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## 11) Flooding Hazard Analysis for New York City

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### a) Hazard Profile

#### i) Hazard Description

A flood is a general and temporary condition of partial or complete inundation of normally dry land areas. Three distinct types of flooding affect New York City: coastal flooding, river flooding, and flash flooding.

##### *Coastal Flooding*

Long and short wave surges that affect the shores of the open ocean, bays, and tidally influenced rivers, streams, and inlets cause coastal flooding. The astronomic tide and meteorological forces such as nor'easters and hurricanes influence the movement of coastal waters.

##### *River Flooding*

River flooding is caused when rivers and streams overflow their banks. Flooding from large rivers usually results from large-scale weather systems that generate prolonged rainfall over wide areas. These same weather systems may cause flooding of smaller basins that drain to major rivers. Small rivers and streams are susceptible to flooding from more localized weather systems that cause intense rainfall over small areas. According to the New York City Flood Insurance Study, while overbank flooding of rivers and streams is the most common type of flood event in New York State, this type of flooding is less frequent and severe in New York City than other types of flooding.

##### *Flash Flooding*

Short-term, high-intensity rainfall that occurs in inland areas with poor drainage often produces urban flash floods. Densely populated areas have a high risk for flash floods. The construction of buildings, highways, driveways, and parking lots increases runoff by reducing the amount of rain absorbed by the ground. During periods of heavy rainfall, storm drains may become overwhelmed and flood roads and buildings. Low spots, such as underpasses, underground parking garages, and basements are especially vulnerable to flash floods. Subway stations and rail lines are also vulnerable to flash floods.

## ii) Severity

The NWS categorizes flooding as major, moderate, and minor.

NWS Flood Categories	
Category	Description
Major	<ul style="list-style-type: none"> <li>• Extensive inundation and property damage</li> <li>• Often involves the evacuation of people and the closure of both primary and secondary roads</li> </ul>
Moderate	<ul style="list-style-type: none"> <li>• Inundation of secondary roads</li> <li>• Transfer to higher elevation necessary to save property</li> <li>• Some evacuation may be required</li> </ul>
Minor	<ul style="list-style-type: none"> <li>• Minimal or no property damage</li> <li>• Possibly some public inconvenience</li> </ul>

**Figure 59: NWS Flood Categories**

## iii) Probability

### *Coastal and River Flooding*

FEMA Flood Insurance Rate Maps delineate special flood-hazard areas and the risk-premium zones in a community. These special flood-hazard areas identify locations that have a chance of experiencing coastal or river flooding in any given year. The 100-year flood designation means the area has a 1% chance of flooding in any given year.

### *Flash Flooding*

Intense rainfall, producing several inches of rain in a short period, is most likely to cause flash flooding and other problems, such as sewer back-ups into residences. These floods are unrelated to the 100-year floodplain designation. According to DEP's rain gauges, the July 18, 2007 storm produced 1.93 inches of rain in one hour in northern Queens. The August 8, 2007 storm, which resulted in levels of flooding throughout the City not seen for decades, produced more than three inches of rain in a two-hour period. Based on historic probability, that level of rainfall has a chance of occurring about once every 25 years. Over the last several years, storms of intense magnitude have been occurring somewhat more frequently than expected, and climatologists warn that the trend may continue as the effects of climate change are felt.

Given the history of flooding in New York City, it is certain future floods will occur. Based on analysis of records from the National Climatic Data Center of NOAA, New York City has experienced flooding 60 times during the 15-year period between 1993 and 2007. Using simple historic frequency to indicate the future flooding potential, New York City will likely experience an average of four floods per year.

#### iv) Location

As shown in Figure 60 through Figure 64<sup>3</sup>, all five boroughs have 100-year flood designations. There are also many low-lying and poor drainage areas susceptible to flash flooding.

##### *Coastal Flooding*

Direct ocean surges and waves affect sections of Queens, Brooklyn, and Staten Island. Coney Island and the Rockaway Peninsula are particularly vulnerable to wave damage. On Rockaway Peninsula and Jamaica Bay, the shoreline configuration has changed considerably over the past 50 years because of dredging and filling. These changes affect wave propagation, particularly in areas such as Rockaway Point and Rockaway Inlet, where the configuration of the point controls the direction of incoming waves. Inundation of low-lying coastal areas in the City is primarily the result of storm surges, wave setup, and wave run-up, which occur during hurricanes and nor'easters. For more information on the combined effects of wind and storm surge and its impact to New York City, see the Coastal Storm Hazard Analysis.

##### *River Flooding*

The Flood Insurance Study conducted for New York City found river flooding was not a major cause of flood damage in the City: Ocean tides influence most of the rivers within New York City. This means the tidal conditions at the mouth of the river control the water levels in the rivers, with little or no influence from the flow in the stream. Therefore, river flooding affects only a small portion of flood-prone areas in New York City, primarily in the Bronx and Staten Island. Flooding from the Bronx and Hutchinson Rivers may potentially cause overbank flooding in the northern portion of the City.

##### *Flash Flooding*

There have long been flash flood-prone areas of the City because of its dense population and abundance of impervious surfaces. In recent years, flash floods have affected a much broader range of communities. Much of New York City's infrastructure, particularly low-lying and poor drainage areas, cannot cope with rainfall of more than one inch per hour. New York City's drainage and sewer system consists of more than 6,600 miles of pipes, the majority of which were laid before 1960. Prior to 1960, sewers were designed to handle up to 1.5 inches of rain per hour. Since 1960, the City built sewers to handle up to 1.75 inches of rain per hour. (1.75 is the national standard.) Adding to the impact of overflows, 70% of the sewer system is combined, which means both storm water runoff and sanitary sewage travel through the same pipes.

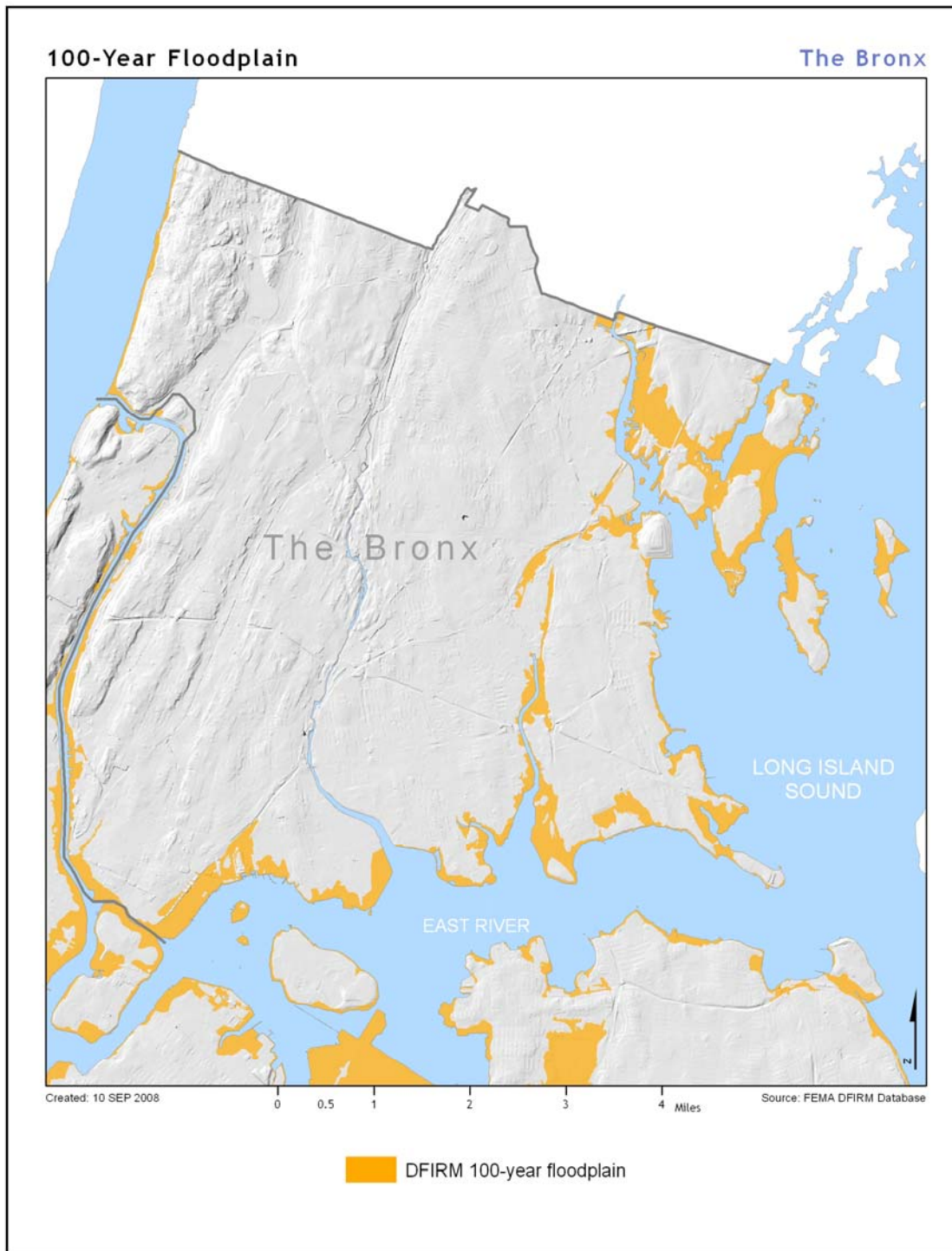
An important factor exacerbating the effects of extreme rainfall is the pattern of residential and commercial development. Runoff from low-density developments like single- and two-family homes has increased 50% since 1950 as residents pave over their

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<sup>3</sup> The floodplain map represents locations that experience natural coastal flooding, unrelated to hurricanes, and are within the FEMA-defined 100-year floodplain. In contrast, the SLOSH map represents locations that may experience flooding from a hurricane storm surge. Hurricane storm surge areas overlap many areas that are designated as the 100-year floodplain, but the hurricane storm surge areas are considerably larger and represent a different hazard.

yards in an effort to secure more parking or living spaces. Widespread use of basements and below-grade areas as dwelling units has also contributed to the increased costs and impacts of extreme rain events.

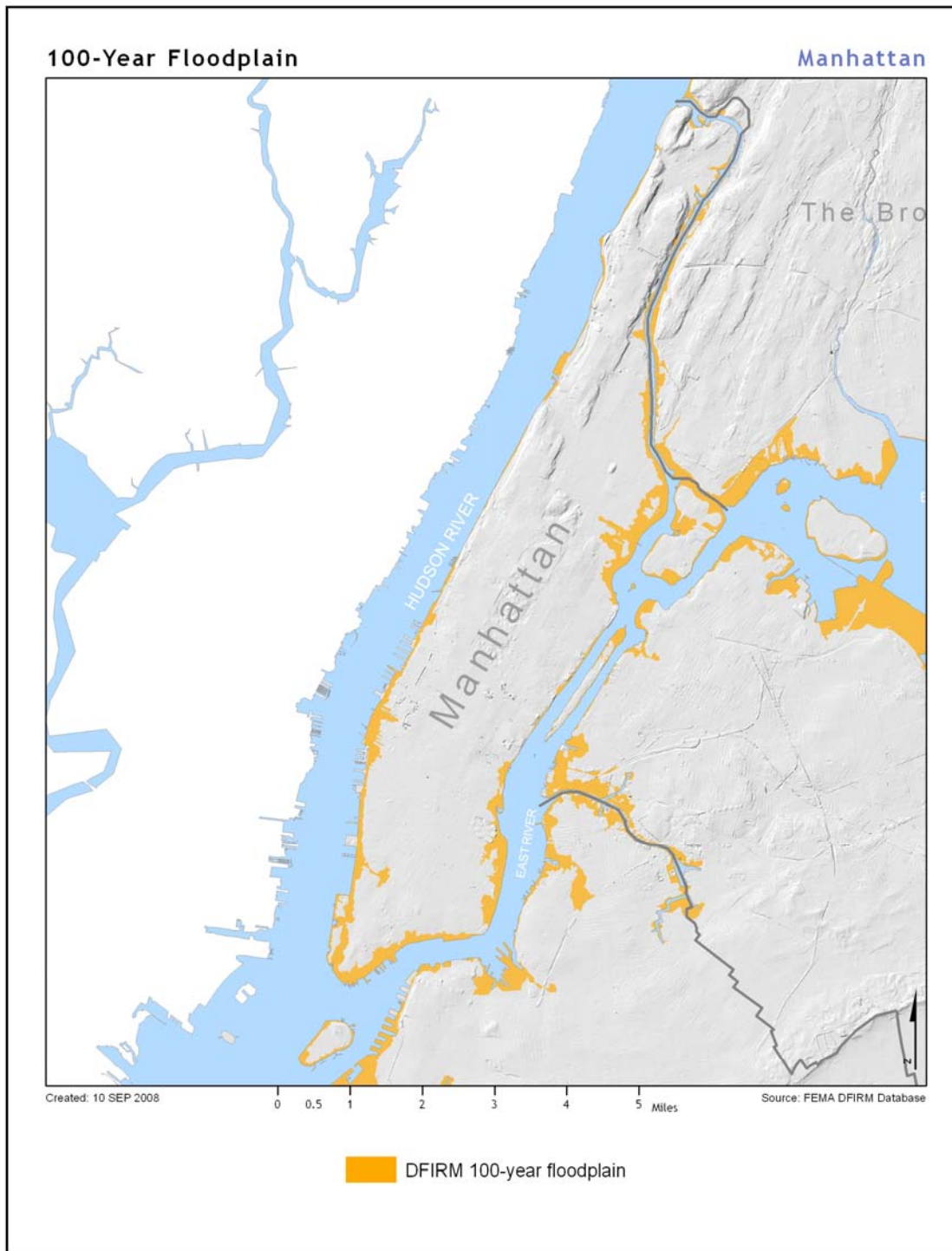
In New York City, flash-flooding locations, often the result of urban drainage issues, are frequently not located in the FEMA-designated floodplain. In 2008, the City developed the New York City Flash Flood Emergency Plan addressing street level cleaning and maintenance, targeted monitoring of reoccurring flood locations, coordinated response, and recovery assistance.



**Figure 60: Bronx 100-Year Floodplain**

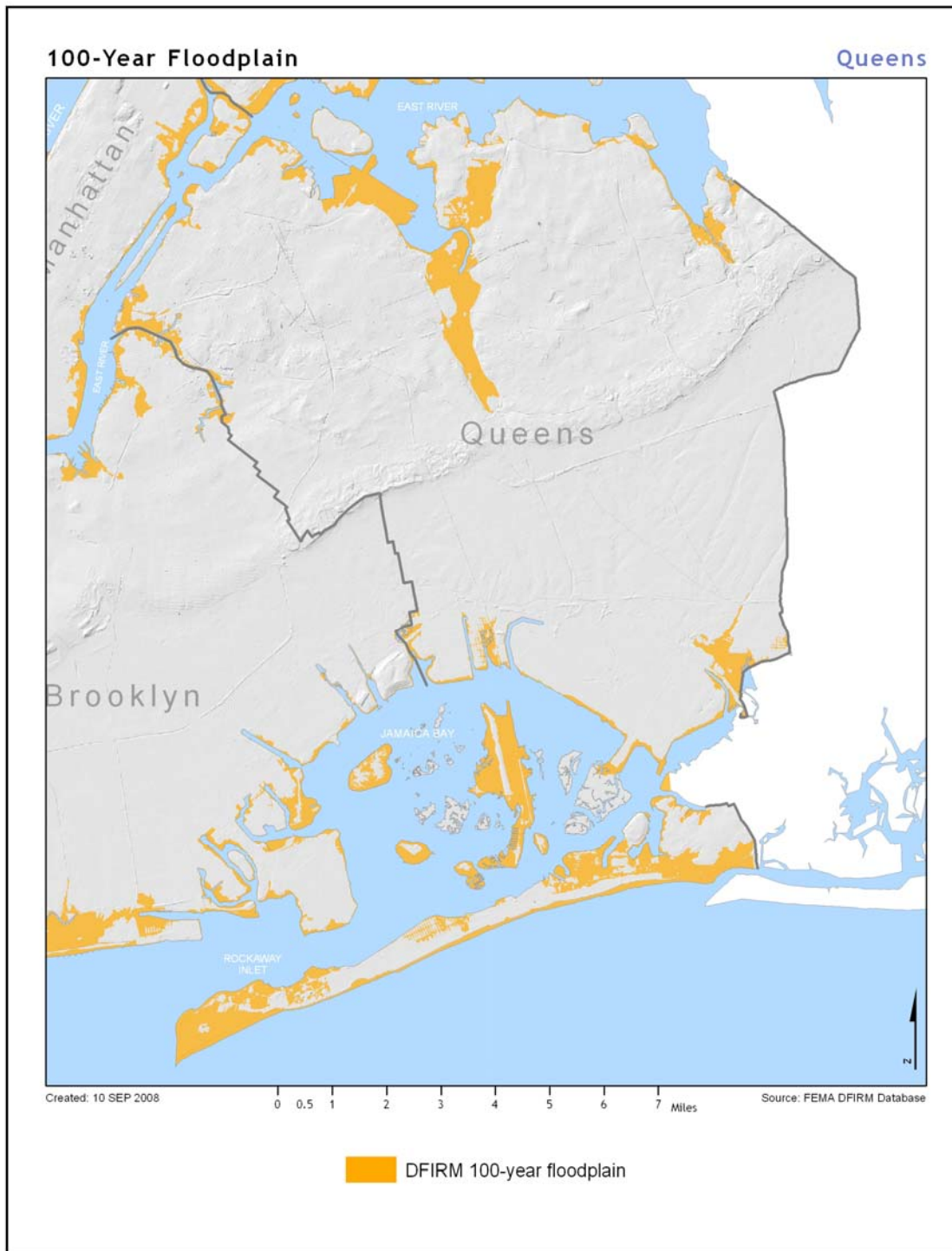


**Figure 61: Brooklyn 100-Year Floodplain**



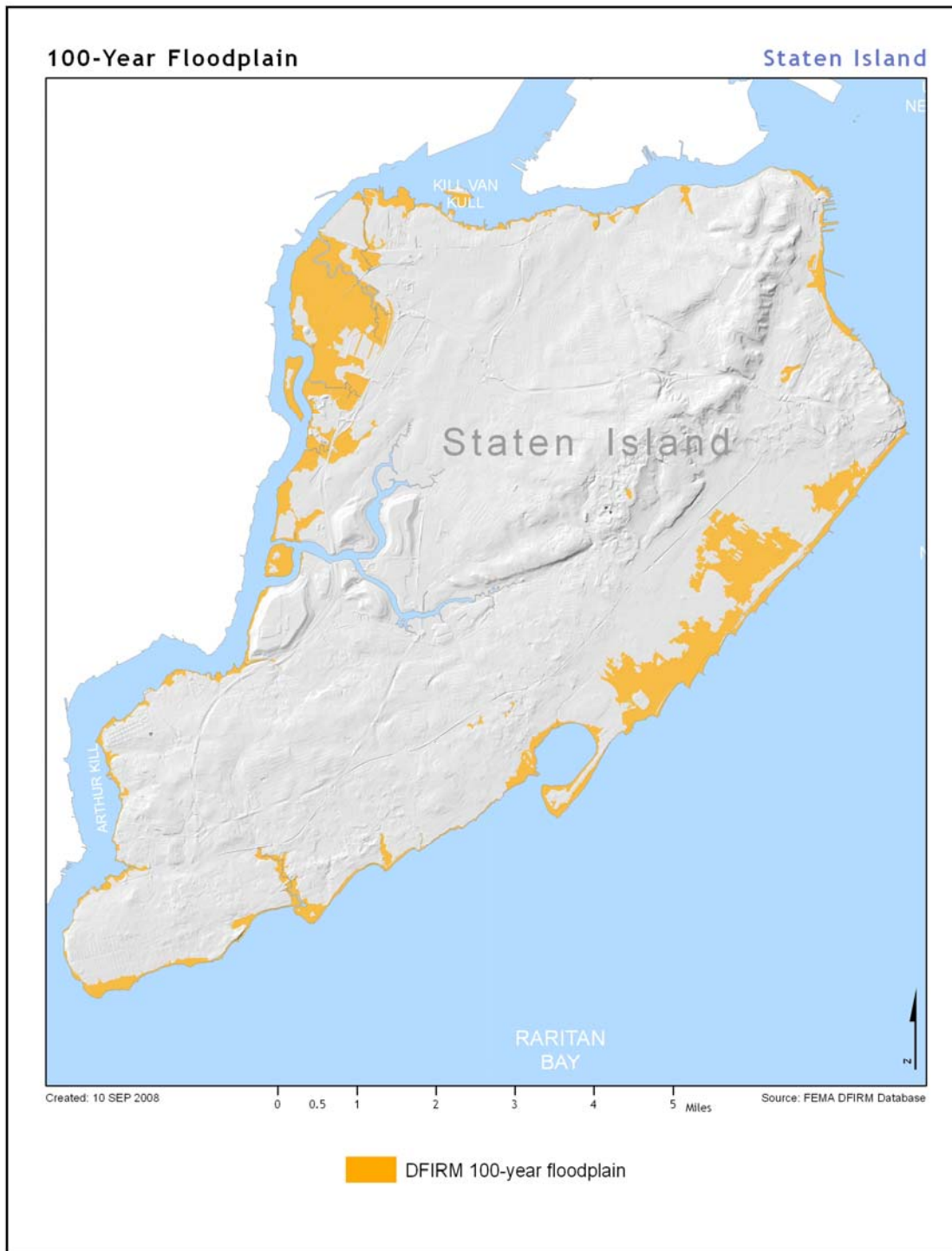
**Figure 62: Manhattan 100-Year Floodplain**





**Figure 63: Queens 100-Year Floodplain**





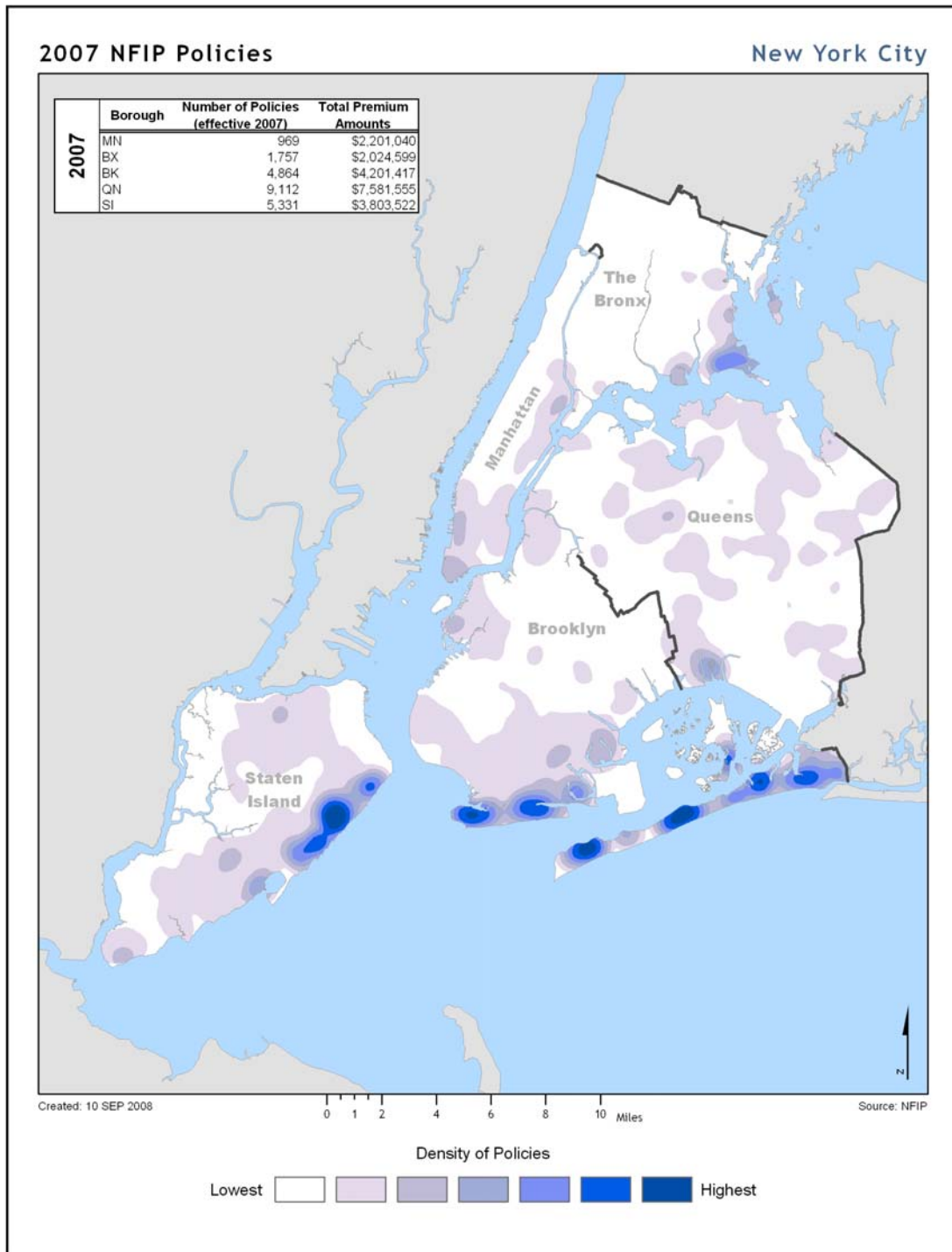
**Figure 64: Staten Island 100-Year Floodplain**

*National Flood Insurance Program*

New York City is a participant of the National Flood Insurance Program (NFIP). The NFIP Administrator, or manager of the NFIP for New York City, collects and stores a vast quantity of information on insured structures, including the number and location of flood insurance policies, number of claims per insured property, dollar value of each claim and repetitive loss claims. In New York City, DOB is the NFIP Administrator.

NFIP data helps indicate the location of potential flood events. The maps on pages 137 through 139 spatially present several types of NFIP insurance data for each borough of New York City. In 2007, the City had 22,033 NFIP policies amounting to \$19.8 million in premiums.

New York City has recorded 2,322 repetitive loss policies amounting to \$33.6 million in payouts. Repetitive loss properties are a high priority for flood mitigation. The Mitigation Strategy section provides actions that aim to reduce the impact of flooding to these properties.



**Figure 65: NFIP Policies by Borough**

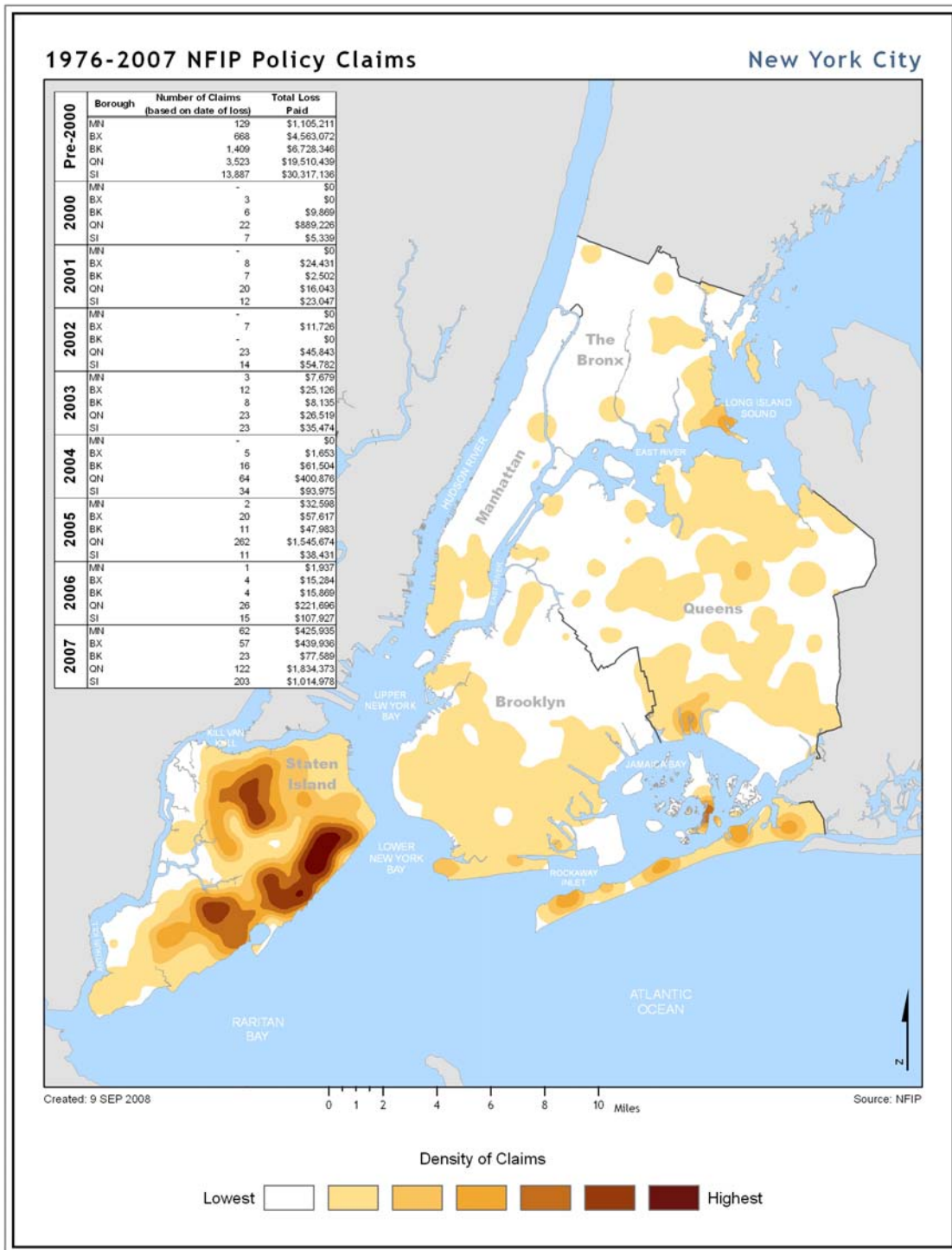


Figure 66: NFIP Claims by Borough

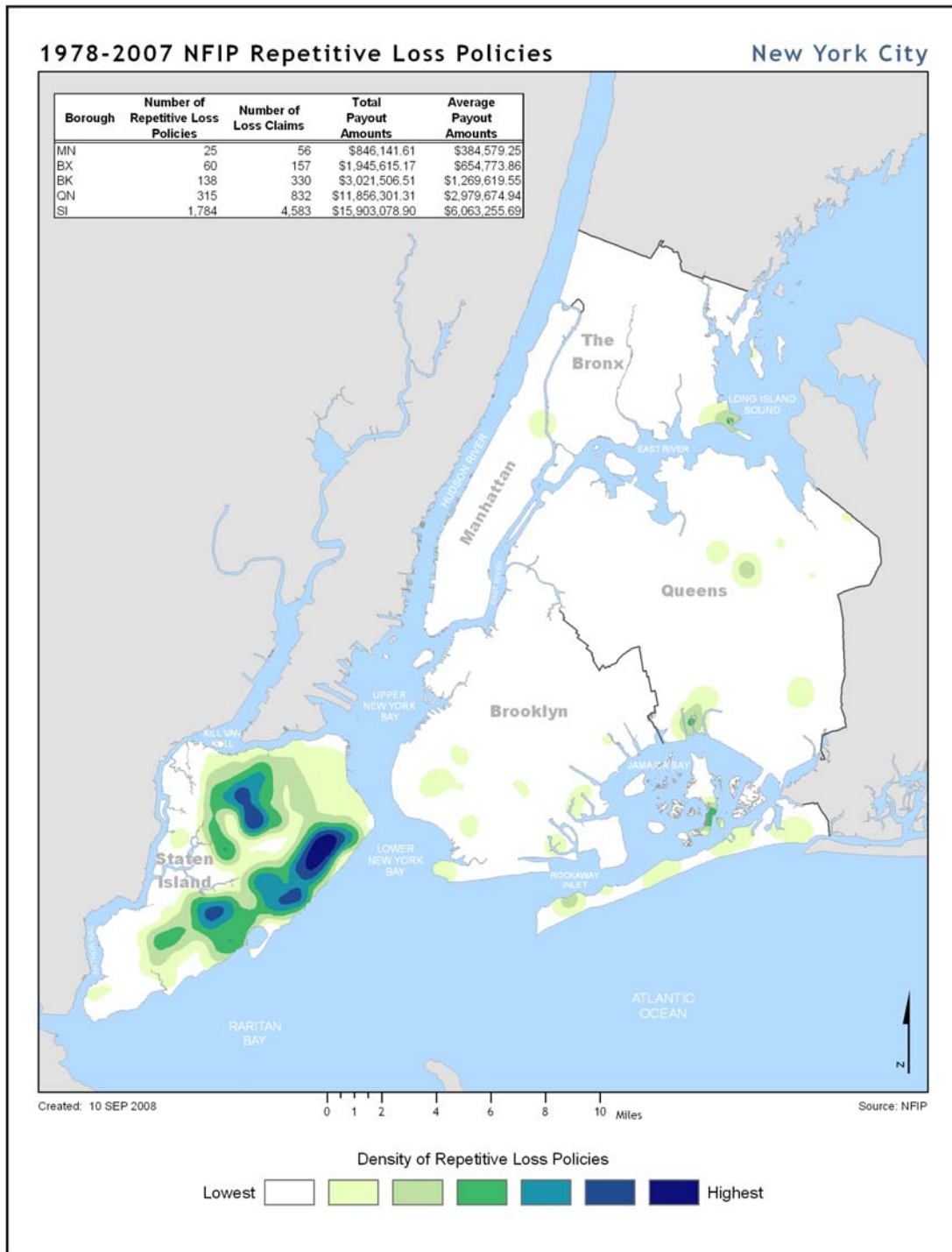


Figure 67: NFIP Repetitive Loss Properties

## v) Historic Occurrences

Historic Occurrences of Flooding in New York City			
Date	Event	Location(s)	Description
Aug. 16, 1993	Flash Flood	Manhattan	<ul style="list-style-type: none"> <li>Widespread rain embedded with thunderstorms</li> <li>Floodwaters partially covered cars, stranding several people on their roofs</li> </ul>
June 29, 1994	Flood/Flash Flood	Citywide	<ul style="list-style-type: none"> <li>Torrential rains of nearly 2.5 inches produced substantial road and highway flooding</li> <li>Many basements flooded</li> </ul>
June 22, 1995	Flash Flood	Brooklyn, Queens	<ul style="list-style-type: none"> <li>No information available</li> </ul>
July 1, 1995	Flash Flood	Staten Island	<ul style="list-style-type: none"> <li>Several homes damaged</li> <li>3 people injured at a movie theater when ceiling tiles fell because of standing water on the roof</li> </ul>
July 17, 1995	Flash Flood	Bronx, Manhattan, Queens	<ul style="list-style-type: none"> <li>Rainfall between 2 and 4 inches</li> <li>Many roadways closed</li> </ul>
July 23, 1995	Flash Flood	Bronx, Queens	<ul style="list-style-type: none"> <li>No information available</li> </ul>
Oct. 21, 1995	Urban Flood	Manhattan, Queens	<ul style="list-style-type: none"> <li>No information available</li> </ul>
Nov. 14, 1995	Coastal Flood	Queens	<ul style="list-style-type: none"> <li>No information available</li> </ul>
Jan. 12, 1996	Urban Flood	Citywide	<ul style="list-style-type: none"> <li>No information available</li> </ul>
Jan. 27, 1996	Urban Flood	Queens	<ul style="list-style-type: none"> <li>No information available</li> </ul>
Apr. 16, 1996	Urban Flood	Citywide	<ul style="list-style-type: none"> <li>No information available</li> </ul>
June 3, 1996	Urban Flood	Citywide	<ul style="list-style-type: none"> <li>No information available</li> </ul>
July 3, 1996	Flash Flood	Queens, Staten Island	<ul style="list-style-type: none"> <li>Cars trapped in flooding on the Long Island Expressway</li> <li>Serious road flooding reported along Richmond Parkway</li> </ul>
July 8, 1996	Flash Flood	Manhattan	<ul style="list-style-type: none"> <li>High winds, large hail, and torrential rain</li> </ul>
July 13, 1996	Flood	Brooklyn	<ul style="list-style-type: none"> <li>Tropical Storm Bertha</li> <li>Serious widespread flooding was reported along the Brooklyn-Queens Expressway</li> </ul>
July 31, 1996	Flash Flood	Brooklyn, Queens, Staten Island	<ul style="list-style-type: none"> <li>2 to 5 inches of rain in 3 hours</li> <li>Several houses damaged in mudslides at Richmondtown</li> <li>Serious widespread flash flooding of roads and numerous basements flooded across Brooklyn and Queens</li> </ul>

Historic Occurrences of Flooding in New York City			
Date	Event	Location(s)	Description
Sept. 8, 1996	Flash Flood	Bronx, Brooklyn Staten Island	<ul style="list-style-type: none"> <li>Thunderstorms produced torrential rain</li> <li>Significant flash flooding of low lying and poor drainage areas, including many streets</li> </ul>
Oct. 19, 1996	Flood	Citywide	<ul style="list-style-type: none"> <li>Heavy flood producing rains and minor coastal flooding</li> <li>3 to 5 inches with isolated higher amounts</li> <li>Serious flooding of basements and first floors caused damage to 226 homes in Flushing and 70 homes in Springfield Gardens</li> <li>Numerous cars were damaged in floodwaters</li> </ul>
Jan. 10, 1997	Coastal Flood	Queens	<ul style="list-style-type: none"> <li>Tidal flooding submerged cars under 2 feet of water along Rockaway Blvd. in Brookville</li> <li>Moderate tidal flooding reported at Howard Beach</li> </ul>
Nov. 2, 1997	Flash Flood	Staten Island	<ul style="list-style-type: none"> <li>Police scuba divers used rubber raft to rescue people from submerged car on Arthur Kill Road in Greenridge</li> </ul>
Jan. 23, 1998	Urban Flood	Citywide	<ul style="list-style-type: none"> <li>Heavy rainfall from 2 to just more than 4 inches</li> </ul>
Mar. 9, 1998	Urban Flood	Citywide	<ul style="list-style-type: none"> <li>Widespread heavy rainfall including thunderstorms</li> <li>Many low-lying and poor drainage areas, including streets were flooded throughout the area</li> </ul>
Aug. 17, 1998	Flood	Bronx, Manhattan Queens, Staten Island	<ul style="list-style-type: none"> <li>Rainfall rates up to 2 inches per hour</li> <li>LaGuardia Airport, 3.54 inches of rain</li> </ul>
Jan. 3, 1999	Urban Flood	Citywide	<ul style="list-style-type: none"> <li>People required rescue from their flooded basement apartments in Springfield Gardens, Queens</li> <li>Water rose within 6 inches of ceilings in several apartments</li> </ul>
Jan. 15, 1999	Flood	Staten Island	<ul style="list-style-type: none"> <li>Heavy rain fell on frozen ground with partially clogged storm drains</li> <li>Up to 2 feet of water collected in many streets in South Beach</li> </ul>



Historic Occurrences of Flooding in New York City			
Date	Event	Location(s)	Description
Aug. 26, 1999	Flood	Bronx, Manhattan, Queens	<ul style="list-style-type: none"> <li>Flash flooding crippled public transit during the morning rush hour</li> <li>Subway service was severely disrupted as 3 to 5 feet of water collected at subway station locations</li> <li>Fifty-two inches of water measured at the #6 station at Cypress Ave.</li> <li>A 10 to 20 foot section of the northbound platform on the 6 line at 28th Street crumbled and washed away</li> <li>Metro-North Railroad forced to close in Mott Haven, South Bronx</li> </ul>
Sept. 16, 1999	Flood	Citywide	<ul style="list-style-type: none"> <li>Remnants of Hurricane Floyd</li> <li>Maximum rainfall rates from 1 to around 2 inches per hour lasted for at least 3 consecutive hours</li> <li>5.02 inches at Central Park</li> </ul>
July 3, 2000	Flash Flood	Brooklyn, Queens, Staten Island	<ul style="list-style-type: none"> <li>Rainfall rates estimated up to 4 inches per hour for less than 1 hour</li> <li>Significant ponding of water trapped people in two cars near the Verrazano Bridge</li> <li>Significant low-lying and poor drainage flooding on Cross Island Parkway near Whitestone Bridge</li> </ul>
Aug. 11, 2000	Flash Flood	Bronx, Queens	<ul style="list-style-type: none"> <li>Slow moving thunderstorms produced rainfall rates estimated at around 2 inches per hour, which caused significant flooding of low-lying and poor drainage areas.</li> <li>In the Bronx, cars were submerged in rising water and many people were trapped.</li> <li>NWS radar estimated a 2 to 3 inch rainfall from 2:30 AM to 3:30 AM, with up to 5 inches during the preceding 24 hours.</li> </ul>

Historic Occurrences of Flooding in New York City			
Date	Event	Location(s)	Description
Aug. 27, 2000	Flash Flood	Staten Island	<ul style="list-style-type: none"> <li>Heavy showers moved very slowly east across Northern Staten Island.</li> <li>NWS radar estimated rainfall rates of 1.5 to 2 inches per hour for at least 2 consecutive hours.</li> <li>Estimated rainfall amounts of 3.5 to 4 inches resulted in serious widespread flooding of low lying and poor drainage areas</li> </ul>
Aug. 28, 2000	Flash Flood	Queens	<ul style="list-style-type: none"> <li>NWS radar estimated rainfall rates from 1.5 to 2.0 inches per hour</li> <li>Total precipitation amount from 3.5 to 4 inches</li> <li>Serious widespread flooding on Cross Island Parkway in Whitestone</li> <li>Up to 5 feet of water ponded on streets in Bay Terrace</li> </ul>
Sept. 3, 2000	Flash Flood	Queens	<ul style="list-style-type: none"> <li>Nearly stationary thunderstorms produced torrential rain</li> <li>People had to be rescued from submerged cars on Northern Blvd.</li> <li>Several residential basements in poor drainage areas were flooded</li> </ul>
June 17, 2001	Flash Flood	Bronx, Brooklyn, Manhattan, Queens	<ul style="list-style-type: none"> <li>Remnants of Tropical Storm Allison</li> <li>Rainfall rates up to 3 inches per hour</li> <li>Numerous reports of street and highway flooding</li> </ul>
June 23, 2001	Urban Flood	Manhattan, Staten Island	<ul style="list-style-type: none"> <li>Several people required rescue from their cars in Staten Island.</li> <li>Large segment of West Side Highway between 100th and 120th Streets closed</li> </ul>
Aug. 13, 2001	Flash Flood	Brooklyn, Manhattan, Queens	<ul style="list-style-type: none"> <li>Rainfall rates in excess of 2 inches per hour in portions of northern Queens</li> <li>Highly localized rainfall amounts of 5 inches or more</li> <li>Several health care facilities flooded, including one area hospital and seven area nursing homes</li> </ul>
June 26, 2002	Flood, Thunderstorm	Bronx	<ul style="list-style-type: none"> <li>Widespread flash floods in the Bronx</li> </ul>

Historic Occurrences of Flooding in New York City			
Date	Event	Location(s)	Description
Aug. 16, 2002	Flood	Bronx, Manhattan, Queens	<ul style="list-style-type: none"> <li>• 3 feet of water on Major Deegan Expressway at Cross Bronx Expressway interchange which required police rescues</li> <li>• Shutdown of the Henry Hudson Parkway from 96th Street to 125th Street</li> <li>• Significant urban flooding in Far Rockaway</li> </ul>
Sept. 2, 2002	Flash Flood	Brooklyn, Queens	<ul style="list-style-type: none"> <li>• Significant street flooding in Greenpoint and on Brooklyn-Queens Expressway</li> <li>• Significant widespread street flooding in Woodside</li> </ul>
July 22, 2003	Flash Flood	Queens, Staten Island	<ul style="list-style-type: none"> <li>• Significant street flooding in Bayside Hills and Ridgewood.</li> <li>• Con Ed reported significant flooding that resulted in street closings near Richmond Avenue and Victory Boulevard</li> </ul>
Aug. 4, 2003	Flash Flood	Brooklyn, Manhattan, Queens, Staten Island	<ul style="list-style-type: none"> <li>• Rainfall rates were between 2 and 3 inches per hour</li> <li>• N and R subway tunnels flooded</li> <li>• Flooded basements in Brooklyn</li> <li>• Sewers and septs backed up onto streets in Annadale</li> </ul>
Aug. 17, 2003	Flash Flood	Brooklyn	<ul style="list-style-type: none"> <li>• Isolated locations received as much as 3 to 4 inches of rain in as little as 2 hours.</li> <li>• NYC OEM reported water levels up to car doors on the Belt Parkway near Pennsylvania Avenue in Brooklyn</li> </ul>
Sept. 23, 2003	Flash Flood	Bronx, Brooklyn, Manhattan, Queens	<ul style="list-style-type: none"> <li>• Several lanes closed on the FDR and Harlem River Drives in Manhattan, the Van Wyck Expressway in Queens, Ocean Parkway in Brooklyn and several local streets in Riverdale in the Bronx</li> </ul>
June 17, 2004	Flash Flood	Bronx, Brooklyn Manhattan, Queens	<ul style="list-style-type: none"> <li>• Significant flash flooding on the roadways resulted in people needing to be rescued from their cars</li> </ul>
June 25, 2004	Flash Flood	Queens, Staten Island	<ul style="list-style-type: none"> <li>• Several cars trapped in floodwaters in Queens and Staten Island</li> </ul>

Historic Occurrences of Flooding in New York City			
Date	Event	Location(s)	Description
July 2, 2004	Flash Flood	Bronx, Queens	<ul style="list-style-type: none"> <li>179th Street and Major Deegan in the Bronx flooded</li> <li>Bell Boulevard and 208 Place intersection in Queens flooded with 2 people having to be rescued from cars</li> </ul>
Sept. 8, 2004	Flash Flood	Bronx, Brooklyn, Manhattan, Queens	<ul style="list-style-type: none"> <li>Remnants of Hurricane Frances</li> <li>Rainfall amounts up to 6 inches</li> <li>Extensive flash flooding across the region, resulting in rescues of people from homes and cars</li> </ul>
Sept. 18, 2004	Flash Flood	Citywide	<ul style="list-style-type: none"> <li>Remnants of Hurricane Ivan</li> <li>Torrential rains up to 5 inches in some areas</li> </ul>
Sept. 28, 2004	Flash Flood	Citywide	<ul style="list-style-type: none"> <li>Remnants of Hurricane Jeane dropped between 3 and 6 inches across Southeastern New York State</li> <li>Numerous roads and highways closed</li> </ul>
July 6, 2005	Flash Flood	Brooklyn	<ul style="list-style-type: none"> <li>Slow moving thunderstorms containing hourly rainfall rates of around 2 inches per hour caused flash flooding of streets</li> </ul>
Oct. 14, 2005	Flash Flood	Brooklyn, Queens	<ul style="list-style-type: none"> <li>Flooding along Ocean Parkway and the Grand Central Parkway</li> <li>Several trees and power poles were leaning from soggy ground</li> </ul>
June 1, 2006	Flash Flood	Staten Island	<ul style="list-style-type: none"> <li>Flash flooding on the West Shore Expressway</li> </ul>
June 2, 2006	Flash Flood	Manhattan, Queens, Staten Island	<ul style="list-style-type: none"> <li>Flash flooding on FDR</li> <li>Flash flooding of roads submerged vehicles and a few houses were surrounded by 5 feet of water in Staten Island</li> </ul>
July 12, 2006	Flash Flood, Thunderstorm	Citywide	<ul style="list-style-type: none"> <li>Flash flooding of the FDR service road at 34th Street</li> <li>Wall collapse in Washington Heights</li> </ul>
July 21, 2006	Flash Flood, Thunderstorm	Citywide	<ul style="list-style-type: none"> <li>Partial road closures on the Staten Island Expressway., the Belt Parkway, the Brooklyn-Queens Expressway., the Grand Central Parkway and Van Wyck Expressway</li> <li>Subway service suspended in both directions on the R and W lines between Whitehall Street in Manhattan and Ditmars Boulevard in Queens</li> </ul>

Historic Occurrences of Flooding in New York City			
Date	Event	Location(s)	Description
Aug. 10, 2006	Flash Flood	Manhattan, Queens	<ul style="list-style-type: none"> <li>Flash flooding forced closure of subway lines 1, 2, 3, and 6.</li> </ul>
Aug. 25, 2006	Flash Flood	Bronx, Queens	<ul style="list-style-type: none"> <li>Flash flooding along many major roads, which resulted in road closures</li> <li>Most significant flooding along the Deegan and Cross Bronx Expressways</li> </ul>
Oct. 28, 2006	Flash Flood	Bronx	<ul style="list-style-type: none"> <li>Flash flooding along portions of the Bronx River Parkway and Bruckner Expressway</li> </ul>
Nov. 8, 2006	Flash Flood	Staten Island	<ul style="list-style-type: none"> <li>Heavy rain flooded multiple basements and closed numerous streets</li> <li>Staten Island Railroad service was suspended because of flash flooding across tracks</li> </ul>
Apr. 15, 2007	Flood	Brooklyn, Manhattan, Queens	<ul style="list-style-type: none"> <li>Nor'easter brought heavy rain and high winds.</li> <li>8.41 inches at Central Park</li> <li>Street flooding along the Belt Parkway and FDR Drive</li> </ul>
Apr. 27, 2007	Flash Flood	Bronx, Manhattan, Queens	<ul style="list-style-type: none"> <li>Rainfall amounts from 2–3 inches</li> <li>Flash flooding of the Jackie Robinson Parkway and West Side Highway</li> </ul>

**Table 36: Historic Occurrences of Flooding in New York City**

#### *August 8, 2007 Storms*

On August 8, 2007, severe storms disrupted transit service throughout much of the New York City area and a rare tornado touched down in Brooklyn. An estimated three inches of rain fell in about an hour, flooding major roads, causing power outages, and disrupting train service. MTA subways, buses, and commuter railroads were overcome by flooding. The flooding affected more than 2.5 million transit customers by mid-morning. The President issued a major disaster declaration on August 31, 2007, which authorized individual assistance for Queens residents who had flood-related losses. Approximately 3,700 households and business owners registered for assistance. Total disaster assistance grants topped \$7.2 million.

## b) Vulnerability Assessment

### i) Impact on New York City

In 2000, more than 200,000 people in approximately 77,700 households live within the 100-year floodplain. Nearly 10% of the City could experience flooding in a 100-year flood event.

Population and Households in 100-Year Floodplain		
Borough	Population	Households
Bronx	11,023	4,188
Brooklyn	63,654	24,477
Manhattan	63,576	24,562
Queens	46,674	18,070
Staten Island	18,108	6,487
<b>Total</b>	<b>203,035</b>	<b>77,784</b>

**Table 37: Population and Households in 100-Year Floodplain (Source: 2000 U.S. Census)**

### ii) Structural Vulnerability

The Planning Team used HAZUS-MH to determine property exposure to flooding. Overall, 13,341 buildings are at risk to damage from a 100-year flood. More than half of these buildings are not predicted to have damage based on the HAZUS-MH output. 2.5% of these buildings are predicted to have significant damage to more than 50% of the structure.

100-Year Flood Building Damage								
Borough	Percentage of Building Damage							Total
	None	1–10%	11–20%	21–30%	31–40%	41–50%	>50%	
Bronx	529	34	295	316	74	90	24	<b>1,362</b>
Brooklyn	2,280	271	450	271	44	46	11	<b>3,373</b>
Manhattan	211	70	70	111	10	1	4	<b>477</b>
Queens	2,512	346	594	655	181	130	89	<b>4,507</b>
Staten Island	1,961	78	478	497	250	148	210	<b>3,622</b>
<b>Total</b>	<b>7,493</b>	<b>799</b>	<b>1,887</b>	<b>1,850</b>	<b>559</b>	<b>415</b>	<b>338</b>	<b>13,341</b>

**Table 38: HAZUS-MH Calculations for Building Damage from a 100-Year Flood**

Table 39 displays the number of critical assets located within the 100-year floodplain. These assets have a 1% chance of being flooded in any given year.

<b>Critical Assets Located in the 100-Year Floodplain</b>	
<b>Critical Asset</b>	<b>#</b>
Subway Stations	14
Rail Stations	18
Bridges and Tunnels	31
Major Roads (miles)	105
Airports	2
Ferry Landings	25
Emergency Services—Police Stations	1
Emergency Services—Fire Stations	8
Emergency Services—EMS Stations	2
Educational—Colleges	4
Educational—Public Schools	45
Educational—Private Schools	18
Healthcare—Hospitals	1
Healthcare—Nursing Homes	10
Cultural Facilities	6
Infrastructure—Power Plants	10
Infrastructure—Wastewater Treatment Plants	1

**Table 39: Critical Assets in the 100-Year Floodplain**

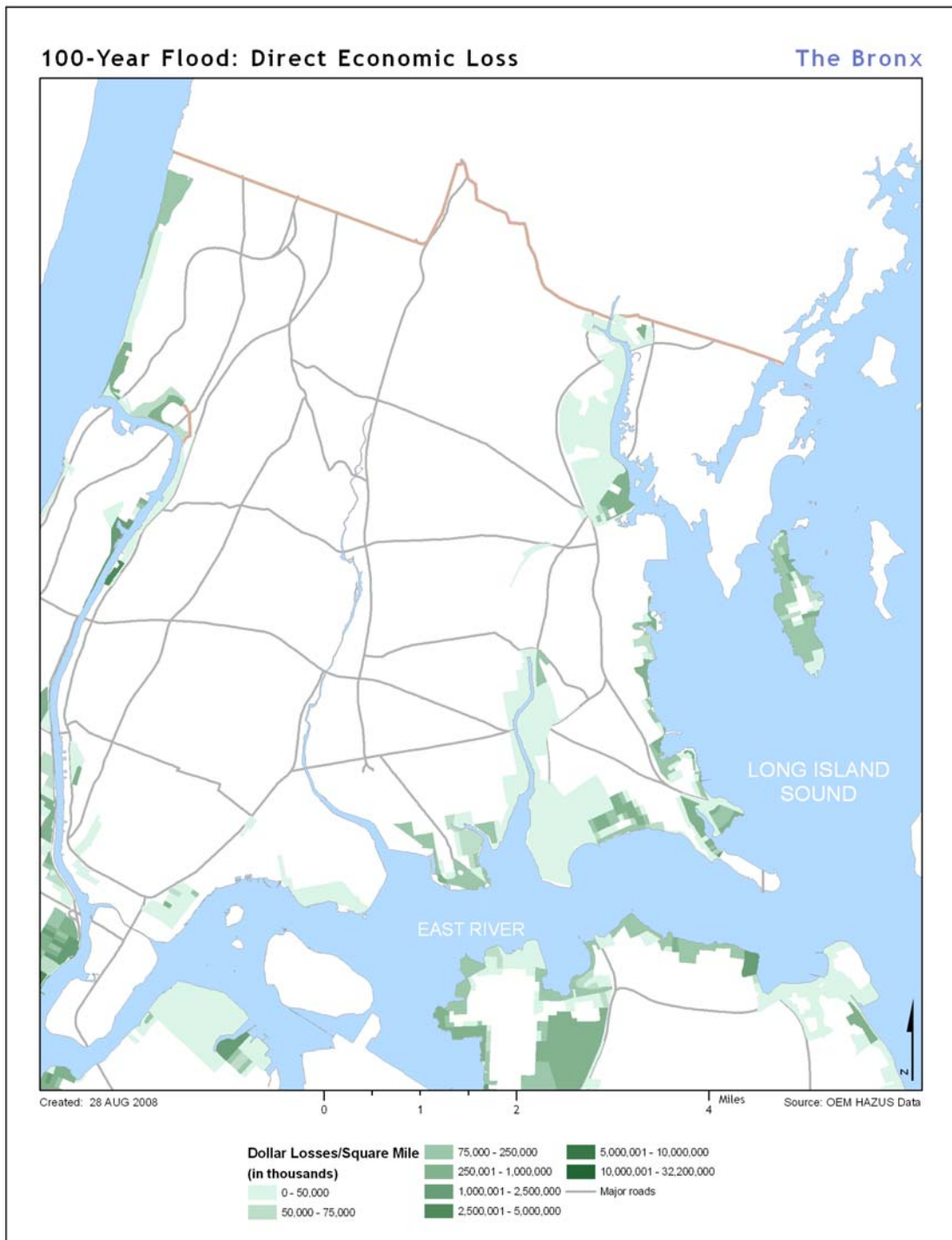
### iii) Potential Loss Estimate

The Planning Team used a deterministic model based on the 100-year flood to estimate potential economic losses. Table 40 and Figure 68 through Figure 72 highlight the key findings from the HAZUS-MH run of a 100-year flood in New York City. A 100-year flood affecting all five boroughs could cause more than \$12 billion in damage. More than 60% of the total damage would be to contents such as furniture, supplies, and other possessions.

<b>Capital Stock Losses for a 100-Year Flood (\$1,000s)</b>				
<b>Borough</b>	<b>Building Damage</b>	<b>Contents Damage</b>	<b>Inventory</b>	<b>Total</b>
Bronx	302,256	439,998	21,455	<b>763,709</b>
Brooklyn	903,775	2,025,808	148,686	<b>3,078,269</b>
Manhattan	1,737,769	2,639,381	49,764	<b>4,426,914</b>
Queens	1,053,671	2,323,539	72,530	<b>3,449,740</b>
Staten Island	224,797	268,275	10,232	<b>503,304</b>
<b>Total</b>	<b>4,222,268</b>	<b>7,697,001</b>	<b>302,667</b>	<b>12,221,936</b>

**Table 40: HAZUS-MH Calculations for Capital Stock Losses for a 100-Year Flood**

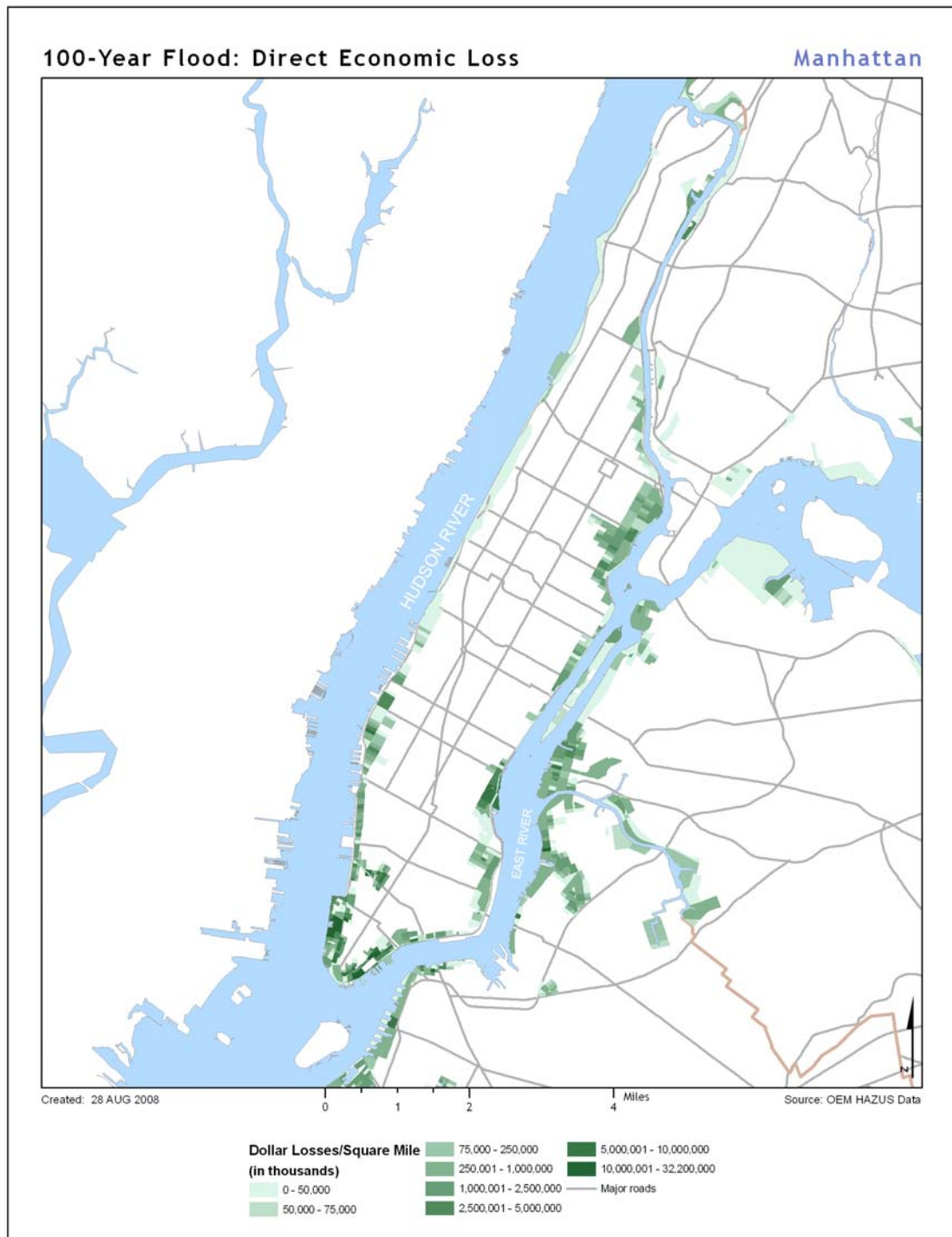




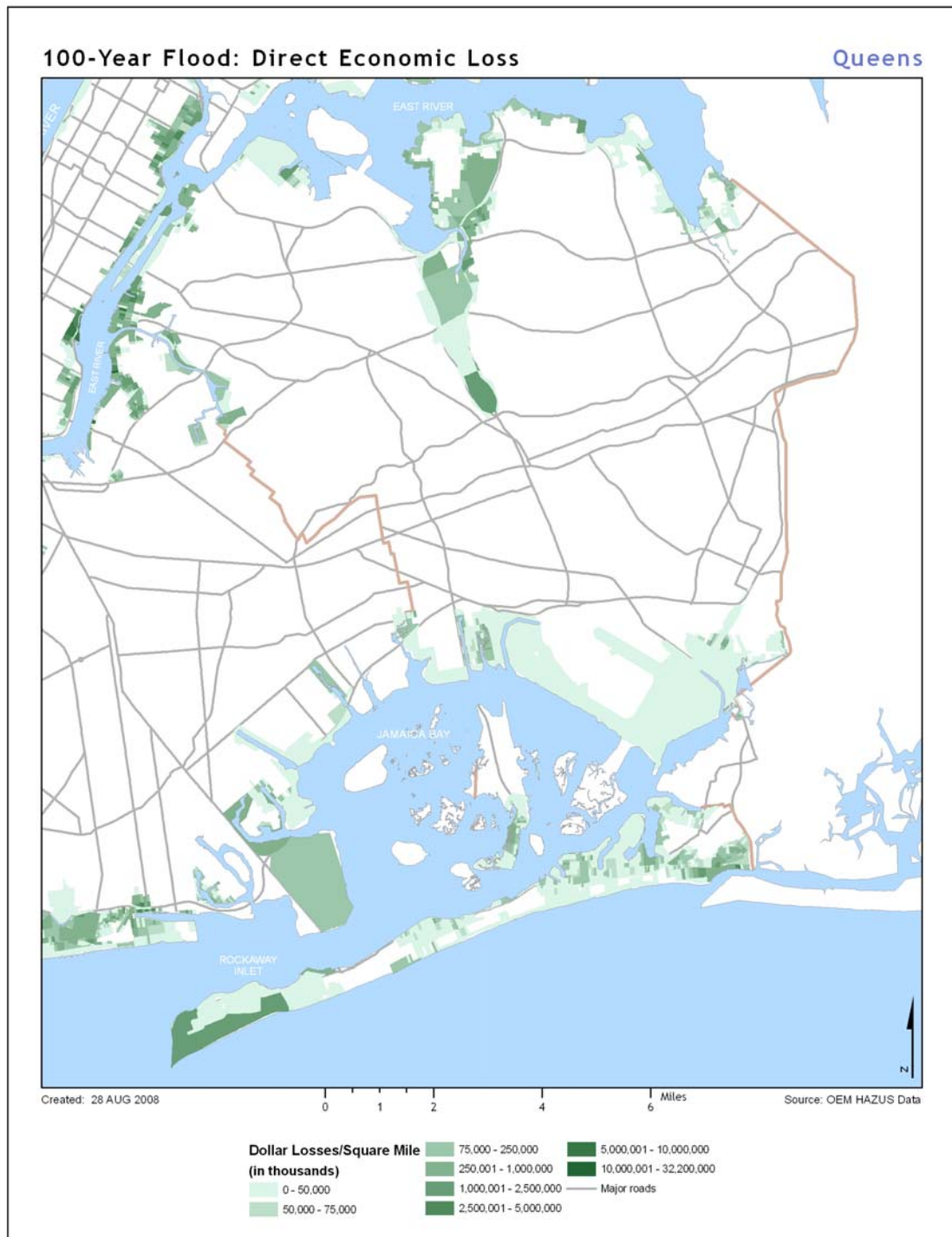
**Figure 68: HAZUS-MH Results for Economic Losses from a 100-Year Flood in the Bronx**



**Figure 69: HAZUS-MH Results for Economic Losses from a 100-Year Flood in Brooklyn**



**Figure 70: HAZUS-MH Results for Economic Losses from a 100-Year Flood in Manhattan**



**Figure 71: HAZUS-MH Results for Economic Losses from a 100-Year Flood in Queens**





**Figure 72: HAZUS-MH Results for Economic Losses from a 100-Year Flood in Staten Island**