



CHAPTER 3

AN INTRODUCTION TO NEW YORK CITY'S RISK LANDSCAPE

New York City is a global coastal city. It is densely packed with diverse communities, complex infrastructure systems, and dynamic natural resources. The future our city will be shaped by our growing population, aging infrastructure, and changing climate. New York City's resiliency will require preparedness for hazard events and the capacity to rebound quickly from them.

This chapter sets the stage for the next chapter's discussion of specific hazards, risks, and risk management strategies.

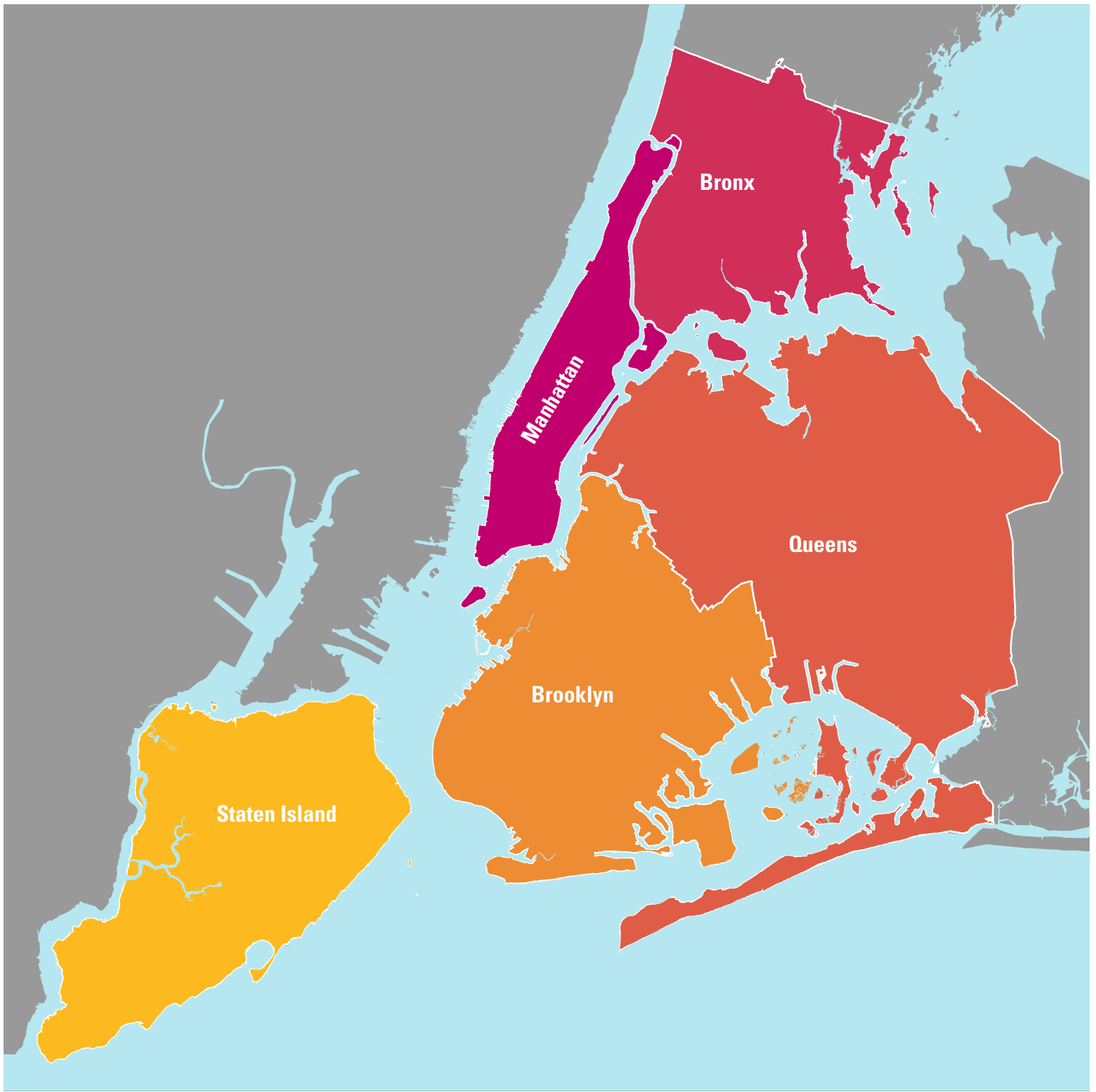
The impact of hazard events on people is of paramount concern. In examining features of our built environment, we pay closest attention to critical infrastructure systems – energy, telecommunications, transportation, and water and wastewater – upon which so much of our city's functioning depends. We conclude with a look at what climate change portends.

Resiliency requires both preparedness for hazard events and the capacity to rebound quickly from them. Damage to and disruption of some vulnerable features of our city can be repaired in mere hours; in extreme cases, recovery can take years.

AT A GLANCE

Complex and dynamic, New York is the most populous city in the United States. It is a global, coastal city and the nation's largest metropolitan area. Here's a sampling of key features that put us at risk:

- We are located on a coastline that is 520 miles long – longer than those of Miami, Boston, Los Angeles, and San Francisco combined. Bordering an ocean, rivers, bays, tidal straits, inlets, and a harbor, parts of the coast is low-lying, making us vulnerable to coastal storms, erosion and different types of flooding.
- We have roughly 8.4 million residents. Commuters, tourists, and other visitors boost our numbers to approximately 9 million on an average day. Our population is projected to grow in the coming decades.
- We occupy only 305 square miles, with population density varying significantly across the city. Each neighborhood's characteristics create a unique set of risk and exposure factors.
- We are embedded in a metro region with a population of roughly 22 million people, and we are heavily dependent on complex, interdependent



MAP OF FIVE BOROUGHS

SOURCE: NYC DCP



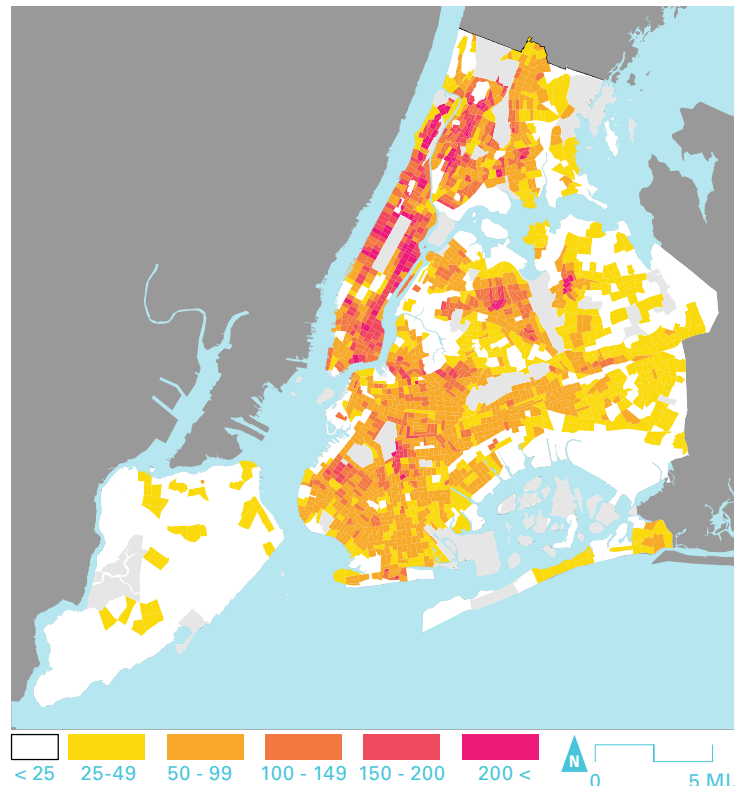
Borough	BRONX	BROOKLYN	MANHATTAN	QUEENS	STATEN ISLAND	TOTAL ALL 5 BOROUGHS
Population	1,419,000	2,592,000	1,626,000	2,296,000	473,000	8,400,000
person / acre	52	57	111	32	13	43

SOURCE: CENSUS BUREAU CURRENT ESTIMATES PROGRAM, 2013



TOPOGRAPHY

DATA SOURCE: NYC DOITT



POPULATION DENSITY PER CENSUS TRACT

SOURCE: US CENSUS BUREAU, 2008-2012 ACS 5-YEAR ESTIMATE, AND NYC DCP

critical systems – energy, telecommunications, transportation, and water and wastewater – some regional in scope. Much of this infrastructure is aging and requires continued and extensive maintenance, which can be a risk factor in itself.

- Our building stock is immense, totaling approximately 1 million buildings. They constitute an enormous financial asset. Many were built prior to newer, stricter Construction Code standards.
- For some New Yorkers, factors such as age, disability, chronic health conditions, poverty, and language barriers can increase vulnerability to certain hazards. With population growth, the number of vulnerable New Yorkers will also likely grow.

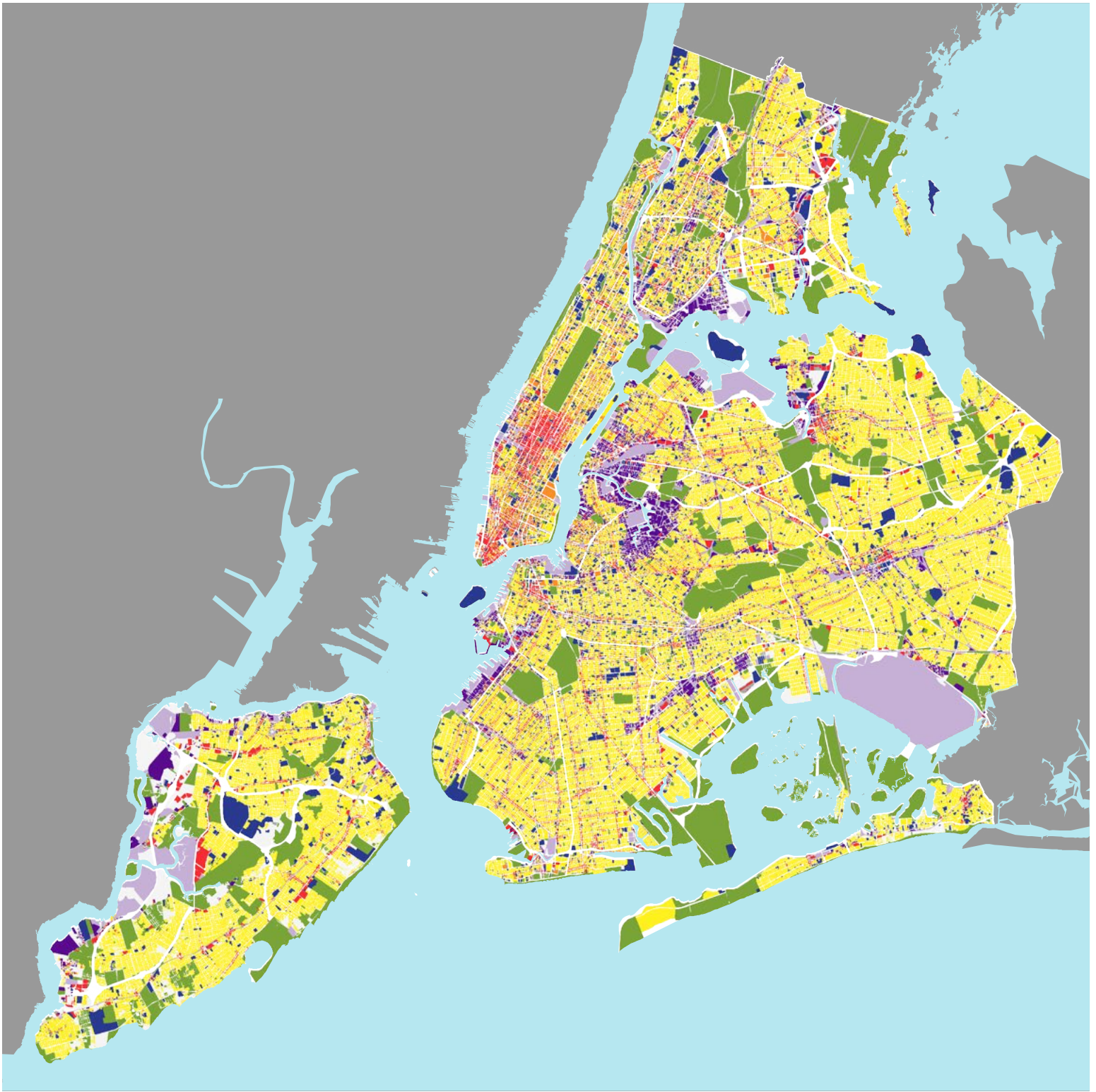
The demands of a growing population on aging infrastructure and critical systems – coupled with the effects of climate change – make our portfolio of hazards particularly serious. The size of New York City’s financial assets and economy and our role in the regional, national, and global economies mean that damage to us can reverberate well beyond our borders.

GEOGRAPHY AND LAND USE

New York is a coastal city. Each borough has extensive stretches of shoreline, and all except the Bronx are islands unto themselves (Manhattan and Staten Island) or part of one (Brooklyn and Queens are part of Long Island). The water bodies we border and contain are as diverse as our urban landscape: canals, creeks, ponds, inlets, straits, rivers, estuaries, bays, a sound, and an ocean. Perhaps nothing has more powerfully shaped our city than the relationship between its land and water.

Over the centuries, the city’s topography was altered as waterways were dredged for shipping, piers and bulkheads were constructed, and landfill extended the shoreline to create more usable land. These changes helped the city flourish. But some natural features that once protected landmasses were lost in the process, exposing people and assets to greater risk.

New York City’s land area covers approximately 305 square miles. Historically, land-use patterns and development trends were driven by economic forces and population growth. As urban planning became a profession and a moderating force, City government

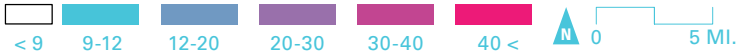
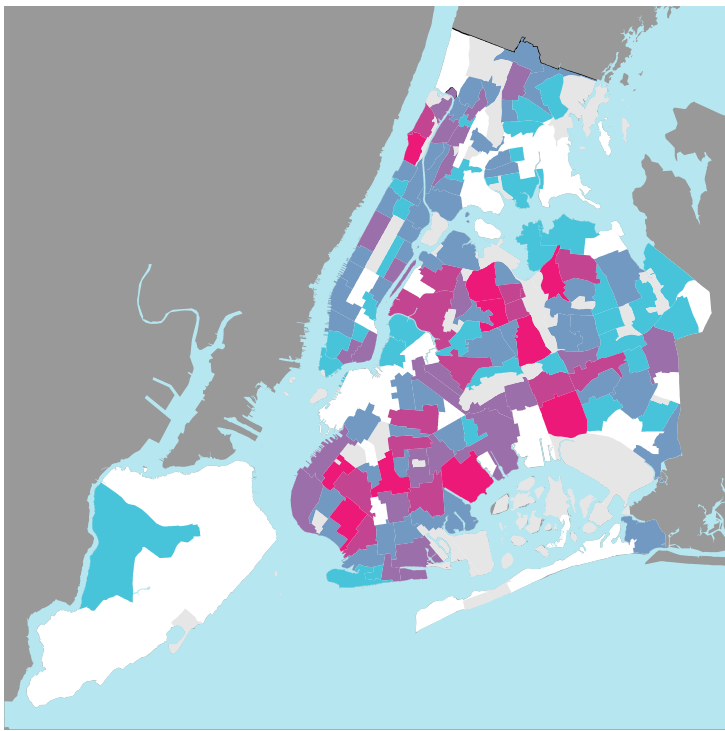


LAND USE

SOURCE: MAPPLUTO 14V1, NYC DCP, 2013

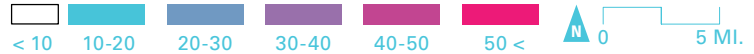
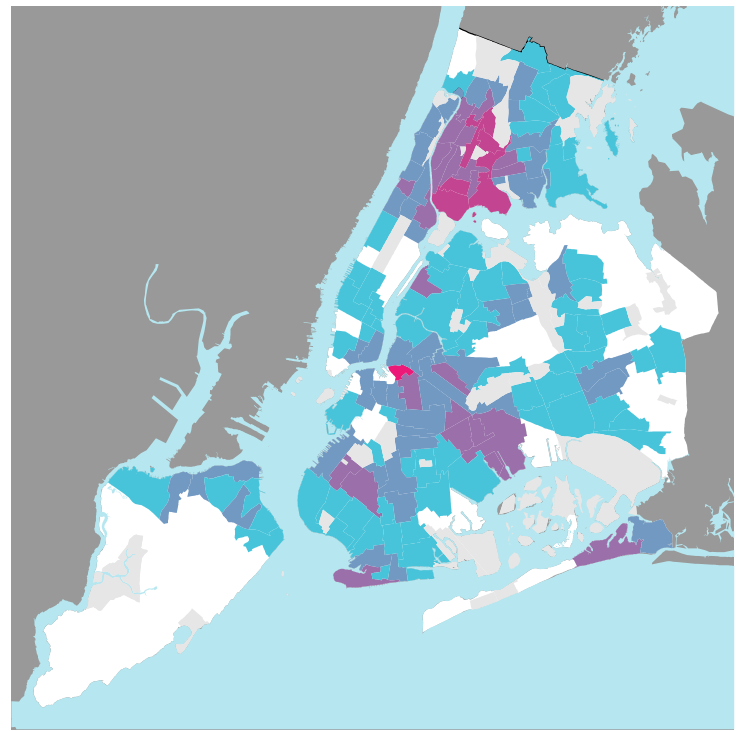


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|---|---|--|---|
|  RESIDENTIAL |  COMMERCIAL |  INDUSTRIAL |  PARKING FACILITIES |
|  MIXED-USE RESIDENTIAL |  INSTITUTIONAL |  TRANSPORTATION AND UTILITIES |  OPEN SPACE & OUTDOOR RECREATION |



FOREIGN-BORN POPULATION BY NEIGHBORHOOD TABULATION AREA (IN THOUSANDS)

SOURCE: US CENSUS BUREAU, 2008-2012 ACS 5-YEAR ESTIMATES, AND NYC DCP



% PERSONS BELOW POVERTY LEVEL BY NEIGHBORHOOD TABULATION

SOURCE: US CENSUS BUREAU, 2008-2012 ACS 5-YEAR ESTIMATES, AND NYC DCP

developed tools to manage growth. Collectively New York City’s zoning regulations, Construction Codes, and planning policies now shape development toward the long-term goals of sustainability and resiliency.

PEOPLE

More people are living in, working in, and visiting New York City than ever before. More than 8.4 million people live in New York City— an average of roughly 43 people per acre. This makes us by far the most populous and densest city in the country, with twice the population of the second-largest, Los Angeles.

Swelling our numbers are commuters, tourists, business travelers, and other visitors. On average, approximately 9 million people may be in the city at any one time. That number can spike on holidays and for special events such as New Year’s Eve, the New York Marathon, and major parades.

While all New Yorkers are potentially at risk of hazards, groups that tend to be most vulnerable are young children, the elderly, people with disabilities and serious health conditions, people who are socially isolated, and households with limited English proficiency. Also, for many hazards, poverty amplifies risk.

CHILDREN AT RISK

Children are particularly vulnerable to natural disasters because they are dependent on parents or adult caretakers for food, shelter, transportation, and guidance. And the stress that follows a natural disaster may linger longer in children than in adults, according to the Federal Emergency Management Agency’s mental health experts.

Our city’s youth population is growing in number. The 2012 U.S. Census data show that about 21 percent of New Yorkers are under the age of 18, and 6.5 percent are under 5. Over 30 percent of all households have children under 18.

SPECIAL FOCUS: SOCIAL ISOLATION

Social isolation can be difficult to identify and hard to assess, making it a serious risk factor. It relates to the kinds of social safety nets that keep us connected and informed, ultimately making us safer.

Isolation can be a function of poverty that limits access to information technologies. It can be a function of limited literacy and/or linguistic isolation. It may be a function of disability, chronic or mental health conditions. Whatever the cause, when a hazard strikes, social isolation can increase vulnerability.

Children are at even greater risk if they are poor or disabled. In New York City, approximately 31 percent of young people 18 years old and under live below the federal poverty level, and more than 100,000 of those children are under the age of 5. The 2012 American Community Survey found that roughly 4 percent of the city's children under age 18 have some form of disability.

SENIORS AT RISK

Older adults who have chronic health conditions or disabilities, live alone or otherwise experience isolation, or have limited access to emergency services face higher risks. Seniors generally depend more heavily on medical services at hospitals and nursing homes than other people do, and if their mobility is limited, they may depend on special needs transportation or other special assistance; for example, help in getting prescriptions refilled. For seniors who rely on medications that require refrigeration, on power-dependent medical equipment like oxygen tanks and motorized wheelchairs, and on elevators, power outages can be particularly dangerous.

Seniors with mental health conditions, such as disorientation, anxiety, or depression, are likely to be more at risk during and after a serious hazard event.

The last 30 years have seen the share of senior New Yorkers grow. According to the 2012 American Community Survey, more than 12 percent of New Yorkers — roughly 1 million residents — are over the age of 65. This group has been growing much more rapidly (12.4 percent since 2000) than the city's overall population (2.1 percent since 2000).

VULNERABLE POPULATIONS

- Children
- Seniors
- People with disabilities
- People with language constraints
- Socially isolated people
- People with low income

The 2012 American Community survey counted approximately 300,000 seniors—or roughly 10 percent of all New York City households—living alone, and it found that almost 50 percent of New York City's older residents are foreign-born. Isolation can be more acute among immigrant seniors: nearly two-thirds of them have limited English proficiency.

DISABILITIES AND CHRONIC HEALTH PROBLEMS AS RISK FACTORS

Some problems that seniors experience are not exclusive to them. The U.S. Census defines four major categories of disabilities:

- **Sensory disabilities** include blindness, deafness, or a severe vision or hearing impairment.
- **Physical disabilities** are long-lasting conditions that substantially limit one or more basic physical activities, such as walking, climbing stairs, reaching, lifting, or carrying things.
- **Self-care disabilities** are conditions lasting six or more months that make dressing, bathing, or getting around inside the home challenging.
- **Go-outside-the-home disabilities** are conditions lasting 6 or more months that make it difficult to shop or visit a doctor's office on one's own.

According to American Community Survey, approximately 10 percent of New Yorkers are estimated to have a disability, as defined by the above categories. The rate increases with age. The ACS estimates that almost 38 percent of New Yorkers

aged 65 and over have at least one type of disability. Approximately 45 percent of the city's seniors with disabilities live within the 1 percent annual chance floodplain in communities such as the Rockaways, Coney Island, and Brighton Beach. Some of the city's hospitals, senior centers, nursing homes, and assisted care facilities are located within the floodplain.

LANGUAGE CONSTRAINTS AS A RISK FACTOR

New York boasts one of the most diverse populations of any major U.S. city. Our 2012 foreign-born population of 3.14 million was the largest in the nation and a historical high for us, representing 38 percent of our population. Queens (with 1.09 million) and Brooklyn (nearly 1 million) together account for two-thirds of all foreign-born residents. Nearly half of Queens' residents were foreign-born in 2012.

Over 200 languages are spoken here. Nearly half of all New Yorkers speak a language other than English at home. As defined by the U.S. Census Bureau, in 2012 an estimated 23 percent of New Yorkers spoke English less than very well.

To reach such a diverse population, the City relies on many forms of communication including, social media, printed literature, web sites, radio, TV, and word-of-mouth outreach through community organizations. Municipal agencies such as the New York City Emergency Management Department provide hazard warning and evacuation notices in multiple languages and accessible formats.

LOW INCOME AS A RISK FACTOR

The U.S. government's official poverty measure is pre-tax cash income. In 2014, the poverty threshold was set at \$11,670 for a one-person household and \$23,859 for a four-person household. Because those levels are not regionally adjusted, U.S. Census numbers may not fully reflect the number of people living with economic hardships in New York City.

The 2012 American Community Survey found over 21 percent of the city's population, or approximately 1,750,000 people, living below the federal poverty line, including over 30 percent of all children under the age of 18. The greatest concentrations of low-income populations are in the South Bronx and Upper Manhattan, and scattered throughout Brooklyn.

Approximately 45 percent of the city's population is "rent-burdened," spending more than 35 percent, a standard established by the Federal government, of household income on rent. This leaves limited margin for unexpected expenses and even less for loss of income due to hazard events.

Most New Yorkers rent their housing. If it is damaged by a hazard event, finding affordable alternative housing to occupy while repairs are made – even temporarily – can be a serious challenge, given the city's limited supply of affordable housing. To avoid higher rent or homelessness, some low-income people may continue to occupy damaged homes.

The New York City Housing Authority, the largest landlord in the city and the largest public housing authority in the country, provides housing to over 400,000 low-income tenants. Public housing complexes were hard hit by Hurricane Sandy, which left approximately 80,000 NYCHA residents in over 400 buildings without power, heat, and/or hot water.

While the scope is large and budget limited, NYCHA is working aggressively to make its buildings more resilient to weather events.

WHO WILL BE THE NEW YORKERS OF THE FUTURE?

The 1990, 2000, and 2010 U.S. Census all reported net increases in our population. It is expected this pattern will continue into the future. By 2040, population is projected to increase by almost 10 percent and surpass 9 million for the first time in our history, with the Bronx, Brooklyn, Queens, and Staten Island home to more residents than ever before. About 62 percent of the total net population increase is expected to take place in Brooklyn and the Bronx.

For a low-income wage earner with little or no savings, a disaster that disrupts employment and therefore income can produce its own cascade of hardships.

By 2040, the age profile of New Yorkers will differ from today's. The most dramatic change is projected for people who will be 65 years or older: this group will grow by approximately 40 percent, varying by borough. This is mainly due to the aging of the large baby boomer cohort, who will all be at least 75 years old by that date, as well as an expected lower fertility rate and longer life expectancy. Currently, this age group makes up approximately 12 percent of our population. The portion of that group that is foreign-born is projected to grow, too.

Compared with growth in the total population, the share of school-age children (ages 5-17) is projected to decrease slightly by 2040. But the number is projected to increase by approximately 6 percent, varying by borough.

OUR ECONOMY

Our economy is large, interconnected and dependent on regional resources. It is no surprise that it is also vulnerable to disruption by hazard events, and the costs of recovering from such events can constitute a secondary hazard impact of its own.

ECONOMIC SECTORS AND OUR WORKFORCE

New York City is a global economic capital and the center of a regional economy that generates upwards of \$1.5 trillion in goods and services annually. Home to Wall Street and two of the world's largest stock exchanges, it is also headquarters to more Fortune 500 and 1,000 companies – including top securities firms, law firms, and banks – than any other U.S. city. Highly skilled professionals from around the country and the world come here to pursue their careers, and their dreams. This intellectual and creative “capital” is among our city's greatest assets.

Real estate is New York's largest sector, adding \$220 billion to the economy each year, followed by finance, insurance, and professional and technical services. Tourism continues to grow. It generated over \$55 billion in revenue in 2012 and employed approximately 400,000 workers. Our world-class cultural institutions and sports facilities are also important sources of revenue and employment as well.

Among many other sectors are construction, retail, arts and entertainment (theater, TV, film), higher education (including leading research institutions), health care and social assistance, old and new media (publishing, TV, radio, the Internet), marketing, and advertising. Over half a million people work for federal, state, and local government.

Technology-based industries, making up “Silicon Alley”, rely on fiber-optic cable for high-speed communication and constitute a burgeoning sector. As measured by venture capital investments in 2013, the city's fastest-growing sectors are software, financial services, and biotechnology.

The local businesses and branches of larger businesses that provide goods and services throughout the city are a vital part of our economy. Grocery stores, convenience stores (often referred to as “bodegas”), pharmacies, banks, laundromats, restaurants, beauty salons, hardware stores, and many other kinds of establishments meet basic needs, add to local quality of life, promote social interaction and social bonds, and contribute to the character of neighborhoods.

Our economy sustains over 4 million jobs. However, in 2012 approximately 400,000 New Yorkers – 1 in 10 working adults – earned below the federal poverty line. While many new jobs are low-paying, the overall rate of job growth in New York City is on the rise and was higher than the state's and the nation's in 2013.

MOVING PEOPLE, FREIGHT, AND INFORMATION

Much of our economic activity takes place inside buildings and depends on critical infrastructure systems – energy, telecommunications, transportation,

PROJECTED TOTAL NEW YORK CITY POPULATION BY BOROUGH, 2010-2040

	2010	2020	2030	2040	Change from 2010 to 2040	PCT Change
NYC	8,242,624	8,550,971	8,821,027	9,025,145	782,521	10%
Bronx	1,385,108	1,446,788	1,518,998	1,579,245	194,137	14%
Brooklyn	2,552,911	2,648,452	2,754,009	2,840,525	287,614	11%
Manhattan	1,585,873	1,638,281	1,676,720	1,691,617	105,744	7%
Queens	2,250,002	2,330,295	2,373,551	2,412,649	162,647	7%
Staten Island	468,730	487,155	497,749	501,109	32,379	7%

SOURCE: NYC DCP

water supply, and wastewater. The following discussion explores the connection between buildings, critical systems and prominent features of our city that make their vulnerabilities acute.

New York City's sprawling, complex transportation system is essential to our economy. Among its heaviest users is the sizeable workforce, who travels within and between boroughs and from neighboring towns and cities, by way of trains, subways, buses, taxis, cars, and ferries. Visitors, who in 2013 numbered more than 54 million people, rely upon the system, too.

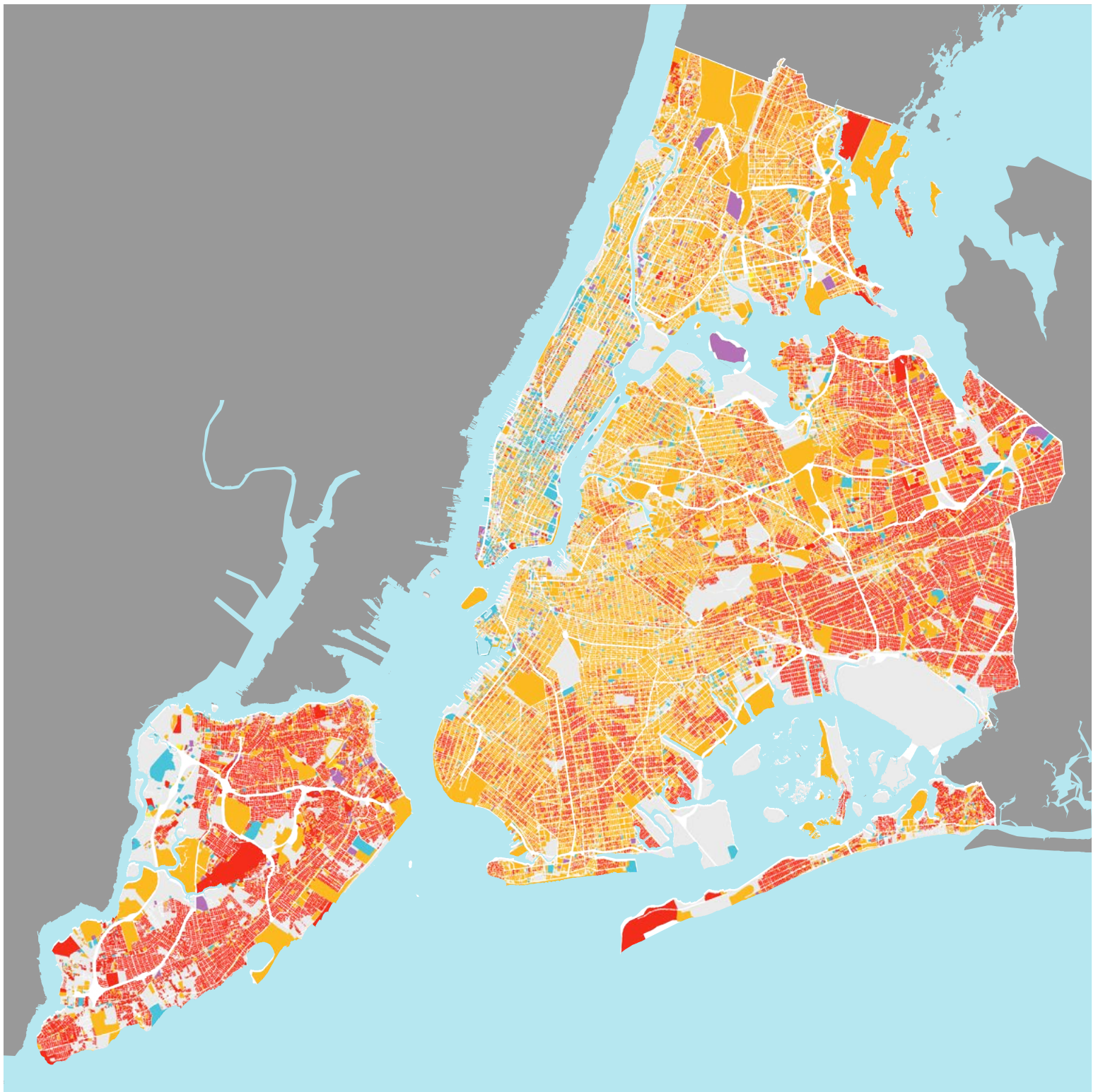
Also essential are the trucks that deliver goods and inventory to our huge retail sector and to households, which are increasingly relying on online purchases that must be shipped. Trucks also ship products manufactured here to markets within the city and beyond.

New York could not be a global city without our region's three major airports – John F. Kennedy, LaGuardia, and Newark Liberty – which constitute the largest air travel market in the world and bring an endless stream of tourists and business travelers to

us. JFK and La Guardia contribute \$37.3 billion to the regional economy and provide about 256,000 jobs. Visitors and businesspeople travel here from other cities by train, as well. Grand Central Station, Atlantic Terminal, and Penn Station are major transportation nodes. The Port of New York and New Jersey, the largest port on the East Coast, handled cargo with an estimated value of \$172 billion in 2013.

Various components of our transportation system are vulnerable to natural hazards and to hazard impacts on energy and telecommunications systems. Most vehicles rely on the liquid fuel supply system.

Some of our most valuable businesses rely on fiber-optic cable for high-speed communication. Most small businesses now rely on information technology (IT), some of them heavily. Clearly, our economy's growth will depend heavily on IT and reliable connectivity. New York City's Department of Information Technology and Telecommunications serves City agencies and also ensures that innovative technology is reliably available for residents, businesses, and visitors. All of this technology depends upon the grid.



CONSTRUCTION TYPE

SOURCE: NYC DOF, 2013



- | | | |
|---|--|---|
|  CONCRETE |  MANUFACTURED HOUSING |  STEEL |
|  MASONRY |  WOOD FRAME |  UNKNOWN |

OUR BUILDING STOCK

Our building stock encompasses approximately one million structures that vary by typology – construction type, age, and use – ranging from single-family, freestanding wood frame structures to attached masonry row houses to public housing projects to mid and high-rise apartment complexes to low-rise retail districts to massive commercial buildings and skyscrapers.

The City's Zoning Resolution and Construction Codes control the built environment. The Zoning Resolution operates on many levels, regulating building size, use, location, and density to shape the character of neighborhoods and quality of life. The Construction Codes specify standards for design, construction, and maintenance of individual buildings, with the aims of protecting public safety, health, and welfare. Both advance sustainability and resiliency goals.

Our built environment has become safer and structurally sounder over the years as zoning laws and Construction Codes have evolved and modernized. However, much of our building stock was built before stricter codes were adopted therefore potentially more vulnerable to certain hazards. The costs of retrofitting older buildings to safer standards can be prohibitive. And even new buildings are not immune from some hazards.

RISK FACTORS: LOCATION, CONSTRUCTION TYPE, AGE, AND MAINTENANCE

Where a building is located can be an important risk factor. Most obviously, buildings in the floodplain are vulnerable to flooding and coastal storms. Hurricane Sandy exposed constraints in codes and zoning law that limited some re-construction needed for recovery and long term resiliency. Many of the constraints have since been removed.

Construction type makes a difference, too. Unreinforced buildings are at a higher risk of earthquake damage than buildings that are reinforced. And buildings attached to each other gain stability: a row of unreinforced masonry buildings interspersed with vacant lots is even more at risk.



OF BUILDINGS BY BOROUGH

SOURCE: MAPPLUTO 14V1, NYC DCP, 2013

Light-frame buildings built decades ago according to less stringent codes tend to sustain more structural damage than newer, heavier buildings made with non-combustible materials like steel, concrete, and masonry. One to two story, low-rise buildings tend to be constructed of wood frame construction type and during a flood, this construction type is more prone to structural damage from flood water forces and fire from electrical shorts than are steel, masonry, or concrete frames.

For all buildings, lack of adequate maintenance can increase vulnerability.

CRITICAL INFRASTRUCTURE SYSTEMS

Anyone who has ever been unable to charge a cell phone is keenly aware of how heavily dependent we are on 21st century energy and telecommunications systems. Transportation, water supply, and wastewater systems are on the list

of critical infrastructure, too. All are vital to public health and safety, our economy, our way of life. In the event of a disaster, they must continue operating to support emergency response and recovery.

Each is vulnerable to multiple hazards, and because they are interdependent, disruption of one can disrupt others. The fact that some are regional in nature adds to the complexities of maintaining, strengthening, and protecting them. So does the fact that, at the same time that they are subject to age-related deterioration.

Who, exactly, is responsible for these critical systems we depend on so heavily? How complex are they? Parts of them are out of public view, in secure facilities or underground. What do they look like? Because hazard impacts on critical systems crosscut Chapter 4, we describe the systems in some detail here to make their physical realities better understood and to identify key players. A sampling of strategies for managing risks associated with them is presented in the next chapter. Please see *A Stronger More Resilient New York* for more details.

ENERGY SYSTEMS

New Yorkers spend roughly \$19 billion a year on energy to power, heat, and cool the city. Our energy infrastructure – electric, natural gas, and steam networks – is one of the oldest and most concentrated in the nation. Yet it is still among the most reliable. Every day, pipelines bring in natural gas from across the country. Power lines link the city to the larger regional grid. Generators burn gas to produce electricity. Steam travels from large boilers and cogeneration facilities to buildings through miles of underground pipes.

Electricity

This system consists of electricity generation, transmission at high voltages to large substations, and distribution from large substations to smaller ones and on to customers. The transmission and

distribution system consists of underground networks and overhead utility lines. Approximately 70 percent of the 130,000 miles of power lines are underground.

Because transmission lines cannot carry enough electricity into the city to meet its peak load, regulations require that in-city generation supply 80 percent of forecasted demand. Transmission lines connecting us to upstate New York, Long Island, and New Jersey import the balance.

Many parties own and operate the in-city generation system. In-city transmission and distribution systems are owned and operated by Con Edison (which serves the majority of New York City electric customers) and PSEG (which serves customers on the Rockaway Peninsula, Queens).

Electricity systems are vulnerable to weather extremes. For example, high winds and ice storms can down overhead power lines, directly or by toppling trees onto them. Flooding is another threat: many of our power generation plants are located in the 1 percent annual chance floodplain. Extreme heat can drive demand for air conditioning beyond the grid's capacity to deliver it, potentially causing outages that in turn can contribute to wide-ranging and severe impacts.

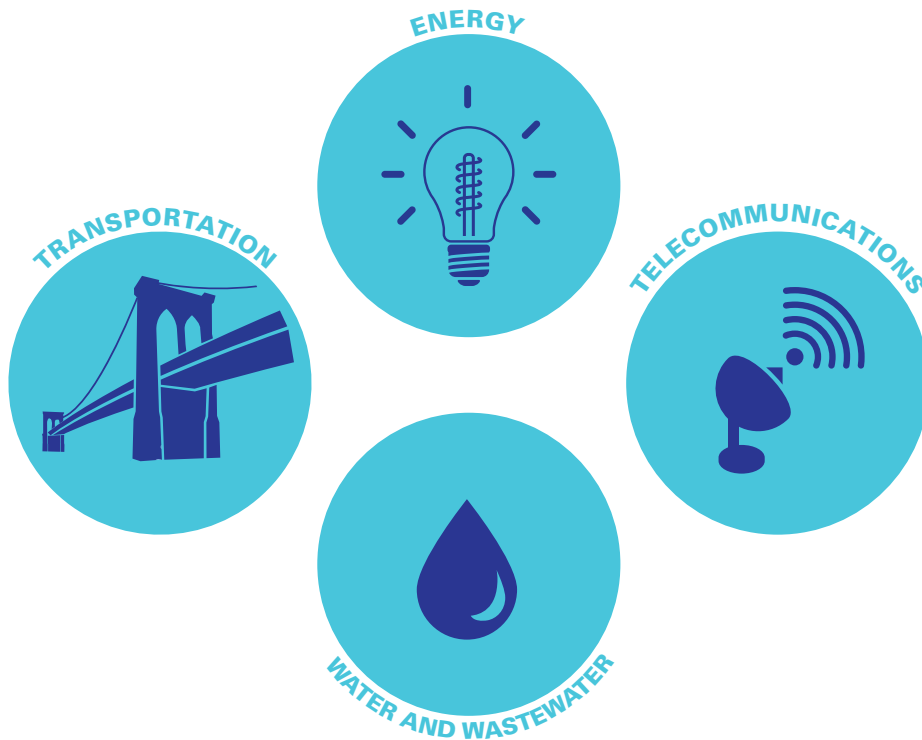
Natural gas

Natural gas meets about 65 percent of our heating needs and a significant percentage of cooking needs. It also fuels more than 98 percent of in-city electricity production by power plants.

Con Edison owns and operates the gas distribution system in Manhattan, the Bronx, and parts of Northern Queens. National Grid owns and operates the system in the rest of the city.

Four privately owned pipelines transport natural gas from the Gulf Coast, Western Canada, and other production areas to interconnection points here called "city gates." From them, high-pressure gas flows through an intra-city transmission system. Power plants generally draw gas directly from it.

CRITICAL INFRASTRUCTURE SYSTEMS



To reach most other customers, gas is delivered through regulator stations that reduce its pressure and send it into a vast network of underground distribution mains. The low-pressure system consists of cast-iron and bare-steel mains—outdated infrastructure that’s gradually being replaced. It is located mostly in the oldest parts of the city. Newer, high-pressure mains tend to be made of coated steel and plastic.

The system can be subject to leaks due to the age of equipment or lack of maintenance. Human error, for example leaving on the gas when the pilot is out, can also cause leaks. Explosions are rare but do occur.

Steam

The Con Edison steam system is one of the largest district steam systems in the United States. Six natural gas- and fuel oil-fired steam-generating facilities in Manhattan, Brooklyn, and Queens cogenerate steam along with electricity, or produce it alone in massive boilers.

A network of 105 miles of underground pipes transports steam to over 1,700 customers in Manhattan south of 96th Street—including 10 hospitals, which depend on steam to sterilize equipment, and many of the city’s largest institutions. Steam provides energy for heat, hot water, and, in some cases, air conditioning. For customers, steam’s advantage is that they do not have to own and maintain their own boilers. The most concentrated distribution centers are in the Financial District and Midtown Manhattan.

Steam pipes are stressed by high temperatures and high pressure. Explosions are rare but can cause injuries and fatalities, and can release asbestos (legacy insulation on very old pipes). They can damage street infrastructure, disrupt telecommunications, and compromise the structural stability of surrounding buildings.

TELECOMMUNICATION SYSTEMS

New York City's telecom sector—which includes the Internet, information services, phone, and cable TV—serves our 8.4 million residents, approximately 4 million workers, 250,000 businesses, and over 50 million annual visitors.

The physical system

The system's main components are these:

- Large distribution and switching centers provide connectivity across all major services.
- Cabling can be strung overhead via utility poles or run underground. New York's oldest cabling is lead-encased copper, with sections ranging from 10 to 90 years old. Most cable is threaded through conduit, underground pipe that's used in the densest areas in all five boroughs.
- Cell sites, typically placed on roofs, include an antenna, electronics, and backhaul circuits (cables that connect the cell site to the larger telecommunications network).
- Equipment in homes, offices, and other buildings distributes signals transmitted via cabling from critical facilities to individual customers.

Many companies provide voice, data, and video services, and many provide wireless, cable, and Internet service. The primary fixed-line telephone provider is Verizon, whose landline business is rapidly shrinking.

The regulatory scheme

This seemingly innocuous topic turns out to be a risk factor of its own. The Federal Communications Commission (FCC) regulates interstate and international communications by radio, television, wire, satellite and cable. Our State Public Service Commission regulates landline telephone service. The City Departments of Information Technology and Telecommunications, Transportation, and Buildings exercise authority over aspects of local physical telecom infrastructure.

Crucially, although federal, State, and City agencies share authority, none is responsible for the entire telecom system, and none must ensure that required service remain available during emergencies. The FCC promotes best practices for resiliency but doesn't require compliance. No single entity prioritizes or enforces measures to promote resiliency across the entire system.

New York City's telecom systems are generally very reliable, but they're vulnerable at a number of points. Telecom is powered by electricity and thus vulnerable to power outages. While critical facilities have back-up batteries and generators, 13 percent of critical telecom facilities are located in flood plains. Rooftop cell sites have limited backup battery power.

Computer-controlled digital and fiber optic equipment is sensitive to heat, humidity, and dust. A prolonged power outage can shorten this equipment's lifespan. High winds, tornadoes, and ice storms can damage overhead cabling. Underground cabling is vulnerable to flooding. A large volume of traffic is routed through a small number of collocation facilities in Lower Manhattan, some near the shoreline and at risk of flooding, as happened during Hurricane Sandy. This centralization increases network vulnerability.

TRANSPORTATION SYSTEMS

New York City's transportation system is sprawling and complex, comprising large, interconnected rail, roadway, air, and waterway networks, all essential for daily travel and transport. Disruption of the system can dislocate families and prevent workers from reaching work, disrupting the operations of businesses, government agencies, healthcare providers, and institutions. Students, shoppers, and tourists can be affected; emergency response could be hindered.

Rail network

Our rail system is one of the most complex in the country. Its interconnected subway and railroad networks carry two-thirds of all U.S. rail riders. Approximately 5.3 million subway riders and approximately 850,000 rail riders commute into and within New York City each day. Rail also carries freight.

No single entity prioritizes or enforces measures to promote resiliency across the entire telecom system.

The State-run Metropolitan Transportation Authority (MTA), the nation's largest transit authority, operates the main rail systems: New York City Transit, which operates the subway; Long Island Rail Road; and Metro-North Railroad, with Grand Central Station its hub. The Port Authority of New York and New Jersey (Port Authority) provides commuter rail service between New Jersey and New York City on PATH trains. Amtrak's rail system helps connect us to other major cities: Penn Station is Amtrak's busiest hub.

The city's rail transportation runs on electricity. The subway system alone consumes 1.8 billion kilowatt hours each year. Power outages can shut rail down.

Due to historical development patterns and operational needs, much rail and subway infrastructure is near the waterfront or in low-lying areas, making it vulnerable to storms and to flooding above ground and underground. Above ground, high winds could tip railcars over or derail them. Extreme cold can cause steel tracks to shrink; extreme heat can cause them to buckle. Both conditions could cause derailments.

Roadway network

Bridges and tunnels provide interborough connections for vehicles and public transit, as well as access to and from New York City. The city has more than 2,000 bridges, many of them over a century old. The City Department of Transportation manages approximately 800 bridge structures and 6 tunnels, and maintains over 6,000 miles of streets, 12,000 traffic signals, sidewalks, and retaining walls.

The MTA also manages roadways, and it operates 304 bus routes and oversees 7 bridges and 2 tunnels used by more than 300 million vehicles each year. Port Authority manages most transportation between New York and New Jersey, including four bridges, two tunnels, and two bus terminals.

All roadway infrastructure is vulnerable to hazards such as flooding of tunnels and low-lying roadways, and to weather extremes.

Air transportation

In 2013, 77 million passengers traveled through LaGuardia and JFK International Airports in Queens. Newark Liberty International Airport in New Jersey also serves the New York City area. The Port Authority operates all three, which together make up the world's largest air travel market. LaGuardia and JFK contribute \$37.3 billion to the regional economy and provide about 256,000 jobs.

Both airports are located in floodplains and are already subject to flooding.

Maritime transportation

The Port of New York and New Jersey, managed by the Port Authority and used by private and public operators, is the largest and busiest port complex on the East Coast. In 2013, more than 34 million tons of cargo with an estimated value of \$172 billion moved through it. It supports nearly 300,000 regional jobs. The port includes three passenger cruise terminals—two in New York and one in New Jersey.

More than 50 piers, docks, and ferry terminals are owned by New York City agencies. Ferry service by private and publicly operated vessels between New Jersey and New York City and between boroughs has expanded. The city now has 47 active ferry landings, and ferries are regularly used by many commuters. The largest commuter ferry is the Staten Island Ferry, operated by the City's Department of Transportation. It reports more than 22 million passenger trips a year between Staten Island and Lower Manhattan.

Storm-related waterfront risks are obvious. Less obvious, but critically important: waterfront operations depend on vulnerable energy and telecommunications systems.



WASTEWATER TREATMENT FACILITIES & MAJOR ROADWAY TRANSPORTATION

SOURCE: SELECTED FACILITIES AND PROGRAM; SITES DATABASE (DEC. 2012), NYC DCP

- WASTEWATER TREATMENT FACILITIES
- MAJOR BRIDGES
- MAJOR TUNNELS
- MAJOR ROADS

WATER SUPPLY

Each day, more than 1 billion gallons of drinking water are delivered to us. The Department of Environmental Protection manages our water supply system, ensuring the steady flow of water from large upstate watersheds through a complex network of aqueducts and tunnels. Within the city, Tunnel 1, completed in 1917, and Tunnel 2, completed in 1936, have been in continuous service since they were built. To increase redundancy and enable inspection and repairs, in 1970 the City began constructing Tunnel 3. This \$5 billion project is scheduled for completion in 2018.

Citywide, water is distributed through 7,000 miles of water mains and pipes that are buried and pressurized to protect them from flooding. Redundancy is built into the system so that water can be diverted to different pipes as needed to ensure constant flow.

The distribution system depends almost entirely on gravity. Water travels from reservoirs with sufficient pressure to reach to the sixth floor of most buildings. High-rise buildings rely on rooftop water towers or electrical pump systems to provide water to upper floors. In a power outage, those pumps cannot pump.

The adequacy of our drinking water supply depends on adequate precipitation upstate to fill our reservoirs, continued good water quality, and the continued reliable performance of our water infrastructure.

WASTEWATER TREATMENT SYSTEM

Sewers collect 1.3 billion gallons of wastewater each day from drains and toilets citywide. Like most old urban centers, the city relies heavily on a combined sewer system to collect sanitary and industrial wastewater, rainwater, and street runoff and convey all of it to wastewater treatment plants. Sanitary waste enters the system through direct connections from buildings. Stormwater enters from catch basins that direct flow to the sewer system. In some neighborhoods, separate storm sewers carry runoff from streets directly to local streams, rivers, and bays.

Wastewater treatment plants require large amounts of electricity, making them vulnerable to power outages. All of our 14 wastewater plants are located along the waterfront at relatively low elevations that are at risk of flooding.

Waterfront locations significantly reduce the cost and environmental impact of treating wastewater. Under normal conditions, the wastewater system can fully treat the combined volume of sewage and stormwater. But when heavy rain or snowmelt swell that volume to beyond twice a plant's dry-weather capacity, the mix of excess stormwater and untreated sewage flows directly into the waterways in "combined sewer overflows" (CSOs).

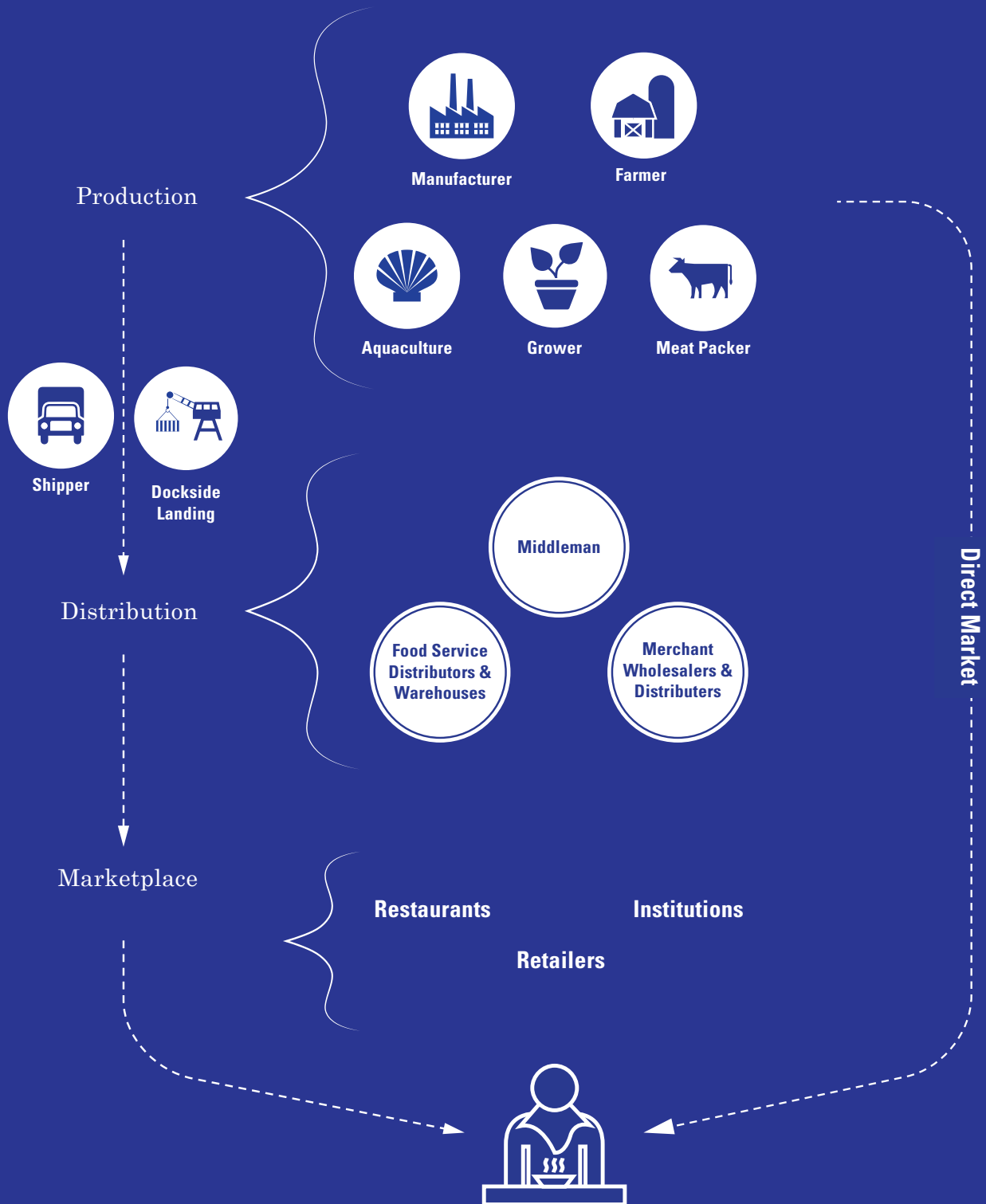
Over many years, the City has invested billions of dollars in infrastructure to reduce CSO events. Recently it adopted an innovative Green Infrastructure Plan that relies on new natural and low-tech features around the city to absorb rain and snowmelt. Complementing it is the City's Bluebelt program, which engineers natural drainage corridors to slow the flow of water, and uses vegetation and other elements to absorb and filter impurities.

FOOD SUPPLY SYSTEM

Most of the food we consume comes from beyond our borders, about 95 percent of it arriving by truck; the rest by ship, air, and rail. The Hunts Point Food Distribution Center in the South Bronx, the largest produce market by revenue in the world, is the epicenter of New York City's food network. Almost 13,000 trucks travel to it every day. Three out of ten trucks that cross the George Washington Bridge are bound for it. With the East River is on two sides and the Bronx River on another, it is no surprise that nearly 30 percent of the site lies within the 1 percent annual chance floodplain.

Perishable food is sold at roughly 10,000 stores in our city, the majority of which are small establishments. Perishable and non-perishable food items are distributed through supermarkets, grocery stores,

Each day, almost 13,000 trucks travel to and from the Hunts Point Food Distribution Center in the Bronx. Part of it lies in a floodplain.



convenience stores, bodegas, farmers markets, food coops, over 24,000 restaurants, nonprofit meal delivery services, soup kitchens, food pantries, and street vendors, as well as institutional kitchens in hospitals, public and private schools and universities and colleges, prisons, and senior centers. (Our institutional kitchens have a food budget estimated as second only to that of the U.S. military.)

This highly decentralized retail system, coupled with our city's scale, makes transportation infrastructure – roads, bridges, and tunnels – and liquid fuel supplies crucial to our food supply system.

Energy is essential, too. It is estimated that at least 70 percent of all food Americans eat each year passes through “the cold chain,” requiring refrigeration or freezing at every stage. Electricity is also needed for lighting, computer systems that track inventory, cash registers and electronic transactions, ATM machines, and other functions. Telecom, which depends upon electricity, is essential for communication between distributors and retailers. Both electricity and telecommunication enable transactions using Electronic Benefit Transfer cards used by the city to distribute funds for purchasing food to low-income residents as part of the Supplemental Nutrition Assistance Program (SNAP, formerly called food stamps).

OTHER ASSETS AND FEATURES AT RISK

This category is very large and could include, for example, the liquid fuel supply chain that many City vehicles, ambulances, buses, taxis, trucks, and private vehicles depend on. What follows is a sampling of a few key features at risk.

SOLID WASTE MANAGEMENT

This function is fundamental to public health. Every day, nearly 1,000 Department of Sanitation trucks collect over 12,000 tons of waste and recyclables from buildings throughout the city. After Hurricane Sandy struck, employees worked 12-hour shifts around the clock, seven days a week, to collect more than 400,000 tons of Sandy-related debris.

Hospitals are heavily energy dependent. Uses range from laundry to sophisticated diagnostic equipment.

The City is shifting its waste collection network from roadways to more environmentally friendly marine routes, and is working to protect critical waterfront facilities from storm impacts. It is also working to strengthen the resiliency of the broader solid waste network – both City- and third-party owned. The performance of this network depends in part on the availability of fuel for trucks, and on functioning roadways.

HEALTHCARE FACILITIES

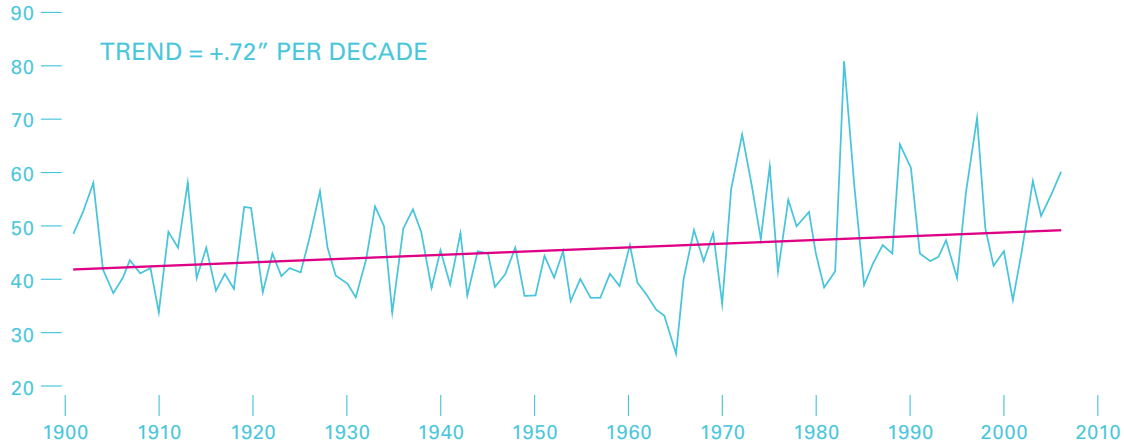
New York City has one of the greatest concentrations of healthcare facilities in the country, with over 60 hospitals, 170 nursing homes, and 75 adult day care centers. The City's Health and Hospitals Corporation operates almost a dozen hospitals, 6 diagnostic and treatment centers, 5 long-term care centers, 31 community healthcare centers, and 21 school-based health centers.

At any given time, some 1,400 residential-based providers are caring for more than 80,000 patients in nursing homes and other facilities offering treatment, care, and supportive housing for individuals with substance abuse problems, developmental disabilities, and other behavioral or mental health challenges.

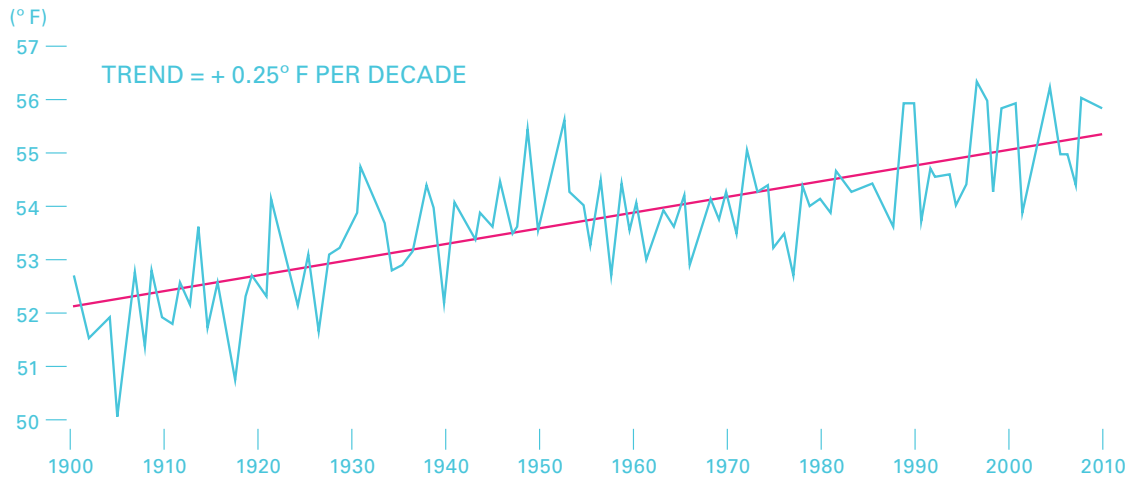
Community-based healthcare providers operate from over 10,000 buildings across the five boroughs. Pharmacies are integral to our healthcare system, too.

During and after emergencies, these facilities function as critical assets. They, too, are at risk, as we saw during Hurricane Sandy when hospitals next to the East River flooded and had to be evacuated. If healthcare workers cannot get to work because transportation has been disrupted, patients are impacted.

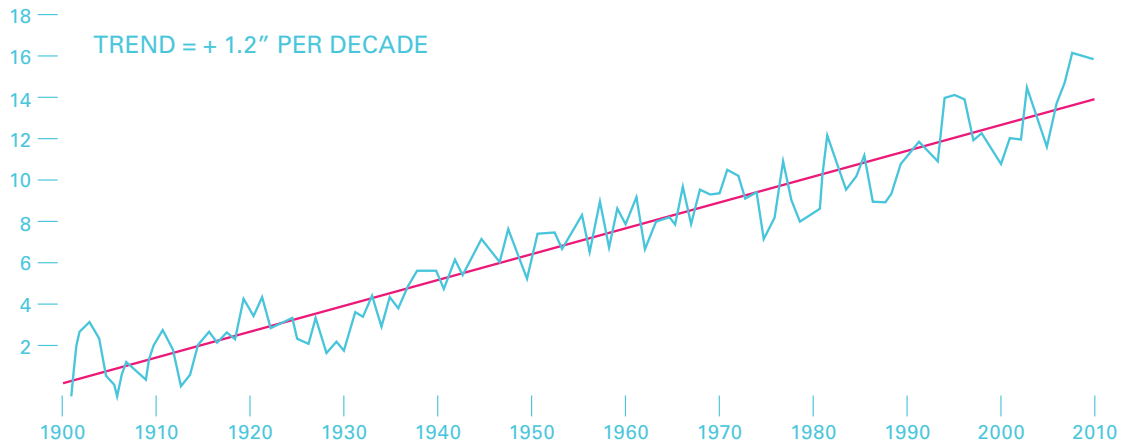
OBSERVED ANNUAL PRECIPITATION IN CENTRAL PARK (INCHES) (Source: NPCC, 2013)



OBSERVED ANNUAL TEMPERATURE IN CENTRAL PARK (1900 - 2011) (Source: NPCC, 2013)



OBSERVED ANNUAL SEA LEVEL RISE AT THE BATTERY, NEW YORK CITY (INCHES) (Source: NPCC, 2013)



Hospitals are major consumers of energy, depending on it not only for basic heating, cooling, ventilation, lighting, and hot water, but to operate sophisticated medical equipment and sterilization units, and for refrigeration, laundry, kitchens, and maintaining and accessing digital health records. During Sandy backup generators in some areas were flooded and unable to provide power.

EDUCATIONAL AND RESEARCH INSTITUTIONS

New York City has more than 2,700 accredited educational institutions including over 100 colleges and universities, just under 850 private schools, and over 1,800 public schools. The intellectual capital represented by the faculty, scholars, and researchers at our colleges, universities, and research institutions is an invaluable asset.

According to the U.S. Census Bureau's 2012 American Community Survey, over 1 million students attend New York City's private and public schools. Our public schools not only educate; they serve a public safety function as emergency shelters during hazard events.

OTHER FEATURES AND CONDITIONS EXPOSED TO HAZARDS

Certain activities or environmental conditions are more vulnerable to hazards events, and may expose communities to hazardous materials or debris.

Examples of this include construction projects and partially completed buildings which are vulnerable to strong windstorms when items such as small tools, lumber and cranes are exposed. The New York City Department of Buildings and State Department of Environmental Conservation regulate activity at construction sites to minimize environmental contamination of water and air, but due to the temporary nature of construction work, materials may be dispersed. Hazardous materials transported by truck, rail, air and water may be exposed to accidents during shipment. To prevent accidental releases, their storage and transport are tightly regulated, but releases do occur.

Piles of unenclosed materials such as non-putrescible waste, recycling, salt, sand and asphalt are permitted to be stored outdoors, and may be vulnerable to dispersion by air or water during storm events, especially if stored in flood zones. Brownfields are vacant or under-used lots that may be contaminated by previous industrial uses; heavy downpours, flooding, and high winds that disturb contaminated soil can disperse contaminants from these sites. The State has designated 17 brownfields in New York City; many are near residential neighborhoods or in flood zones.

OPEN SPACE AND THE NATURAL ENVIRONMENT

New York City's public parks range from wild to manicured, shoreline to inland, and large to vest pocket – playgrounds, waterfront esplanades, wetlands, hiking trails, dog runs, boating and kayaking areas, athletic courts and fields, beaches and swimming pools, monuments and historic buildings. Parks and open spaces managed by the City's Department of Parks & Recreation span over 29,000 acres, covering 14 percent of the city and encompassing approximately 2,000 sites.

Among these assets, beaches, boardwalks, and waterfront parks cover over 7,300 acres, or 30 percent of the Department's total land area and occupy 150 miles—almost 30 percent—of our coastline. The city's 9,900 acres of natural areas—over a third of the acreage in the system—include grasslands, wetlands, streams, and other natural areas that play a critical role in absorbing runoff and reducing the impacts of extreme weather events.

The City's trees, managed by the Parks Department, moderate temperatures, remove carbon dioxide and pollutants from the air, enhance sidewalks and other settings, protect waterways by reducing stormwater runoff, and help reduce the urban heat island effect (explained in Chapter 4). Since the *MillionTreesNYC* initiative was announced in PlaNYC in 2007, the City has planted nearly 760,000 trees.

HOW FUTURE CLIMATE WILL SHAPE OUR CITY

While no one can reliably predict the future of New York City, we can identify key factors that will shape it. Among them are: population growth and demographic trends, land-use development, new technologies, economic conditions, and City, State, and federal fiscal capacities, including the size of public investment in aging infrastructure – and the interplay among these factors.

Yet another key issue that will shape our city in the future is climate change. Its impacts crosscut a number of hazards that New Yorkers face.

THE CITY MARSHALS ITS EXPERTS

The New York City Panel on Climate Change (NPCC), a body of leading climate and social scientists and risk management experts, was convened by the City in 2008 to produce climate projections for New York City and inform City government’s decision making and the public.

In January 2013, to inform planning for rebuilding and resiliency after Hurricane Sandy, the NPCC updated its projections by drawing on the latest climate models, recent observations about climate trends, and new information about greenhouse gas emissions.

The resulting report, *Climate Risk Information 2013*, forecasts more severe weather. More high winds, more hot days and longer heat waves. More heavy downpours, and more frequent storms.

FORECAST: SEA LEVEL WILL CONTINUE TO RISE, AS WILL THE RISK OF FLOODING

New York City’s sea levels have been rising, and this trend is expected to continue.

- Middle-range projections for the 2020s indicate a four to eight inch rise, while high-end projections show as much as 11 inches.

- By mid-century, high range projections indicate sea levels could rise as much as 2.5 feet (31 inches), especially if the polar ice sheets melt faster than previously anticipated. This would threaten low-lying communities with regular tidal flooding. At the Battery (the southern tip of Manhattan), flooding as severe as that from today’s 100-year storm would be up to five times more likely.
- By the 2020s, the area that could be flooded in a 100-year storm could expand to 59 square miles and encompass approximately 88,000 buildings.
- By the 2050s, with more than 2.5 feet of sea level rise, New York City’s 1 percent annual chance floodplain could be 72 square miles—a staggering 24 percent of the city—an area that today contains approximately 114,000 buildings and currently accounts for 97 percent of the city’s power generation capacity, 20 percent of its hospital beds, and a large share of its public housing.

FORECAST: MORE HEAT WAVES AND HEAVY DOWNPOURS

The New York Panel on Climate Change predicts that by the 2050s heat waves—three or more consecutive days of daily high temperatures at or above 90 degrees—could more than triple in frequency, lasting on average one and a half times longer than they do today.

Total annual precipitation will increase slightly: up to 10 percent by the 2020s and up to 15 percent by mid-century. It is more than 90 percent probable that the New York City area will see an increase in heavy downpours by mid-century.

Hurricane Sandy is an example of how extreme weather events and the cascade of impacts they trigger can affect our densely populated, 21st century coastal city. In the future, extreme heat, flooding due to coastal storms and heavy downpours, high winds, and ice storms may impact our critical infrastructure systems. Much of our energy generation, transmission, and distribution system is located in the preliminary Flood Insurance Rate Maps 1 percent annual chance floodplain, as is 13 percent of our telecom system.

Climate change boosts risk, and looking back over this chapter, it is clear that – given the extent of New York City’s vulnerabilities to natural and non-natural hazards and their potential severity – the stakes at the risk and resiliency table are high and warrant the broad array of risk management strategies that our City and its partners now employ and are working aggressively to strengthen.