routes within the range of the batteries, and can be recharged overnight at distribution facilities. There is a potential for air pollution reductions in cities by removing a large source of diesel emissions from vehicles. The shift to much quieter electric vehicles also reduces noise pollution.

Figure E-18: FedEx electric delivery vehicle (FedEx, 2012)

Smith Electric Vehicles (Bronx, New York)

Smith Electric Vehicles, a leader in zero-emission, all-electric commercial vehicles, is establishing an electric truck assembly plant in the South Bronx, adding 100 jobs to the region. Working with bus fabricator Trans Tech of Warwick, NY, Smith will also be producing electric school buses. Smith was recruited to New York State based on an incentive package including an industry-wide electric truck incentive program announced by Governor Cuomo that provides up to $20,000 per vehicle to partially defray the incremental costs of an EV over an internal combustion engine. By replacing the average diesel truck of this size with a zero emission alternative, more than 26 tons of GHGs are offset each year per vehicle, along with 2,228 gallons of fuel saved annually. The Smith plant is currently in the later stages of refurbishment expected to begin assembling trucks in 2013.

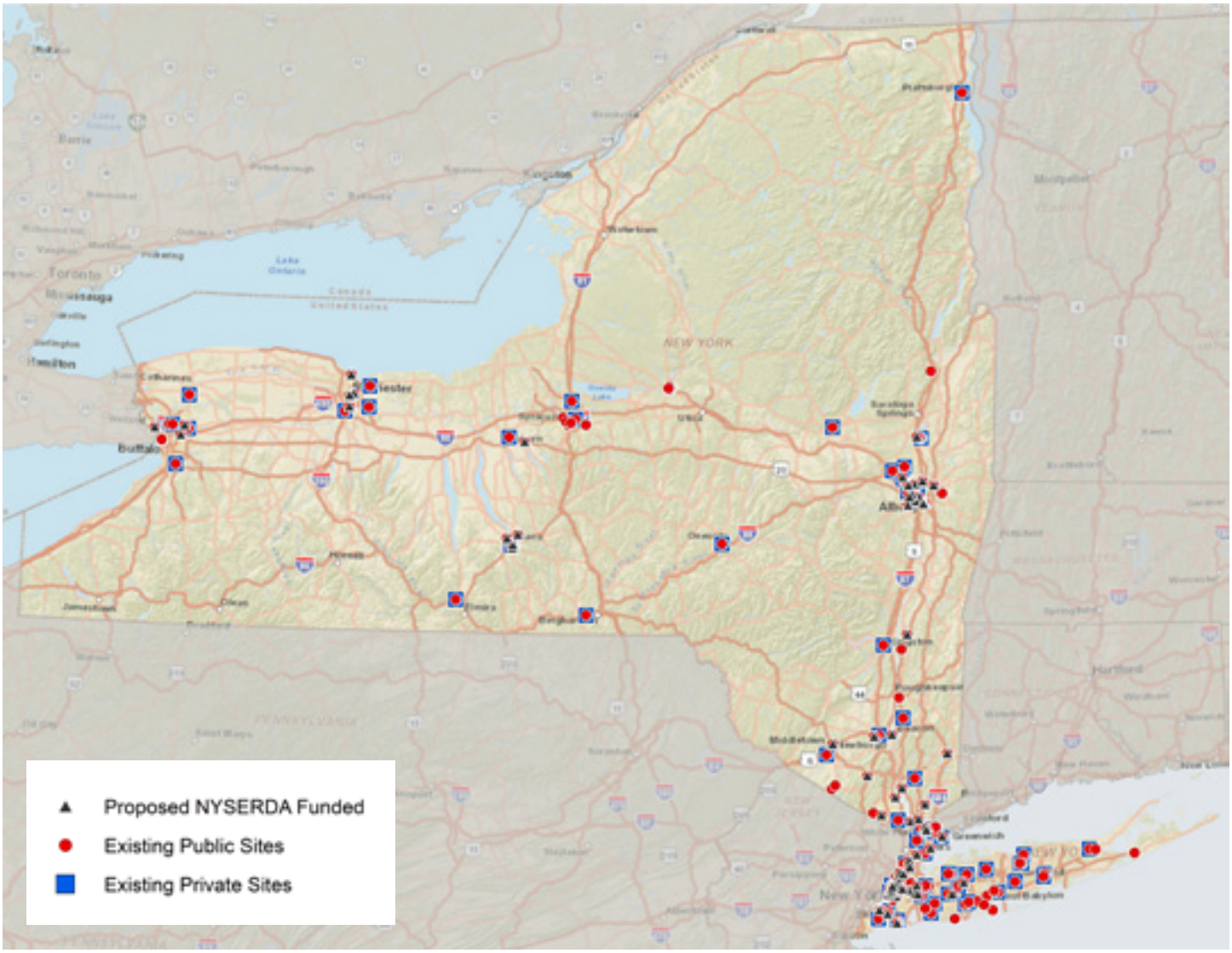


Figure E-19: Existing and proposed electric vehicle charging locations in New York State (NYSERDA, 2012)

Electric Vehicle and the Smart Grid in Denmark (Bornholm, Denmark)

Since 2009, a consortium of research institutions, energy companies and private technology developers has been testing the integration of electric vehicles and smart grid infrastructure in a small city in Denmark.[26] The project aspires to assess the viability of an integrated charging and grid system that uses information and communication technology to control stored energy in vehicle batteries. The system allows stored energy in vehicle batteries to power the grid during times of high demand or when intermittent power generation sources, such as wind, are not actively producing power. Denmark's high proportion of wind power makes it the perfect location to test the feasibility of a vehicle-to-grid system. Furthermore, the project will help support Denmark's long-term objective of having 200,000 electric vehicles on the road.

Design rate structures and create incentives to encourage distributed generation and smart grid investments

The existing energy regulatory framework was designed for large, centrally coordinated systems of generation, transmission and delivery of energy to consumers. There are a number of initiatives that could help support a shift to distributed energy that improve the efficiency of the power system and resilience for the State and benefit both providers and customers.

Price energy markets to all customers in real-time to maximize grid efficiency and enhance resilience

The electricity system is built to meet peak demand. This means that some of the infrastructure is only utilized for a relatively small number of hours each year. To meet higher demand for electricity at peak periods, higher-cost power generation units come online causing the wholesale price of electricity to vary with demand in real time. The vast majority of residential and small commercial electricity customers are informed of the price of electricity only upon receipt of a monthly bill.

Employing a utility rate plan based on prices that vary by time-of-use, and reflects the actual cost of energy in near real-time, coupled with advanced metering could improve electric system efficiency by reducing peak demand. Under this rate design, consumers can shift loads to periods of low demand and pay a lower price for electricity — this could provide system-wide leveling of demand and reduce the need for additional infrastructure to meet what would otherwise be higher peak demand. The PSC should work with utilities to develop these market mechanisms to help make the grid more efficient by allocating/distributing resources to where they are needed most.

Real-time pricing and the advanced metering necessary to support it need to be demonstrated (perhaps with several demonstration projects) and carefully explained to the rate payer, as well as made user friendly, so that they understand how and where these savings are generated and are thus motivated to support their use. Due consideration should be given to the practical hardships and difficulties related to implementing time-of-use rates for certain residential customers (e.g., elderly or disabled customers unable to shift load), and all possible means taken to mitigate any such hardship, such as including tiered rate structures for residential customers that do not penalize lower income citizens and those who use less electricity. Real-time pricing and the advanced metering to create it need to be explained to rate payers so that they understand how these savings are generated.

The Commission recommends the State consider requiring electricity to be priced to reflect the real-time cost, including exploring tiered pricing structures for residential and smaller commercial customers.[f] This will require a statutory change to eliminate the current prohibition of mandated real-time rates to residential customers.

Such pricing mechanisms will help make the grid more efficient by sending the economic signals that result in allocating and distributing resources to where they are needed most.

[f] This will also require digital metering equipment

Energy Storage Innovation (New York, United States)

The US Advanced Battery Consortium (USABC) is a research and development partnership of the major US automakers, EPRI and electric utilities to develop electrochemical energy storage technologies that support commercialization of fuel cell, hybrid, and electric vehicles. The Consortium's long-term goal to enable electric vehicles with energy storage systems costing $100/kWh, which is approximately 20 to 25% of current cost. At this level, electric vehicles would be less expensive to purchase and operate than internal combustion vehicles enabling large-scale deployment. Electric vehicles would also produce fewer emissions than internal combustion vehicles, even based on the nation's current power generation mix which includes significant amounts of coal. New battery chemistries continue to be developed for electrified transportation including advanced lithium-ion and sodium-metal halide batteries. Further improvements in energy density, power, cycle life, and cost will continue for existing technologies while new chemistries such as metal-air batteries will continue to be developed.

Similar benefits can be provided to the electric grid through medium and heavy-duty transportation storage, such as electrified delivery trucks and electrified rail. Energy storage options for distributed energy storage at customer locations and at the transmission and distribution level also include electrochemical systems, fuel cells with hydrogen storage, thermal storage, kinetic storage such as flywheels, and hydroelectric storage. New York academia, industry and government are seeking to capitalize on these benefits through the work of the New York Battery and Energy Storage Technology (NY BEST) Consortium.

Diversify fuel supply, reduce demand for energy, and create redundancies

Fuels such as coal, natural gas, heating oil, gasoline, and diesel, most of which are imported into New York State, contribute to climate change and make the State's system dependent on various delivery systems that themselves are vulnerable to climate change and other disasters. By diversifying our energy supply to include renewable energy sources (e.g., solar panels on rooftops, onshore and offshore wind farms, energy crops or waste and wastewater-to-energy), the State will be more energy secure and reduce its contribution to climate change. These resources have the added benefit of keeping New Yorkers' dollars spent on energy inside the State, supporting the local economy. In addition to a cleaner supply, an increase in energy efficiency and conservation will reduce the demand for imported fuels.

Facilitate greater investments in energy efficiency and renewable energy

Energy efficiency and renewable energy will continue to be priority resources for managing the growing demand for electricity and fuels within a resource-constrained environment. New York is recognized as a leader in the areas of energy efficiency and clean energy deployment, spending close to $1 billion annually through utility and state-sponsored programs. The Commission recognizes the importance of these areas and encourages New York to continue its leadership. Building energy efficiency measures (doors, windows, structural systems and insulation) could also strengthen a residential or commercial building's resilience to violent storms, and in the event, will reduce the need for fewer or smaller generators.

The state has a long history of supporting energy efficiency and renewable energy deployment through the Renewable Portfolio Standard and the Energy Efficiency Portfolio Standard, both currently approved by the PSC through 2015. These programs provide rebates and other incentives to overcome barriers to individuals making investments in energy efficiency and renewable energy investments.

The PSC should review these programs in light of the 2015 program expiration date and extend them to provide longer-term market certainty. In addition, the next step in New York's energy efficiency program should be to leverage additional private sector investment through public-private financing mechanisms. In 2012 New York launched a state-wide on-bill financing program that is still in its infancy. This program, administered by NYSERDA, allows electricity and natural gas customers to make energy efficiency improvements in residential, small commercial, not-for-profit, and multifamily structures through a loan from NYSERDA that is paid back through energy savings and a surcharge on utility bills. The program requires that the energy savings each month are greater than the loan repayment surcharge. To grow this program, the State should encourage the private sector to participate in the financing of these loans.

Diversify fuels in the transportation sector

New York's transportation sector is 97% dependent on petroleum fuels to power passenger and commercial freight movement. Such single fuel dependency reduces system resiliency. The impacts to disruptions in the fuels distribution system may have profound effects on the ability to move people and maintain commerce. This danger is compounded by the fact that petroleum is not produced or refined in New York, leaving New York vulnerable to disruptions caused by storm events or other incidents outside of New York. To reduce that vulnerability, New York should continue to pursue opportunities to increase diversity in the fuels used to power its transportation sector, and target programmatic opportunities that foster new technologies and alternate fuels. Some of these alternate fuel opportunities can be found in turning to electricity, natural gas and low-carbon sustainable biofuels that can be produced using materials such as switchgrass. Near-term opportunities exist for government and commercial fleet vehicles, including expanding use of E-85 (ethanol 85%, gasoline 15%), LNG, compressed natural gas (CNG), hybrid, and electric vehicles.

New York is building on the success of the regional approach created through Regional Greenhouse Gas Initiative (RGGI) to foster new transportation policies, programs and projects through the Transportation and Climate Initiative (TCI), an 11-state plus District of Columbia initiative to advance alternate transportation fuels, in the integrated Northeastern fuels markets. The TCI has adopted a comprehensive approach to transportation alternatives, and is looking at a suite of policies to reduce the use of petroleum, including alternate fuels opportunities provided by electric and natural gas vehicles.

Alternative fuels can be expanded in the transportation sector. The State should explore mechanisms to develop higher biodiesel usage in diesel fuels, supporting development of E-85 (ethanol 85%, gasoline 15%) usage by consumers, and use of LNG, CNG, hybrid, and electric vehicles (particularly in government and commercial fleets).[g]

New York should continue to examine whether regulatory policies can help to foster increased use of alternative fuels. States in the Northeast and Mid-Atlantic region have engaged in analytical work to determine whether a clean fuels standard, if adopted across all the Northeastern states, provides environmental benefits as well as economic opportunity to increase the use of alternate fuels. While California has implemented a clean fuel standard, New York should continue to track whether this approach, or a modified variation targeted to increased use of electric and natural

[g] Provided that fugitive methane emissions associated with the use of LNG/CNG vehicles are minimized.

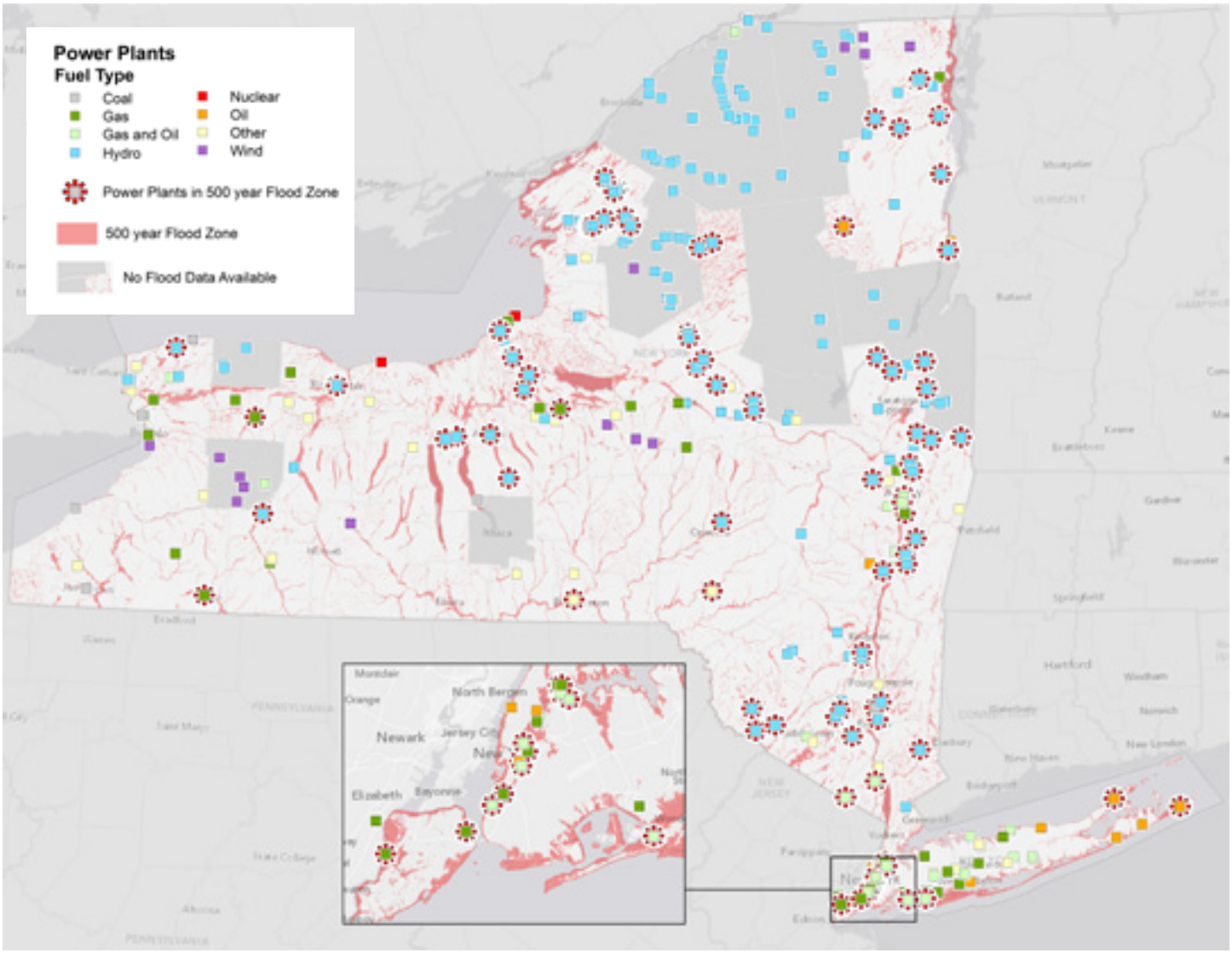


Figure E-20: Power plants in New York State by fuel source in and out of the 500 year flood zone (NYSDPS, 2011; NYSDEC, 2012)

gas-fueled vehicles, could provide a viable program platform for adoption across the region.

Support alternative fuels across all sectors

In the transportation sector, implementing a clean fuels program could promote fuel diversity, cut local air pollution and help prevent transportation fuel types from getting more carbon intensive. New York should begin to track the carbon intensity of the existing fuel mix it uses, including gasoline, diesel, ethanol and other alternative fuel supply and should adopt 'no-backsliding' measures on carbon intensity. These measures keep the fuel mix from getting dirtier (e.g., fuel providers should have a disincentive for increasing the carbon intensity of the fuel they sell). The State, including NYSERDA and the Department of Environmental Conservation (DEC), should explore ways to create incentives that cut, or at a minimum, maintain the carbon intensity of the fuel mix. This could lead to fuel diversification that increases domestic energy security and reduces overall fuel costs and price fluctuations.

There are diversification opportunities across all energy consuming sectors in New York. In the power sector, diversification that supports more distributed power resources helps to build resiliency for power supplies that are not dependent on central station power plants. Such diversification should be explored for high-efficiency, alternate power generation opportunities

that continue to use conventional fuels, including applications for microgrids and/or cogeneration technologies that support industrial use complexes. Distributed configurations that can look to combinations of renewable generation with energy storage backup capability should also be explored.

In the waste and agriculture sector, New York should continue to pursue energy production options that provide both energy and waste minimization benefits. For example, there is potential to introduce biogas produced from sewage treatment infrastructure, landfills and waste-to-energy infrastructure into the natural gas pipeline. This biogas (after treatment) could provide a local, renewable energy source, or could be processed into CNG and used for transportation fleets (bus or vehicle) or backup fuel power. Enabling alternative fuels and energy such as biogas and wind and solar electrification provides benefits to local air quality and GHG reduction. For the agriculture and food processing sectors, expanded use of anaerobic digesters can continue to provide the dual benefits of on-site energy resources coupled with effective waste management practices. New York should also support new economic opportunities for the agriculture sector in the form of dedicated energy crops, such as switchgrass and willow, on underutilized land.

In the buildings sector, for home heating oil, greater efficiencies or energy conversion to lower-carbon fuels can be combined with weatherization efforts so that smaller amounts of heating fuels provide higher levels of heating capacity. When combined with on-site renewable options such as solar thermal, these combined renewable energy and energy efficiency opportunities can initiate more holistic approaches to home and commercial buildings energy use, and provide opportunities for GHG reductions.

Lastly, increased research, development, and deployment of micro-combined heat and power (CHP) options and other solutions should be pursued to capture potential improvements for on-site heating systems.

Lower the greenhouse gas cap through RGGI

One primary strategy to promote a cleaner energy supply is to further lower the GHG emission cap through the existing RGGI. This will, in turn, increase funding for cleaner supply projects.

RGGI is a groundbreaking nine-state program designed to cap, and reduce, power sector carbon pollution which contributes to climate change. RGGI has been in place for three years, with emissions from the power sector dropping well below the existing cap. This is due to a variety of factors including reduced economic activity, the low price of natural gas and energy efficiency measures. Lower emissions have reduced the demand for allowances. Allowances are selling at the minimum price and nearly half remain unsold. The current system is no longer driving emission reductions and investments in climate action have dwindled.

RGGI states are now evaluating options for increasing its effectiveness. Reducing the cap can restore RGGI's ability to reduce carbon pollution, and proceeds from the sale of allowances can be used for clean energy programs and transitioning communities to a lower-carbon future.

State legislation proposed by Governor Cuomo in 2012 would help to accomplish this recommendation. The Clean Energy and Economic Revitalization Act of 2012 would have authorized the use of RGGI proceeds generated as a result of a lower RGGI cap, for emission reduction projects in the power sector (e.g., renewable energy deployment or re-powering). The bill would have also provided municipal assistance and created additional revenue for other uses. By implementing measures to reduce GHG emissions through the RGGI auction, revenue will be generated for New York State that can be used to fund investments in modernizing the grid and expanding renewable energy, in addition to lowering emissions. The Commission recommends that the State work with other states in the Northeast to lower the RGGI cap.

Develop long-term career training and a skilled energy workforce

There is a lack of young members of the workforce with skills in the energy sector. Several utilities have identified and addressed a major risk affecting their long-term planning, namely the high percentage of employees that are nearing retirement age, and who have a great amount of experience that is hard to transfer to younger employees. A recent study showed that more than 20% of New York's utility employees are over the age of 55.[27] Exacerbating this problem is that while there are many skilled employees with one to five years of experience, there are not nearly enough with ten to fifteen years — the managerial and skilled tradespeople who would normally have the plant experience and skills to move into more senior positions vacated by retirees. This problem has arisen in part due to the difficulty in retaining young employees.

Without a skilled pool of workers to draw from, New York State will be unable to meet the demands of the energy system. The problem is exacerbated when considering the upgrades, repairs and new construction that are required to protect our energy infrastructure. Further complications due to labor shortages will arise when the energy system experiences stresses that cause disruption to services.

The State needs to be able to provide enough skilled energy workers from within its own borders to repair damage to equipment and reestablish service. Growing the pool of available skilled workers will put the State in a position to handle the current and future needs of its energy system during normal conditions and when extreme weather events disable the system. A concerted effort should be made by the State Department of Education, the State University of New York (SUNY) and the City University of New York (CUNY) programs, Regional Planning Boards, the New York State Department of Labor, NYSERDA, and industry groups to develop the energy workforce within New York State which will make the State's energy infrastructure system more self-reliant and robust by addressing impending and long-term labor shortages.

Create a workforce development center with utilities

The State should facilitate the development of a regional workforce development center to train the next generation of technical and operations workers for the utilities industry, and more broadly, the clean energy industry, by working with NYPA, NYSERDA, and Investor Owned Utilities. Envisioned as a training center for utilities, and other non-utility energy companies, with modified curricula and equipment tailored to each, this center would be designed to reach out and serve the regional business community, especially manufacturing companies that could share training on the advanced manufacturing equipment and techniques that are critical to global competitiveness with other countries and states. NYPA should take the lead to identify potential locations and develop a business plan for this center in 2013.

Expand energy career training and placement programs

New York State career training and placement programs should be expanded to meet the demands of the energy sector during both normal and emergency operations. Energy jobs require highly skilled workers with years of training, so the investment in training programs should begin immediately to account for future needs. NYSERDA has funded a statewide network of clean energy training providers that offer courses and certifications for energy efficiency and renewable energy jobs.

Creating a larger network of training programs and centers will help form a foundation for the continued development of the energy workforce for years to come. SUNY and CUNY, New York State Department of Labor, NYSERDA, and industry groups should aim to put these programs in place by the end of 2015. These programs should be continually reviewed, updated and revised to remain relevant in the changing technological environment.

Promote awareness of the need for skilled energy workers

Coinciding with the development of these educational programs, the State should promote awareness of our need for skilled energy workers. This can be done through the ongoing work of NYSERDA in different regions of the State. Students, educators, parents and non-energy laborers should be informed of the opportunities for employment in the State's energy sector starting in 2014.

Coordinate workforce development among all stakeholders within the energy sector

Coordination among State agencies, education institutions and businesses will play a vital role in the success of developing the State's long-term energy workforce. Energy and labor organizations should collaborate to establish a comprehensive plan that will be updated to reflect sector trends every one to five years. This plan should project trend development over a 20-year period, and be submitted to NYSERDA for distribution throughout the State.

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Land Use

Overview

Superstorm Sandy exposed significant vulnerabilities in New York's land, coasts, and waterways. The storm damaged over 300,000 homes and upended millions of lives throughout the densely populated and flood-prone region.[1] Sandy, like Hurricane Irene and Tropical Storm Lee that preceded it, demonstrated the risks of extreme weather events aggravated by climate change.

Environmental and land use protections will serve as New York's first line of resilience to climate change over the coming decades. The protection of our homes, businesses, transportation networks, energy resources, and other critical infrastructure depends fundamentally on ensuring that we properly manage the natural environment (Figures L-05 and L-06). New York's resilience against natural threats requires repairing and strengthening damaged infrastructure, integrating naturally resilient functions into the built landscape, and enhancing protections at the water's edge. Our recommendations focus on those actions that would offer the most significant protection.

To enhance the resilience of New York's economy, environment, and its growing population over the decades of the 21st Century, the Commission developed a series of recommendations, which are grouped into five categories:

1. **Protect coastal and Great Lakes communities.** Our coastlines, one of our most vulnerable assets, are home to a vast majority of the State's population. Because of the significant risk of coastal problems resulting from climate change, this category of recommendations focuses specifically on immediate actions to restore and mitigate coastal infrastructure to protect communities, and on strategies for using natural as well as engineered measures to improve resilience.

2. **Reduce inland vulnerability to extreme weather events.** Climate change poses a risk not only to coastal communities, but to the inland communities of New York State as well. An increase in extreme weather can damage buildings and infrastructure, cripple economies, and create public health hazards. This category of recommendations identifies measures to manage the effects of freshwater flooding and drought, and reduce their impact.

3. **Strengthen wastewater infrastructure.** Critical wastewater infrastructure in the State is highly vulnerable to storms and serves a growing population. This category of recommendations focuses on updating the design, planning, and operation of New York's treatment facilities, pump stations, and pipes to reflect new risks.

4. **Develop probabilistic hazards mapping and risk mapping.** Superstorm Sandy exposed major weaknesses in our capacity to predict flood events and determine affected areas. Identifying risks is critical to preparing for, and reacting to, weather events and other disasters. This category of recommendations identifies problems and solutions for current methods of hazard and risk assessment.

5. **Strengthen land use programs, standards, policies, guidelines, and procedures.** To fully prepare for the effects of climate change, we must encourage sound uses of land to minimize vulnerabilities and preserve communities. This category of recommendations outlines how New York can use programs, incentives, policies, and procedures to shape better land use and building practices.

Within each of the areas, recommendations include short-term steps based on lessons learned from recent events; medium-term projects that require more extensive planning and development; and long-term solutions that require systemic planning, process refinement, capital budgeting, and large-scale project implementation.

Extreme Weather Events in New York

Within a period of 14 months beginning in August 2011, New York State experienced three significant extreme weather events, which resulted in 38 of 62 New York counties being declared disaster areas.[1]

Figure L-01: Floodwaters from Irene in Oswego, New York. (NYS Responds Report, 2012)

Figure L-02: Floodwaters from Irene inundate dairy barn at Maple Down Farms II. (NYS Responds Report, 2012)

Hurricane Irene hit New York State on August 28, 2011. The storm especially devastated communities from the Catskills through the Schoharie and Mohawk Valleys, and up to the Keene Valley and Essex County. Just one week later, the state was hit by Tropical Storm Lee. The storm brought nearly a foot of rain to much of the Southern Tier of New York State, causing widespread flooding. Many waterways and surrounding buffer lands were scoured down to bedrock and deprived of their ability to properly absorb future storms. Schoharie County's waterways were among the hardest hit by Irene and Lee. The force of the storms stripped five miles of the Little Schoharie Creek down to bedrock, destroying the natural curves of the waterway and undermining roads and bridges. Flood waters destroyed barns, acres of planted corn, and killed livestock. The storms caused extensive damage to Schenectady's wastewater system, including the historic North Ferry Street Pump Station. Flood waters from the Mohawk River completely inundated the control and electrical systems, as well as the emergency generator.

Figure L-03: Building damage in the Rockaways. (NYSDOS, 2012)

Figure L-04: Robert Moses Circle. (OPRHP, 2012)

In late October 2012, Superstorm Sandy completely removed naturally protective sandbars and dune systems, and significantly eroded the beaches in the City of Long Beach and Rockaway, leaving homes, businesses and development and infrastructure vulnerable to future storm impacts. Loss of natural protection for infrastructure and development has also become a problem along Ocean Parkway on Jones Beach Island where a 2-mile section of the roadway was undermined. On Fire Island, many homes were lost and the barrier island was cut in three places to form new inlets. In the Hamlet of Montauk, beaches were eroded and dunes washed away, leaving hotels and the community's economic future vulnerable.

[1] Based on FEMA reports for Hurricane Irene, Tropical Storm Lee and Superstorm Sandy

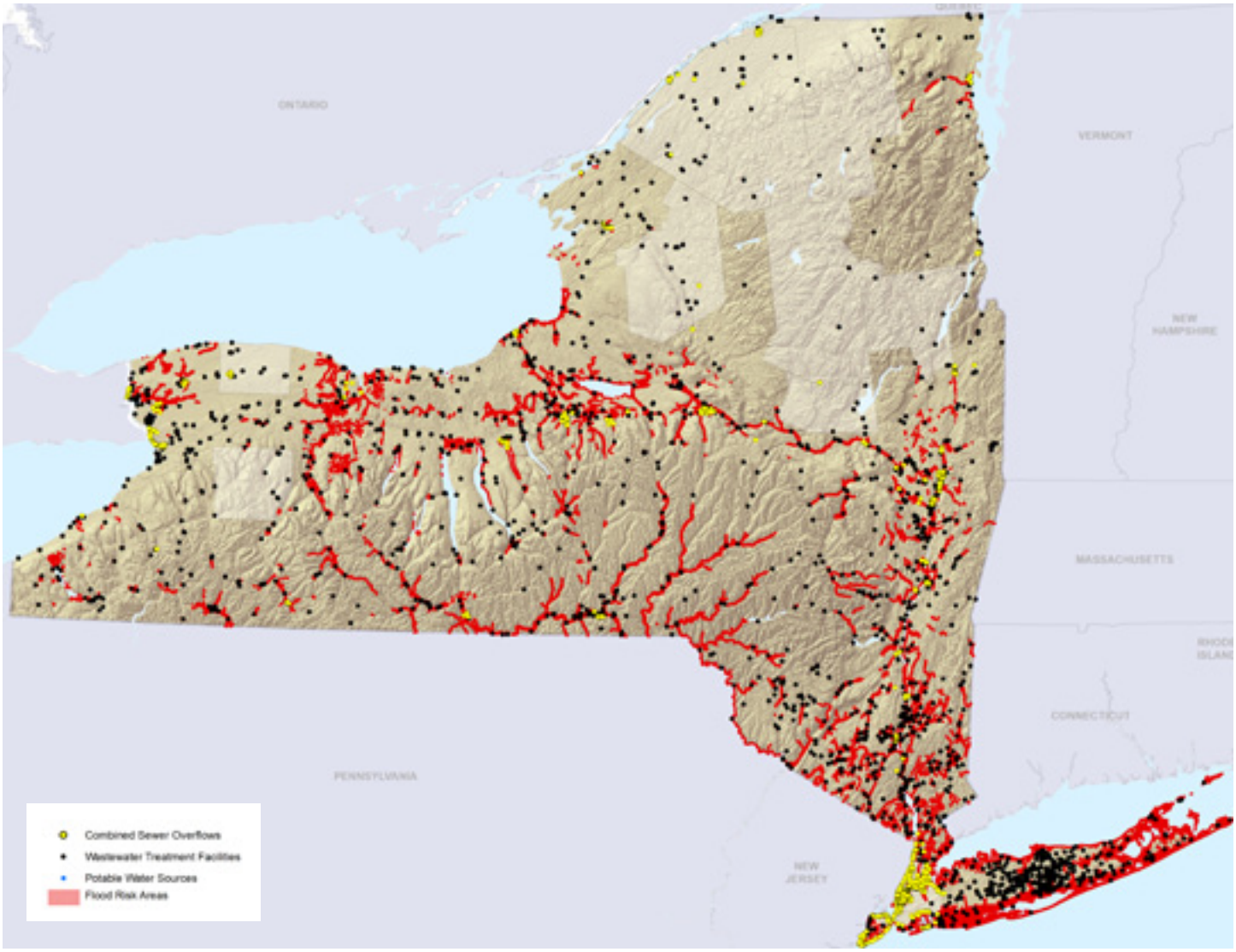


Figure L-05: Water-related Infrastructure, New York State (State of New York, 2012)

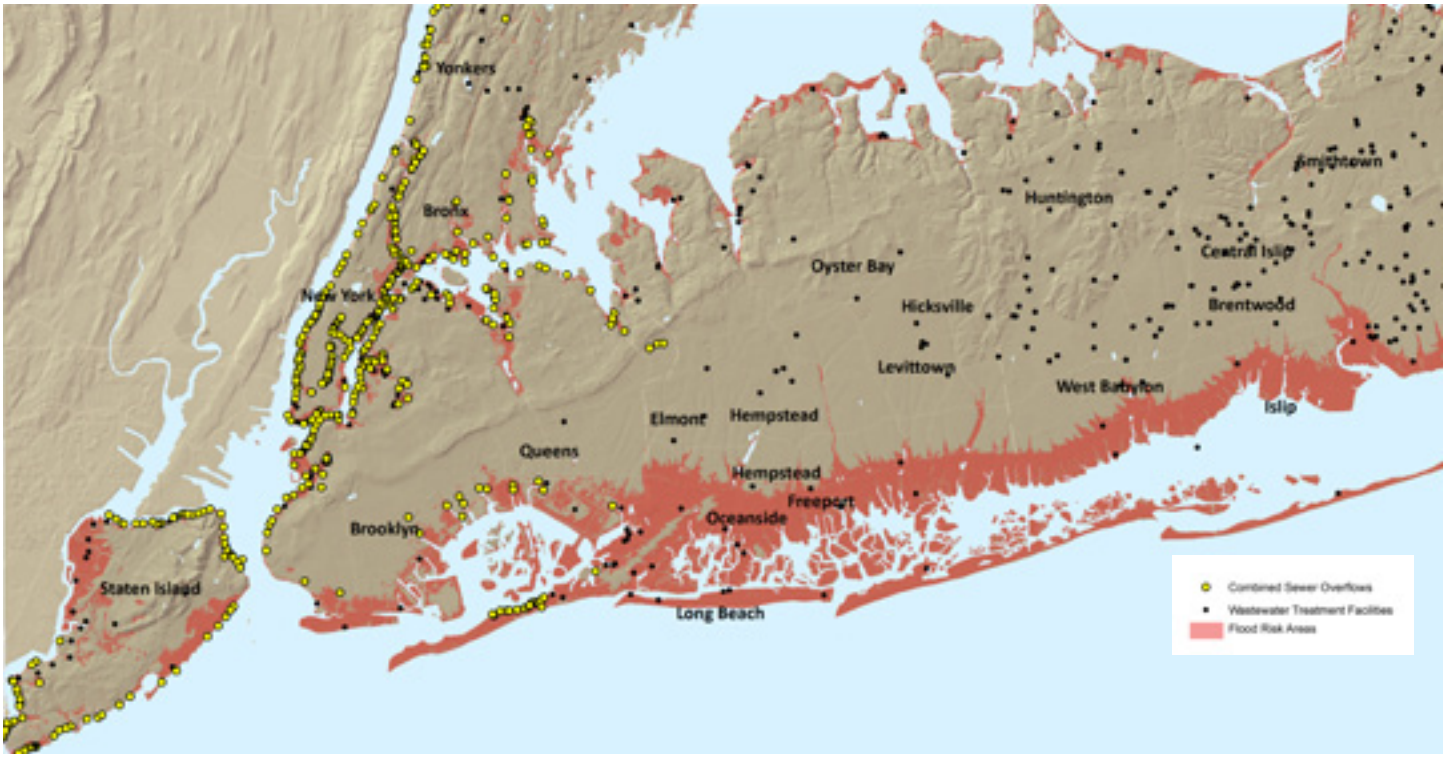


Figure L-06: Water-related Infrastructure, New York City (State of New York, 2012)

Protect coastal and Great Lakes communities

Over 90% of New York's population is centered on the Atlantic Ocean, Hudson River, and Great Lakes coasts.[2] Our coasts and waterways remain among the state's most important economic assets — providing for waterborne commerce, tourism, residential development, and commercial fishing — as well as major recreational and cultural assets.

Further, New York's coast encompasses uses as diverse as parkland, transportation corridors, critical infrastructure assets, industrial sites, and waterfront communities. This range of use demands a multilayered and site-specific resilience strategy.

Coastal resilience strategies must adapt to the new challenges that arise from the acceleration of climate change and the resulting increase in temperatures and sea levels. Over the decades, increased frequency and severity of storms, drought, and temperature extremes is likely, necessitating a progressive need for protection.

The first set of recommendations addresses the urgent need to repair the protective systems, recently damaged by Sandy, that buffer vulnerable communities along the Long Island and New York City coastline. Recommendations for re-creating the resilience of New York Harbor call for the State to start now with an innovative mix of built and natural infrastructure and to look out over a long time horizon to ensure the city remains one of the greatest for coming centuries, despite future challenges of changing climate. Additional recommendations described below include repairing and protecting the coasts and developing a Great Lakes resilience strategy.

Immediately protect the most vulnerable populations in coastal areas

The Commission recommends that the State act immediately to repair damage from Sandy in the coastal communities of Long Island, New York City and the Lower Hudson Valley. By wiping out defenses, Sandy left many communities more vulnerable to future storms. Despite the scale and cost of these protections, these are vital, non-discretionary investments. Immediate action will improve short-term resilience, and restore the coast to its pre-Sandy condition or better, and enable the State to rebuild for the future from a position of strength. Specific measures should include the following:

Restore damaged dunes, beaches, and barrier islands

Superstorm Sandy wiped out dunes and beaches across the region. In Rockaway and Long Beach, the State should immediately rebuild the dunes and beach to provide a level of temporary protection exceeding that which existed before the storm for the 300,000 residents who are now vulnerable. This will require dredging sand from adjacent inlets, shoals, and offshore sources and using it to create new dunes and elevated or wider beaches. Other priority dune and beach projects demanding immediate attention include Westhampton, Shinnecock, Fire Island, and the Seagate portion of Coney Island. The popular Jones Beach State Park and Robert Moses State Park lost significant beachfront which should be replenished before the summer season.

On other barrier islands along the Long Island coast, the State should preemptively prevent breaching by future storms by filling low spots in dunes, focusing on Jones Beach Island eastward. The State and U.S. Army Corps of Engineers could implement this emergency action in coordination with other dredging actions. The State and Corps must also quickly assess vulnerable sites, estimate the quantities and identify whether sand will need to be dredged or trucked in. Prevention of breaches will minimize the likelihood of additional flooding impacts on the mainland of Long Island without significant long-term impacts, but may not be the preferred long-term solution. Long-term solutions will need to consider the benefits of breaches in specific areas.

Figure L-07: Thick iron reinforced seawall in the Rockaways broken by force of storm surge (NYSDEC, 2012)

The breaches at Cupsogue and Moriches Inlet on Fire Island have already been closed. The State should monitor the impact of the Fire Island Wilderness breach on the barrier island, the bay, and the mainland to determine whether or not to close that breach in the near future. Limited monitoring to date suggests that the inlet is stable or closing slightly. This has resulted in improved water quality in Great South Bay and created a platform for new eelgrass and wetland growth, which may actually reduce flooding in certain cases (i.e., when winds blow from the west).

The State should dredge sand from the Fire Island Inlet and use it to restore the beach and dunes in front of Ocean Parkway. Once the protective dunes system has been restored, additional measures should be implemented to restore traffic flow to the two-mile section that was damaged. While repair of Ocean Parkway makes sense at this time, options should be considered to establish redundancy over the long term, through alternative traffic routes and modes of transportation.

Repair and strengthen critical hard infrastructure along the coast

Sandy heavily damaged bulkheads, riprap shoreline, levees and seawalls from Montauk to Manhattan, including the shoreline riprap at Mt. Loretto Unique Area on Staten Island. The storm surge overtopped and compromised the levee at Oakwood Beach and the Asharoken Seawall, which protects Asharoken Avenue and protects the mainland to Eaton's Neck. The bulkhead at Roberto Clemente State Park in Harlem was heavily damaged. The State should repair and improve these structures. The State should also assess whether new levees or seawalls are necessary to protect the Staten Island shoreline.

Repair and protect wastewater infrastructure

Sandy heavily damaged dozens of wastewater treatment plants across the region, necessitating nearly $200 million in repairs. The damage led to the release of hundreds of millions of gallons of raw sewage into nearby waterways over the

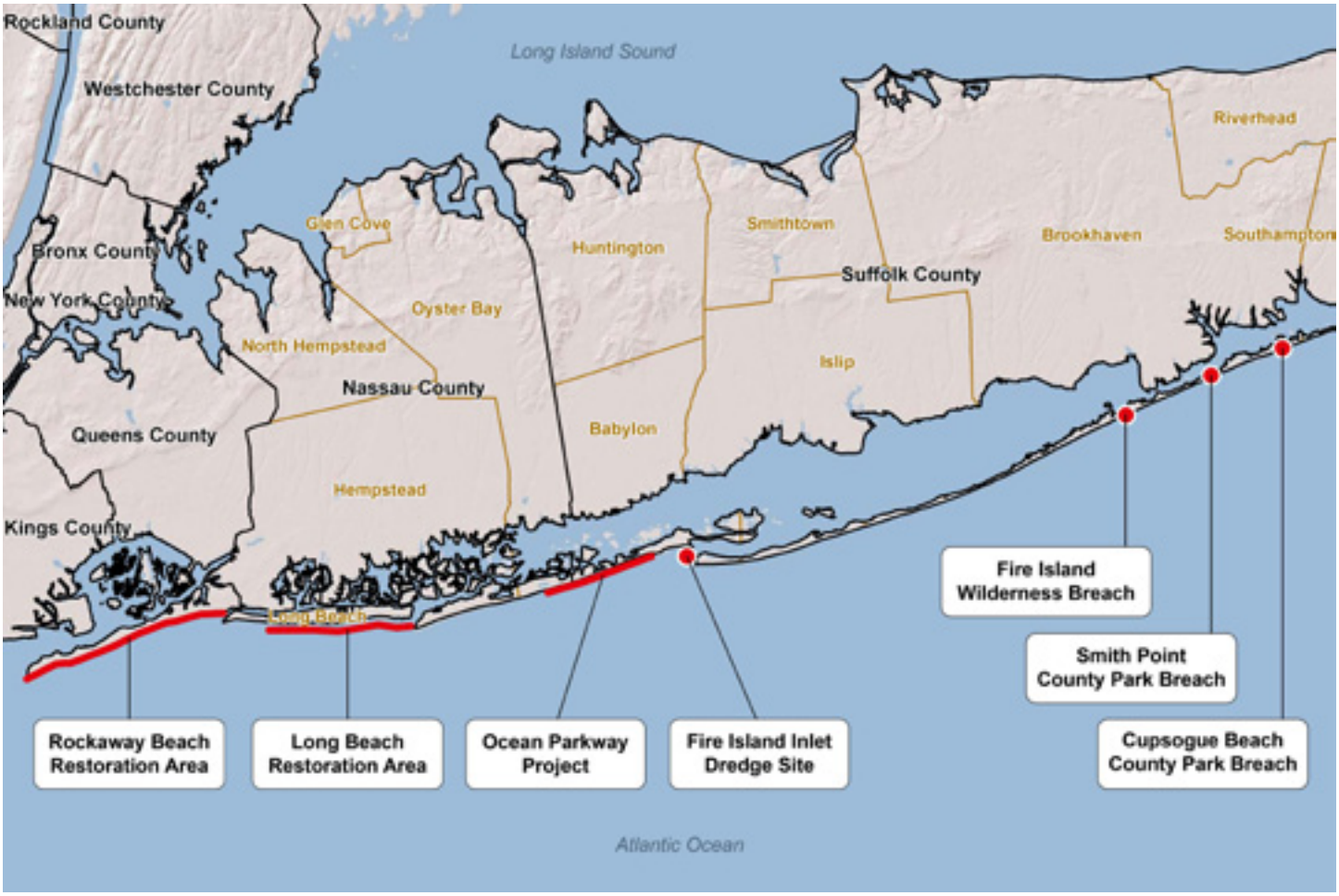


Figure L-08: Immediate actions along barrier islands that are required in response to Sandy. (NYSDEC, 2012)

course of the week,[3] causing the closure of numerous commercial shell fishing beds. Because wastewater infrastructure is a pillar of public and environmental health, these repairs and mitigation efforts must be performed and they are already underway.

The section titled "Strengthen wastewater infrastructure" recommends intermediate to longer term actions for the State's wastewater infrastructure.

Repair important public recreational infrastructure

The State should help to bring damaged public recreational infrastructure back to full operation before the summer season where possible. The Jones Beach boardwalk sustained $40 million[a] of crippling damage from Superstorm Sandy. Riverbank and Gantry Plaza State Parks sustained significant landscape, amenity, structural and utility damage. Other parks across Long Island and the Lower Hudson Valley lost hundreds of trees, trails, and support facilities. Structures and piers at the Hudson River Park in Manhattan sustained significant damage to structural, electrical, and mechanical equipment damage and distribution systems. Some of the Park's recreational amenities, such as floating docks and playing fields, were also destroyed by the storm surge.

Develop a resilience strategy for New York Harbor

Superstorm Sandy destroyed any lingering perception that the New York Harbor shoreline was sufficiently robust to withstand a significant storm surge. The Harbor's limited coastal defenses failed as water stormed over beaches and bulkheads and into homes, businesses, tunnels, and power substations. Without significant changes to the State's coastal protection, New York City communities will face increased risks from coastal storms and other extreme weather. The challenge before this Commission is to present a bold, achievable resilience vision to prepare all of New York for this new norm.

A key to understanding how to build the resilience of New York Harbor is to understand what was lost during development: many of the Harbor's natural defenses. Over the course of more than 350 years, New Yorkers dramatically reshaped, expanded, hardened, and deepened the waterfront to accommodate an ever expanding population and critical maritime commerce (Figure L-07). By the mid-19th century, more passengers and products came through the port of New York than all other harbors in the country combined.[4] By 1916, half of the gradually-sloping Manhattan waterfront was replaced by a massive, 100,000-foot-long seawall with deep-water access.[5]

As shoreline flats were filled and land was expanded, the Harbor lost 80% of its historic tidal wetlands[6] and virtually all of the 200,000 acres of historic oyster reefs.[7] The end result was a commercially accessible waterfront that fueled the growth of New York City, but one that paradoxically left the City vulnerable to storms.

Today, Manhattan's man-made shoreline properties alone are home to 70,000 people and approximately 3,000 employers, representing $15 billion in annual business activity — the equivalent of 115th out of 192 countries in economic productivity.

In recent decades, New York has become less dependent on waterfront commerce; only a small percentage of the waterfront is still dedicated to intensive commercial use. This transition provides New Yorkers with an opportunity to re-envision and redesign a resilient shoreline that will support the residential, commercial, recreational and ecological needs of New York for centuries to come.

The Commission has two major recommendations to enhance the resilience of New York City's harbor region over the coming decades and longer.

First, the Commission recommends that the State develop a plan, after careful site analysis, to restore the resilience of the harbor area through a combination of natural shoreline restoration and hard infrastructure improvements where appropriate. This would require the development of a comprehensive strategy comprised of both ecological system restoration and construction of sophisticated engineering projects designed to support or mimic natural processes. Such a strategy should not only reduce the risks from storm surge and sea level rise, but also provide a vast array of additional environmental and economic benefits, as described further below.

Second, the Commission recommends that the State promptly initiate a study to assess whether a system of storm surge barriers is advisable and feasible to protect New York Harbor from cataclysmic events and the environmental, economic, and social consequences of its installation and use.

The Commission recommends that the State launch a rigorous environmental, engineering and economic feasibility analysis for the creation of an integrated natural and hard infrastructure system in New York Harbor.

Natural infrastructure has been increasingly recognized and promoted among hazard and climate planners and managers. A growing body of evidence indicates the value of coastal ecosystems in wave attenuation, deflection, and erosion reduction. These systems can also retain stormwater during rain events, preventing surface flooding.

In addition to mitigating coastal risks, natural infrastructure systems offer significant co-benefits. Wetlands help cleanse urban stormwater of contaminants before it enters waterways, improving overall water quality. Shoreline green space provides habitat for wildlife, opportunities for fishing and recreation, and improved quality of life for urban residents. It also provides cooling effects, helping to combat the urban heat island effect. Many green

[a] New York State Office of Parks, Recreation and Historic Preservation (NYSOPRHP) damage estimate

Figure L-09: Expanding shoreline of lower Manhattan from 1609 to today. The last map in this series shows lower Manhattan in 1609 with present day man-made areas in blue and Superstorm Sandy storm surge areas in yellow. Most of the areas that were flooded by storm surge overlap with the man-made areas. (NYS DHS; Mannahatta Project, 2010; New York Public Library, 1766 - 1817; NYS Land Office, 1860; NYC Information Technology and Telecommunications, 1924; NYS Orthoimagery, 2011)

infrastructure techniques intended to retain and absorb stormwater at the surface have the benefit of reducing the strain on storm sewer capacity by reducing the volume of stormwater that enters the piped system.

From an economic standpoint, natural solutions require lower maintenance and management costs when compared to traditional built infrastructure. Analyses performed by McKinsey, Swiss Re, and the Rockefeller Foundation have shown that reef and wetland management and restoration can be among the most cost-effective approaches for hazard mitigation.[8] The authors of the Palisade Bay proposal sought to show how various types of natural protective infrastructure can be placed in the New York and New Jersey Upper Harbor (Figure L-08). The Museum of Modern Art "Rising Currents" workshop and exhibition further developed this approach through five detailed designs for the NY Harbor.

These approaches, however, also have limitations. While they reduce damage and erosion due to waves, they do not serve to protect against stillwater flooding, for example. They also may not be appropriate in some urban areas or preclude competing land uses. As such, feasibility analyses must evaluate how to integrate natural solutions with repairs to existing hard shoreline defenses such as riprap, bulkheads, levees, and berms as well as newly created hard defenses. Measures should also include land use and zoning appropriate for achieving risk reduction in New York City. More importantly, the comprehensive package should not impair any existing or contemplated commercial and navigational interests.

The Commission recommends the State conduct a detailed feasibility study to explore how the five major types of natural infrastructure presented on the next page should be used as parts of a Harbor resilience strategy. In particular, the analysis should include the following.

Beaches and dunes: Identify how to expand and protect barrier islands, beaches,

Figure L-10: Proposed natural protective infrastructure from On the Water | Palisade Bay by Guy Nordenson, Catherine Seavitt and Adam Yarinsky. The designers who participated in the workshop suggested that a dense network of piers, islands, wetlands and oyster beds could project out into New York Harbor from the waterfronts on all sides, breaking up storm surges. An additional archipelago of small fingerlike islands could be built in the center of the harbor, and old subway cars could be dumped into the water to form reefs. (Guy Nordenson et al, 2010)

and dune systems as a first level of defense against storm surge. This effort should build on the more immediate beach and dune restoration efforts discussed above.

Tidal wetlands: Determine how and where to protect and enhance existing tidal wetlands and identify strategic areas for the creation of new ones.

Oyster reefs: Explore ways in which oyster reefs might be recreated in the most vulnerable parts of the Harbor without impairing navigational channels.

Living shorelines: Expand the creation of living shorelines around the Harbor and its tributaries. The State should identify and evaluate shoreline areas where the use of living shoreline techniques would best offer natural coastal protection. Selected areas could include sites experiencing significant erosion, especially vulnerable areas in Brooklyn and Staten Island.

Maps: Use existing mapping resources to identify vulnerable areas that could be buffered by natural systems. Neighborhoods with high concentrations of socially vulnerable residents, critical infrastructure (including but not limited to power plants, substations, hospitals, transportation facilities, and major roads), and high population densities should be prioritized.

Funding: Develop detailed proposals on how projects would be funded, constructed and maintained. This should involve determining how a wetland banking system could engage the private sector in building new, protective tidal wetland and natural features systems, as described in the Infrastructure Finance chapter

Pilot soft infrastructure: Employ soft infrastructure protections on a pilot basis. The State should work with municipal agencies and the U. S. Army Corps of Engineers to identify and evaluate shoreline areas where the use of living shoreline techniques would be appropriate for potential use of soft infrastructure coastal protection strategies.

Conduct a comprehensive storm surge barrier assessment for New York Harbor

Storm surge barriers are large moveable gates that close during storm events to protect coastal areas from flooding. Extensive storm surge barriers have been used in various locations including the Netherlands, London and St. Petersburg, Russia. Similar but smaller-scale barriers protected the waterfront of Stamford, Connecticut and Providence, Rhode Island from the surge associated with Superstorm Sandy. Although these barriers are each different, they all involve engineered systems that mechanically move gates into place several hours prior to the arrival of a storm to hold back the storm surge entirely and protect the area behind the barrier.

A system in New York Harbor would have to be much more complex than those in London and St. Petersburg, because of the size, geography, and hydrology of New York Harbor. On the ocean side either two barriers would be required -- one across the Verrazano Narrows and one at the mouth of the Arthur Kill between Perth Amboy New Jersey and Staten Island -- or a single one extending from Sandy Hook, New Jersey to the Rockaways in New York. An additional barrier would be needed at the entrance to the East River from the Long Island Sound (Figure L-15). Cost estimates for the construction of either option of three or two surge barrier locations vary widely, from $7 to $29 billion.[b]

The State should conduct a comprehensive assessment of the need, feasibility, costs, and impacts of storm surge barriers as a first line of defense for New York Harbor. Well-designed storm surge barriers can provide protection against the combination of coastal storm surge and rising sea levels. For example, the barriers could be designed to hold back the surge that may accompany a Category 1 hurricane on top of the six feet of sea level rise that might be experienced by the end of this century.[c]

[b] In 2009, Halcrow Group Ltd. proposed a single barrier stretching from Sandy Hook to the Rockaway Peninsula at a cost of $5.9b, while the Stony Brook University Storm Surge Research Group proposed a three-barrier system for $9.1b. Dr. Jeroen Aerts, who has been assessing flood risks and protective measures for New York City, has estimated barrier construction costs of up to $17b for a four-barrier system (Arthur Kill, Verrazano Narrows, East River, Jamaica Bay), with an additional $10b to $12b required to provide protection to areas to the sides of the barriers which would bear the force of deflected storm surge.

[c] In the ClimAid report, scientists from Columbia, Cornell and the City University of New York project that sea levels could rise by as much as 55 inches by the 2080s, when accounting for a rapid ice melt scenario. NOAA issued a report in December 2012 estimating that sea levels could rise 6.6 feet by 2100 under a rapid ice melt scenario.

Figure L-11: Ocean Parkway before and after Sandy. If dunes were not there, more damage may have occurred. (NYSOPRHP, 2012)

Figure L-12: Tidal wetlands restoration of Paerdegat Basin, Jamaica Bay. (NYSDEC, 2012)

Figure L-13: Engineered Oyster reef, North Coast, New Zealand. (Ben Gertzfield, 2007)

Figure L-14: Living shorelines, Brooklyn Bridge Park. (Michael Van Valkenburgh Associates Inc.)

Figure L-15: Natural berm (Adam Whelchel/ TNC)

Five major types of natural systems that can limit flooding and climate-related impacts within the New York Harbor

Barrier beach and dune systems

Barrier islands, dunes and beaches are the first level of defence against storm surge. A wide beach and dune complex provides significant storm protection. During storms, beaches and dunes can mitigate storm impacts by absorbing and dissipating wave energy. While storms can move sand from the beach into the ocean, erode dunes, and push sand into areas behind the dunes, these changes are natural responses to storm surge and high waves and are often less costly to repair than damage to homes, businesses, and infrastructure.

Preliminary indications following Sandy are that communities located behind restored dunes (such as Point Lookout, Lido Beach, Atlantic Beach, Coney Island and Plumb Beach) experienced less damage than those that did not have protective dunes.[9]

Tidal wetlands

Tidal wetlands can protect coastal communities from storm damage by reducing wave energy and amplitude, slowing water velocity, and stabilizing the shoreline through sediment deposition. More than half of normal wave energy is dissipated within the first three meters of marsh vegetation such as cord grass. In addition, given sufficient sediment deposition, wetlands are able to build elevation in response to sea-level rise, providing a buffer against climate change and coastal submergence.

New York City has over 4,000 acres of tidal wetlands, about 20% of historic levels. Since 2002, Federal, State, and City agencies have invested over $56m to restore or create over 146 acres of wetlands. In addition, over one-third of Staten Island is served by natural drainage corridors, called blue belts, including streams, ponds, and other wetland areas. These wetland systems convey, store, and filter stormwater, saving tens of millions of dollars in infrastructure costs compared to conventional storm sewers.[10]

Oyster reefs

The Eastern oyster has been called an “ecosystem engineer” because its reefs provide many benefits to coastal and estuarine systems, in particular, shoreline stabilization. Oyster reefs contribute to shoreline stabilization by reducing wave action and providing coarse material along marsh and estuarine shorelines. Much like a man-made breakwater, the physical structure of a reef absorbs and dissipates wave energy prior to the wave reaching the shore, thereby reducing the erosion of coastal systems such as tidal wetlands and beach or dune systems. Re-engineered oyster reefs perform these functions in many places around the country including the gulf coast of Louisiana and Florida and in the Chesapeake Bay.

Living Shorelines

Living shorelines are coastal areas that are designed with salt-tolerant plantings, riprap, and other measures to prevent or reduce shore erosion and dampen wave energy while emulating the physical and biological conditions of naturally occurring, stable shorelines. Several examples of living shorelines exist and are being designed in New York Harbor. Harlem River Park in Manhattan includes oyster beds and eelgrass plantings, tide pools, and gabions that step into the water to provide public access as well as strategically placed seawalls to minimize flood risks and improve water quality and public access to the water.

Natural Berms and Levees

The use of large earthen walls, or berms, can effectively direct flood waters away from vulnerable areas and protect infrastructure on the landward side if properly designed.

The proposed barrier from Sandy Hook to the Rockaways could be designed to protect most of the areas flooded by Sandy in the urban core of the New York City metropolitan area. If such a barrier system had been in place, it likely would have prevented the flooding of the subways, tunnels, airports, wastewater treatment plants and other critical infrastructure. A barrier from Sandy Hook to the Rockaways could have prevented much of the damage to homes and communities on Staten Island.

Storm surge barriers have certain shortcomings, however, that must be recognized and further explored. First, they provide little protection in dealing with other threats. For example, they do not mitigate the effects of freshwater flooding caused by extreme precipitation associated with hurricanes or other heavy rain events such as Hurricane Irene in 2011.

Second, in a constricted waterway such as the Long Island Sound, surge barriers may actually worsen the flooding impacts outside of the surge barriers because the water that is prevented from entering the protected area will be deflected elsewhere. Similar impacts would be expected along the Rockaway Peninsula. Unintended flooding impacts could result in other parts of Long Island, Westchester, Connecticut or New Jersey.

Third, since barrier systems must allow for the flow of water during times other than storm events, they also do not protect against coastal inundation that will result from sea-level rise. Some localized areas will be increasingly at risk of flooding during events that would not trigger closure of the barriers and some will eventually be permanently under water.

Lastly, storm surge barriers have major environmental and economic impacts that must be carefully studied. Surge barriers would have to be designed to prevent significant adverse impacts on physical oceanographic conditions in the harbor area, the aquatic life, sedimentation or erosion, shipping, and recreational uses in New York Harbor. The proposed comprehensive assessment must thoroughly review the benefits and drawbacks of surge barriers and their potential application in New York Harbor. Careful attention must be paid to how such barriers would be integrated with other natural and hard infrastructure systems around the Harbor and the region. The assessment must also incorporate input from the two affected jurisdictions (New York City and Long Island), as well as from New Jersey and Connecticut.

Coastal Resiliency (Rotterdam, Netherlands)

Netherlands has one of the world's most sophisticated coastal resilience strategies that integrate natural and hard protections. At the entrance to the Rotterdam harbor, the Eastern Scheldt Barrier is a storm surge defense built to withstand a 100-year storm. Further up the coast, an enormous deposit of sand known as a "sand engine" provides continual reinforcement for beaches and dunes. Behind these oceanfront systems are layers of redundant levees, berms, wetlands and green infrastructure that provide an additional layer of protection. A third level of protection is provided by resilient building practices, such as underground parking garages that can double as reservoirs for floodwaters. Further inland, the Room for Rivers program controls upland flooding through the creation of parklands that are designed to double as floodplains, which create an attractive locus for residential development. Together, the programs increase the total resilience of the shoreline to withstand a 10,000 year storm.

Figure L-16: Eastern Scheldt storm surge barrier in the Netherlands. (Delta Works Online, www.deltawerken.com)

Dredge inlets and address beach breaches on Long Island and the Great Lakes

Dredging schedule

The current inlet dredging schedule may not be frequent enough to ensure that coastal beaches and dunes are replenished. The State should establish a schedule to dredge inlets on a two- to four-year cycle and shift the sand to adjacent beaches to keep the beaches and dunes healthy. The health of the natural coastal system depends on the transport of sand along the shoreline by the

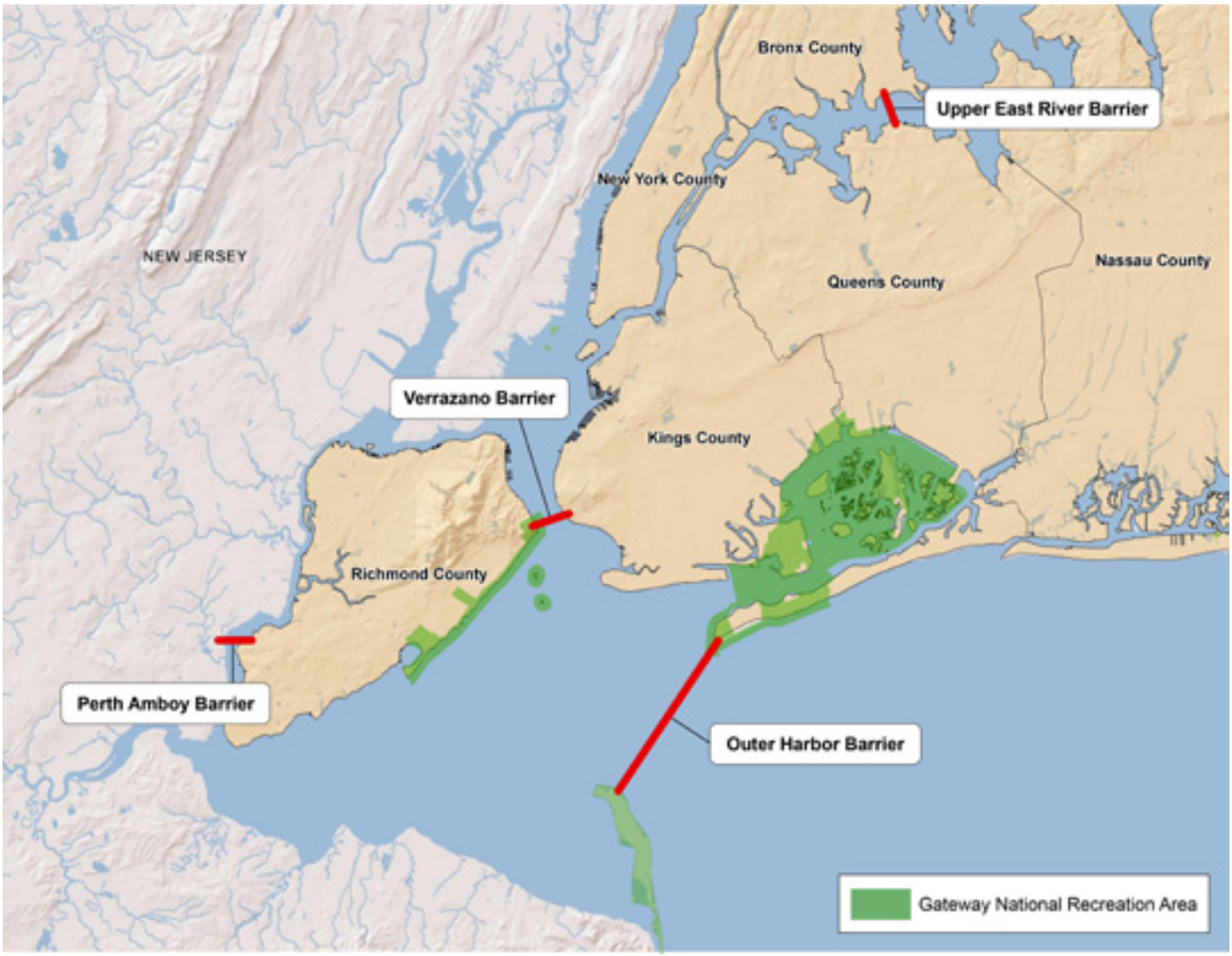


Figure L-17: Significant sections of New York could be protected from extreme storm surges and coastal flooding with three storm surge barriers (Perth Amboy, Verrazano, and Upper East River barriers). An alternative arrangement places a barrier between Sandy Hook, NJ and Far Rockaway, NY (Outer Harbor barrier). This would obviate the need for the Verrazano and Perth Amboy barriers, plus provide additional protection for northern New Jersey, Brooklyn, Queens, Jamaica Bay and the south shore of Long Island. (ASCE, 2013)

action of waves. However, inlets stabilized by jetties fill up with sand and they block its transport, resulting in the accumulation of sand in and around the inlet, where it can cause navigation problems and deprive beaches of sand. To remedy this over the short term, inlets and their shoals should be periodically dredged and the sand placed on the sand-starved beaches to address the incremental chronic erosion. Dredging on the larger inlets is generally performed by the U.S. Army Corps of Engineers, but usually for navigation purposes only. More routine dredging to address erosion will require State or local action. In addition to protection against storms, inlet dredging on the Great Lakes also protects the recreational boating and fishing industries.

Routine Review of the Breach Contingency Plan

Since the coastline naturally changes over time, our preparation for barrier island breaches must also be regularly reviewed and adapted, as necessary. The State and the U.S. Army Corps of Engineers should establish a regular cycle of review for the Breach Contingency Plan. This would

Jamaica Bay Salt Marsh Island Restoration (New York City, United States)

The ongoing collaborative effort to re-construct salt marsh islands in Jamaica Bay is an example of an effective program to construct protective natural infrastructure. This project has resulted in the reconstruction of 148 acres of salt marsh islands within Jamaica Bay. Many more acres of salt marsh islands should be reconstructed in New York Harbor and along New York's Atlantic coast.

Figure L-18: Jamaica Bay ecosystem restoration project. (NYSDEC)
Figure L-19: West Elders marsh restoration project using beneficial use of dredged material (NYSDEC)

These islands provide important storm buffering for the communities and public infrastructure in and around the bay. During Superstorm Sandy, the islands reduced wave action and slowed the speed of the current. Although these islands were ultimately submerged by Superstorm Sandy's stormwaters, they emerged unharmed, and are still providing their many benefits.

Figure L-20: Reconstructed Jamaica Bay salt marsh islands emerged unharmed from Sandy's flood. Left: Pre-Sandy, Right: December 3, 2012. (NOAA, 2012)

include evaluation of approaches to closure of breaches in the barrier islands, and the environmental, public safety, and property effects. The Breach Contingency Plan was prepared by the U.S. Army Corps of Engineers, New York State, and other federal partners in 1994 following the opening of a breach in Westhampton. Inaction allowed that breach to grow, and the cost for closure one year later exceeded $8 million. However, our understanding of breaches (which are new inlets) is constantly improving. We now recognize that these breaches are important transporters of sand into the bays, which allows new wetlands and eelgrass beds to start and provides a platform for the barrier islands to roll onto as sea level rises. Absent this platform, the barrier islands may drown in place. Further, new inlets can improve water quality in the bays.

Protect and restore coastal wetlands

Tidal and coastal wetlands protect upland areas from flooding and shorelines from erosion associated with storms. As such, their protection and enhancement must be a central part of a coastal resilience strategy. A typical tidal wetland is the salt marsh that is found in the near shore areas all around Long Island, the lower Hudson River, and in protected bays along the entire Atlantic coast of the United States. These areas are dominated by grasses and other marsh plants that are adapted to the rise and fall of the tide and the salt water the tide brings. Coastal wetlands are also found on the Great Lakes. They perform many important ecosystem services, including providing critical spawning grounds, nurseries, shelter, and food for finfish, shellfish, birds, and other wildlife. They also improve surface water quality by filtering, storing, and detoxifying wastes and provide valuable wildlife habitat.

If wetlands are unable to move upland as seal levels rise, they will be submerged and disappear. The State should review the Tidal Wetland Act to incorporate projections of future sea level rise and determine where protection of additional upland buffer areas would be appropriate.

The State should also consider increasing regulated buffers to at least 75 feet in New York City (already 75 feet on Long Island) and establish rolling buffers that will advance with the migration of wetlands. Permit and regulatory determinations should take into account sea-level rise, storm surge, wetland migration and flooding. In addition, the State and coastal communities should seek to reduce the barriers to wetland migration, including acquiring land in potential migration pathways and minimizing use of hard shore protection on bay shorelines.

The State should restore tidal wetlands along the coasts in coordination with federal, local, and private entities. These projects can be accomplished using U.S. Army Corps of Engineers or private funding from the creation of wetland mitigation banks. The Jamaica Bay wetlands restoration project serves as a model project.

Develop a Great Lakes coastal resilience strategy

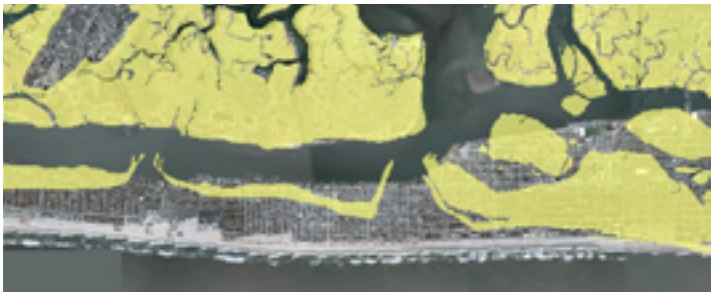
New York's "north coast" encompasses approximately 700 miles of shoreline along two inland seas, Lake Erie and Lake Ontario, and includes two international rivers — the Niagara and St. Lawrence. Built infrastructure along this coast suffers from significant storm surge inundation. Climate change is causing warmer lake temperatures, resulting in a decrease in winter ice coverage and thereby increasing the risk of flooding and shoreline erosion from powerful winter storms.

The State should develop a strategy to mitigate flood impacts on the Great Lakes while improving its overall ecology, including the following:

- Increase natural shoreline protections along the Great Lakes, including the construction of offshore artificial reefs, restored beaches, dunes, and habitat-friendly breakwaters to reduce storm surges and wave forces on unprotected shorelines. Proper management and restoration of coastal wetlands would increase flood water holding capacity.
- Conduct a coastal property vulnerability analysis. This would include an analysis of improvements to hard infrastructure protections for homes along the Lakes, as well as restrictions on the re-construction of public infrastructure and other buildings in high risk flood and erosion zones.

New York State has also recently been asked to support an international plan to raise water levels on Lake Ontario in order to promote wetlands restoration and a longer recreational season. Some commentators have raised concerns that increased water levels could result in slight increases in shoreline erosion, however the recommendations above would make the coastline more resilient regardless of whether the State supports the international plan.

1. Coney Island (1878 to 2011; 133 years)



2. Hempstead Bay (1880 to 2011; 131 years)

3. Point Lookout (1926 to 2011; 85 years)

4. Oyster Bay (1880s to 2011; ~131 years)

5. Tobay Beach (1880 to 2011; 131 years)

6. Bellport Bay (1875 to 2011; 136 years)

Figure L-21: Changing shoreline of Long Island from the 1870s to today.(NYS Division of Homeland Security and Emergency Services, 2012; NYS Office for Information Technology Services, 2012)

Reduce inland vulnerability to extreme weather events

The extreme weather of Hurricane Irene and Tropical Storm Lee devastated many upstate New York communities. Record rainfall triggered massive floods in 27 counties and wreaked havoc on the built and natural environments. As the climate continues to change, more rain will fall during intense storms and one- to three-month summer droughts will become more frequent.[11] Regions that were historically snowy in winter and only infrequently experienced ice storms in the past are now seeing less snow and more ice storms. Ecosystems that are already stressed will soon be further stressed by these extreme events.

To confront these diverse and serious challenges, the State must develop and maintain natural and hard defenses as an integrated protective system. Natural features, such as wetlands and streams, should be protected. Green infrastructure should be used to retain rain where it falls. The section "Protect coastal and Great Lakes communities" discusses recommendations to protect the public from the immediate dangers to wastewater infrastructure exposed by Sandy. Additional longer-term actions are identified here.

Protect and restore statewide freshwater wetlands

Wetlands, which include swamps and marshes, serve an important role in absorbing runoff from the landscape and slow floodwaters within stream and river systems.

New York State has over 2.4 million acres of freshwater wetlands — an astounding number, but as much as 60% below historical figures. While the State has slowed the destruction of wetlands in recent years, a significant number of wetland acres remain unprotected. The State should enhance wetlands protections in flood prone areas around the State.

Expand wetlands protections in flood prone areas

First, the State should update its wetlands maps in a narrow set of priority watersheds based on flood risk where possible. Most State wetland maps are seriously outdated and inaccurate, leaving hundreds of thousands of acres of unmapped wetlands vulnerable to destruction. Under current New York law, if a freshwater wetland is not formally mapped it is not protected or otherwise regulated by the State. One recent remapping effort in the New York City drinking water watershed found 12 square miles of completely unmapped wetlands in a 360-mile area.

Second, the State should consider a statutory amendment that would extend the scope of wetlands jurisdiction to cover wetlands that are smaller than the current 12.4-acre threshold if they are within an area at high risk of flooding. Small wetlands are a significant percentage of overall wetlands. New York can no longer rely on federal wetland regulations, as federal protections for smaller wetlands and headwater stream areas have been limited by recent court decisions on the scope of the federal Clean Water Act.

Wetlands protection efforts have been contentious in New York and across the country for decades. As a practical matter, the threshold size for wetlands protection and whether wetlands are mapped (and therefore protected) can affect real estate development opportunities and have local tax revenue implications. Therefore, any new mapping effort or changes to wetland jurisdictions to reduce vulnerability to storms and droughts must be narrowly targeted to address such critical objectives and will require extensive public education and engagement.

Create a wetlands and natural systems mitigation banking program to promote restoration

The contention over wetlands protection

Figure L-22: Destruction and damage from Irene and Lee (NYSDEC, 2011)

could be greatly reduced if the State adopted carefully designed wetland banking mechanisms.

While "mitigation" or "conservation" banking is not a new concept, it has not been widely used in New York. At the federal level and in other states, mitigation banking has been used on a patchwork basis to address freshwater wetlands, endangered species, impaired watersheds, and stormwater controls.

Portions of the Ohio River watershed, for example, employ conservation banking to meet water quality goals. The Willamette Watershed Basin in Oregon uses mitigation banking to offset a wide variety of impacts. North Carolina has a transportation-focused mitigation banking program (see North Carolina Mitigation Banking Program box). Following the success of these other states, New York could begin with a pilot program to test the idea's feasibility.

The bank would be created using a public-private partnership among project developers, regulators, and private investors, after public consultation with stakeholders. In exchange for permanently protecting the land or wetland, the bank manager could sell associated natural resource value credits to developers who need to satisfy legal requirements for compensating environmental impacts of development projects.

A New York State wetlands bank would help create a market for natural resource protection credits by enabling private investors and landowners to undertake environmental restoration and protection projects using private capital, thereby funding environmental protection projects that would otherwise go unfunded. The bank could expedite permitting and reduce overall costs of projects by providing readily available, preapproved mitigation measures or credits to address adverse environmental impacts associated with project developments.

Critics of environmental banking argue that it encourages development, providing an avenue to regulatory approval that did not exist before. On the other hand, under the status quo, development projects typically languish at the wetland-mitigation phase, during which a lengthy and expensive battle ensues, involving the regulator, developer, and environmental groups. The result has typically been that the development project goes forward after much delay and expense but with two undesirable outcomes: 1) a poorly formulated compromise wetlands mitigation requirements that are not likely to succeed and 2) frustration and unnecessary costs and delays faced by all parties.

A well designed environmental mitigation bank could produce better environmental and economic development results.

Provide protection for small streams across the state

The destruction of small streams and associated shunting of stormwater elsewhere exacerbates flooding in the same manner as the loss of wetlands or floodplains or the creation of new impervious surfaces. Small streams, like smaller wetlands, typically account for the bulk of the land area in a watershed and provide crucial stormwater attenuation. Under current law, minor streams (typically classified as "C" or "D") are at risk of damage when regulatory protection is not afforded them under State "Protection of Waters" laws. Of the 86,000 miles of streams in New York, 52,000 miles have no or limited State regulatory protection. As with many smaller wetlands, U.S. Army Corps of Engineers and EPA jurisdiction over such water bodies has been limited by federal court decisions.

The State should consider expanding the Protection of Waters Law to extend regulatory protection to minor streams in prioritized flood prone areas and include minimum regulated setbacks and buffers. This would enable the State to create a streamside buffer beside such streams where appropriate. Appropriate regulatory variance criteria should be developed to prevent undue hardships or protect other important economic or social interests.

As with enhanced wetland protections, new stream and watershed protections to reduce vulnerability to storms and droughts and to enhance the resilience of nearby communities will require extensive public education and engagement.

North Carolina Mitigation Banking Program (North Carolina, United States)[12]

North Carolina's mitigation banking program strives to restore and protect North Carolina's natural resources for future generations while supporting responsible economic development. In its operation, it helps public and private sectors to satisfy mitigation requirements for development projects. The initiatives offset unavoidable environmental damage from transportation-infrastructure improvements and other economic development, and help to prevent harmful pollutants from endangering water quality in sensitive river basins. North Carolina reports that, since 2003, there have been no delays in state Department of Transportation projects because of a lack of mitigation, facilitating over $14 billion in project implementation.

To date, the in-lieu-fees generated have funded 580 projects worth over $500 million to conserve, restore, or enhance 630 miles of streams, 30,000 acres of wetlands, and 680 acres of buffers and to remove over 1.5 million pounds of nutrients from their natural systems. An additional 50,000 acres of natural areas were preserved for future generations. Nearly 4,000 developers and partners participated and reported a 100% satisfaction rate.

Expand green infrastructure and urban forests

Further promote and expand green infrastructure

New York should promote a statewide effort for green infrastructure in an effort to slow the flow of stormwater and also to make cities more livable. Traditional hard infrastructure "end of the pipe" solutions to stormwater typically focus on draining water off the landscape as quickly as possible—something that exacerbates the water quality problems during flood conditions.

Green infrastructure uses engineered systems to mimic natural processes to infiltrate, evaporate, retain and reuse stormwater. Some typical applications of green infrastructure include green roofs, city parks, permeable pavement, rain barrels, vegetative planters that infiltrate water into soils, wetlands, roadside bioswales, drywells, and urban forests. Holding and infiltrating stormwater on the landscape is not only fundamental to peak flood hazard mitigation and preserving water quality, but also to aquifer and reservoir recharge for drought prevention. By holding or directing stormwater to absorptive vegetation, green infrastructure can help prepare urban areas for the effects of climate change, promote energy efficiency, improve air quality, provide natural habitat, and make communities more livable. This approach can also make cities more resilient by slowing stormwater runoff and reducing ambient air temperatures. Steps to promote green infrastructure should include the following.

Clean water regulations: Amend New York's clean water regulations to ensure that the state more fully incorporates green infrastructure practices into its clean water permitting and regulatory programs. This includes the regulatory programs to reduce levels of runoff into combined sewer overflow systems. The current programs encourage the construction of hard infrastructure solutions without coordinated consideration of green infrastructure. Communities such as New York City and Syracuse, with encouragement from the State, are re-deploying funds from combined sewer overflow ("CSO") grey infrastructure projects to more cost effective green infrastructure.

Stormwater management design manual: Update the New York State Stormwater Management Design Manual (the design criteria for both the "General Permit for Construction Activities" and "General Permit for Municipal Separate Storm Sewer Systems") to require the use of updated precipitation data in the design of stormwater management practices to ensure that runoff from new development mimics pre-development rates of runoff for design storms including the 100-year event.

Green infrastructure incentives: Incorporate increased green infrastructure incentives into the State clean water infrastructure funding programs operated by DEC ("Water Quality Improvement Program" grants, EFC ("Green Innovation Grant Program") and the Department of Agriculture and Markets ("Agricultural Environmental Management" program).

Linear practices: Develop protocols on incorporating linear green infrastructure practices, such as road-side bio-swales on state roads — serving as a model for action by counties and municipalities on their roadways.

Urban parks: Pilot the creation of innovative urban parks that are designed to serve as an absorptive and calming flood plain during high water. Such parks can increase the value of nearby properties. These parks have the added benefit of increasing nearby property values

Further promote and expand urban forests

Greening our cities with trees and other plants can help mitigate the effects of heat waves. Heat waves pose the greatest danger to human life in urban areas, where the urban "heat island" effect can cause parts of cities to be up to 10 degrees hotter than surrounding rural areas. The heat island effect is attributable to the large amounts of concrete and asphalt that absorb heat and tall buildings that prevent the heat from dissipating. Marginalized or disadvantaged communities already burdened by environmental challenges are often the most vulnerable to extreme urban heat conditions, due to less access to air

Figure L-23: Examples of Green Infrastructure – Green roof at SUNY Orange Newburgh Campus (Left), Kingston Library Rain Garden (Middle), and Bioretention at Vassar College (Right) (NYSDEC, 2012)

Save the Rain (Onondaga County, United States)

An excellent example of a New York community that has embraced green infrastructure is Onondaga County. The Save the Rain program (www.savetherain.us) is a comprehensive stormwater management plan that relies upon a suite of green infrastructure initiatives to beautify the City of Syracuse while reducing combined sewer overflow ("CSO") discharges into the Onondaga Lake Watershed. This nationally-recognized program is being undertaken in cooperation with the State as a cost-effective alternative to a series of large tanks and centrifuges proposed under a prior CSO reduction plan.

Figure L-24: Large green roof installed at "OnCenter" in Syracuse is a major project of the "Save the Rain" Program (Onondaga County, 2012)

Devastating Heat Waves in Europe

The devastating 2003 European heat wave resulted in perhaps more than 70,000 deaths across Europe as a whole, and over 14,800 deaths in France alone. Paris was hit the hardest, due to a roughly 8 degree heat island effect in that urban setting. The prevalence of heat waves will increase — both duration and intensity — over the coming years as a result of climate change. For example, the Northeast Climate Impacts Assessment report, "Confronting Climate Change in the U.S. Northeast" (2007), predicts that the number of days above 100 degrees in New York City each year will increase from an average of 2 days per year to at least 7 and as many as 25 days, depending in part on the rate of growth in GHG emissions.

conditioning, buildings with relatively poor insulation, and less green space. The State should pursue the following measures to promote urban forests.

Tree planting: Establish a goal of planting a significant number of trees per year in urban areas around the State. Tree planting is an integral part of a comprehensive strategy to combat stormwater runoff and urban heat. A single tree on an urban street can absorb 4,075 gallons of stormwater per year, preventing runoff that exacerbates flood conditions.[13] Tree canopies shade buildings, sidewalks, streets, and other structures, keeping them cooler, reducing air conditioning and other energy needs in the summer and reducing the overall urban heat island effect. Trees also remove pollutants from the air and soil and can shelter buildings from cold winds in winter months, reducing heating costs.

Tree repair: Tens of thousands of trees were lost to Superstorm Sandy in the downstate New York area. Help local communities repair damage by providing trees for replanting.

Carefully manage drinking water supplies

New York State's water supplies include reservoirs, rivers, aquifers, single streams and private wells. Although most of these are relatively resilient to the impacts of climate change, sea level rise, drought and storm events can threaten some drinking water systems. The Commission recommends the following measures to help protect New York State's drinking water systems.

Stream restoration program: Work with New York City to adopt a heightened and expedited watershed stream restoration program in order to stabilize and re-vegetate watershed streams. In New York City, 9.4 million people receive their drinking water from 19 upstate reservoirs and controlled lakes, which are fed to the city through hundreds of miles of water tunnels. This is one of the largest and purest unfiltered

supplies in the world. Recent storms caused extensive stream bed and bank damage with a resulting significant increase in suspended clay particles. If left unaddressed, this turbidity could threaten the "unfiltered" status of the city's drinking water supply under the federal Safe Drinking Water Act. Detailed stream management plans that are already developed would provide a specific blue print for implementation.

Aquifer protection: Enhance protocols to protect the Long Island Pine Barrens and similar deep flow aquifer recharge areas on Long Island. One important step in protecting the Long Island aquifer from saltwater intrusion due to rising sea levels over the long term is to maintain an adequate supply of clean rainwater and waterway infiltration while promoting the efficient use of withdrawn water for the three million people it supplies. Water supply permits, over time, should incorporate conservation protocols to maintain a sustainable water balance in the aquifer. The State should continue to monitor the slow process of saltwater intrusion to determine if additional steps are necessary.

Backup water supplies: Work with Poughkeepsie and the other cities that rely on Hudson River water to identify and assure adequate and redundant backup water supplies in keeping with current State regulations. Drinking water supplies that rely on Hudson River water are vulnerable to the northward migration of the tidal saltwater front — the shifting and imprecise dividing line between the freshwater upstream and the salt water migrating northward with sea level rise. This threat can be exacerbated by drought, which reduces the flow level of fresh water in the Hudson.

Identify systems: Identify the drinking water systems and aquifer systems that could be most vulnerable to drought, monitor the quantity of water in those systems, develop guidance on appropriate water efficiency measures, and identify alternative supplies. Drought can threaten smaller village drinking water systems that rely on a single stream or well fields for water. A long-term drought that substantially reduces the flow in those streams or localized aquifers could deprive thousands of people of clean drinking water. In addition, drought can also cause many of the more than one million backyard drinking water wells to be exhausted.

Water efficiency: Help municipalities control the infrastructure costs of their water systems by financing the installation of water meters and water-saving devices, and implementing other municipal water efficiency programs by providing interest-free loans to municipalities throughout New York. Water conservation programs can help communities reduce costs of infrastructure construction and make systems more resilient to drought and power outages. Such programs have been shown to reduce water use by up to 30%, save ratepayers money, support infrastructure investment, and provide savings to allow for economic growth without spending additional resources for water or wastewater capacity

Drought emergency: Enable the Governor to declare a drought emergency. In New York State, the Governor has very limited authority to regulate water use restrictions during times of even extreme drought. State agencies currently only have the limited authority to issue non-binding, staged warnings pegged to the severity of drought conditions. Local water utilities typically do a good job of controlling water usage. However, allocations and binding conservation practices can become the focal point of significant dispute in times of extreme scarcity. In order to ensure that critical public health and safety needs are protected, the Environmental Conservation Law should be amended to enable the Governor to declare a drought emergency. This would require the development of regulations that ensure systematic and equitable reductions of water use when necessitated by worsening drought conditions.

Strengthen dams and levees to protect the public from inland flooding

Natural systems can provide protections against flood waters, but only up to a point. As demonstrated by the extreme conditions during Irene and Lee, engineered defenses in the Southern Tier such as dams, levees, and berms provide invaluable protection to New Yorkers. The State should enhance these defenses.

The State manages 80 miles of levees and other flood control projects along inland waterways, including barriers which protect extensive portions of New York's Southern Tier. The City of Binghamton, for example, would have been inundated in during major storms in 1996 and 2011 if not for its system of levees and pump stations. These levees held during Lee and Irene, but sustained significant damage in some locations. Repairs are underway.

New York has over 700 dams that play an important role in flood control. In 2009, State dam safety regulations and engineering criteria were modernized in accordance with recommended national protocols. Many dams, including some owned by State agencies, require structural upgrades and detailed emergency response plans to become fully compliant. DEC conducted over 250 emergency dam safety inspections in the aftermath of Lee and Irene, with substantial damage identified for repair at some locations.

Unlike a natural flood, which spread across the landscape relatively slowly, a flood caused by levee- or dam-failure is often rapid, forceful, and extremely damaging, and occurs with little or no warning. In addition, levees and dams that have been in place for years can accumulate significant levels of sediment in the reservoirs that form upstream behind them. Flood waters released suddenly by a levee or dam failure can strip river systems of vegetation along banks, causing damaging shoreline erosion and channel incision, washed away wetlands, change to the structures of

Figure L-25: Batavia Kill Dam No. 1 with flow through emergency spillway eroding downstream bank during Irene (NYSDEC, 2011)

New York Works program for flood-control projects

Governor Cuomo has acted to address the risks posed by neglected dams and levees (highlighted by Tropical Storm Lee and Hurricane Irene) through his establishment of a $102 million "New York Works" fund to properly maintain the 106 levees and flood-control projects in New York, while bringing dozens of State-owned dams up to modern safety criteria. While they do provide some protection, many of the levees, which were often designed and built some 50 years ago, are significantly undersized relative to the existing and projected flood risks. The structural enhancement of existing flood control dams, levees, conduits, and the like should be considered as part of a package of potential actions to address peak flood risks.

rapids and river contours, changes in water temperatures, turbidity and sedimentation in water, and release of toxins potentially stored in impounded sediment.

The Commission recommends that the State should consider the following actions:

Dam safety criteria: Revise State dam safety criteria and associated flood inundation zones to ensure that they are adequate under extreme weather scenarios. The 2009 regulatory changes should be revisited to take into account the long-term impacts of a changing climate.

Levee adequacy: Review the adequacy of flood protections afforded by levees under their current and sometimes substandard design. While strengthening these levees could be extremely expensive, the State and the U. S. Army Corps of Engineers should assess the need for levee expansion projects where a range of alternative flood-hazard mitigation measures would be insufficient to provide adequate protection of high-population areas. These projects could be integrated into long-term capital planning to protect communities against flooding.

Protect and secure petroleum, chemical, and hazardous waste tanks located on waterways

Flooding and storm surge events pose risks to oil, chemical and hazardous waste tanks and containers located in areas subject to flooding. If these tanks and containers are improperly designed, constructed, and maintained, flood waters can cause partial or total failures, leading to contamination of flooded areas and posing risks to public health and the natural environment.

Sandy alone resulted in over 4,400 identified spills, mostly from residential heating oil. Surge damage to several large oil storage facilities in New Jersey resulted in spills and in one case, a spill of over 100,000 gallons.

The State should review the relevant code provisions and regulations to ensure the resilience of large tanks within the 500-year flood plain. Presently, State law requires only new or substantially damaged structures to have their oil tanks elevated 1 to 2 feet above the 100-year flood level. The State should update requirements applicable to all tanks located in the 500-year flood plain in order to ensure that tanks or containers used to store hazardous materials/waste in flood zones are installed and operated so as to prevent releases to the environment if flooded. Possible approaches include protecting tanks from water infiltration and damage from moving water, and ensuring that containers used in flood zones are designed not to release their contents when they float or are immersed.

City of Binghamton Bulk Storage Facilities in Flood Risk Areas (Binghamton, United States)

After Tropical Storm Lee, the Susquehanna River area was deemed a public health emergency and flooding of the river was responsible for environmental spills at 731 sites. Contractors were hired at 580 sites for remediation work. Sewage treatment plants were inundated, incapacitating or damaging 124 in Pennsylvania and another 35 in New York. Diluted sewage was swept downstream.[14] Damage to the Broome County sewage treatment plant is estimated to be nearly $25 million and the mitigation measured to substantially protect against future flooding has been estimated to cost $12 million.

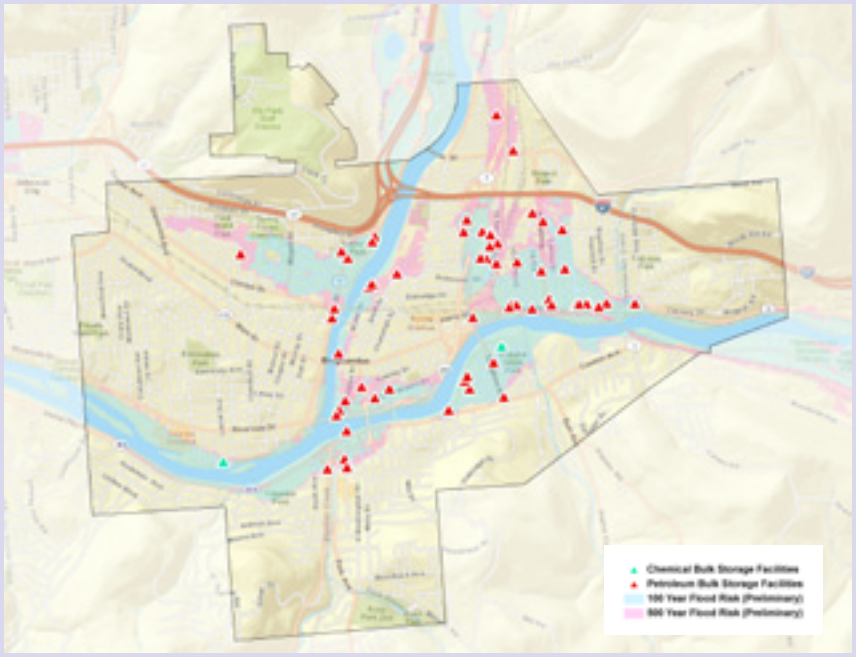


Figure L-26: Map of bulk storage facilities in flood risk areas in Binghamton, New York. (FEMA, 2012; NYSDEC, 2012)

Strengthen wastewater infrastructure

Wastewater treatment is a critical part of the state's infrastructure and an important factor in preserving public health. New York has over 600 municipal sewage treatment plants, 2,500 pumping stations, and over 1,000 associated collection systems that together handle over 3 billion gallons of sewage and industrial wastewater every day. This infrastructure comprises pipelines and pumps that transport wastewater from homes, buildings, and factories to treatment plants, where sewage is treated and effluent is discharged into New York waters.

Sandy, Irene, and Lee wreaked havoc on the State's wastewater water infrastructure. Surging floods from Sandy alone knocked out power and operations at dozens of wastewater treatment plants along the coast, leading to the discharge of hundreds of millions of gallons of raw sewage into waterways. The section "Protect coastal and Great Lakes communities" discusses recommendations that are necessary to protect the public from the immediate dangers to wastewater infrastructure exposed by Sandy. While these measures will strengthen some parts of wastewater infrastructure, there are additional vulnerabilities in wastewater infrastructure that exist without the effects of climate change, and which are exacerbated by extreme weather events.

Most critical wastewater infrastructure was built in the 1970s and early 1980s. These facilities were overwhelmed before the impacts of climate change became evident, with an estimated cost in excess of $36 billion for repairs and standard maintenance projected over the next 20 years.

Require installation of disinfection systems in certain plants

Wastewater treatment plants should have sufficient backup power to maintain disinfection and to minimize environmental damage during storm events. A major health hazard was averted in the aftermath of Superstorm Sandy because many of the downstate treatment plants were able to disinfect partially-treated waste discharges. However, many municipal wastewater treatment plants are not equipped with disinfection capability, nor are they required to disinfect their effluent. Despite the public health benefits, municipalities are often slow to adopt disinfection practices, mainly because of the cost of the disinfection systems. The cost for full implementation of disinfection systems at the 180 municipal treatment plants that do not currently use disinfection is estimated to be $245 million.

The State should require disinfection systems with backup power at priority facilities across the State based on such criteria as plant size, proximity to drinking water supplies, and the scale of human contact with the receiving waters. The State could require such disinfection as a condition for receiving State financing for such infrastructure. This approach would avoid imposing statewide unfunded mandates.

Update design standards for wastewater systems and treatment plants

Many systems and treatment plants are currently located in coastal flood plains, areas subject to sea level rise, or inland flood plains. The State should set a goal of building or upgrading vulnerable wastewater treatment plants and collection systems to continue functioning in 500-year flood events, taking into account anticipated sea level rise. The State should work with those municipalities in such flood plains and other stakeholders to modify design standards to ensure that they provide an adequate level of protection from storm events and rising waters. In addition, the State should develop criteria for when plants undergoing reconstruction should be relocated from untenable locations if feasible.

Improve long-term maintenance and planning

The State should assist municipalities with the development of engineered facility asset-management plans to address extreme storm vulnerabilities and system resilience. Asset management planning at wastewater treatment plants and other heavy industrial facilities has gained recognition across the world for its effectiveness in maximizing the value of capital, as well as operations and maintenance expenditures. Through an asset management plan, critical assets that are necessary to maintain proper operation of a treatment facility during a severe storm can be better maintained and protected to increase the resilience of the system. These asset management plans provide a blueprint for specific structural resilience measures to protect costly infrastructure and a mechanism to manage this infrastructure using facility revenues. Plans would address all elements of wastewater and drinking water treatment systems, including energy and water efficiency and standard maintenance practices. A plan would provide a complete inventory of a community's hard assets, such as miles of sewer pipes and pumps, as well as human and financial assets for operation and maintenance of the facility. The plan would also identify the criticality of each asset to the treatment system performance, along with its vulnerability to damage by storm events. Whether such plans are required by the State and/or the State provides assistance to develop such plans, they should be a priority for State action to protect these systems.

Bay Park sewage treatment plant flooding (East Rockaway, United States)

The Bay Park Sewage Treatment Plant (STP) is located in southern Nassau County and serves a population of approximately 550,000 residents. The Bay Park STP stopped operating during Superstorm Sandy when the plant was flooded by a 9-foot wall of water pushed ashore. The plant was off-line for approximately 58 hours. It is estimated that sixty-five million gallons of partially treated sewage from the plant overflowed into the Reynolds Channel portion of Hempstead Bay.Statewide, twelve wastewater treatment plants reported flooding and ten released partially treated or untreated sewage because of Sandy.[15]

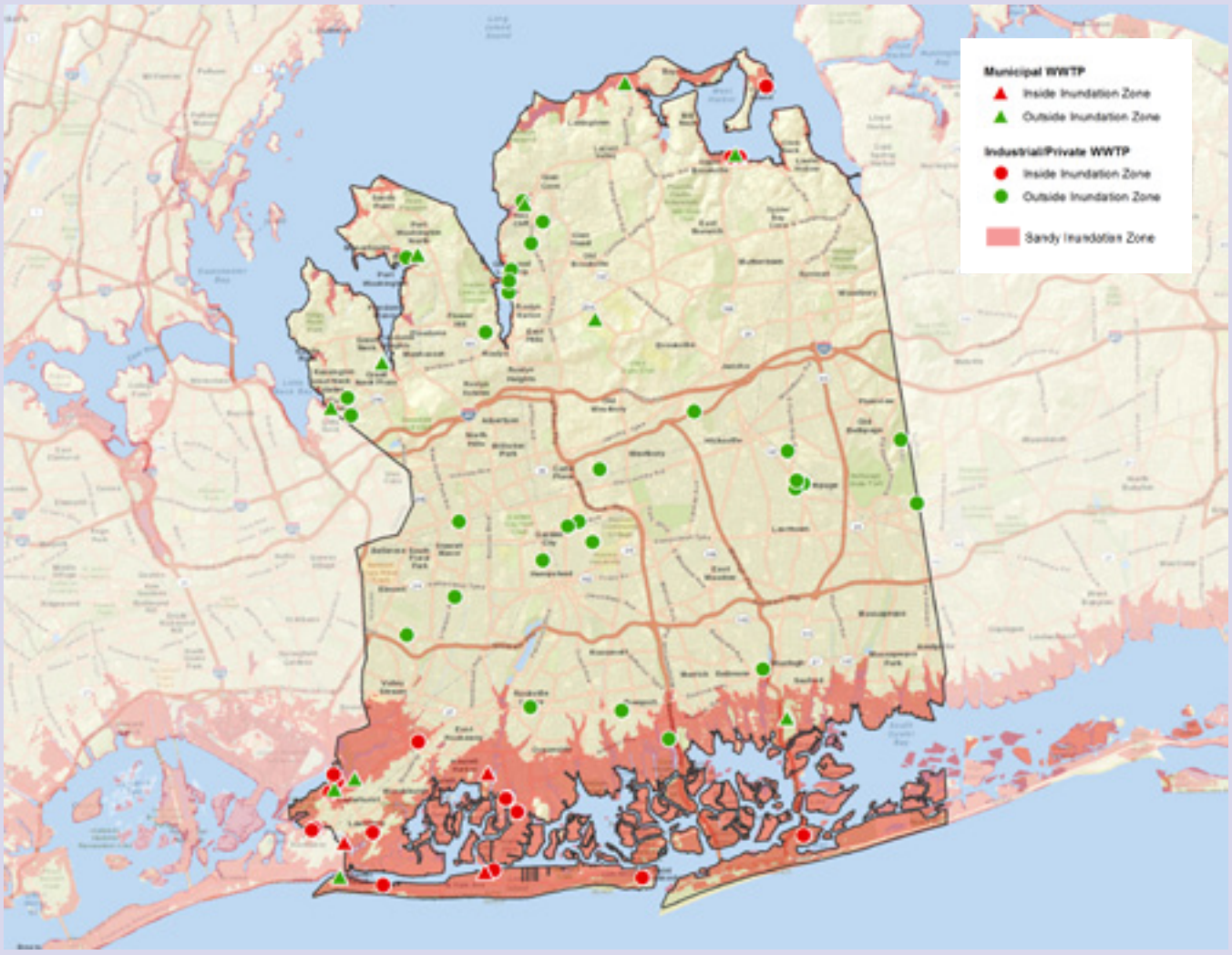


Figure L-27: Wastewater treatment facilities and Superstorm Sandy inundation zone in Nassau County (FEMA, 2012; NYSDEC, 2012)

Develop probabilistic hazards and risk mapping

Hazard maps for flooding and storm surge serve a fundamental purpose of warning individuals, businesses, and governments of a significant potential for harm to persons, property, and critical systems — health, transit, electric, information, levees, and clean water. This information is fundamental to considering the range of protective actions that may be taken for any particular activity or at any particular site. Hazard mapping also provides an important foundation for policy decisions on which criteria should be used to foster resilience through laws, engineering standards, building codes, insurance rates, grants, community plans, and the like. As our weather is dynamic and changing, the risk maps will need to be regularly adjusted to reflect available information. The maps will also need to recognize a significant level of uncertainty in any risk projection — so that a safety margin is incorporated to prevent a false sense of security.

The Federal Emergency Management Agency (FEMA) will soon release updated Flood Maps, with the familiar 100-year and 500-year inundation lines, many of which were outdated. The State should assess those maps to determine whether it may be necessary to incorporate an additional margin of safety into in certain cases to protect inland areas. This margin of safety should recognize the level of uncertainty with any such risk prediction and incorporate such factors as increased precipitation and wind associated with climate change.

The State's Coastal Erosion Hazard Area maps are complementary hazard reduction maps. Under State law, these maps operate to limit the potential for structures to be built in highly dangerous erosion and inundation hazard areas along the Atlantic Ocean, Long Island Sound, and the Great Lakes. These maps also operate to prevent construction on coastal dunes, beaches, and bluffs. They were last updated in the early 1980s and are in the process of being updated statewide. Given the protective function served by natural coastal structures, the Commission recommends that the State finish updating and publish the revised Coastal Erosion Hazard Area maps and the associated regulatory program as soon as is practicable.

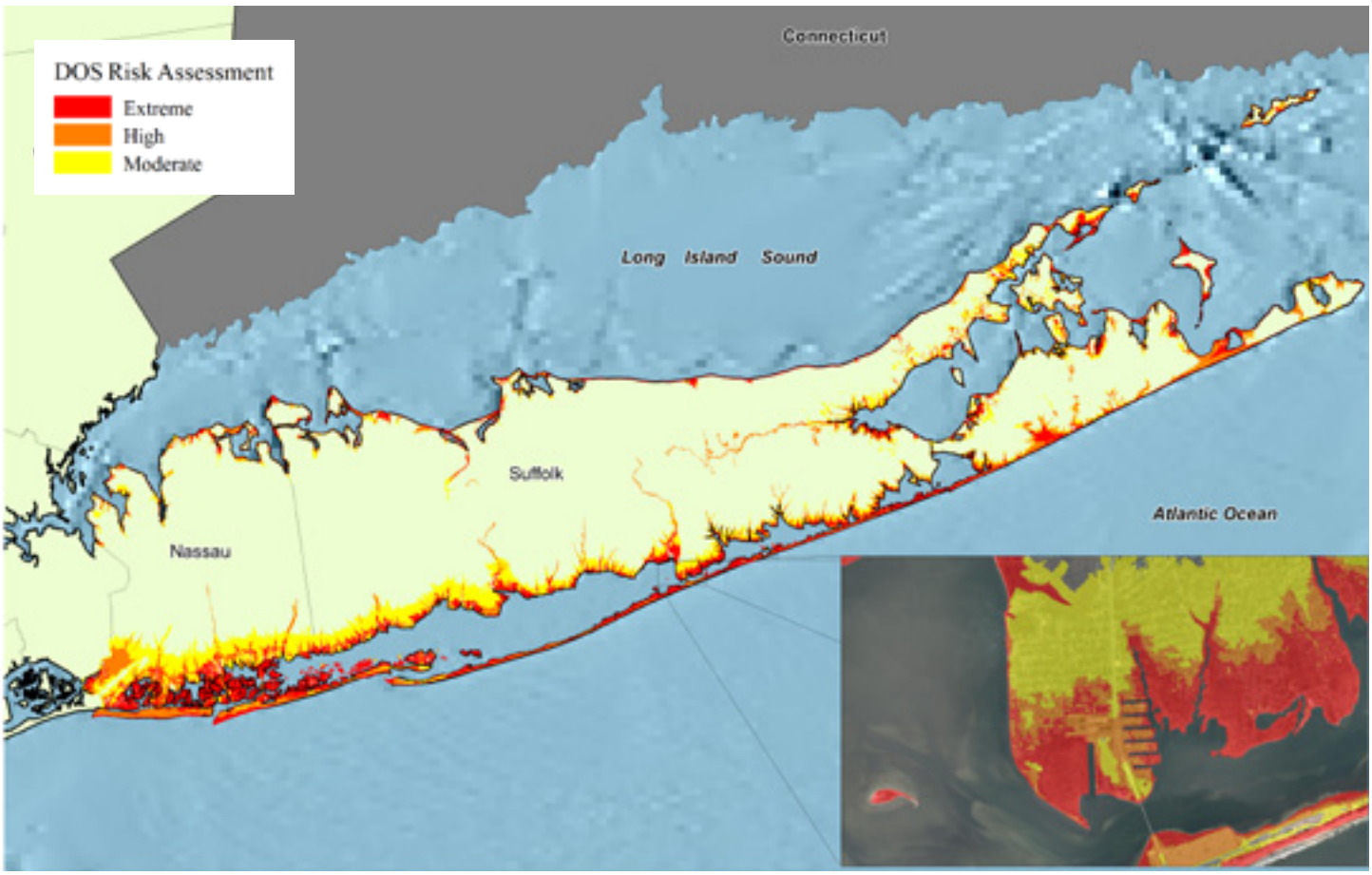


Figure L-28: NYS DOS Coastal Risk Assessment Areas (NYSDOS, 2012; NOAA CSC, 2012)

In addition to updating regulatory maps, the State is developing maps for regional coastal resilience planning, in collaboration with the National Oceanic and Atmospheric Administration (NOAA) and FEMA, combining regulatory and probabilistic criteria. The Commission recommends the use of such probabilistic mapping products, using compiled model results, for example, that look ahead to estimates of sea level rise, potential storm surge heights, and other elements that contribute to future hazard levels. Some of this probabilistic mapping work is underway, particularly the development of a coastal risk assessment map layer, which results in a conservative estimate of coastal areas susceptible to extreme, high, and moderate inundation risk. To ensure that the best available information is used in future risk assessment mapping, all flood inundation prediction models and information used by those models need to be updated and modernized. A 2009 report "Mapping the Zone – Improving Flood Map Accuracy" by the National Research Council of the National Academies for FEMA and NOAA emphasizes the importance of accurately reflecting current topographic and bathymetric data, incorporating both surge and wave action along the coast and risks to users.

The Commission further recommends that an expert working group be established to 1) update the mapping criteria to take into account probabilistic forecasts of climate change; 2) present the maps in a manner that allows individuals and communities to understand and visualize the full scope of the risk; 3) provide mapped information layers of critical infrastructure elements or systems at risk, taking into account security considerations; and 4) develop a web-based and structure-specific inundation warning system to provide the type of information that facilitates evacuation and individual actions to protect valuable possessions — an alert system that has been found to reduce property damage by up to 30% for warned individuals.

Invest in stream flow/rain gage and groundwater monitoring

United States Geological Survey (USGS) stream gages are used by federal and state officials to monitor the flow and supply of water. Gages that monitor water flow and supply are typically operated by USGS in partnership with the State.

During Hurricane Irene, USGS stream gages provided immediate data indicating dramatically increased precipitation and flood rates above those contained in warnings provided by the National Weather Service. These gage readings, connected via satellite and internet, prompted emergency service alerts in Green and Schoharie County that allowed alerted individuals to evacuate to higher ground. Stream gages and rain gages provide information used to regulate major dam releases under emergency conditions and to time the operation of flood control gates and pumps within New York's 106 flood control projects. These gages, along with ground water monitoring wells, also provide the basic information to assess drought and drought emergency conditions. The data provided by these gage systems are fundamental to understanding changing weather conditions, flood and inundation levels, and storm characterizations associated with climate change.

The Commission recommends that the State work with the USGS to expand the stream gage program to ensure for the sufficient placement of gages in flood prone areas. These gages serve as the information backbone to any effective National Weather Service or State-initiated flood early warning system that may be developed in the future.

Strengthen land use programs, standards, policies, guidelines, and procedures

A combination of changes to land use planning processes and new tools may better address the range of effects of climate change. Building for a resilient future will require incorporating climate data and projections into existing planning and decision-making processes, risk assessment, investment prioritization, and mitigation measures.

Regional resilience strategies will identify community assets at risk in order to permit the coordination of individual municipal-level actions on a larger scale. Environmental impact reviews can be updated so that future projects or activities properly consider adaptation and resilience to climate change impacts. Land use policies can account for climate change effects and incentivize proper development and smart growth.

The Commission recommends that the State:

- Develop regional resilience strategies
- Update State Environmental Quality Review Act processes
- Establish new land use policies

Develop regional resilience strategies

New York is a "home-rule state" — through enabling legislation, local governments may enact laws and ordinances governing allowable land uses within the bounds of State and federal laws. Municipal land use controls, primarily in the form of zoning regulations, are established and policed by the local legislative body. Therefore, municipal governments hold individual powers to determine the mechanisms by which land development and management are addressed. Furthermore, municipalities own and control infrastructure within their communities and may be able to establish criteria in allocating funding resources for new projects, maintenance, and repairs.

However, climate change affects a larger regional area, and to be effective, individual municipal-level actions should be coordinated on a larger scale. This coordination will encourage compliance, avoid "downstream" adverse effects of one community on another, take advantage of scale economies in certain circumstances, and avoid companies and developers from "venue-shopping" for the least protective jurisdiction.

The Commission recommends the State support the creation of integrated regional resilience strategies in all regions of the state and that it do so in close cooperation with local and federal governments, Regional Economic Development Councils, and other public and private stakeholders. These strategies will assist each region with the identification of community assets at risk to the effects of climate change, including storm surge, sea-level rise, inland flooding, and heat and drought. The regions will then develop site-specific strategies to address those risks.

The Commission further recommends the State first develop regional resilience strategies with the coastal area communities on the Atlantic Ocean, Long Island Sound, New York Harbor, the Great Lakes, and the Hudson, Niagara, and St. Lawrence Rivers. With almost 90% of the state's population living in coastal areas, long-term resilience strategies must be developed for all of them, not just those damaged by Sandy. Long-term community recovery efforts are already underway in the upstate communities severely affected by Hurricane Irene and Tropical Storm Lee. As with the New York Harbor resilience strategy above, the regional coastal resilience strategies must integrate restoration and enhancement of natural systems, hard structures, and land use controls to achieve multiple benefits.

New York State should encourage and incentivize municipal scenario planning processes. This effort will help communities and regions develop the strategies needed to minimize further risk. In support of the scenarios exercise, maps and interactive tools should be developed to illustrate different hazards (wind, storm surge, flood, drought), what areas are at risk from these hazards, current and projected land uses, population density, critical infrastructure, and other needed geographic information.

Scenario analysis provides a straightforward process for evaluating risk to human, environmental, and economic assets from coastal storms and sea-level rise and other risks. It would provide the information needed to determine where action is needed the most, select complementary land use and hazard-mitigation measures, and formalize a long-term adaptation strategy to effectively manage storm impacts. Communities would be able to adapt structural development in the coastal area over the course of time and conserve, restore, or create natural systems to improve safety and livability.

Incorporating resilient adaptation into development, infrastructure, and post-storm recovery decisions is a cost-effective way to reduce risk and preserve the flexibility needed to address changing conditions over time.

Update the State Environmental Quality Review Act to incorporate resilience

The State Environmental Quality Review Act (SEQRA) requires all State and local government agencies to consider environmental impacts during discretionary decision-making.

The Commission recommends that the State require lead agencies to assess climate change adaptation and resilience measures, as well as actions to mitigate climate change, as part of their SEQRA environmental impact review. To accomplish this, the State would have to amend its SEQRA Handbook to include such a requirement. The State should also ensure that its SEQRA "workbooks" make clear that adaptation and resilience to climate change should be properly considered when determining the significance of an action under SEQRA.

These changes to SEQRA guidance should not add time or significant expense to the environmental review process. But they will help to ensure that new projects contribute to, rather than undermine the State's preparedness for severe climate impacts.

Establish new land use policies to account for climate change effects

New York and its citizens should pursue climate resilient land use policies that incentivize appropriate development and smart growth strategies; in some instances, these strategies should include encouraging property owners to avoid building in highly vulnerable areas. In the wake of Sandy, questions regarding rebuilding in vulnerable areas have inevitably been raised. While keeping people and infrastructure from vulnerable areas is one of the most effective means of eliminating flood risks, there are practical and policy reasons which make this strategy extremely difficult to implement. Clearly, this is not a strategy that the State or local zoning boards can dictate in isolation. Rather, all parties must be become better informed and accountable when it comes to deciding whether, where and how best to rebuild.

The realities of post-storm recovery present an opportunity for communities and individuals to reevaluate previous decisions about where and how to build or rebuild. This reevaluation will involve taking a hard look at the balance of risk and beneficial use of any particular property. In addition to private decisions, public authorities can create opportunities, programs, and incentives to assist communities and individuals who are interested in realigning and relocating buildings and infrastructure this would be an important step out of vulnerable areas. This would be an important step to moving New York towards a more resilient future.

Accordingly, there may be circumstances where a strategic coastal realignment strategy is appropriate and practical. In some instances, this will occur as a result of the landowner's choice, perhaps driven by difficulty in obtaining flood insurance or mortgages. There are a number of options for private and public infrastructure, ranging from physically moving a building to a different location on the same property to the outright acquisition of a property from willing sellers.

While direct acquisition of vulnerable properties along the coast can be prohibitively expensive, there are a number of federal, state and local land acquisition programs that can be used to pursue such opportunities. Additionally, a variety of tools are available to facilitate voluntary acquisition of vulnerable coastal property that should be considered in appropriate cases.

The Commission recommends the State should consider each of the following actions.

Land exchange: A land exchange allows an agency to transfer property it owns in exchange for another property. In most situations, there is a direct exchange of one parcel or group of parcels for others at the same time. Depending upon the appraised values of the two properties, sometimes they are equalized with cash or a donation from the non-public landowner. A program for land swaps has already been implemented in Suffolk County.

Retained use and occupancy: A retained use and occupancy means that the landowner sells the property but remains in possession for a period of time after the sale. The landowners are paid the full fair market value of the property minus a deduction based upon the number of years they will remain in possession. Periods of retained use can be established either based on a term of years or the lifetime of a living person. Typically, structures that are destroyed during the retained occupancy cannot be rebuilt.

Land bank: The basic idea of a land bank is that land ownership is converted to "credits" which can be bought, sold and exchanged more efficiently and flexibly than occurs through traditional purchase and sale procedures. Current values are determined through market forces, which can be more responsive to changing land prices than the routine government appraisal, funding authorization and closing processes. Lands are allocated a number of credits, determined by an established approach, such as acreage, number of units permitted under existing zoning, environmental constraints, etc. All lots with similar characteristics are allocated the same number of credits. Landowners can withdraw an equal, or in some situations, even larger number of credits, in return. The credits then allow development to occur on the parcel withdrawn.

Purchase of Development Rights and Transfer of Development Rights: Under a Purchase of Development Rights program, a landowner voluntarily sells his or her right to develop a parcel of land to a public agency or qualified conservation organization. The landowner retains all other ownership rights attached to the land, and a conservation easement is placed on the land and recorded on the title. Transfer of Development Rights programs allow development rights to be directed away from one parcel of land — presumably not well suited for development — to another site more appropriate for growth.

New York's Open Space Program: New York uses its Open Space Program to protect and conserve existing natural systems that provide important protection against severe weather events. The State could require that natural systems are not adversely impacted before permitting development in areas identified in its Open Space Program. Any unavoidable impacts should be mitigated and, where possible, construction should be built according to codes that provide for resilience from climate impacts.

State-funded economic development projects: The State should update its selection criteria and contract conditions

for economic development project funding to incorporate resilience against climate change. For more information on integrating resilience and capital investment criteria, see the finance recommendation on adopting a standard set of criteria for project selection and prioritization.

State-funded infrastructure on developed land: The State should target infrastructure funding in previously developed areas or areas specifically designated for growth. Controls can be established that serve to discourage State-funded infrastructure development that enables sprawl or eliminates valuable green space that has been identified as critical for climate resilience. For example, the New York State Energy Research and Development Authority selection processes for grant monies under its Cleaner, Greener Communities Regional Sustainability Planning Program[16] can incorporate resilience criteria into the grant selection process.

Smart growth benchmarks: New York should use its 2010 Smart Growth Public Infrastructure Policy Act to align project investment with State policy regarding climate change resilience. The Act requires publicly-funded infrastructure projects, which are financed or supported by a designated "State Infrastructure Agency" to be consistent with smart growth criteria specified in the statute. This includes elements directly relevant to climate resilience, including the promotion of sustainable planning in new and existing communities and the prioritization of projects that maintain or improve existing infrastructure. To align agency-based selection criteria with the State's overall climate adaptation and mitigation policy goals, statewide criteria or benchmarks for public infrastructure resilience and mitigation should be issued via Executive Order or through regulation for application by individual agencies. This approach should result in the discouragement of use of State funds to build infrastructure, such as roads and utilities that would bring growth to high hazard areas. The State should encourage local governments to include the use of construction setbacks and non-structural buffers into local zoning to further protect infrastructure located near high-risk areas.

Land acquisition: New York State should acquire and protect land that may be prone to damage from climate effects, as well as land that may buffer or protect other lands from these risks, using a similar approach to New Jersey's current Blue Acre Program.[17]

None of these approaches will be appropriate in every place. But as each community plans to improve its resilience and protect against future threats, the State should make information about such voluntary options available to communities to consider in their planning processes. In addition, the State should review existing laws to ensure that these voluntary options are available and are not precluded by law, and that it has taken advantage of its capacity to provide all possible incentives at its disposal.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Insurance

Overview

In the past two years, New York State has experienced a tropical storm, a hurricane, an ice storm and other extreme weather events. Occurrences that were once seen as out of the ordinary are now becoming the new normal. Risk avoidance and mitigation strategies, such as those recommended throughout this report, reduce the extent of future losses and are thus the first priority of New York State. However, we cannot prevent these events and no state can fully insulate itself against their effects. Insurance, therefore, must also play a key role in ensuring the resilience of New York State and its residents to extreme weather events like Superstorm Sandy. Insurance can be used to manage risks at many levels: to provide coverage to individual homes and businesses, to safeguard public infrastructure and to help the state overall anticipate, plan for and manage losses from future shocks.

The Commission identified a range of insurance-based recommendations designed to help individuals and the State manage climate-driven risks. Broadly speaking, these recommendations fall into two distinct areas. The first pertains to protecting the state as a sovereign entity and its infrastructure assets, and the second to helping protect individual residential and commercial policyholders in the event of a natural disaster. The latter can be further subdivided into recommendations that reduce underinsurance and promote coverage in normal times, and catalyze actions that will help to protect consumers in post-disaster circumstances such as those experienced in the wake of Sandy.

The Commission has grouped its recommendations into two areas:

1. **Protect New York State** and enhance its ability to rebound from devastation. The resilience of the State not only depends on the severity of any catastrophic event, but also on available funding for relief, recovery, and reconstruction. This section describes actions the State can take to manage risk holistically and protect itself against financial shocks arising from large losses from disaster.

2. **Protect consumers and business** and mitigate risk to individual policyholders. This section highlights actions the State could take to reduce underinsurance and promote coverage in normal times, as well as actions that would help to protect consumers in post-disaster circumstances.

Within each of the areas, recommendations include short-term steps based on lessons learned from recent events; medium-term projects that require more extensive planning and development; and long-term solutions that require systemic planning, process refinement, and implementation.

Protect New York State

This section provides a description of the insurance recommendations designed to protect and mitigate risk to New York State as a sovereign entity, including to its infrastructure. The State shoulders most of the cost of relief and recovery efforts at least in the first instance, such as administering first aid, providing emergency supplies and clearing roads. The consequences are wide-ranging. Broken-down infrastructure and slow repairs can have costly secondary effects, such as lower economic growth and shortfalls in (future) tax revenues. This, in turn, can further slow rebuilding efforts, creating a vicious cycle. The faster a state can return to its normal state of affairs, the smaller the long-term impact of a disaster. The resilience of a state – or its ability to rebound from devastation – not only depends on the severity of the catastrophic event, but also on available funding for relief, recovery, and reconstruction. These include actions the State can take to manage risk holistically and protect itself against financial shocks arising from large losses from disaster.

We propose two key actions to help the State achieve this goal:

1. **Promote State-level risk management:** New York State should integrate and coordinate risk management functions across different government agencies in order to help the State identify, prioritize and prepare for risks and optimize the allocation of risk management resources.

2. **Consider options to pre-fund disaster recovery and transfer catastrophic risk to the insurance and capital markets:** New York State should study options to transfer catastrophic risk to non-state entities, including to the insurance and capital markets through purchase of sovereign insurance (or "macro-insurance") instruments to prefund disaster recovery and protect the State from large losses.

Promote State-level risk management

By identifying and assessing the likelihood and consequences of potentially disastrous events, risk assessment provides government with the basis for prioritizing investments in risk reduction, improvement of emergency management and design of financial protection strategies in a manner that addresses local conditions, needs, and preferences. The results inform and educate stakeholders about the most important threats society faces.

A holistic governmental approach helps to assess the full spectrum of risks and identify gaps in risk ownership and preparedness. A continual process should be documented, monitored and regularly re-evaluated over time. This requires the aggregation of assorted information and interdisciplinary findings, along with scenario building and simulations, which can be supplemented by expertise from a wide range of disciplines and countries. Data repositories on hazards, exposures, vulnerabilities and losses enhance the accuracy of risk assessment, contributing to more effective measures to prevent, prepare for and financially manage disasters. Integrated risk management approaches can help states identify and prepare for risks and optimize the allocation of risk management resources. An "all hazards approach" demands a high-level of coordination across public agencies and even private sector bodies.

Across many governments, the risk management function is prevalent, but often cordoned off in different agencies with little interaction or consideration for initiatives across sister agencies. A State-Level Risk Officer (SRO), or a unit in which risk management across agencies was consolidated, would act as a coordinating entity to eliminate redundancies, enhance cooperation and reduce budgetary costs to the State. The SRO would lead the comprehensive integration of risk management by consolidating the currently segregated processes.

Additionally, the SRO would communicate the risk landscape to the Governor and individual State agencies, and the general public, and steer mitigation efforts to address the most significant risks. The SRO would also be in a position to advise the State on sovereign risk management strategies, such as those described below and in previous sections of this report. The SRO would also be in a position to advise the State on sovereign risk management strategies, such as those described below and in previous sections of this report.

Consider options to pre-fund disaster recovery and transfer catastrophic risk to the insurance and capital markets

Traditionally, the public sector has adopted a post event approach to disaster funding. The federal government has played a substantial role in providing assistance for disaster recovery. Important additional sources of funding have come from increasing taxes, reallocating funds from other budget items, and accessing domestic or international credit.

In addition to the critically important federal support after natural disasters, New York State should consider tapping new sources of funding for disasters. The financial and insurance markets can play a key role in preparing for the impact of extreme natural events and can also help to diversify risks. Transferring catastrophic risk to the private sector can be a key element in the financial strategy of a disaster-prone region, similar to the way that corporations and individuals pass on peak risks to insurers in order to reduce financial volatility and avoid exposure from events that exceed their resources.

A new generation of sovereign insurance (or "macro-insurance") instruments can make it easier for governments to cope with disasters. Such products can help governments and individuals in a number of ways, including the following:

- Ensuring that funds are in place for recovery and rebuilding efforts as well as to compensate victims of catastrophic events;
- Protecting their budgets and reducing financial volatilities;
- Providing greater financial security in the face of changing economic circumstances, reducing distress and conflict; and
- Providing the State with an independent market-based and market-validated pricing of risk to inform the State's risk management strategies.

Such insurance products are already being used by government entities in the United States and around the world (see case study box).

To be sure, this type of insurance may not be appropriate in certain circumstances. It requires an outlay of premiums that must be weighed against other budget priorities and against the value of self-insuring against disasters. To assess these benefits and weaknesses, New York State should study options for transferring catastrophic risk and whether New York should include the insurance and capital markets by purchasing sovereign insurance (or "macro-insurance") instruments to pre-fund disaster recovery. In evaluating this and any other type of solution, the State's risk analysis should include evaluation of both the probability of future natural disasters and the size and timing of costs to the State, relative to expected and unrecovered losses.

MultiCat Mexico

As early as the 1990s, the Mexican government identified disaster risk reduction as a national priority, creating the Fund for Natural Disasters (FONDEN) in 1999 to improve the nation's financial preparedness for natural disasters. The fund helps the general population in the event of natural catastrophes, but becomes depleted in years with many catastrophes. To avoid this budget volatility, starting in 2006, the Mexican government began buying reinsurance protection in the capital markets to provide additional funds to complement and support Fonden. Today this reinsurance program can provide Mexico with nearly US $1 billion of rapid disbursing insurance coverage in the case of a natural disaster. The government of Mexico has also used this partnership with the reinsurance industry to enhance its risk management, including building sophisticated risk models that show the costs of a disaster in almost real time.

Alabama State Insurance Fund

In 1923, Alabama established its own State Insurance Fund (SIF) to protect public institutions against catastrophic losses. By 2008, the fund provided insurance for state properties, colleges, universities and most public schools, covering potential damage of more than $41 billion. Faced with the dilemma of having to prepare for growing costs associated with hurricanes while at the same time keeping its public finances in check, Alabama decided to opt for a new approach. In 2010, it became the first State nationwide to purchase parametric insurance coverage, which transfers natural catastrophe risk to the private sector using an index-based trigger.[1]

Protect consumers and business

Superstorm Sandy demonstrated the strengths and limitations of the insurance system in New York State and the surrounding region. The storm also highlighted key areas for improvement that should be considered to assure resilience during future events.

The days and weeks after Superstorm Sandy were chaotic times. Property owners were displaced from their homes. Emergency orders prevented businesses from opening. Many businesses and residents lost both physical and electronic copies of their policies, including such critical information as policy numbers, coverage limits, deductibles, and provisions for alternative housing. In most instances, New Yorkers' attention was divided between securing basic needs for their families, demands related to continuing or returning to work, and the demands of beginning the recovery. Their access to cable, phone, and internet services was lost for extended intervals, either because those services were themselves degraded by the storm, or due to lack of electrical power, or both. Their travel was restricted due to loss or damage of personal vehicles, fuel shortages, transit shutdowns, or emergency restrictions. In addition to these ongoing challenges, many policyholders had little or no prior experience with filing complex claims. Damaged property was not, or could not, be inspected immediately. In the aftermath of the storm, property owners did not understand what damage was covered under their policy or policies and how much must be paid out-of-pocket as a deductible before a claim would be paid. These delays slowed the payment process.

This section provides a description of the recommendations designed to protect and mitigate risk to individual policyholders, both businesses and residential. These recommendations include actions the State could take to reduce underinsurance and promote coverage in normal times, as well as actions that would help to protect consumers in post-disaster circumstances. In what follows, we use the term "consumer" to refer to both individual and business policyholders.

Below is a list of recommendations we believe would help the State to achieve this goal:

1. **Promote investment in mitigation:** New York State should advocate for stimulating investment in mitigation activities through mechanisms such as on-bill financing, a revolving mitigation fund and tax-relief, among others. Such measures would reduce future losses and should minimize increases in insurance premium and property taxes.

2. **Improve consumer awareness through education:** New York State should work closely with the industry to create a consumer education and disclosure initiative, aimed at providing clarity and transparency for consumers throughout the State.

3. **Prevent underinsurance for flood risk and for certain covered perils:** The State should address the persistent issue of underinsurance by requiring a survey of the amount and types of coverage purchased by homeowners, and developing strategies for increasing take-up rates of flood insurance and other coverage. In addition, to address the issue of policyholders receiving less coverage when damage is caused by both covered and excluded perils, the Department of Financial Services (DFS) should study carefully the use of anti-concurrent causation clauses (ACC), from the points of view of both public policy and marketplace viability, in order to determine whether the State should permit the continued use of such clauses.

4. **Improve business coverage by authorizing expanded coverage for business interruption:** New York State should authorize an expanded "civil authority" line of business to provide expanded protection to businesses against business interruptions.

5. **Promote a comprehensive insurance emergency measures act:** New York State should authorize a Comprehensive Insurance Emergency Measures Act to help consumers and insurers handle the challenges faced during and after a natural disaster.

6. **Provide catastrophe response services:** New York State should continue to refine and enhance its catastrophe response services, review existing disaster plans, and incorporate the lessons learned from Sandy into its planning for a robust response to the next natural disaster.

Promote investment in mitigation

Mitigation activities, such as retrofitting homes and hardening infrastructure to protect against weather-related damage, are critical to building resilience to climate change and related shocks. The benefits of mitigation measures are many. Communities and citizens benefit from limiting the economic and psychological damage from a catastrophe. Research has shown that every dollar spent on mitigation saves three dollars in potential loss.[2] Consumers can obtain premium discounts, credits, or other related incentives for fortifying new homes or retrofitting existing homes to certain standards. Private insurers, in turn, seek to insure mitigated homes, which invigorates the market.[3]

According to the Federal Emergency Management Agency (FEMA), for the building to survive a hazard event with minimal damage, proper zoning, foundation, design, engineering, construction and maintenance practices are important factors. Risk management models can estimate the impact of specific building improvements on reducing probable losses from wind or other perils, and enable an analysis that weighs the benefits of mitigation measures against their costs. Even minimal initial investments in additional mitigation have many long-term benefits, including saving

lives, reducing premiums, and limiting property losses.[4]

While retrofitting or hardening structures can have profound impacts on protecting key assets, such measures also require up-front investment. The associated costs constitute a barrier to undertaking building improvements, despite the likelihood that they will have a positive 'payback' for consumers. The resulting underinvestment in risk mitigation affects the availability and affordability of insurance, as homeowner insurance and related premiums are likely to rise in order to reflect the additional risk attached to unnecessarily vulnerable properties and infrastructure.

New York State can play a critical role in stimulating investment in mitigation activities, thereby reducing future (first time and repetitive) damage, minimizing increases in property taxes and insurance premiums, and maximizing the availability of private insurance coverage. Specifically, the State could generate the data necessary to undertake a cost-benefit analysis of specific mitigation activities, provide or guarantee financing to cover the up-front cost of mitigation, and enable on-bill recovery and related mechanisms to facilitate repayment of loans for mitigation measures. We recommend that New York State do the following:

Commission surveys, models, and guides designed to assess existing building stock; assess the reduction in expected losses for different properties from implementing different levels of fortification; and provide building guides that direct homeowners and other consumers toward appropriate improvement measures. The New Orleans Recovery Authority contracted Applied Research Associates to undertake a similar analysis in Orleans Parish following Hurricane Katrina.[5]

The State's investments in data and mitigation-related analysis could include:

- Hurricane risk models (commissioned from industry accepted firms) that indicate the reduction in expected losses for different properties from implementing different levels of standardized fortification (such as the Insurance Institute for Business and Home Safety (IBHS) Bronze, Silver, Gold levels) as well as individual mitigation measures (e.g., roof strapping and ring shank nails). To be optimally useful, this model would seek to identify which property types would most benefit from fortification and individual mitigation measure upgrades. It should also show the magnitude of losses avoided and how that varies under different scenarios of future storm severity.
- Building guides for new construction and substantial repair projects that indicate the appropriate measures to reach fortified standards.
- A funded inspection program to certify that a property has reached such standards. This program would especially help modest-income households for whom the cost to inspect or evaluate the property is a barrier to program entry.

a. Create tax-exemptions for mitigation measures. The State should study and identify individual mitigation measures and codify those measures as part of a catastrophe mitigation program ("CMP") whereby localities could permit property tax exemptions.

Once the market value of a property is assessed, the local jurisdiction determines the corresponding property tax liability. Any improvements to a property that increase its value are typically subject to an increased assessment and property tax. However, a CMP would instead provide tax relief for those property owners who have taken steps to guard against future losses from natural disasters. Specific mitigation measures could be identified and selected as appropriate for preferred tax treatment, based upon the nature of the improvement and the dollar amount invested. The mitigation measures could also be valued and a schedule formulated to calculate the exemption. The exempt amount for each year could be a percentage of the increase in the assessed value attributable to the construction or improvement.

A CMP would incentivize property owners to engage in mitigation activity by providing a tax incentive to mitigate buildings in order to better withstand future natural disasters.

b. Establish a revolving fund ("Mitigation Fund") to provide incentives and upfront financing for risk mitigation activities. The Fund would provide homeowners, businesses, and other entities the upfront capital necessary to avoid the full cost out of pocket.

The Mitigation Fund could provide a combination of grants and loans, either directly or through guarantees to banks that lend to consumers. Approval would be contingent on appropriate inspections, and the terms of finance (grant, concessionary loan, market-rate loan) could vary based on household income. In order to maximize its value, the Fund should focus on supporting the fortification of structures in the most storm-affected regions, where mitigation measures present the largest (and/or shortest) payback. We expect that homeowners and banks will step in once positive payback has been established.

New York State would not be the first to propose a dedicated fund for mitigation. The Alabama Coastal Recovery Commission recently recommended a Coastal Mitigation Fund ("Alabama Fund"), to be created using public monies, to provide grants and guarantees to banks to lend to home and business owners. In creating a New York Mitigation Fund, we recommend a careful review of the Alabama Fund,

Alabama Coastal Recovery Commission and Coastal Mitigation Fund

Since Hurricanes Ivan and Katrina, homeowners along Alabama's two coastal counties have had a hard time finding affordable property insurance. Insurance companies, concerned after suffering significant losses from the storms, have ceased writing insurance in the region or have instituted strict underwriting guidelines. As a result, the price of risk-based premiums for coverage has increased while the marketplace for insurance has shrunk, with few insurers offering comprehensive coverage. A growing number of homeowners are "functionally uninsured," a category that includes people who have property insurance but do not have wind insurance, or have wind insurance as part of a policy but do not have the money to pay the deductible. The Alabama Coastal Recovery Commission insurance subcommittee has focused to increase the availability and affordability of insurance. The importance of fostering a robust private market for insurance has been emphasized with the importance of finding ways to lower premiums for homeowners. Strategies to encourage mitigation of new or existing homes and properties against natural disasters have been an area of focus.

Mitigation recommendations:

- Establish a trust fund to provide incentives and financing for homeowners to take mitigation measures.
- Commission a study of what hurricane models suggest that mandated mitigation discounts should be for homeowners in Alabama.
- Require consumers, Realtors and builders to identify to potential home buyers all the wind-mitigation features on a home.
- Evaluate whether to require admitted carriers to obtain proof of wind and flood coverage from consumers located in zones A and V.
- Develop a nonprofit entity to utilize FEMA's Hazard Mitigation Grant Program (HMGP).
- Strengthen local inspection programs for mitigation measures by developing sources of funding to increase the operating budgets of local building-code departments.
- Encourage accurate mitigation inspections by requiring they be conducted by trained and licensed professionals.
- Eliminate sales tax on materials used to retrofit homes against the effects of storms.
- Educate consumers and other stakeholders about the potential insurance cost savings and return-on-investment that can come from fortifying and retrofitting their homes.[6]

but acknowledge that the funding and structure of a New York Fund is likely to differ.

c. Enable streamlined repayment of mitigation loans by allowing policyholders to remit payments through their mortgages or other bills. This is frequently referred to as 'on-bill financing,' and is a mechanism the State approved in 2011 as a result of Governor Cuomo's advocacy to fund energy efficiency retrofits. It authorized residential on-bill loans to utility customers. The loan pays for energy efficiency improvements to the customer's house or building and the regular monthly loan payments are collected by the utility on the utility bill until the loan is repaid. On-bill financing has provided an opportunity to implement efficiency improvements that may have otherwise gone unrealized because there was no other way to finance such improvements.

Similarly, loans for property improvements to mitigate catastrophe losses, whether made by the Mitigation Fund directly or by a private bank with a Fund guarantee, could be serviced by repayments in the form of an installment charge on the customer's monthly mortgage payment. If the mitigation costs and commensurate repayment obligations can be structured such that they are less than the reduction in the prior total billed amount, this would result in a net reduction in costs to the policyholder. Regardless, on-bill programs enable property owners to make property improvements when traditional financing may not otherwise be available at a reduced rate of interest.

d. All of the mitigation measures detailed above should be incorporated into the underwriting of property insurance. Discounts and other premiums adjustments should reflect the reduced risk and should be filed with the DFS, as appropriate. In addition, insurers should confirm in a separate submission to the DFS that those mitigation measures approved by the Mitigation Fund, eligible for tax-exempt status, or otherwise determined as a state approved building fortification measure, has in fact lowered rates or deductibles due to the reduced risk of loss.

Improve consumer awareness through education

Too many policyholders do not fully understand which damage is covered under their homeowner policies. Confusion and misunderstanding increases dramatically in the wake of a natural disaster.

A few of the most persistent and serious misunderstandings include:

a. Optional wind damage deductibles under homeowner's policies. Damage from winds below hurricane force is covered in a standard homeowner policy. However, policyholders can opt for a higher wind deductible in exchange for a lower premium amount. These higher deductibles can leave policyholders excessively vulnerable in the face of severe storms.

b. Mandatory hurricane deductible under homeowners policies. Homeowner's insurance generally contains mandatory hurricane deductibles (often 2% to 5% of the insured value of the house) for hurricane-related damage. Thus, in the case of a hurricane, a damaged house with an insured value of $400,000 may require the homeowner to pay as much as $20,000 in order to repair the damage.

c. Cap Disclosures. Many consumers are ill informed about capped amounts on claim payments, including the caps on replacement costs of damaged houses and mold remediation costs. This creates particular vulnerabilities given that replacement costs for labor and materials often increase dramatically when demand for them surges following a disaster.

d. Coverage for mold losses. Even when a homeowner's policy covers mold damage under certain circumstances, restrictions on that coverage, including caps on reimbursement or exclusion of mold damage caused by flooding, can leave the homeowner effectively without protection.

e. Flood policies. Although policyholders are informed in annual notices that homeowner's policies do not cover flooding losses, many homeowners do not understand that flood damage is covered separately by flood insurance, which is a federal program administered by FEMA.[7] Furthermore, many residential policyholders are unaware that the flood policy covers structures up to only $250,000 (regardless of the insured value of the dwelling) and provides limited coverage for basements.

To improve consumer awareness of these and other issues, the Department of Financial Services should work closely with the industry to create a consumer education and disclosure initiative, aimed at providing clarity and transparency for consumers throughout the State. That initiative should also include a disclosure and explanation process at the point of sale, using a checklist to be reviewed and acknowledged by the consumer, outlining his or her coverage choices as well as the resulting effects in terms of deductibles, coverage limits, and premium payments—all disclosed in dollar, as well as percentage terms.

For example, if the consumer opts to trade reduced premium payments for a higher deductible for windstorm coverage, the consumer should receive a clear explanation of the additional risk, as well as the related premium savings. A summary list of excluded perils (such as flood), caps on coverage limits, and mandatory deductibles written in plain, simple language for easy comprehension should also be included in the checklist at the point of sale.

Insurance-related consumer education should build upon work that has been done to improve consumer understanding of mortgages and other financial services. For example, the Dodd-Frank Act requires that consumer-facing material contain a clear and conspicuous disclosure that, at a minimum, uses plain language comprehensible to consumers; contains a clear format and design, such as an easily readable type font; and succinctly explains the information that must be communicated to the consumer.[8]

These measures would both ensure that consumers are making the choices they actually intend to make, and encourage consumers to plan more effectively for realistic natural-disaster scenarios.

Prevent underinsurance for flood risk

Across the northeast, only about 30 percent of the single family homes that are located in a 100-year flood plain carry flood insurance.[9] In theory, this should happen only to the roughly one-third of New York homeowners who have self-financed their homes or paid off their mortgages, because banks typically require flood coverage for homes on which they hold a mortgage.

There are many contributing factors to this underinsurance. Research has shown that when the probability of an event is below a certain level, individuals tend to ignore the risk. Flood and wind risk fall into this category, because major events in a particular location can be many years apart.[10] These inducements to underinsure may be further strengthened by expectations of federal assistance when an event does occur.

Underinsurance creates a vicious cycle. When homeowners fail to consider the full cost of living in at-risk areas when deciding where to live or how much to spend on loss-mitigation measures, they put themselves at greater risk and leave themselves vulnerable to financial catastrophes from which they are unprepared to recover.

The State should address the persistent issue of underinsurance by surveying the amount and types of coverage purchased by homeowners, and developing strategies for increasing take-up rates of flood insurance and other coverage. Such strategies may include programs to incentivize or otherwise

oblige consumers to properly insure against natural disasters. For instance, in a 100-year flood plain, the State should investigate the impacts of requiring homeowners to purchase flood insurance.

Prevent underinsurance for certain covered perils

Underinsurance also occurs when the insurance policy does not provide the coverage expected by consumers. The anti-concurrent causation (ACC) clause in policies is one such example. Coverage under an insurance policy is normally bound to the particular peril that caused the damage: fire, wind, flood, and so on. These bindings have been established over time by historical precedent as well as by regulation, and they are not always intuitive; for example, damage from fire peril is covered in a standard homeowner's policy, but damage from flood peril is not. The approach has the virtue of straightforwardness: if one knows the cause of the damage, one can usually identify the correct policy and carrier. However, that straightforward approach can break down when confronted with a natural disaster such as a severe storm event. Damage from a storm may result from a combination of causes including fire, wind, and/or water; this is called "concurrent damage."

Depending on the policy and carrier, concurrent damage may come from a mix of covered and uncovered causal forces; for example, a storm could cause (covered) wind damage as well as (uncovered or excluded) flooding damage. Most policies contain language (known as anti-concurrent causation clauses) that denies the claim whenever an excluded peril directly or indirectly causes damage, even if another, covered peril or event contributed to cause the loss. Usually, the clause is written in such a way that it does not matter whether the excluded peril contributed at the same time ("concurrently") or in some other, particular order. Put simply, anti-concurrent causation clauses give insurers the ability to deny claims if any of the resulting damage can be attributed to an excluded peril. After Hurricane Katrina, a large number of contested claims around this issue bogged down thousands of homeowners and insurance companies in unproductive litigation for years. The extensive amount of wind and flood damage resulting from Superstorm Sandy will certainly bring this issue to the forefront yet again.

The DFS should study carefully the use of ACC clauses, from the points of view of both public policy and marketplace viability, in order to determine whether the State should permit the continued use of such clauses. At issue are the questions of whether marketplace realities make such clauses unavoidable; whether they impede the disaster recovery efforts of the State and its citizens to an unacceptable degree; and whether they are equitable and consistent.

Improve business coverage by authorizing expanded coverage for business interruption

The State should consider authorizing an expanded "civil authority" line of business which would authorize insurers to provide expanded protection and coverage against business interruptions. In New York currently, business interruption insurance does not provide coverage for modern emergency-response practices that force large-scale emergency access restrictions ("civil authority orders") when there has been no physical damage. (Physical damage from a covered peril is a well-established trigger, or pre-requisite, for business interruption coverage.) Thus, if an area is pre-emptively evacuated, there is often no business interruption coverage for businesses because there is no physical damage. However, if an evacuation was ordered because of a nearby collapsed building (a covered peril), business interruption coverage is available to the policyholder. This anomaly creates inconsistent coverage.

By creating a new line of insurance for civil authority coverage that is not triggered by an underlying peril, New York businesses could be provided with greater protection against future disasters, and New York's insurers could obtain a new product opportunity.

In addition to making this particular revision to the insurance law, New York should also study the emerging patterns in natural and man-made disasters and authorize new lines of authority for any identified, emergent risks deemed increasingly likely to threaten New York residents in coming years. In addition to business-interruption risks, other, as-yet-unidentified market rigidities or gaps could hinder recovery from future disasters. Systematic, periodic review and analysis of this sort will reduce the losses faced by New Yorkers in upcoming disasters, and can materially improve the State's resilience.

Promote a comprehensive insurance emergency measures act

When a disaster is highly disruptive, insurance transactions are greatly hindered. The government must take reasonable measures to protect policyholders, ensure the operation of an orderly insurance market, and permit other insurance-related accommodations, while also providing for effective regulation immediately before and during periods of major disruption.

Prior to and during the aftermath of Superstorm Sandy, the Governor and the DFS took a number of steps to achieve these goals. These steps were structured as a series of individual actions, by means of Executive Orders, DFS Orders, Emergency Regulations and Circular Letters. These steps were numerous, and they required careful, repeated, time-consuming clarifications to the industry, local jurisdictions, and the general public.

These same issues could be handled much more efficiently by means of a single, Comprehensive Insurance Emergency Measures Act ("CIEMA"). The DFS Superintendent could trigger some or all CIEMA provisions in the wake of a State emergency. At a minimum, the following provisions should be considered for inclusion in CIEMA:

- A moratorium on the termination, cancellation, or non-renewal of commercial, homeowners or auto policies held by residents of the counties suffering the greatest storm damage, to take effect for a reasonable, designated (and potentially extensible) amount of time after the storm.[11] This protects policyholders who, in the immediate aftermath of a disaster, may experience overwhelming logistical barriers to making timely payments complying with "normal times" policy provisions, or finding alternative insurance coverage.
- An extended renewal period for insurance producer licenses scheduled to expire on or after the storm. The logic here is similar to the logic of the moratorium; namely, to ensure that the services provided to consumers by their insurance agents and brokers will not be impeded because disaster-related barriers render those individuals unable to renew their licenses to practice.[12]
- A waiver, for a defined period of time, allowing homeowners to document their own losses in situations where an immediate cleanup is necessary to protect the health and safety of the policyholder or public, or to prevent further damage to property.[13] Currently in New York State, no claim of loss can be processed until a claims adjuster has physically examined the damage, and homeowners are responsible for retaining damaged property until an adjuster can arrive. After Sandy, areas of debris and rotting property presented serious health concerns, requiring immediate action before adjusters could arrive. Under CIEMA, homeowners would be allowed to submit proof-of-loss: documentation of the damaged or destroyed property, including photographs or video recordings, material samples, inventories and receipts for critical repairs.
- A reduced time-period for the commencement of claims processing, from a maximum of 15 days in normal times, to a maximum of 6 days during the time-window covered by CIEMA.[14]
- An expedited process for issuing temporary independent and public adjuster licenses for adjusters in good standing from other states.[15] In a natural disaster such as a hurricane, the large number of losses creates a spike in demand for adjusters. To ensure the state's resilience, it is essential to provide an adequate supply of qualified adjusters, to affected areas promptly. Temporary licensing meets that need without distorting the supply of or demand for adjusters during normal times. (During Sandy, this procedure more than doubled the number of adjusters available to work in New York, from approximately 15,000 to 34,100.)
- Establishment of uniform access rules for claims adjusters, applicable statewide over all local jurisdictions in disaster and/or emergency zones. This would reduce one of the major obstacles to getting claims adjusters to where they are needed most in the early days post-disaster.

The CIEMA legislation could allow the Superintendent of DFS to set a single duration for all of these emergency provisions, to tailor the durations to the particular interventions, or to tie the durations to that of the state-of-emergency. CIEMA would enhance stability during the recovery process by setting reasonable and predictable expectations for government and carrier responses among insurers, local jurisdictions, and the general public.

Provide catastrophe response services

Policyholders should have redundant avenues of redress and information. The DFS, as the State's insurance regulator, stepped in to provide assistance to consumers and to ensure that the State's insurance carriers responded to the need for Sandy-related insurance information and redress in a number of ways:

- A DFS Disaster Hotline to answer consumer questions, available 24 hours a day, 7 days a week.
- A dedicated website for Sandy-related insurance issues, www.nyinsure.ny.gov, to answer frequently asked questions, provide report cards of the performance of insurance companies since Sandy, and allow homeowners to file complaints against insurers.
- Disaster Assistance Centers located throughout Kings, Queens, Richmond, New York, Bronx, Westchester, Rockland, Orange, Nassau and Suffolk counties (the designated disaster area). In the immediate aftermath of the storm, DFS and other agencies staffed 39 of these centers to assist consumers with their insurance-related questions and concerns.
- Participation in the "Insurance Corral", an independently-initiated effort in Long Island, which brings together multiple carriers in a single locale (Cedar Creek Park), and operated daily, 8am-8pm. The Corral provided information and advice to residents on how to file insurance claims, as well as providing immediate access to several large insurance companies.
- A Mobile Command Center ("MCC") which travels to disaster areas. This is a self-powered unit, similar to an RV, which is equipped and staffed to provide citizens with insurance expertise and support.
- The Insurance Emergency Operations Center (IEOC) The IEOC provides a venue where liaisons from every major

property/casualty insurer co-locate with DFS personnel in order to streamline and speed communications between DFS and each carrier, as well as among carriers.

- Most recently, the Sandy IEOC has operated in Albany continuously since October 31, 2012 and is the primary disaster liaison staffed with at least 17 companies and three trade organizations. In addition, each day there are two conference calls so that insurers and the DFS can share information on the latest updates and findings. Representatives from FEMA participate in the conference calls.
- The IEOC is particularly powerful when integrated with the information gathering and consumer contact functions of the programs described above, because it allows inquiries generated in the field, online, or by phone to receive quick and authoritative answers. These programs also allow DFS to closely monitor carrier performance; for example, DFS in staff in the field could identify companies failing to make adjusters available in communities, and the IEOC was able to identify patterns of these problems and get responses and resolution directly from insurers.
- Finally, IEOC allows carriers to inform DFS quickly of ways to eliminate bureaucratic delays. For example, based on information generated in the IEOC, DFS and NYS DMV collaborated to expedite issuance of duplicate titles (a necessary prerequisite for claims adjustment) for flooded motor vehicles. Similarly, at DFS request, NYS Department of Environmental Conservation issued blanket notices to residents and businesses to clarify property owners' responsibility for oil-spill remediation. Once the property owner is deemed responsible, then the insurer may have to cover cleanup cost, if appropriate.

Based on evidence from Sandy, all of the current DFS activities provide important value to residents, businesses, insurance carriers, and other government activities. The State should continue to refine and to enhance these services in order to further increase their value.

As an example, the State should conduct a cost-benefit analysis to determine whether DFS should acquire more Mobile Command Centers. The MCC allows staff to be deployed to many locations that may not have electricity or suitable indoor locations. These mobile centers also can reach communities in need of immediate assistance, but are in areas far from standing Disaster Recovery Centers.

New York State should also supplement outreach efforts with social media. Social media has proved particularly useful in its ability to achieve contact with citizens even over degraded telecommunications systems, as well as its ability to share knowledge rapidly and efficiently with wide audiences. Many consumers rely on mobile devices for information, especially when displaced, and the State should develop a disaster relief website or application for or compatible with mobile devices. This would make information more accessible, including real-time news alerts and directions to nearby Disaster Assistance Centers. In addition to the benefits from additional redundancy that social media provides, the use of social media in other agencies has been shown to maximize the speed at which an entity can reach affected citizens, and thereby increase the resilience of citizen response to the disaster.

DFS should continue to review its existing disaster plan and incorporate the lessons learned from this catastrophe into its planning for a robust response to the next natural disaster.


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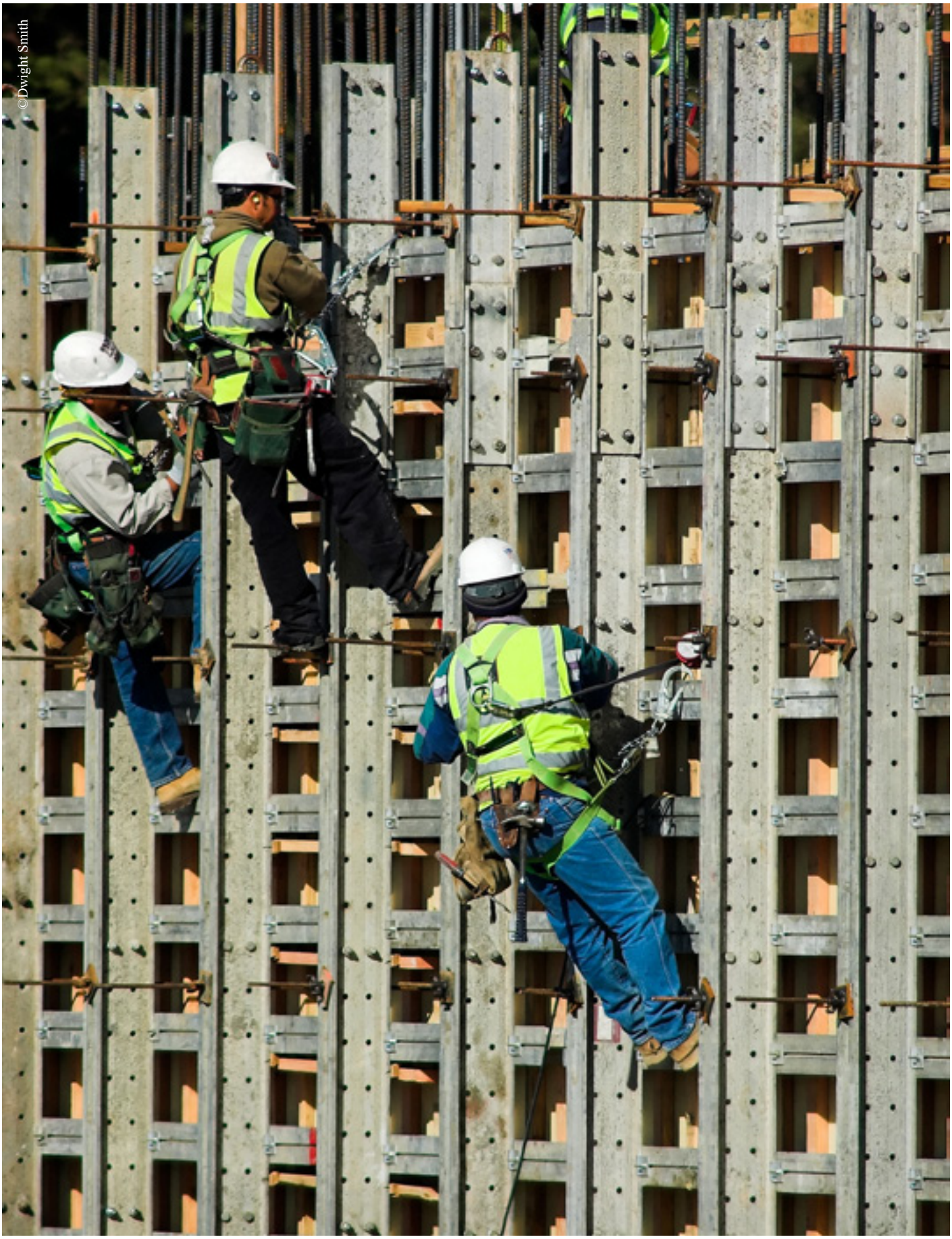
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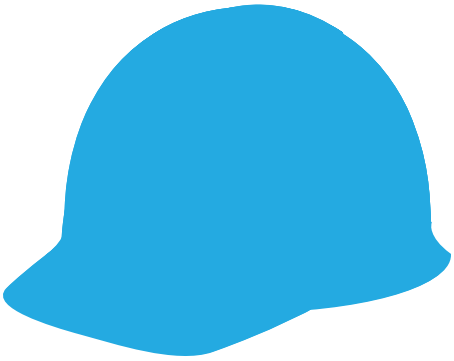
Infrastructure Finance



Overview

As Superstorm Sandy made clear, New York State must adapt its infrastructure to meet the needs of a changing world. The State and region's infrastructure is essential for economic growth, job creation, and quality of life. It will need to keep pace with the State's demographic trends, regional priorities, and weather patterns if we are to maintain our long-term competitiveness. It is incumbent upon the State to plan, finance, fund, and support a range of infrastructure solutions in order to ensure that our economy and communities are resilient in the 21st century. Planning, financing, and funding these modifications, including short-, mid-, and long-term design and construction of traditional "gray infrastructure" projects like bridges and tunnels, as well as "green infrastructure" projects like wetlands and dunes, will be a continuous process requiring ongoing evaluation and refinement. Integration with the State's existing economic, environmental, and social infrastructure planning and development efforts will be critical.

New York State has faced three challenges to its infrastructure development in recent decades:

- Large-scale and complex needs.
- Significant fiscal constraints.
- A capital planning process that is not sufficiently coordinated or entrepreneurial.

To address these challenges, the State has revised its capital planning process. In addition, in 2011 legislation was passed to facilitate design-build projects, described below, which enable a new approach to cost-effective infrastructure development. The Tappan Zee Bridge replacement project has demonstrated the feasibility and speed of this approach, as described in the text box.

The Commission's infrastructure finance recommendations build upon these successes. New York State should develop an improved, systemic approach to capital investment. The State needs to explore mechanisms for financing the resilience and expansion of critical infrastructure, and should leverage private capital to do so. It will need to rigorously evaluate and prioritize projects in accordance with a statewide and regional economic development strategy. An enabling regulatory and policy environment and new approaches to generating and capturing multiple revenue streams should be employed to fund the infrastructure changes needed to make the State more resilient.

The Commission has grouped its recommendations into four areas:

1. **Establish an "Infrastructure Bank" to coordinate, allocate, and maximize investment** in the construction, rehabilitation, replacement, and expansion of infrastructure.

2. **Adopt a standard set of criteria for project selection and prioritization** to optimize resources statewide, in accordance with State and regional resilience and economic development strategies.

3. **Develop a range of sources of revenue and cash flow** to identify appropriate and adequate mechanisms to pay for infrastructure projects and capture cost savings and avoided losses.

4. **Continue to improve the enabling environment** and overall policy and regulatory landscape for infrastructure investment to facilitate the identification, financing, funding, and efficient use of the State's infrastructure.

Within each of the areas, recommendations include short-term steps; medium-term efforts that require more extensive planning and development; and long-term solutions that require systemic planning, process refinement, capital budgeting, and coordinated implementation. Each of these recommendations has independent value, but they are significantly more powerful when advanced together.

The first two recommendations work in tandem to support the creation of a comprehensive and integrated decision making and investment approach for the State. A critical function of the proposed bank, for example, would be to implement standardized criteria for project prioritization and investment. The third and fourth recommendations are targeted at expanding the pool of possible project revenue sources and improving the enabling environment for infrastructure investments, which could significantly expand the range of activity available to the bank and increase its potential impact. An "enabling environment" is one in which a broad range of public-private partnerships can be used to assist in project finance when there is alignment of interests among the State, communities, and the private sector.

The term "public-private partnership" (PPP) refers to a wide variety of alternative arrangements for infrastructure design, construction, operation, and finance. PPPs are designed to transfer more of the risk associated with, and control of, a project to a private partner. In part, this is achieved through bundling multiple stages of project planning and execution, similar to the process that New York State enabled when it passed design-build legislation at the end of 2011. Design-build is authorized in a number of states, and is the most common form of public-private partnership for infrastructure in the United States. In a design-build delivery model, the private partner assumes responsibility for the majority of the design work and all construction activities, together with the risks associated with providing these services for a fixed fee. As noted in the text box, the State's plan to replace the Tappan Zee Bridge was enabled by the recent passage of design-build legislation.

PPPs may also take a more extensive form in which a private firm provides financing for an infrastructure project, designs and builds it, and, in exchange for a revenue stream such as tolls or other user fees, usually operates and maintains it over its useful life. This type of PPP may be appropriate in circumstances when it provides the State with greater value for money than a traditional (purely public) approach to infrastructure finance, provided appropriate standards and safeguards are in place. This type of PPP is more common outside the United States, and has been used extensively in Canada, Australia, and the United Kingdom. In 2008, for example, the Australian government created a statutory authority called Infrastructure Australia to plan and coordinate infrastructure investments in the country, including PPPs, based on the premise that new sources of funding were required to bridge the infrastructure deficit and public sector constraints. In countries that enable more extensive PPPs, large institutional investors such as pension funds may invest in these projects, unlocking significant additional capital for infrastructure finance. The text box below illustrates the infrastructure investment strategy of the Ontario Municipal Employees Retirement System.

Figure IF-01: Rendering of Selected Design Proposal for the New Tappan Zee Bridge (New York State Thruway Authority, 2012)

The Tappan Zee Bridge (New York, United States)

The 3.1 mile Tappan Zee Bridge, the only bridge serving the congested Westchester/ Rockland suburban corridor, carries approximately 140,000 vehicles per day, nearly eight times the original traffic volume when it opened in 1955. The bridge was built without necessary breakdown lanes, resulting in massive traffic backups after traffic incidents. For decades these issues were not effectively addressed. In the year since the passage of innovative design-build legislation, New York State has completed an environmental review in 11 months instead of the average 78 months and awarded a contract to design and build a replacement bridge at a cost of $3.1 billion, 40% less than the $5.2 billion original cost estimate. The Governor's initiative to replace the Tappan Zee Bridge illustrates how creative project delivery methods can result in tangible benefits to the public.

Large-scale and complex needs

Delivering the infrastructure that is essential to the economic and physical security of New York State is a massive undertaking. The State has 19.5 million residents, a $1.2[1] trillion economy, and faces a huge range of environmental risks – extreme temperature, heavy rains, snow, sleet, and

ice. More recently, hurricanes and tropical storms, along with record storm surges, have put an increasing stress on New York's infrastructure. Climate change is expected to increase these risks. As a result of significant investment and programs to expedite project delivery, the State has begun to make progress in upgrading its aging infrastructure and reducing the backlog of operating repair needs. Significant work remains, however, especially considering the risks that extreme weather poses to outdated infrastructure. The Transport, Energy, and Land Use sections of this report detail potential projects.

Ontario Municipal Retirement System (Ontario, Canada)

The Ontario Municipal Employees Retirement System (OMERS) is one of the largest institutional investors in Canada. It has approximately $55 billion in assets under management, which represent the combined pension assets of almost 420,000 members, including fire-fighters, police, and emergency services staff. OMERS has five divisions, one of which is Borealis Infrastructure. Through Borealis, OMERS has helped structure and place billions of dollars in infrastructure investments, most of which are designed to produce steady and predictable cash flows over a long term. Earlier in 2012, OMERS joined with the Pension Fund Association and a consortium led by Mitsubishi Corporation in Japan to launch the $7.5 billion Global Strategic Investment Alliance, a fund whose mission is to invest in large infrastructure investments.

Significant fiscal constraints

New York State invests heavily in its infrastructure in order to deliver what New Yorkers need. In the current fiscal year alone, 46 State agencies and authorities will make nearly $21 billion in capital investments, including maintenance to keep equipment and systems in a state of good repair and investment in the construction of new facilities. Roughly half of this capital spending ($9.7 billion in the current fiscal year) is part of the State budget, with the rest financed by public authorities. Since 2011, the State has taken steps to improve fiscal discipline and substantially limit on-budget capital spending.

The money for capital investment comes from three sources: Federal aid, State pay-as-you-go financing (i.e., revenue from taxes, tolls, fares, and fees), and borrowing. In the decade preceding 2011, total outstanding State on-budget debt grew at a compounded annual growth rate of 18%. This happened, in large part, because the majority of capital spending increases had been financed by debt without commensurate increases in revenue. In the State's current capital plan, the percentage of capital expenditures financed by debt is projected to decrease by 8% from 2012 to 2017. Although New York State is seeking funding from the Federal government to help recover from Superstorm Sandy, the current fiscal environment in Washington suggests that further Federal aid will be limited. In addition, the State has a cap on issuing State-supported debt, limited to 4% of State personal income, and is nearing that cap. For these reasons, New York State faces the challenge of doing more with less in its infrastructure planning.

A capital planning process that was not sufficiently coordinated or entrepreneurial

Historically, New York State has not had a comprehensive, unified, long-term process for evaluating and prioritizing capital projects. Capital resources were allocated in silos without reference to statewide or regional needs, priorities, or ability to pay, and sometimes without rigorous evaluation of the impact of projects. Recognizing the need for more efficient, effective, and extensive investment in infrastructure, in May 2012 Governor Cuomo launched the New York Works Task Force, described in the text box on this page. The recommendations in this report build upon the important work already underway.

Until 2012, New York State had not taken advantage of the benefits of design-build mechanisms to accelerate and reduce the costs of large public infrastructure projects. Nor had there been sufficient efforts to spur private investments in such projects. Well-structured public-private partnerships, defined as discussed in this section, could in certain instances allow the public sector to harness the efficiency and innovation of the private sector while reducing the public sector's investment risk on large projects. The Commission recommends taking additional steps to make the infrastructure planning and financing process more entrepreneurial.

Establish an "Infrastructure Bank" to coordinate, allocate, and maximize investment

The Commission recommends the establishment of a new Infrastructure Bank (the Bank) to assist the State in making more efficient and effective use of public infrastructure funding and mobilizing additional resources to meet its infrastructure needs. While some aspects of the Bank described below have already been implemented in part, a more comprehensive application of this initiative would represent an unprecedented, systemic approach and generate significant additional infrastructure investment.

The Bank should:

- Develop objective, uniform criteria to select and prioritize projects.
- Provide a statewide entity to assess infrastructure projects across agencies and authorities, rather than separately within each agency and authority.
- Manage capital including, where appropriate, portions of Federal and State recovery funds, to ensure the highest return on investment, broadly defined. This is an especially crucial task given the State's current capital constraints and the requirements of the Superstorm Sandy recovery.
- Structure and negotiate opportunities for private sector investment to maximum public benefit.
- Finance approved projects, whether by directing revenues to implementing agencies, pledging revenues to raise capital directly, or by providing loans.

Initially, the Bank should focus on four critical sectors: Transportation, Energy, Environmental Resources, and Emergency Response. The Bank should have a broad mandate to coordinate financing and directly finance the construction, rehabilitation, replacement, and expansion of infrastructure. The ongoing statewide infrastructure planning function, begun by the New York Works Task Force, should be further formalized by embedding it in the Bank's evaluation process, ensuring that priority is given to projects that advance the overall health, welfare, resilience, and competitiveness of New York State. The Bank would convene experts from each of the sectors and enable infrastructure planning on a broad scale across the State, with a regional, systemic approach (e.g., multi-modal, but also multi-type of infrastructure – energy, transport, communications, etc.) to make more effective strategic investments. This planning function would:

- Consider projects from multiple sources, including State agencies and authorities, the NYS 2100 Commission, the Statewide 10-Year Capital Plan, the Regional Economic Development Councils, and non-governmental entities.
- Champion medium- and long-term solutions, ensuring sustained attention and action.
- Serve as a coordinator and knowledge-sharing hub for sub-system players, and develop, gather, and disseminate information on potential vulnerabilities, potential solutions, pilot projects, best practices, and lessons learned so that decisions can be made and actions taken with the best possible information.
- Coordinate work on regional infrastructure issues with neighboring states and provinces.

The Bank should be structured as follows:

- It should be incorporated as a public benefit corporation with a board that includes the State Budget Director and the Deputy Secretary for Economic Development.
- A Financing Council composed of the Division of the Budget, the Bank, and the State's major financing public authorities should be established to coordinate financing of large-scale, infrastructure projects vital to the State's economy.
- The Bank should be staffed with current State agency and authority infrastructure investment experts but have the ability to hire outside technical, legal, and financial experts as necessary.

In order to maximize its effectiveness, the Bank should be able to make use of a number and range of potential sources of funds, including:

- Federal funds, including those allocated to the State for Superstorm Sandy recovery as appropriate.
- Diverted or created revenue.
- Proceeds from the sale of long-term debt with maturities as long as 49 years, up from the current limit of 30 years.
- Credit enhancements from other State entities.

Projects may be funded by user fees and payments from the State or municipalities (with revenue generated by tax increment financing, special assessment districts, etc.) or any other lawful means.

The Bank would also be able to deploy funds using a variety of mechanisms, including:

- Direct loans to projects, including long-term, senior notes, subordinated debt, and short-term construction financing.
- Loan guarantees to State, local, and private entities, limited to a percentage of the potential loss.
- Grants for pre-development costs

The Bank should also be able to co-finance with other public and private lenders and investors (e.g., a pension fund desiring to share in the cash flow from the project as opposed to interest income); have the ability to combine Federal, State, local, and private funds to finance projects; and be able to use alternative project delivery methods (e.g., design-build-finance-operate-maintain contracts). The minimum transaction size threshold should vary by region. Size and related requirements should be set

so as to include distributed and natural infrastructure solutions when cost efficient.

When developing projects, the Bank should promulgate principles of design excellence and value engineering. It should require an engineering peer review and other relevant assessments of the technical quality of proposals. Enlisting a broad array of experts in the planning process would help ensure that New York State delivers exceptional projects, as it was recently able to do with the Tappan Zee Bridge replacement. As part of that process, a team of artists, architects, technical experts, and community leaders rigorously evaluated proposals. Its recommendations contributed to the selection of a bridge that will be safe, efficient, and effective, and serve as a Hudson River landmark.

The State should also consider establishing, either as part of the Bank or as an associated entity, an Exchange platform (the Exchange) to spotlight and catalog specific projects and opportunities well suited for public private partnerships. The twin goals of the Exchange would be to engage the private sector in finding creative solutions to infrastructure challenges and to grow the market for private investment in infrastructure. The Exchange could be modeled on the recently launched West Coast Infrastructure Exchange.[2]

New York Works (New York, United States)

Recognizing the need for more efficient, effective, and extensive investment in infrastructure, Governor Cuomo launched the New York Works Task Force in May 2012, bringing together leading finance, labor, planning, and transportation professionals to coordinate a statewide infrastructure plan to more effectively and strategically allocate the State's capital investments. The Task Force's mission is focused on growing the economy, creating jobs, and improving all New Yorkers' quality of life.

Since its launch, the Task Force has accelerated the delivery of a number of infrastructure projects, in part by employing the design-build contracting method that newly enacted legislation made available to State agencies for the first time. This work includes:

- Improving 55 parks and historic sites;
- Inspecting and repairing 118 dams and flood protection projects;
- Repairing more than 2,100 miles of roads; and
- Repairing 112 bridges and finally moving forward with the new Tappan Zee Bridge.

The Task Force has also initiated a state-wide process both to assess the current state of capital investment and to develop new tools to better coordinate capital planning and allocate resources statewide. The strategic response to Superstorm Sandy will be a key part of the statewide process. This statewide planning mechanism:

- Maximizes the impact of New York State's infrastructure systems on the intertwined economic systems that depend on them;
- Recommends projects for replacing, expanding, and improving critical infrastructure;
- Advances a multi-modal and cross-sectoral approach – covering energy, transportation, communications, land use, water, sewer, etc. – and evaluates individual project proposals' ability to increase the utility and effectiveness of statewide and regional infrastructure systems; and
- Evaluates projects using criteria developed by the Task Force.

South Carolina Transportation Infrastructure Bank (South Carolina, United States)

South Carolina created the South Carolina Transportation Infrastructure Bank (SCTIB) as part of a pilot program established by the 1995 National Highway System Designation Act, and has since invested nearly $2.8 billion, making it the most active state infrastructure bank in the United States. A one-time earmark of $66 million from the State General Fund was provided to the SCTIB, which also has dedicated state revenues for bond repayments, including the state gas tax and vehicle registration fees.

The SCTIB supports highway and bridge projects with costs in excess of $100 million and transit projects of any size. Loans, in the form of bonds, as well as some grants are provided to projects, with preference given to projects that can demonstrate a local match.

Projects funded by the SCTIB include the Arthur Ravenel Jr. Bridge, the Conway By-Pass, and the Palmetto Parkway. Additionally, the SCTIB helped achieve a statewide initiative to accelerate the timeline of 200 transportation projects from 27 years to 7 years.

Adopt a standard set of criteria for project selection and prioritization

Infrastructure planning and investment decisions, when made in isolation and without the benefit of appropriate analysis, are likely to result in an inefficient allocation of resources. A siloed and ad-hoc approach prevents a holistic analysis of the State's needs, is susceptible to specific demands for "pet projects," and fails to capture the multiple potential benefits (or costs) of a single investment. The Infrastructure Bank should optimize public resources by applying a standard set of criteria to the selection and prioritization of projects statewide, in accordance with State and regional economic development strategies.

The Commission has worked closely with members of the New York Works Task Force to refine the criteria that were recently developed to select and prioritize investments in infrastructure. Specifically, the Commission focused on overlaying the resilience characteristics described in the Executive Summary of this report onto the existing set of New York Works criteria.

The Commission recommends that the State consider and apply the following four criteria through a resilience lens:

State of good repair
Whether the proposed repair, renovation, or upgrade of a given asset extends its useful life in a cost-effective way, either by avoiding replacement or extending its depreciation schedule. As appropriate, the state of good repair will consider the level of redundancy and flexibility created by an investment.

Systems focus
Whether the proposed investment in a given asset increases the productivity or lowers the operating costs of the economic or ecological systems in which it is situated, including its impact on jobs. This criterion includes, importantly, consideration of system resilience, such as its level of flexibility, capacity for limited failure and rapid rebound, and redundancy.

Financial and environmental sustainability
Whether the proposed investment in a given asset increases the State's sustainability by lowering ongoing, or avoiding future, costs. These costs include direct monetary outlays as well as negative externalities such as damage to the environment.

Maximize return on investment
Whether the proposed investment has a positive cost/benefit ratio, wherein the total costs and benefits over the asset's lifecycle have been quantified and accounted for.

As resilience thinking suggests ongoing learning and evolution, the Commission also recommends that the application of the New York Works criteria be monitored over time and adjusted as needed.

Develop a range of sources of revenue and cash flow

As projects are identified, prioritized, and financed, it will be necessary to identify appropriate and adequate sources of revenue to pay for them. World leaders who convened in November 2012 at the Global Infrastructure Initiative in Istanbul emphasized that "'willingness to pay' the full cost of the actual infrastructure asset is essential, regardless of whether the financing is debt or equity or whether the financier is public or private, domestic or international."[3] The Commission recommends identifying the widest possible range of revenue sources, including Federal grants, taxes, user fees, and targeted programs like the Regional Greenhouse Gas Initiative, which is discussed in the Energy section of this report and described in the text box below. Importantly, sources of funds are not limited to positive revenue-generating mechanisms or taxes and fees. Savings from efficiency improvements and avoided losses have great potential to generate cash flow for infrastructure investment. Possible mechanisms for generating funds or cost savings include:

- Programs, requirements, and incentives that encourage energy efficiency (such as on-bill payment and PACE), use of alternative transportation, and other actions that reduce costs as well as greenhouse gas emissions.
- Pay-for-performance mechanisms, which have particular potential in the case of green infrastructure, that allow the State to pay for outcomes delivered by non-governmental entities at a price that could be less than what it would have been if incurred by the State, or have other demonstrable co-benefits. Enabling such mechanisms can allow the State to set expense targets for the delivery of infrastructure below what it could achieve based on its own estimates, and then compensate non-governmental entities that can deliver outcomes at lower costs. In Philadelphia, for example, the State of Pennsylvania is exploring the use of distributed green infrastructure, including retrofitting commercial buildings and remediating vacant lands, to provide "greened acres" that reduce stormwater runoff and flooding.
- A New York State wetlands bank, as described in the Land Use section of this report, or alternative mechanisms that create a market for natural resource protection credits by enabling private investors and landowners to undertake environmental restoration and protection projects using private capital, thereby funding environmental protection projects that would otherwise go unfunded.
- Tax increment financing and other methods of value capture that use projected future gains or savings to subsidize current improvements.

Regional Greenhouse Gas Initiative (Northeast and Mid-Atlantic States, United States)

The Regional Greenhouse Gas Initiative (RGGI) is an effort among nine Northeast and mid-Atlantic states to reduce CO_2 emissions. RGGI uses a market-based cap and trade program to reduce CO_2 emissions, while at the same time creating green jobs. RGGI has set a goal to reduce CO_2 emissions from the power sector by 10% by 2018.

Emission allowances are sold through auctions and the revenue is then invested in clean energy, energy efficiency and renewable energy. Each state has a CO_2 budget trading program that is implemented through state legislation, but is regionally linked through allowance reciprocity. New York State's RGGI program is implemented through the New York State Department of Environmental Conservation's CO_2 Budget Trading Program and the New York State Energy Research and Development Authority's CO_2 Allowance Auction Program.

Between December 2008 and December 2010, New York State sold over 116 million CO_2 allowances and received $282 million in auction proceeds. Additional funds could be generated if the current cap is lowered (please refer to the Energy section of this report). These funds were then allocated across the following program areas:

- Residential/commercial/industrial/municipal.
- Transportation.
- Power supply and delivery.
- Sustainable agriculture and bioenergy.
- Multi-sector.

Continue to improve the enabling environment

An enabling environment can facilitate the identification, financing, funding, and efficient use of the State's infrastructure. The State should evaluate and improve the overall policy and regulatory environment for infrastructure investment, including:

- **Enhance State procurement processes.** The State should continue to review and benchmark its procurement processes against best practices and revise them accordingly.
- **Public Private Partnerships.** PPPs refer to a wide variety of alternative arrangements for infrastructure design, construction, operation, maintenance, and finance, but are all designed to transfer more of the risk associated with, and control of, a project to a private partner. PPPs take a variety of forms, as described above. More extensive use of PPPs in New York State could have the benefit of shifting infrastructure investment risk to the private sector, freeing up short-term State funds, and lowering life-cycle costs.[4] The State expanded its recourse to PPPs when design-build legislation was passed in 2011. This could be further expanded with additional legislation and the establishment of a PPP program office, ideally within the Bank, to assist State and local agencies in planning, evaluating, structuring, implementing, and overseeing project delivery options to maximize both the supply of available finance and the public benefit created. Infrastructure Australia, referenced earlier in this section, was created in 2008 to undertake a similar function in that country. As noted in a recent publication by the Australian Government, "Governments around Australia recognize that, given budgetary constraints, they will not be capable of bridging the gap [in infrastructure finance]. Governments require new methods to develop the infrastructure needed to improve national productivity if we are to sustain and improve living standards."[5] PPPs, under some circumstances and when undertaken with appropriate safeguards, have the potential to generate better value for public dollars and transfer design and execution risk to the private sector. They also have the potential to unlock capital from institutional investors, whose combined assets under management exceed $20 trillion in the United States. A number of these investors, notably public pension funds such as the New York City Employees' Retirement System and the New York State Common Retirement Fund, have Economically-Targeted Investing policies that motivate them to pursue regional economic develop priorities that are well aligned with the interests of the State and communities. In December, the New York City Teachers Retirement System pledged $1 billion to new investments in infrastructure projects, including improvements to transportation, power, water, communications, and housing in New York City and throughout the tri-state area in the wake of Superstorm Sandy.
- **Expedited permitting.** Finding ways to improve permitting process efficiency can reduce delays and costs, as exemplified by the Tappan Zee Bridge project. In post-disaster scenarios like Superstorm Sandy, permitting processes are often waived or expedited. We should learn from these events to promote efficiencies in routine permitting.
- **Tax abatement.** Tax abatement can encourage business relocation or real estate development. At the local and state level, tax abatement can be used to encourage and assist communities in investing in resiliency projects that protect community assets from severe storm damage. Among other possibilities, the State should consider property tax abatements to avoid penalizing homeowners who make improvements to their homes to protect against future storms. This practice is described in detail in the Insurance section of this report.
- **Expand participant pool in financial guaranty protection.** Currently, the State is limited by the requirement that only monoline insurers—of which there is only one in New York—can provide this coverage. The lending capacity of commercial banks could be expanded if multi-line insurers were permitted to participate in financial guaranty protection.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Conclusion

The NYS 2100 Commission's overarching, and arguably most vital, role is to initiate a dialogue about the public policy changes – and changes to the public consciousness – that need to be adopted in order to build New York State's resilience in the face of any disaster. The suffering and damage created by Superstorm Sandy could not be more obvious. However, Sandy and other recent storms also provide an opportunity to address vulnerabilities that will cause damage in the future, if not addressed. The Commissioners universally agreed that we are at a historical and economic watershed. All New Yorkers hold the possibility to positively drive the future of our State. The Commission's goal in this report is to seize this moment and frame a very different and increasingly secure future.

NYS 2100 recognizes that a range of ideas great and small needs to become action. As we coordinated our work and aligned our recommendations, the entire Commission agreed that we need new ways of financing these actions.

We recommend making use of public resources and leveraging private capital to make sound investments in our State today, and jumpstarting a new economy. Jobs – and entire industries – promise to grow from the new opportunities described in this report. We include ideas and options for building smarter, but also a means to begin investing and financing these steps to a more resilient future. We fully believe that embracing resilience and changing how we think about and approach the future will bring not just greater security, but also economic prosperity.

To that end, we offer recommendations identifying exactly where and how alternatives and redundancies can be most effective -- not just to our infrastructure systems and markets, but also to the people and supplies needed to drive them.

While protecting existing economic activities, we also spent time thinking about new ones. For example, while no one questions the inherent beauty of our coastlines, protecting the waterfront brings huge challenges. We make the recommendation to include natural mitigation methods as well as traditional engineered solutions or other means. Finding natural and green methods for protection creates a crucial complement to both existing and new "hard" defenses. A broader adoption of green infrastructure can minimize local problems with flooding, contamination or erosion. This recommendation will require individuals to be trained for new jobs while encouraging existing companies to grow and increase their investment in new products and services. We also expect individuals to start new businesses specifically tailored to meet the needs of a more resilient future.

The Commission has made these recommendations based on our unique perspective on the long-term challenges that our State will face in the coming years. By 2100, there will be dramatic changes in our population and our climate, which we must be prepared to address. Our directives and the fruits of our recommendations – structural, cultural and economic – will therefore grow and evolve over the decades to come.

The recommendations put forward in this report represent the building blocks for the next century. Our work provides the types of actions that New York State and New Yorkers will need to take to meet the challenges of the years ahead.

By taking proactive action today, New York State can design the model for resilient communities across the United States and the world. Many recommendations are intended for the short term; others will be realized over much longer periods. Our infrastructure was not built or financed in a day. Making it more resilient will take longer than a day, or a year, or even a decade. But the time to start is now.


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References

Abbreviations

Abbreviation	Definition
AASHTO	American Association of State Highway and Transportation Officials
ACC Clause	Anti-Concurrent Causation Clause
ALB	Albany International Airport
AMI	Advanced Metering Infrastructure
ARRA	American Recovery and Reinvestment Act of 2009
ASCE	American Society of Civil Engineers
BRT	Bus Rapid Transit
BUF	Buffalo Niagara International Airport
Caltrans	California Department of Transportation
CBD	Central Business District
CBTC	Communication-Based Train Control
CHP	Combined Heat and Power
CIEMA	Comprehensive Insurance Emergency Measures Act
CIRIS	Critical Infrastructure Response Information System
CMP	Catastrophe Mitigation Program
CNG	Compressed Natural Gas
ConEd	Consolidated Edison Company of New York
CSO	Combined Sewer Overflow
CUNY	City University of New York
DEC	Department of Environmental Conservation
DEIS	Draft Environmental Impact Statement
DERM	Distributed Energy Resource Management
DFS	The Department of Financial Services
DG	Distributed Generation
DML	Durchmesserlinie
DMS	Distribution Management System
DOT	Department of Transportation
D-SCADA	Distribution Supervisory Control And Data Acquisition

Abbreviation	Definition
EA	Environmental Assessment
ECL	Environmental Conservation Law
EFC	Environmental Facilities Corporation
EIS	Environmental Impact Statement
EPF	Environmental Protection Fund
EPRI	Electric Power Research Institute
ESA	East Side Access
EV	Electric Vehicle
EWR	Newark-Liberty International Airport
FAA	Federal Aviation Administration
FEMA	Federal Emergency Management Agency
FHWA	Federal Highway Administration
FONDEN	Fund for Natural Disasters
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
GB/VMPO	Greater Bridgeport/Valley Metropolitan Planning Organization
GCM	Global Climate Model
GCT	Grand Central Terminal
GFDRR	Global Facility for Disaster Reduction and Recovery
GHG	Greenhouse Gas
GIS	Geographic Information System
HMGP	Hazard Mitigation Grant Program
HOV	High-Occupancy Vehicle
HUD	United States Department of Housing and Urban Development
HVCEO	Housatonic Valley Council of Elected Officials
IBHS	Institute for Business and Home Safety
ICC	International Code Council
IEOC	Insurance Emergency Operations Center

Abbreviation	Definition
ISO	Independent System Operator
ITS	Intelligent Transportation Systems
JFK	John F. Kennedy International Airport
LFC1	Lifeline Facility - Class 1
LFC2	Lifeline Facility - Class 2
LGA	LaGuardia Airport
LIPA	Long Island Power Authority
LIRR	Long Island Rail Road
LNG	Liquefied Natural Gas
LRFD	Load and Resistance Factor Design
LRT	Light Rail Transit
MAP-21	Moving Ahead for Progress in the 21st Century
MBCR	Massachusetts Bay Commuter Railroad Company
MBTA	Massachusetts Bay Transportation Authority
MCC	Mobile Command Center
MNR	Metro-North Railroad
MPO	Metropolitan Planning Organization
MSA	Metropolitan Statistical Area
MTA	Metropolitan Transportation Authority
MW	Megawatt
NAIC	National Association of Insurance Commissioners
NAP	Non-Insured Assistance Program
NEC	Northeast Corridor
NEPA	National Environmental Protection Act
NJDOT	New Jersey Department of Transportation
NJT	New Jersey Transit
NJTPA	North Jersey Transportation Planning Authority
NOAA	National Oceanic and Atmospheric Administration

Abbreviation	Definition
NYC	New York City
NYCDOB	New York City Department of Buildings
NYCDOT	New York City Department of Transportation
NYCRR	New York Codes, Rules, and Regulations
NYCT	New York City Transit (Division of MTA)
NYISO	New York Independent System Operator
NYMTC	New York Metropolitan Transportation Commission
NYPA	New York Power Authority
NYS	New York State
NYSDOT	New York State Department of Transportation
NYSERDA	New York State Energy Research and Development Authority
NYSTA	New York State Thruway Authority
NYU	New York University
OLTPS	New York City's Office of Long-Term Planning and Sustainability
PACE	Property-Assessed Clean Energy
PANYNJ	The Port Authority of New York and New Jersey
PATH	Port Authority Trans-Hudson
PEV	Plug-in Electric Vehicle
PPP	Public-Private Partnership
PSA	Penn Station Access
PSC	New York State Public Service Commission
PSE&G	Public Service Electric & Gas
PTC	Positive Train Control
R&D	Research and Development
RFK	Robert F. Kennedy Triborough Bridge
RGGI	Regional Greenhouse Gas Initiative
RIDOT	Rhode Island Department of Transportation
RMA	Risk Management Agency

Abbreviation	Definition
ROC	Greater Rochester International Airport
ROW	Right-of-Way
RTA	Greater Cleveland Regional Transportation Authority
RTEMP	Regional Transportation Emergency Management Plan
RTO	Regional Transmission Organization
SBS	Select Bus Service
SEQR(A)	State Environmental Quality Review (Act)
SEQRA	State Environmental Quality Review Act
SIF	State Insurance Fund
SRO	State-Level Risk Officer
SUNY	State University of New York
SWF	Stewart International Airport
SWRMPO	South Western Region Metropolitan Planning Organization
SYR	Syracuse Hancock International Airport
TCI	Transportation and Climate Initiative
TDR	Transferrable Development Rights
TIF	Tax Increment Financing
TMC	Transportation Management Center
TZB	Tappan Zee Bridge
UK	United Kingdom
USDOT	United States Department of Transportation
V2G	Vehicle to Grid

Glossary

Term	Definition
Abutments	Supporting structures that hold up or provide a foundation for a bridge.
Articulated Bus	A public transit vehicle consisting of two rigid sections linked by a hinged or pivot joint. This arrangement creates a longer vehicle that can accommodate a higher passenger capacity, while still allowing the vehicle to maneuver adequately on the streets of its service route.
As-Built Drawings	Drawings that show existing conditions as they are today.
Automated Metering Infrastructure (AMI)	Allows two way communication with smart meters, customers and operational databases.
Barbs	A projection of rocks from a riverbank to redirect water flow away from an eroding bank.
Biodiesel	A form of diesel fuel that can be manufactured from vegetable oils, animal fats, or recycled restaurant greases.
Biogas	The gaseous product of anaerobic digestion (decomposition without oxygen) of organic matter.
Bioswale	A vegetated swale which collects stormwater run-off to remove silt and pollution.
Block, Fixed	Distinct sections of rail track. Most blocks are "fixed," in that they include the section of track between two fixed points (e.g., stations).
Bulkhead	A retaining wall along a waterfront.
Bus Bridge	A temporary MTA transportation initiative that transported passengers between Manhattan and Brooklyn in the wake of Superstorm Sandy when subway service between the boroughs was limited due to flooded tunnels.
Bus Rapid Transit (BRT)	A high performance transit system that combines the speed, reliability and amenities of rail-based transit systems with the flexibility of buses. To meet high performance standards, BRT incorporates certain features, including dedicated and/or physically separated lanes, priority signaling at traffic lights, off-board fare collection, level boarding at multiple doors, real-time bus arrival information, and distinctive branding.
Busway	A lane, or lanes, reserved for buses. They may, but are not necessarily, physically separated from other traffic lanes.
Capacity	The number of units (people, pounds of cargo, etc.) a transportation asset or mode can carry or accommodate under given conditions, e.g., the number of vehicles a lane of highway can carry in an hour or the number of passengers in an airplane.
Carbon Intensity	Carbon dioxide emissions per unit of energy consumed.
Chief Risk Officer	Government agent that provides a platform for coordination between different State agencies and neighboring municipalities and creates the basis for an “all hazards” approach to planning, investment, and decision-making.
Clean Water Act (1948)	Establishes the basic structure for regulating discharge of pollutants into the waters of the United States and regulating quality standards for surface water.
Combined Heat and Power (CHP)	Combined heat and power, also known as cogeneration, is the simultaneous production of electricity and heat from a single fuel source, such as: natural gas, biomass, biogas, coal, waste heat, or oil.
Combined Sewer Outflow (CSO)	Stormwater run-off events that overload the sewer system and directly discharge a combination of stormwater and sewage into local water ways.

Term	Definition
Communication-Based Train Control (CBTC)	A subway signaling system that uses telecommunications between train and track equipment to manage and control train traffic.
Commuter Rail	A passenger rail transportation service that primarily operates between a city center and the more suburban areas that draw large numbers of commuters to the city. They often coexist, sharing the rail right-of-way with freight or intercity rail services. Compared to the subway, or other rapid transit systems, commuter rail has lower frequency and fewer stations spaced farther apart.
Compressor	A machine used to supply air or other gas at increased pressure.
Cost recovery	Recoupment of the purchase price of a capital or qualified asset through depreciation over a prescribed period.
Critical Infrastructure Response Information System (CIRIS)	Uses Geographic Information System (GIS) technology to support analysis, visualization, and real-time decision making for agencies within New York State.
Cross-Honoring	A temporary system whereby a transit provider/operator allows passengers to use tickets/passes purchased for another mode of transportation or from another provider/operator. This is usually enacted in times of need when transit systems are debilitated and passengers need to use other travel options to get around.
Culvert	An enclosed channel open at both ends that carries water from a stream or water course through a manmade barrier such as a roadway embankment.
Demand Response	Changes in electric usage by demand-side resources from their normal consumption patterns in response to changes in the price of electricity over time, or incentive payments designed to induce lower electricity use at times of high wholesale market prices or when system reliability is jeopardized.
Depot	A storage facility.
Design-Build	A project delivery method that combines into a single contract the two, usually separate, services of designing and building an infrastructure asset. This contrasts with the traditional approach (design-bid-build) of entering into a design contract and then bidding out the construction of the completed design. It is intended to ensure that design decisions directly take into account the cost of construction leading to cost-effective decision-making.
Design-Build-Finance-Operate-Maintain (DBFOM)	A project delivery method that bundles together the responsibilities for designing, building, financing, operating, and maintaining an infrastructure asset and transfers those responsibilities to private-sector partners. There is a great deal of variety in DBOFM arrangements in the United States, and especially the degree to which financial and construction responsibilities and risks are actually transferred to the private sector. One commonality that cuts across all DBFOM projects is that they are either partly or wholly financed by debt leveraging revenue streams dedicated to the project. Direct user fees (e.g., tolls) are the most common revenue source.
Design-Build-Operate-Maintain	A project delivery method that bundles together the responsibilities for designing, building, operating, and maintaining an infrastructure asset and transfers those responsibilities to private-sector partners. Financing remains the responsibility of the public sector. As is the case with DBOFM arrangements, the degree to which financial and execution risk is actually transferred to the private sector varies widely.
Design Life	The life expectancy of a piece of infrastructure, or the period of time during which an infrastructure project is expected to function within its specified parameters.

Term	Definition
Distributed Energy Resource Management (DERM)	Coordinates the dispatch of central power stations and the distribution management system to economically schedule demand response and distributed energy resources.
Distributed Generation (DG)	Small electrical power generators installed in homes, businesses, and office buildings, that can supply power to a location when grid power is not available.
Distribution	Local wiring between electrical substations and customers.
Distribution Management System	A decision support system for utilities to assist control room and field operating personnel to monitor, control and optimize the electric distribution system without compromising safety and assets.
Distribution Supervisory Control and Data Acquisition (D-SCADA)	Collects and reports voltage levels, current demand, apparent power, reactive power, equipment state, operational state, and event logging allowing operators to remotely control capacitor banks, breakers and voltage regulation.
Drywells	An underground structure which collects stormwater run-off and slowly dissipates it into the ground.
E-85	Transportation fuel composed of 85% ethanol and 15% gasoline.
Ecosystem Services	Components of nature directly enjoyed, consumed or used to yield human well-being. Examples include fresh water, timber, climate regulation, recreation and aesthetic values.
Egress	The act of exiting or leaving.
Electric Vehicles (EV)	Vehicles using electric motors powered from stored electrical energy.
Embankments	A mound of earth or stone built to hold back water or to support a roadway.
Emergency services	The public organizations that respond to and deal with emergencies when they occur, esp. those that provide police, ambulance, and firefighting services.
Energy Highway Blueprint	The Energy Highway Blueprint outlines 13 recommended actions in four focus areas that utilize public-private partnerships to help transport New York's aging energy infrastructure into the future.
Environmental Assessment (EA)	A concise screening document used as part of the NEPA process to evaluate a proposed project and determine if an agency will need to prepare an EIS. If not, the agency must demonstrate a "Finding of No Significant Impact" (FONSI), which presents the reasons why an action will not have a significant effect on the environment.
Environmental Impact Statement (EIS)	A comprehensive document used as part of the NEPA process that describes the environmental consequences of a proposed project and alternatives. An EIS describes, among other things, the environmental impacts of the proposed action; any adverse environmental impacts that cannot be avoided should the proposal be implemented; reasonable alternatives to the proposed action; and any irreversible and irretrievable commitments of resources that would be involved in the proposed action should it be implemented.
Environmental Justice	The fair treatment and involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. EPA has this goal for all communities across the U.S.
Fixed-Block Signal System	Communication system used to control trains between fixed blocks. Used to enable the safe and efficient operation of railways.
Flood Gates	Adjustable gates used to control water flow in flood barriers, reservoir, river, stream, or levee systems.

Term	Definition
Fuel Cell	A device that continuously changes the chemical energy of a fuel and an oxidant into electrical energy.
General Aviation	General aviation is all civil aviation operations other than commercial air services. General aviation flights range from gliders and powered parachutes to corporate jet flights. The majority of the world's air traffic falls into this category, and most of the world's airports serve general aviation exclusively.
Geographic Information System (GIS)	An integrated system of data, hardware and software used to analyze and display geographically referenced information.
Green/Soft Infrastructure	In the context of stormwater management, green infrastructure includes a wide array of practices at multiple scales to manage and treat stormwater, maintain and restore natural hydrology and ecological function by infiltration, evapotranspiration, capture and reuse of stormwater, and establishment of natural landscape features. On a regional scale, green infrastructure is the preservation and restoration of natural landscape features, such as forests, floodplains and wetlands, coupled with policies such as infill and redevelopment that reduce overall imperviousness in a watershed or ecoregion. On the local scale green infrastructure consists of site- and neighborhood-specific practices and runoff reduction techniques.
Greenhouse Gas (GHG)	A gas that contributes to the greenhouse effect by absorbing infrared radiation, e.g. carbon dioxide.
Grey Infrastructure	Manmade systems which route stormwater runoff to off-site locations for treatment or storage.
Groins	Man-made structures constructed perpendicular to the shoreline and extending into the ocean. They are designed to trap sand as it is moved down the beach by a current, causing the drift current to slow down and change direction.
Harden	The process of securing a system by reducing its vulnerability.
Heavy Rail	A railway with the capacity for a heavy volume of traffic, characterized by: high speed and/or rapid acceleration; all or mostly grade-separated; and high-level boarding. Also known as subway, metro, rapid transit, or commuter rail.
High-Occupancy Vehicle (HOV)	A car or other vehicle carrying a required minimum number of passengers.
Intelligent Transportation System (ITS)	Advanced technologies that utilize computers, telecommunications, global positioning systems (GPS) the Internet, and other resources to improve transportation system performance and efficiency by conveying information about transportation conditions to various users.
Islanding	Intentional islanding is the purposeful sectionalization of the utility system during widespread disturbances to create power "islands".
Levee	An embankment for preventing flooding.
Life-Cycle Cost	Sum of all recurring and one-time costs over the full life span of a product, service, structure, or system. Includes purchase price, installation cost, operating costs, maintenance and upgrade costs, and any remaining value at the end of its useful life.
Lifeline Network	A collection of transportation infrastructure/facilities in New York State that are considered essential to State and regional mobility during and after events. Network facilities must remain open at all times to maintain regional mobility, such as the movement of goods, commodities and emergency or relief services.
Lift Bridge	A type of movable bridge in which a span rises vertically while remaining parallel with the deck.

Term	Definition
Lock	A device for raising and lowering boats between stretches of water of different levels on waterways, making them more easily navigable. The distinguishing feature of a lock is a fixed chamber in which the water level can be varied.
Maritime Transportation Network	All navigable water-based facilities, both natural and man-made, that accommodate the movement of people and freight, via waterborne vessels, to, from and through the State
Megawatt (MW)	A unit of power.
Metropolitan Planning Organizations	Federally mandated and federally funded transportation policy-making organizations in the U.S. that are made up of representatives from local government and transportation authorities. The Federal-Aid Highway Act of 1962 required the formation of an MPO for any urbanized area with a population greater than 50,000. Some federal funding for transportation projects and programs are allocated by MPOs.
Microgrid	Clusters of homes and buildings that share a local electric power generation and/or energy storage device while disconnected from the utility grid.
Mode	A means of transportation (e.g., private automobile, bike, transit, etc.).
National Environmental Policy Act (NEPA)	The 1969 U.S. environmental law that established as national policy the protection and enhancement of the environment. The NEPA process with regard to construction activity consists of an evaluation of relevant environmental impacts of a federally-funded project or action, including a series of pertinent alternatives.
New York Metropolitan Statistical Area (MSA)	A geographic entity containing a core urban area of 50,000 or more population and one or more counties containing the core urban area as well as adjacent counties that have a high degree of social and economic integration (measured by communing to work). New York's MSA includes New York, Northern New Jersey, Long Island, and parts of Pennsylvania.
New York State Public Service Commission (PSC)	A New York State regulatory agency that oversees the provision of electric, gas, steam, telecommunications, and water services in New York State.
New York Works Task Force	A group comprised of leading finance, labor, planning, and transportation professionals focused on developing a statewide infrastructure plan to effectively allocate investment and create jobs. It is a key part of Governor Cuomo’s New York Works program to improve the economic competitiveness of New York State.
Northeast Corridor (NEC)	The fully electrified rail line running from Boston, MA to Washington, D.C. with branches serving other metropolitan areas. The NEC is owned primarily by Amtrak and is used by Amtrak's Acela Express and Northeast Regional services in addition to several commuter and freight rail services. The NEC is the busiest passenger rail line in the United States by ridership and service frequency.
Pay-for-Performance	A program that provides financial incentives to a provider to meet pre-established targets for delivery of a service. Examples include energy efficiency improvements in buildings and the provision of healthcare services.
Permeable Pavement	Pavement which allows stormwater runoff to infiltrate the surface and filters pollutants.
Pile	A heavy beam of timber, concrete, or steel, driven into the earth as a foundation or support for a structure.
Positive Train Control (PTC)	A system for monitoring and controlling train movements to provide increased safety. With this system, a train receives information about its location and where it is allowed to safely travel. Equipment on board the train then enforces this, preventing unsafe movement.

Term	Definition
Public Private Partnership (PPP)	A contractual agreement between a public-sector agency and a private-sector entity under which the private-sector entity provides a public service or project and assumes substantial financial, technical, and/or operational risk.
Public Service Commission (PSC)	Regulates public utilities (gas, electric, telephone, water, and sewage disposal companies).
Regional Greenhouse Gas Initiative (RGGI)	Mandatory, market-based effort to reduce greenhouse gas emissions in Northeastern and Mid-Atlantic states via a cap-and-trade system.
Relief Services	Life-saving food, water, medicine, etc. provided after a severe event.
Renewable Portfolio Standard	Regulations requiring a specific amount of energy to be produced through renewable (wind, solar, etc.) resources.
Resilience	The ability of a system to withstand shocks and stresses while still maintaining its essential functions.
Right-of-Way	A general term denoting land, property, or interests therein, including easements. A right-of-way is usually a strip or parcel acquired for or devoted to a highway or railroad.
Riprap	Rock or other material used to line and protect shorelines, streambeds, bridge abutments, pilings and other structures against scour, water or ice erosion.
Risk Assessment	Determination of the quantitative or qualitative value of risk related to a concrete situation and a recognized threat or hazard.
Road Bed	The foundation and surface of a road.
Roll-Down Doors	A slatted door or covering that can be rolled down and locked into place.
Safe Drinking Water Act (1974)	Ensures the quality of Americans' drinking water.
Scour	The removal or erosion of sand and rocks from the base of roads and bridges, usually by rapidly moving water, that exposes foundation elements.
Selective Undergrounding	Locating certain energy infrastructure underground based on feasibility and other criteria.
Smart Grid	System that integrates modern communications to coordinate electricity generation and consumption within the electrical distribution network.
Spur	A very short branch line, or secondary railway line which branches off a major through route.
Spur Dikes	Embankments designed to direct flood flows into a bridge opening located at an appropriate point from the bridge and extending upstream. Spur dikes should be installed at an angle to redirect water flow into the bridge opening, reducing the potential for erosion along and under the bridge piers and abutments, and along the bridge embankment.
Stafford Act	Federal legislation that governs public funding to repair, restore, reconstruct, or replace public facilities destroyed in a major disaster.

Term	Definition
State Environmental Quality Review Act (SEQRA)	In New York State, most projects or activities proposed by a state agency or unit of local government, and all discretionary approvals (permits) from a State agency or unit of local government, require an environmental impact assessment as prescribed by the State Environmental Quality Review (SEQR). SEQR requires the governmental body to identify and mitigate the significant environmental impacts of the activity it is proposing or permitting.
State Infrastructure Bank	Revolving infrastructure investment funds that are established and administered by states. The infrastructure banks can offer loans and credit assistance enhancement products to public and private sponsors of infrastructure projects.
Storm Surge Barrier	Also known as a flood barrier, is a specific type of floodgate designed to prevent storm surge from flooding the protected area behind the barrier.
Stormwater Run-off	Water from rain or melting snow that does not naturally percolate into the ground, but flows into waterways over paved areas, sloped lawns and bare soil.
Substation	A set of equipment that reduces the high voltage of electrical power transmission to a suitable voltage for supply to consumers.
Supply Chain	A system of organizations, people, technology, activities, information and resources involved in moving a product or service from supplier to customer.
Surge Barrier	A type of flood gate that is used to prevent storm surge from flooding certain areas.
Sustainable Community Grants	Monies provided through the U.S. Department of Housing and Urban Development (HUD), U.S. Department of Transportation (DOT), and the U.S. Environmental Protection Agency (EPA) to help communities in the U.S. improve access to affordable housing, increase transportation options, and lower transportation costs while protecting the environment.
Switch	A mechanical installation enabling railway trains to be guided from one track to another, such as at a junction or where a spur branches off.
Switchgear	Any of several devices used for opening and closing electric circuits.
Thermocouples	Consists of two conductors of different materials (usually metal alloys) that produce a voltage (i.e., power) in the vicinity of the point where the two conductors are in contact.
Throughput	In transportation, the average rate of vehicles passing through a transportation system.
Tide Gates	An opening through which water may flow freely when the tide sets in one direction, but which closes automatically and prevents the water from flowing in the other direction.
Time-of-Use Rates	A method of billing for electricity consumption using real-time electricity rates.
TRANSCOM	A coalition of 16 major transportation and public safety agencies in the New York-New Jersey-Connecticut metropolitan region. It was created in 1986 to provide a cooperative and coordinated approach to regional transportation management.
Transformer	A device in electrical infrastructure that increases or decreases voltage for transmission and distribution.
Trans-Hudson	Refers to any infrastructure or system - bridges, tunnels, etc. - that crosses or spans the Hudson River.
Transmission	Bulk transfer of electrical energy over electrical lines from power plants to electrical substations.
Transportation Agency	A Federal, State, or local government entity responsible for planning and designing transportation systems and facilities for a particular jurisdiction.

Term	Definition
Transportation Climate Initiative (TCI)	A regional collaboration of 12 Northeast and Mid-Atlantic jurisdictions that seeks to develop a clean energy economy and reduce greenhouse gas emissions in the transportation sector.
Transportation Infrastructure	Physical transportation assets or facilities, including airports, bridges, railroads, roads, sidewalks, tunnels, etc.
Transportation Management Centers (TMC)	Facilities that monitor traffic and provide rapid police response, multi-agency/multi-modal operational coordination, and travel advisories. TMCs are manned by staff from multiple agencies or jurisdictions working as a team.
Tri-State Region	The group of states comprised of New York, New Jersey and Connecticut.
Vanes	Upstream-angled lines of boulders. While water usually covers the shorter section during normal flows, the taller sections deflect flow away from the banks of the stream. Flow is diverted over the rock walls and concentrated down the center of the channel.
Vehicle-to-Grid (V2G)	A system in which plug-in electric vehicles, such as electric cars and plug-in hybrids, communicate with the power grid to sell demand response services by either delivering electricity into the grid or by throttling their charging rate.
Ventilation Shaft	Vertical passage used in tunnels to move fresh air underground, and to remove stale air.
Walking Facilities	Sidewalks, crosswalks, dedicated paths, and any other pedestrian facilities.
Waterways	A river, canal, or other route for travel by water.
Wayside	The edge of a road or rail right-of-way.
Wetlands	An area that is regularly saturated by surface water or groundwater. Examples of wetlands include swamps, bogs, fens, marshes, and estuaries.

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