Section 3.12: HURRICANE

(Tropical/ Coastal Storms/ Nor'easter)

2014 SHMP Update

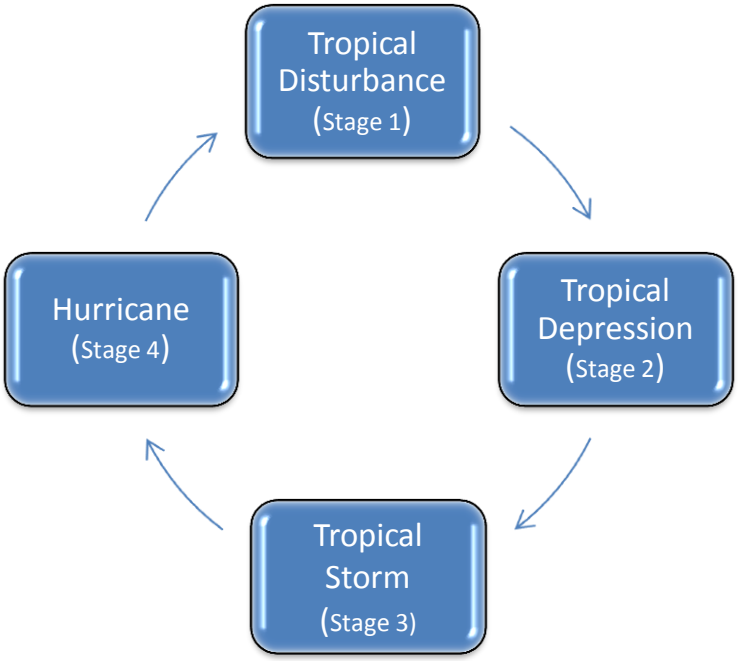
- Reformatted 2011 Mitigation Plan into 2014 Update outline
- Added Tropical Storms, Coastal Storms, & Nor'easter hazards to Hurricane Profile
- Added new key terms to 2011 Mitigation Plan's list of terms
- Updated past hurricane occurrences section
- Inserted Events and Losses table
- Inserted new Hurricane Events and Property Losses maps
- Added information on New York Bight
- Added active State development projects

3.12.1 Hurricane (Tropical/ Coastal Storms/ Nor'easters) Profile

Coastal storms, including Nor'easters, tropical storms, and hurricanes can, either directly or indirectly, impact all of New York State. More densely populated and developed coastal areas, such as New York City, are the most vulnerable to hurricane-related damages.

Before a storm is classified a hurricane, it must pass through four distinct stages: tropical disturbance, tropical depression, tropical storm and lastly a hurricane.

Figure 3.12a: Four Stages of a Hurricane



Characteristics

Below are some key terms to review relating to hurricanes, tropical storms, coastal storms and nor'easters:

Hazard	Key Terms and Definition
Hurricane	• *Nor'easter-* An intense storm that can cause heavy rain and snow, strong winds, and coastal flooding. Nor'easters have cold, low barometric cores • *Tropical Storm*- An organized system of strong thunderstorms with a defined surface circulation and maximum sustained winds of 39-73mph • *Tropical Cyclone*- An organized, rotating, low-pressure weather system of clouds and thunderstorms that develops in the tropics • *Tropical Depression*- A tropical cyclone with sustained winds of 38 mph or less • *Hurricane-* Tropical cyclones, formed in the atmosphere over warm ocean areas, in which wind speeds reach 74mph or more and blow in a large spiral around a relatively calm center or "eye". Circulation is counterclockwise in the Northern Hemisphere • *Storm Surge-* A dome of water pushed on shore by hurricane and tropical storm winds Storm surges can reach 25 feet high and be 50-100 miles wide • *Storm Watch*- A warning issued by the National Weather Service indicating that Hurricane/ Tropical Storm are possible in the specified area, usually within 36 hours • *Storm Warning*- A warning issued by the National Weather Service indicating that Hurricane/ Tropical Storm conditions are expected in the specified area usually within 24 hours

Nor'easters

Nor'easter storms usually form off the East Coast near the Carolinas then follow a track northward along the coast until they blow out to sea, hence the term "Northeaster." Consequently, extreme cold and heavy snowfall can immobilize the entire state causing road closures, power outages, disruption in communication services, and no heat for several days.

Occasionally these storms are large enough to cover almost the entire State. One such storm was the Blizzard of 1993. Most often, however, Nor'easters affect primarily eastern and southern New York. Nor'easters are most notable for snow accumulations in excess of nine (9) inches, accompanied by high, sometimes gale force, winds, and storm surges which cause severe flooding along the Long Island coastline. Bronx, Kings, Nassau, New York, Queens, Richmond and Suffolk Counties (Region I) were all severely impacted by Hurricane Sandy, the second costliest impacted by one of the largest Nor'easters in 2012.

Nor'easters can cause beach erosion and structural damage as a result of heavy snow, rain and enormous waves that come along with these intense storms. Wind gusts associated with nor'easters can exceed hurricane strength in intensity. Unlike tropical cyclones (including tropical depressions, tropical storms and hurricanes), nor'easters encompass a cold core of low barometric pressure. Their strongest winds are close to the earth's surface and they often measure several hundred miles across. Additionally, nor'easters can produce low-level storm surges, which place the areas along the immediate coastline at a greater risk of coastal flooding.

Tropical Cyclones

A tropical cyclone, developed in the tropics, is an organized rotating weather system. They begin as a tropical depression with sustained winds below 38 mph, they can potentially develop into a tropical storm (with sustained winds of 39 to 73 mph) or a hurricane (with winds of 74 mph and higher).

Tropical cyclones contain a warm core of low barometric pressure and can produce heavy rainfall, powerful winds, and storm surge. While generally these cyclones are less dangerous than hurricanes, tropical depressions, and tropical storms they can still be deadly. Heavy rains, coastal flooding, and severe weather, such as tornadoes, pose the most significant threat.

Hurricanes

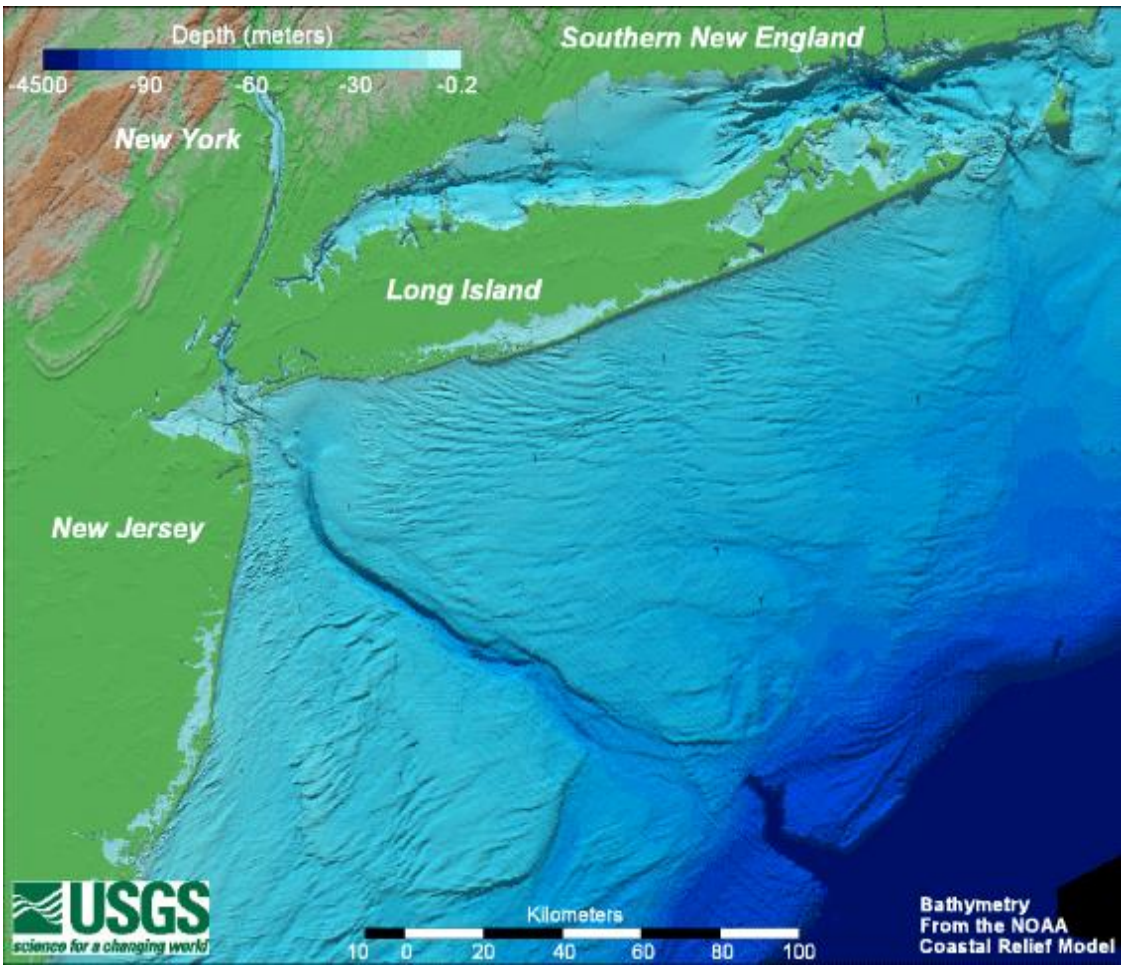
One of the most destructive types of storms is a hurricane which can last for extended time periods, vary in size, and carry wind speeds that can rip through trees, demolish homes and make loose objects deadly. Storm surges are the most serious hurricane-related hazard. Storm surges combined with normal high tides can create hurricane storm tides, in excess of 25 feet above the average water level. In addition, wind driven waves are superimposed on the storm tide. The rise in water level can cause severe inundation in coastal areas, particularly when storm tides coincide with normal high tides. The typical hurricane season begins in the summer during the month of June and last until November. Hurricanes form in the warm tropical waters of the Atlantic Ocean, Caribbean Sea, or Gulf of Mexico, and make their presences at any point of an active hurricane season.

Coastal Storms

Coastal Storms can take form and occur over the course of an entire year. All coastal regions experience coastal storms of some sort and are likely susceptible to storm-related damages and/ or losses. On average during an active hurricane season there are approximately 11 named storms, including six hurricanes, two of which are major events.
The coastal regions of the State are more susceptible to hurricanes largely due to their geographical location. New York City, in particular, is vulnerable to storm surges because of a physical characteristic referred to as the *New York Bight*. A bight is a curve in the

shoreline of an open coast that funnels and increases the speed and intensity of storm surge. The Bight is found at the point where the States of New York and New Jersey meet, forming a right angle along the coastline (Shown below in **Figure 3.12b**).

Figure 3.12b: New York State Bight



Source: USGS, NOAA

Hurricane classifications are determined by the Saffir-Simpson Scale. The National Hurricane Center (NHC) defines the Saffir-Simpson Hurricane Scale as a 1-5 rating based on a hurricane's present intensity (See **Table 3.12a** below). This is used to give an estimate of the potential property damage and flooding expected along the coast upon a hurricane's landfall. Wind speed is the determining factor in this scale, as storm surge values are highly dependent on the slope of the continental shelf and the shape of the coastline, in the landfall region.

Table 3-12a: Saffir- Simpson Hurricane Scale

Saffir-Simpson Hurricane Scale				
Category	**Storm Surge (ft.)**	**Winds (mph)**	**Damage**	**Damage Description**
1	6.1-10.5	74-95	Moderate	• Damage primarily to trees and unanchored homes • Some damage to poorly constructed signs • Coastal road flooding
2	13.0- 16.6	96-110	Moderate-Severe	• Some roofing material, door, and window damage to buildings • Considerable damage to shrubbery and trees • Flooding of low-lying areas
3	14.8-25	111-130	Extensive	• Some structural damage to residences and utility buildings • Foliage blown off trees and large trees blown down • Structures close to the coast will have structural damage by floating debris
4	24.6-31.3	131-155	Extreme	• Curtainwall failures with utilities and roof structures on residential buildings • Shrubs, trees, and signs all blown down • Extensive damage to doors and windows • Major damage to lower floors of structures near the shore
5	Not predicted	>155	Catastrophic	• Complete roof failure on many residences and industrial buildings • Some complete building and utility failures • Severe, extensive window and door damage • Major damage to lower floors of all structures close to shore

Location

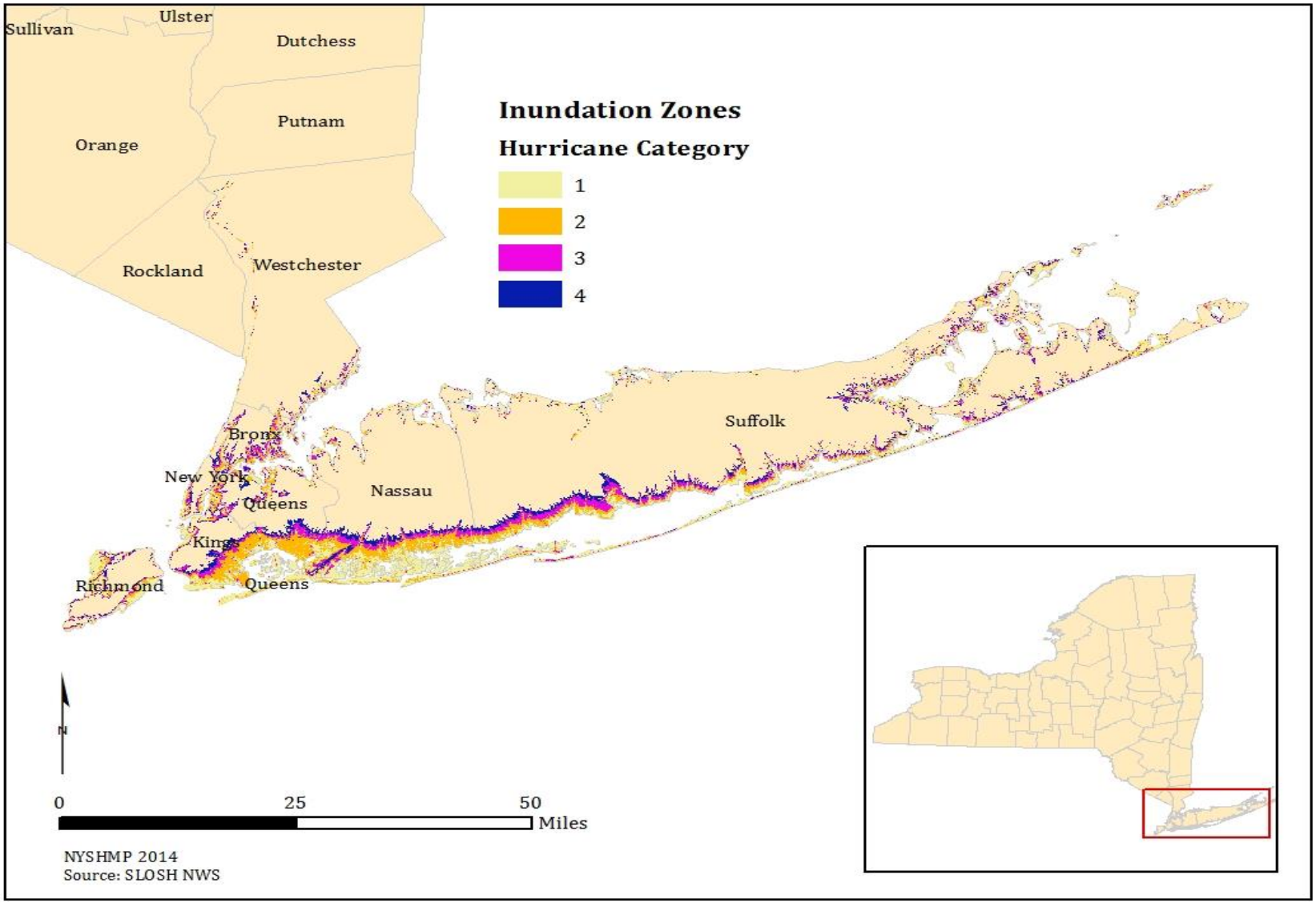
Hurricane risk in the United States extends along the entire east coast from Maine to Florida, the Gulf Coast (including Florida, Alabama, Louisiana, and Texas), and Hawaii. Hurricanes and tropical storms are the two major types of storm events that generally impact the State's marine coastline and adjacent inland areas. According to the NCH the United States is currently in a period of heightened hurricane activity which began around 1995 and is expected to last for at least another decade.

The Office of Emergency Management (OEM) utilizes a computer based model that hypothetically generates the effects of storm surges, as well as assist with planning efforts for coastal storms that is known as SLOSH (Sea, Lake, and Overland Surges from Hurricanes). This model computes storm surges based on storm movement in varying directions and strengths. SLOSH models analyze storms moving northeast, northwest, and changing in strength from Category 1 to Category 4.

SLOSH calculations are based on storm surges reaching above average tides and strong potential winds for each category storm. The error of this model ranges between plus or minus three feet. Furthermore, the SLOSH model can compute inundation levels for specific locations as if a hurricane hit head-on. These findings from the SLOSH model are based on a "worst-case" scenario for storm surge.

Figure 3.12c shows hurricane storm surge zones for the southern coast of New York. Inundation zones were developed using NOAA's Sea, Lake and Overland Surge from Hurricanes (SLOSH) model projections to show what areas would be inundated for specific hurricane categories.

Figure 3.12c: Storm Surge in Coastal New York



The data generated through SLOSH illustrates that the five boroughs of New York City, Nassau, and Suffolk Counties were the primary areas affected; however, areas north of Rockland and Westchester Counties have not been mapped for SLOSH surge zones. The map provides a visual representation of New York State's physical vulnerabilities. It is important to note that upstate counties found along the Hudson River including Rockland, Westchester, Orange, Putnam, Dutchess, Ulster, and Albany also experienced storm surge inundations as a result of Hurricane Sandy.

Figure 3.12d show the methodology to estimate population in storm surge zones, based on a GIS overlay analysis of US Census Block Points and the SLOSH model.

Figure3.12d: New York State Coastal Storm Surge

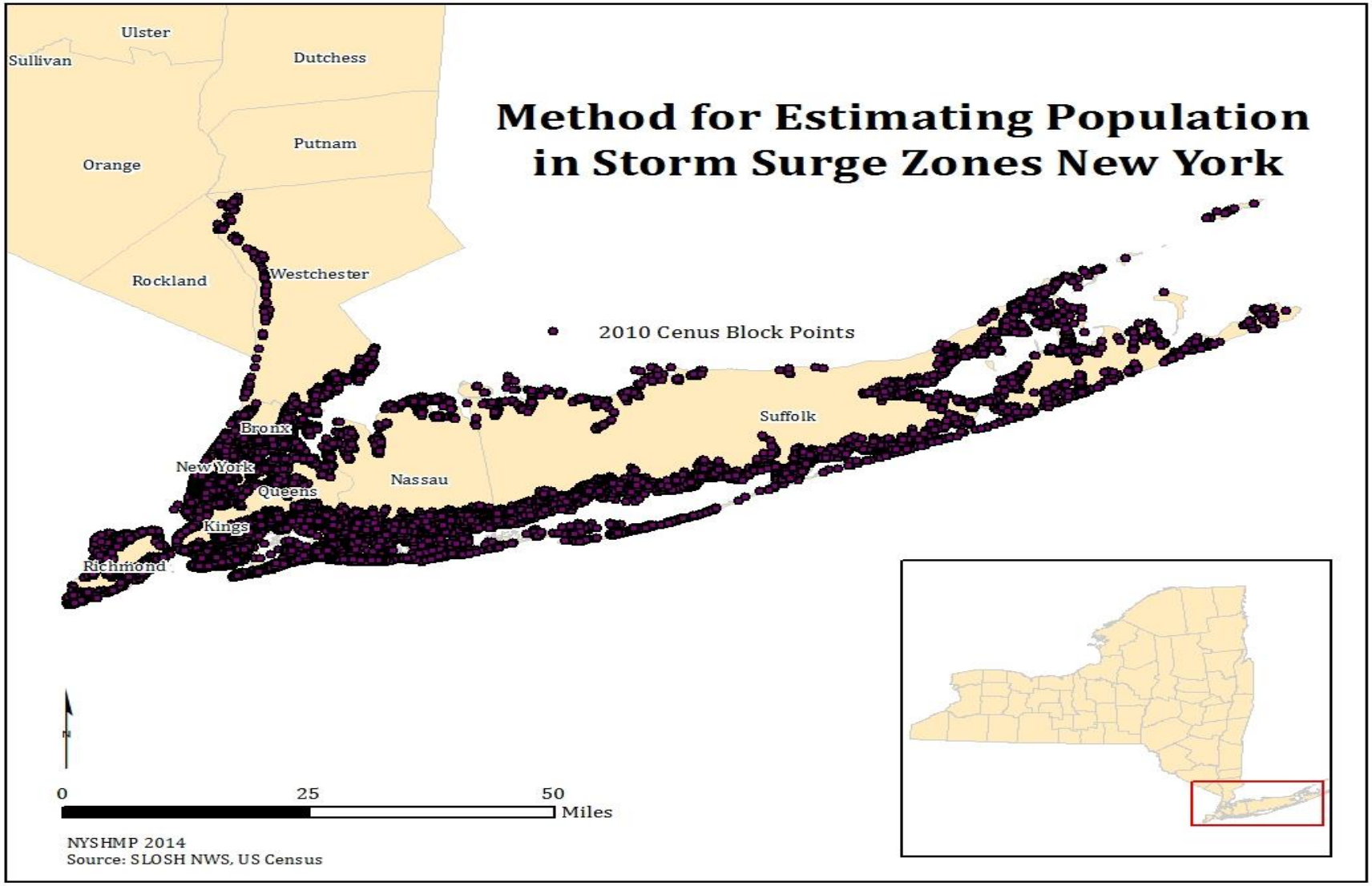


Table 3.12b provides the result of the analysis shown above, with estimated population that would be affected by hurricane storm surge for particular hurricane category events.

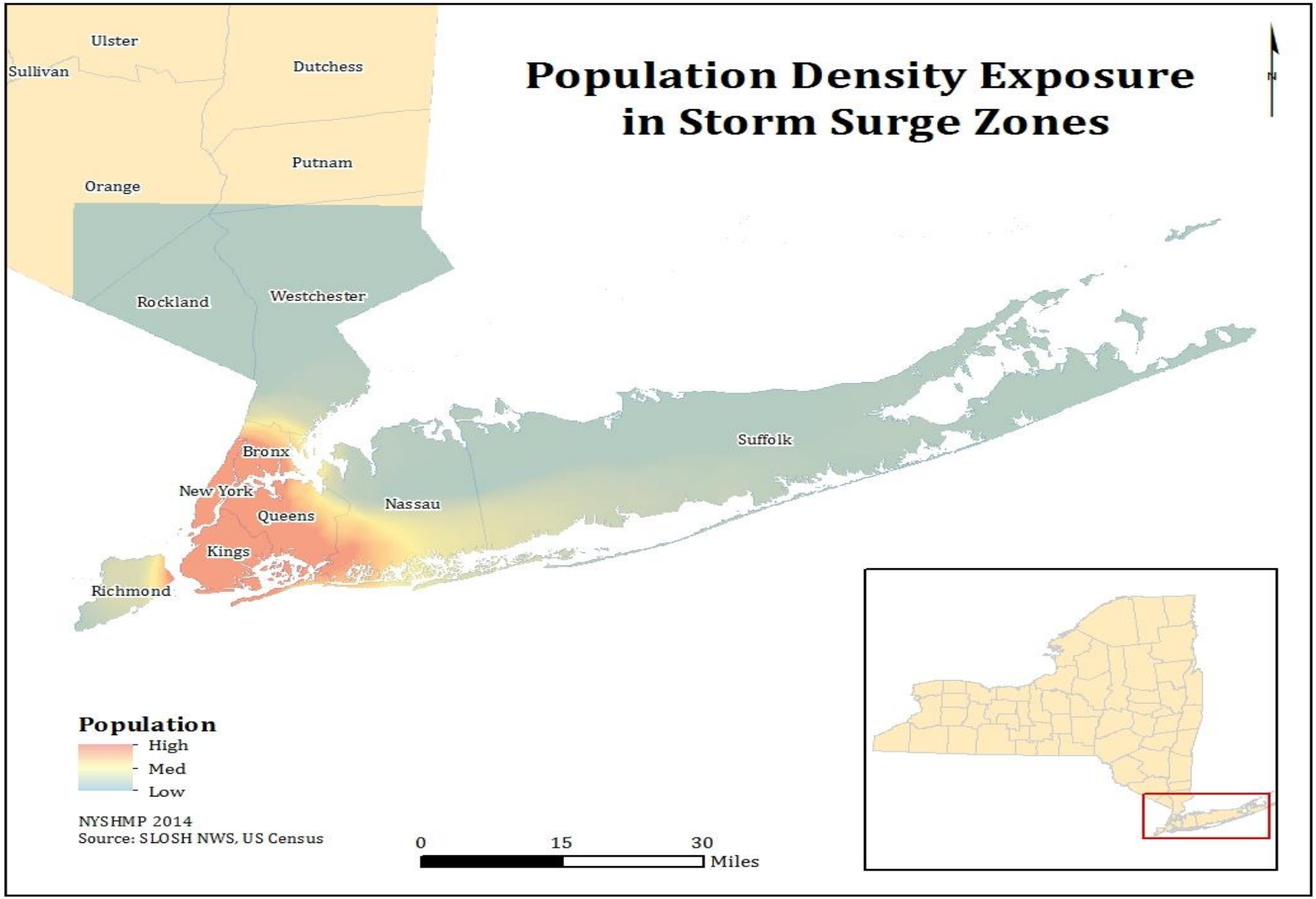
Table 3.12b: Estimated Population in Storm Surge Zones

Storm Zone	Population
Category 1	517,940
Category 2	1,549,103
Category 3	2,429,424
Category 4	3,225,374

(Category 2-4 Inclusive of Proceeding Storm Surge)

Figure 3.12e and **Table 3.12b** also provide the result of the GIS analysis shown above, but show population in surge zones by county as a population density analysis from the block points.

Figure 3.12e: Population Density Exposure in Storm Surge Zones



Previous Hurricane (Tropical/ Coastal Storms/ Nor'easter) Occurrences

Since 2011, the State of New York has experienced a tropical storm, two hurricanes, two mandatory evacuation ordinances, and billions of dollars in damages. Considering Hurricane Sandy alone, the governor's office estimates that 305,000 homes have been destroyed primarily from storm surges. New York City's Office of Management and Budget, appraises the total damage including private, public, and indirect cost to be $19 billion ($4.5 billion to city agencies; $5 billion to New York City Metropolitan Transit Authority (MTA), and $2.5 billion in supplementary transportation infrastructure). In addition, the New York Stock Exchange experienced the longest shutdown since the Blizzard of 1888, closing for two consecutive days. Flood waters reached several feet high in areas of Manhattan, Brooklyn, and Long Island. The data expounded in this section was gathered from a compilation of sources deriving from FEMA, SHELDUS, and Hazus-MH 2.1

Represented below in **Table 3.12c** are hurricane, tropical storm, and severe wind events previously declared as major disaster actions in the State of New York between 1954 and 2013. The damages consist of coastal and riverine flooding, as well as wind damage primarily affecting trees and electric power lines. Note that a number of the following Federal Disaster Declaration requests were denied; one withdrawn, and one received SBA/ USDA disaster declarations.

Table 3.12c: Historical Major Disaster Declarations from 1954 – 2012

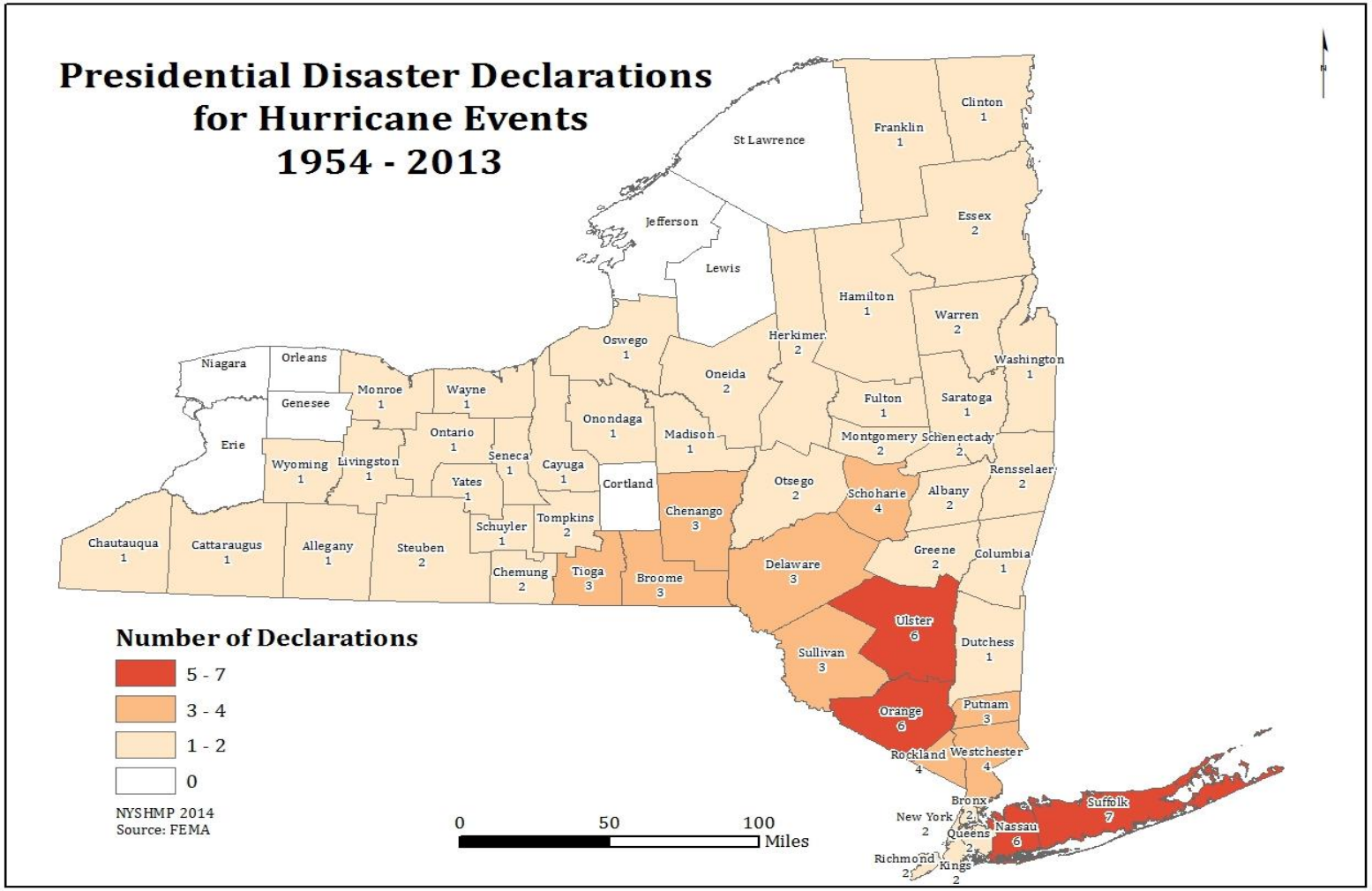
Disaster Number	Date Declared	Incident Type	Location Affected
4085	10/30/2012	Hurricane Sandy	Bronx County, Greene County, Kings County, Nassau County, New York County, Orange County, Putnam County, Queens County, Richmond County, Rockland County, Suffolk County, Sullivan County, Ulster County and Westchester County.
4031	9/13/2011	Remnants of Tropical Storm Lee	Broome County, Chemung County, Chenango County, Delaware County, Herkimer County, Montgomery County, Oneida County, Orange County, Otsego County, Schenectady County, Schoharie County, Tioga County, Tompkins County and Ulster County.
4020	8/31/2011	Hurricane Irene	Albany County, Bronx County, Clinton County, Columbia County, Delaware County, Dutchess County, Essex County, Franklin County, Fulton County, Greene County, Hamilton County, Herkimer County, Kings County, Montgomery County, Nassau County, New York County, Orange County, Otsego County, Putnam County, Queens County, Rensselaer County, Richmond County, Rockland County, Saratoga County, Schenectady County, Schoharie County, Suffolk County, Sullivan County, Ulster County, Warren County, Washington County and Westchester County.
1869	12/31/2009	Severe Storms and Flooding Associated with Tropical Depression Ida and a Nor'easter	Nassau & Suffolk
1565	10/1/2004	Tropical Depression Ivan	Broome, Chenango, Delaware, Orange, Schoharie, Steuben, Sullivan, Tioga, & Ulster
1296	9/16/1999	Tropical Strom Floyd	Albany County, Essex County, Greene County, Nassau County, Orange County, Putnam County, Rockland County, Schoharie County, Suffolk County, Ulster County, Warren County and Westchester County
918	9/16/1991	Hurricane Bob	Suffolk County

Disaster Number	Date Declared	Incident Type	Location Affected
750	10/18/1985	Hurricane Gloria	Nassau, Suffolk
520	9/3/1976	Hurricane Belle	Nassau, Rensselaer, Suffolk
338	6/23/1972	Tropical Storm Agnes	Allegany County, Broome County, Cattaraugus County, Cayuga County, Chautauqua County, Chemung County, Chenango County, Livingston County, Madison County, Monroe County, Oneida County, Onondaga County, Ontario County, Orange County, Oswego County, Rockland County, Schuyler County, Seneca County, Steuben County, Tioga County, Tompkins County, Ulster County, Wayne County, Westchester County, Wyoming County and Yates County.
45	8/22/1955	Hurricane, Floods	None
26	10/7/1954	Hurricane	None

Source: FEMA

Figure 3.12f displays the Presidential Declared Disaster totals by county for hurricane events for the period of 1954 through July 2013. Suffolk, Ulster, Nassau, and Orange Counties have the highest number of hurricane declarations.

Figure 3.12f: Presidential Disaster Declarations



Found in **Table 3.12d, Figure 3.12g** and **Figure 3.12h** is a list of historical events and recent losses organized by county. In addition to hurricanes, the data displayed in Table 3-12d includes Tropical, Coastal Storms and Nor'easter occurrences from 1960 to 2012 that was extracted from SHELDUS, the Spatial Hazard Events and Loss Database for the United States. Suffolk County has had the greatest amount of losses in terms of property damage since 1960. Based on historical frequency, Suffolk County has also had the highest number of hurricane events to occur in the State.

Table 3-12d: Hurricane Events and Losses by County

Historical Record (1960-2012)							
County	**Future Probability %**	**Recurrence Interval**	**No. of Events**	**Fatalities**	**Injuries**	**Property Damage**	**Crop Damage**
Albany	8	13	4	0	2	$193,835	$3,914
Allegany	2	52	1	0	0	$8,065	$0
Bronx	17	6	9	1	2	$5,525,611	$4,002,632
Broome	4	26	2	0	1	$136,270	$1,282
Cattaraugus	2	52	1	0	0	$8,065	$0
Cayuga	4	26	2	0	1	$136,270	$1,282
Chautauqua	2	52	1	0	0	$8,065	$0
Chemung	4	26	2	0	1	$136,270	$1,282
Chenango	4	26	2	0	1	$136,270	$1,282
Clinton	2	52	1	0	0	$8,065	$0
Columbia	8	13	4	0	2	$193,835	$3,914
Cortland	4	26	2	0	1	$136,270	$1,282
Delaware	4	26	2	0	1	$136,270	$1,282
Dutchess	10	10	5	0	2	$193,835	$3,914
Erie	2	52	1	0	0	$8,065	$0
Essex	2	52	1	0	0	$8,065	$0
Franklin	2	52	1	0	0	$8,065	$0
Fulton	4	26	2	0	1	$136,270	$1,282
Genesee	2	52	1	0	0	$8,065	$0
Greene	8	13	4	0	2	$193,835	$3,914

Historical Record (1960-2012)							
County	**Future Probability %**	**Recurrence Interval**	**No. of Events**	**Fatalities**	**Injuries**	**Property Damage**	**Crop Damage**
Hamilton	4	26	2	0	1	$136,270	$1,282
Herkimer	6	17	3	0	2	$167,520	$1,282
Jefferson	4	26	2	0	1	$136,270	$1,282
Kings	17	6	9	2	2	$5,494,361	$4,002,632
Lewis	4	26	2	0	1	$136,270	$1,282
Livingston	2	52	1	0	0	$8,065	$0
Madison	4	26	2	0	1	$136,270	$1,282
Monroe	2	52	1	0	0	$8,065	$0
Montgomery	6	17	3	0	2	$167,520	$1,282
Nassau	19	5	10	2	2	$7,994,361	$6,502,632
New York	13	7	7	1	2	$124,295	$0
Niagara	2	52	1	0	0	$8,065	$0
Oneida	4	26	2	0	1	$136,270	$1,282
Onondaga	4	26	2	0	1	$136,270	$1,282
Ontario	4	26	2	0	1	$136,270	$1,282
Orange	12	9	6	2	2	$200,245	$3,914
Orleans	2	52	1	0	0	$8,065	$0
Oswego	4	26	2	0	1	$136,270	$1,282
Otsego	4	26	2	0	1	$136,270	$1,282
Putnam	15	7	8	0	2	$5,825,245	$4,003,914
Queens	15	7	8	1	2	$5,494,361	$4,002,632
Rensselaer	8	13	4	0	2	$193,835	$3,914
Richmond	13	7	7	1	2	$119,361	$2,632
Rockland	15	7	8	1	2	$5,697,039	$4,002,632
Saratoga	8	13	4	0	2	$193,835	$3,914
Schenectady	6	17	3	0	2	$167,520	$1,282
Schoharie	4	26	2	0	1	$136,270	$1,282
Schuyler	4	26	2	0	1	$136,270	$1,282
Seneca	4	26	2	0	1	$136,270	$1,282

Historical Record (1960-2012)							
County	**Future Probability %**	**Recurrence Interval**	**No. of Events**	**Fatalities**	**Injuries**	**Property Damage**	**Crop Damage**
St Lawrence	4	26	2	0	1	$136,270	$1,282
Steuben	4	26	2	0	1	$136,270	$1,282
Suffolk	21	5	11	4	2	$7,994,361	$6,502,632
Sullivan	6	17	3	0	1	$136,270	$1,282
Tioga	4	26	2	0	1	$136,270	$1,282
Tompkins	4	26	2	0	1	$136,270	$1,282
Ulster	10	10	5	0	2	$193,835	$3,914
Warren	6	17	3	0	2	$162,585	$3,914
Washington	4	26	2	0	0	$34,380	$2,632
Wayne	4	26	2	0	1	$136,270	$1,282
Westchester	13	7	7	2	2	$5,447,039	$4,002,632
Wyoming	2	52	1	0	0	$8,065	$0
Yates	4	26	2	0	1	$136,270	$1,282

Source: SHELDUS

Figure 3.12g: New York State Storm Events

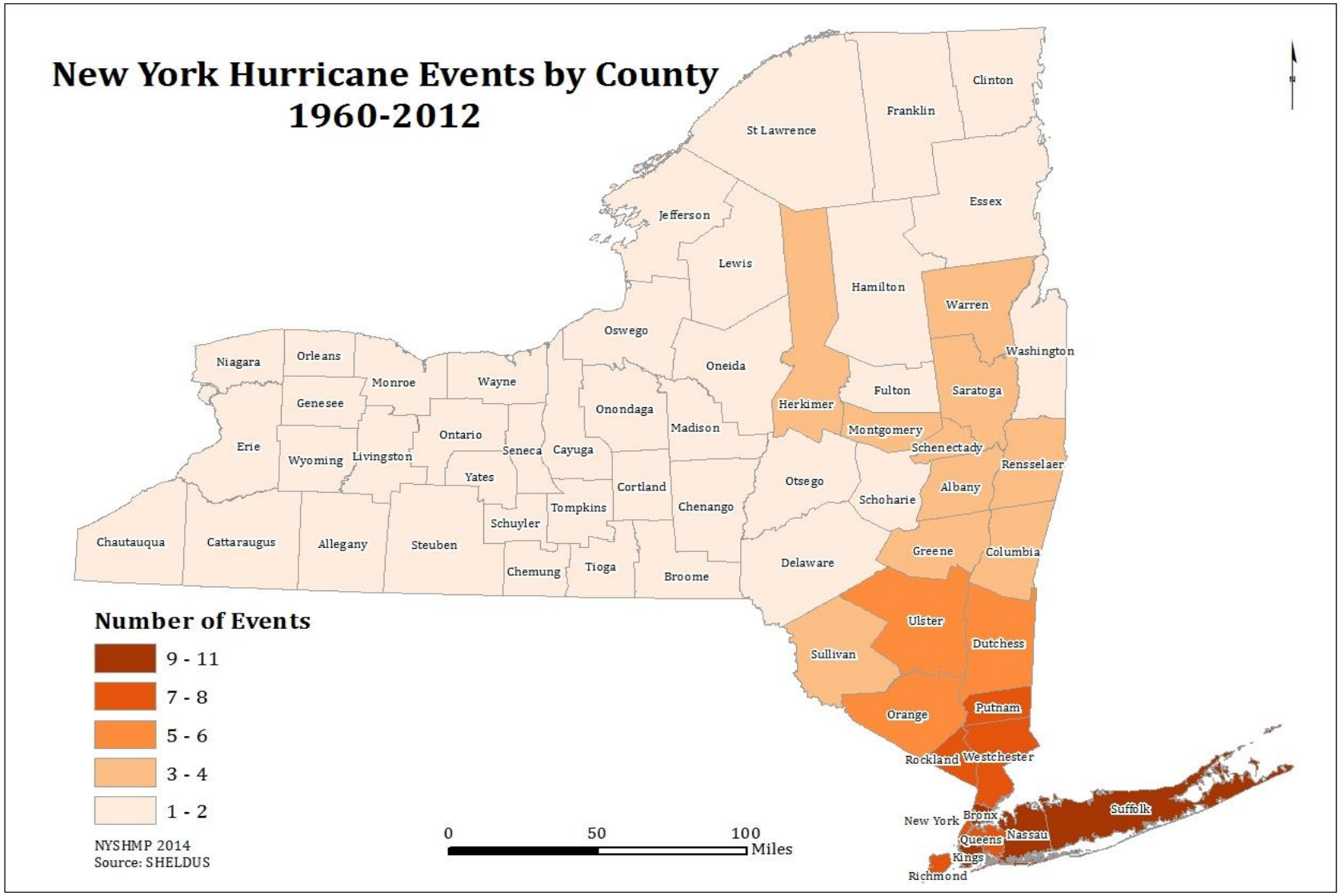


Table 3.12d, the preceding table, list annualized property losses for New York Counties based on data gathered from SHELDUS. Suffolk, Nassau, and Putnam Counties are the top three counties with the highest total property loss. **Figure 3.12g** illustrates New York State's property damage from 1960-2012, which shows a significant amount of losses concentrated in the southern coastal area of the State.

Figure 3.12h: New York Hurricane Property Damage 1960-2012

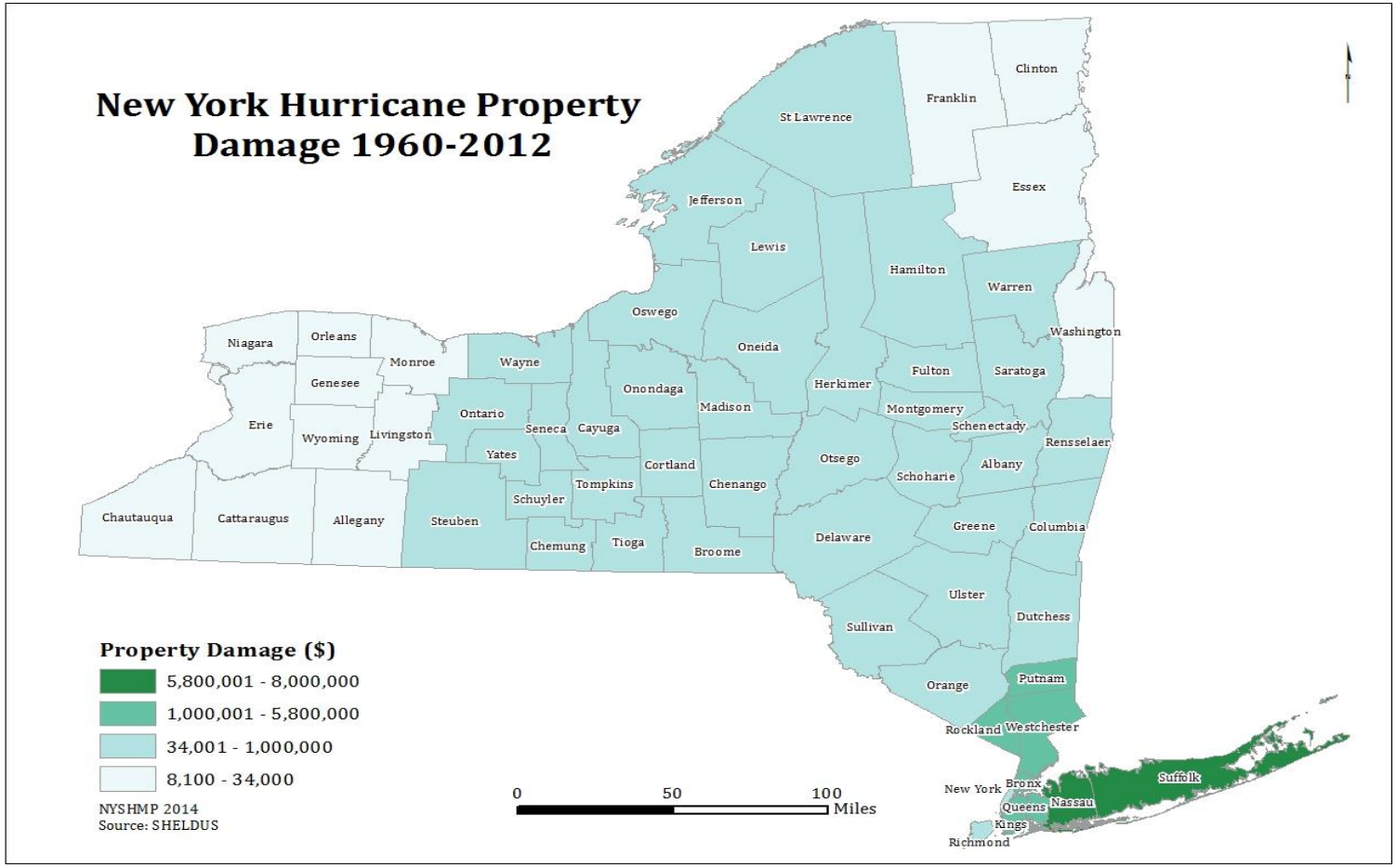
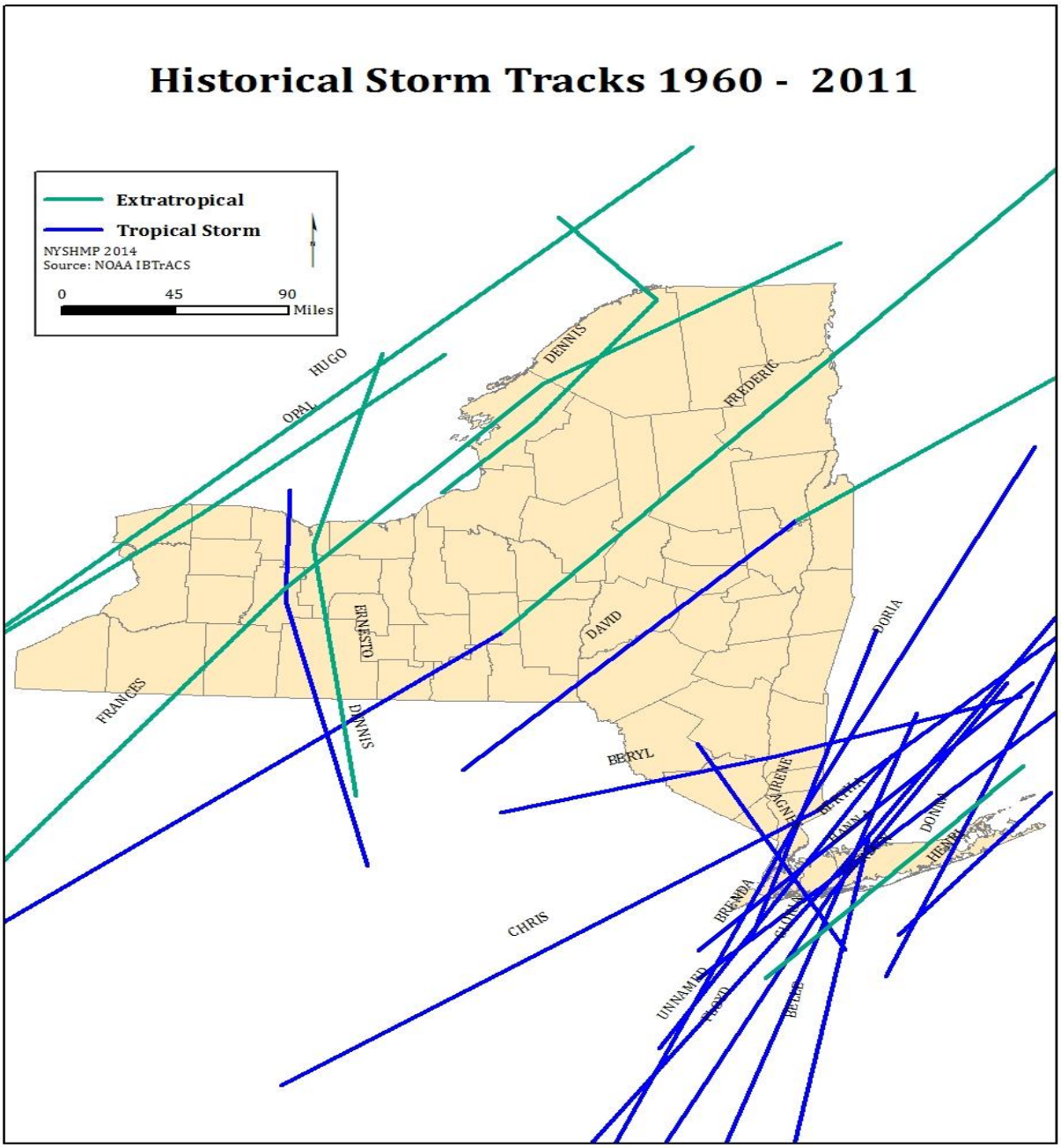


Figure 3.12i show historical storm tracks that have gone through the State of New York for the period of 1960 through 2011, and their associated intensity. Best storm track data goes through the year 2011 from The International Best Track Archive for Climate Stewardship (IBTrACS) from the National Climatic Data Center (NCDC). It is worth noting that by the time some of these systems reached New York, they were downgraded from hurricane status to tropical or extratropical storm, as was the case for Hurricane Irene in 2011.

Figure 3.12i: Historical Storm Tracks



*The 2012 storm tracks including Hurricane Sandy have not been integrated into this figure.

Storm occurrences in the New York State region date back as far as 1821, yet the first named storm to hit the area were not until Hurricane Carol in 1954. Before Hurricane Irene and Hurricane Sandy there were other notable cyclones such as the 1938 storm commonly referred to as, 'The Long Island Express' or 'The Great New England Hurricane of 1938.' The storm claimed lives and injured hundreds of people, costing millions in sustained damage. The 'Long Island Express' was initially expected to hit the state of Florida, yet took an unexpected detour and plowed directly into Long Island making landfall on September 21 with wind speeds reaching 60 to 70 mph.

Many hurricane experts are observing that the Atlantic Ocean and the Gulf of Mexico are yielding more frequent and destructive hurricanes than in previous decades. In a ten year period from 1995 to 2005 a record of 15 hurricanes made their way into the North Atlantic Ocean alone. The data below was provided by the New York City Office of Emergency Management which gives an overview of historical hurricane occurrences impacting the State[1].

Source: NWS, Westhampton, NY; ***1938 Hurricane***

1821 Hurricane

Making landfall on September 3, 1821, it is believed that modern day New York City was directly hit with a single hurricane. With tides rising 13 feet in one hour, the East River met the Hudson River across lower Manhattan reaching as far north as Canal Street. There were minimum deaths attributed to the storm largely due to the sparsely populated neighborhoods of the time.

1938 Hurricane

The most powerful hurricane, a category 3, known to make landfall in the State of New York occurred in 1938. The storms eye crossed over Long Island and then into New England, killing nearly 200 people. It is reported that the storm killed 10 people in New York City and caused millions of dollars in damage. Its floods knocked out electrical power in Manhattan, the Bronx, and subway lines. In Central Park 100 large trees were destroyed. New York City experienced the weaker "left side" of the 1938 hurricane, fortunately, with 75 miles between the eye and Long Island when the storm passed over.

[1]NYC Hazards: NYC Hurricane History.
http://www.nyc.gov/html/oem/html/hazards/storms_hurricanehistory.shtml

Carol – 1954

In 1954, Hurricane Carol the first named storm, made landfall in Eastern Long Island and Southeastern Connecticut. Sustained winds over 100 mph and gusts of 115 to 125 mph, it was the most destructive hurricane to hit the Northeast coast since the Long Island Express in 1938. Fortunately for residents, the storm's track was 40 miles further east resulting in major flooding throughout the City.

Connie & Diane – 1955

Leftover rains from hurricanes Diane and Connie caused significant flooding in the New York City area in August 1955. Although the eye of those two storms did not cross directly over any of the five boroughs, the Rondout Creek and the Walkill River saw record breaking flooding. Diane caused more than 200 deaths in Pennsylvania, New York and New Jersey. Connie dropped more than 12 inches of rain at LaGuardia Airport.

Donna – 1960

On September 12-13 1960, Hurricane Donna created 11-foot storm tides along the New York Harbor causing extensive pier damage.

Agnes – 1972

Tropical Storm Agnes, in June 1972, merged with another storm system in the northeastern region of the United States. Flooding was recorded in areas from Georgia to New York State, causing 122 deaths and more than $6 billion dollars in damage (when adjusted for inflation).

Fire Island, NY, **Hurricane Gloria** September, 1985

Gloria – 1985

According to the US Army Corps of Engineers, 1985's Hurricane Gloria could have been catastrophic if it arrived at high tide and just a little closer to New York City. [2]

Felix– 1995

The third named hurricane of the highly active 1995 hurricane season

[2](Photo courtesy World Wide) Roof of homes ripped off in 115-mph gusts during Hurricane Gloria on Long Island in September 1985. http://www.oocities.org/hurricanene/hurricanegloria.html

was Hurricane Felix. High tides caused erosion problems on several beaches along the New York coast line, most notably to the Westhampton Beach on Long Island.

Bertha– 1996

A weakening Tropical Storm Bertha brought heavy rain to New York City in July 1996.

Edouard- 1996

Hurricane Edouard, the second major hurricane classified in the 1996 Atlantic hurricane season, produced storm surges of 1 to 2 feet causing over wash along southern Long Island as a result of high tides.

Floyd- 1999

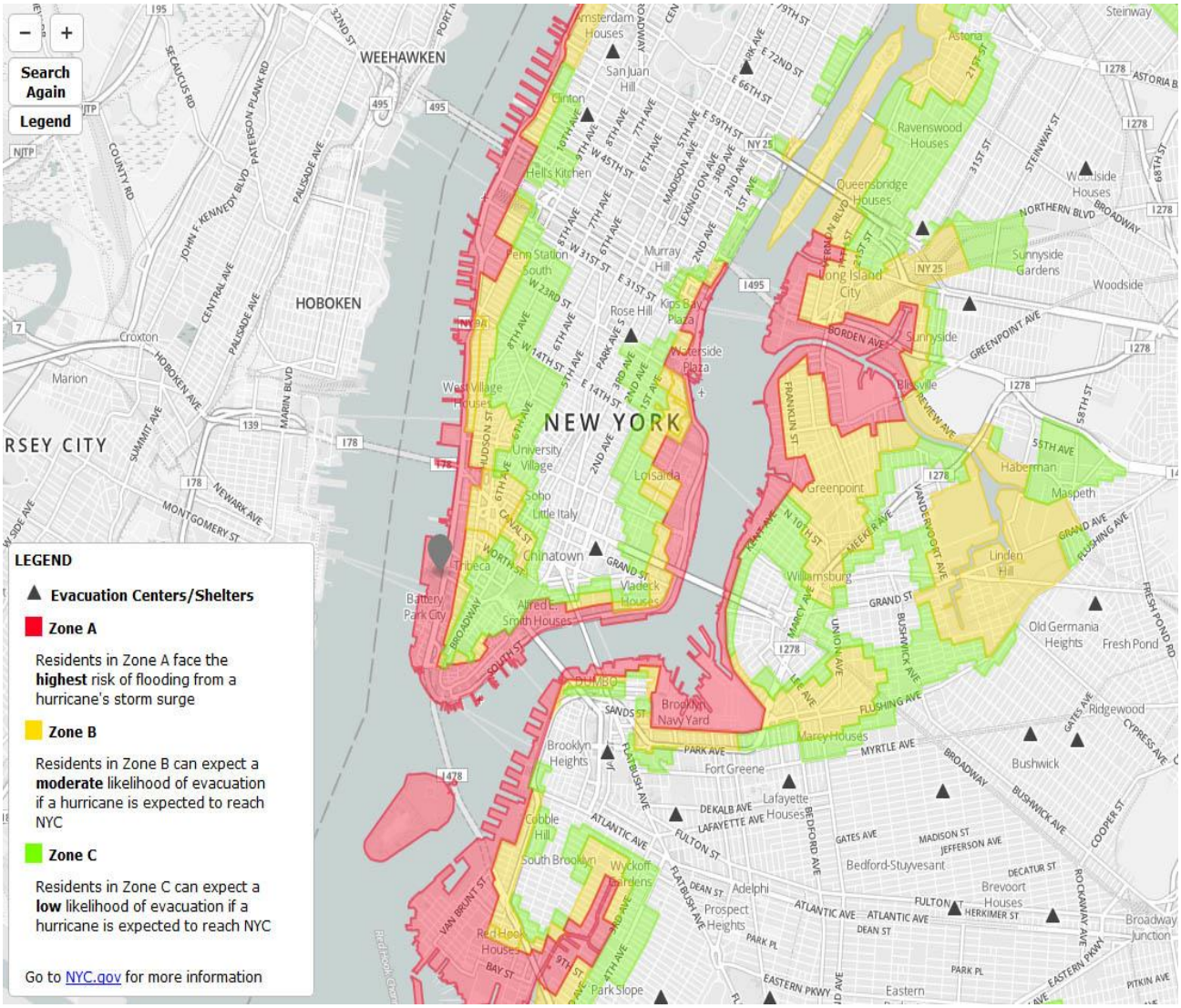
In September 1999, one of the most powerful tropical storms to affect New York City in a decade was Tropical Storm Floyd. The storm system brought sustained 60 mph winds and dumped 10-15 inches of rain on upstate New Jersey and New York State over a 24-hour period. Flash flooding from this tropical storm forced hundreds of people to leave their homes in counties just outside the five boroughs. Floyd caused New York City's schools to close for the first time since 1996 and led the city to open emergency storm shelters as a precautionary measure.

Irene- 2011

August 2011, Hurricane Irene was downgraded to a tropical storm right before making landfall. In preparation the City of New York issued the first-ever mandatory evacuation of coastal areas on August 26, 2011. The evacuation encompassed 375,000 residents living in evacuation Zone A, the entire Rockaway Peninsula, and 34 health care facilities located in evacuation Zone B. The City sheltered 10,000 evacuees at 81 shelters. The rest stayed with family and friends outside the evacuation zones. Irene dropped up to seven inches of rain across the city and brought winds of 65 mph.

Below in **Figure 3.12j** is a map from New York City's hurricane contingency plan that illustrates the three evacuation zones that were in effect during Hurricane Irene, but have since been changed: Zone A, Zone B, Zone C, and the hurricane evacuation centers.

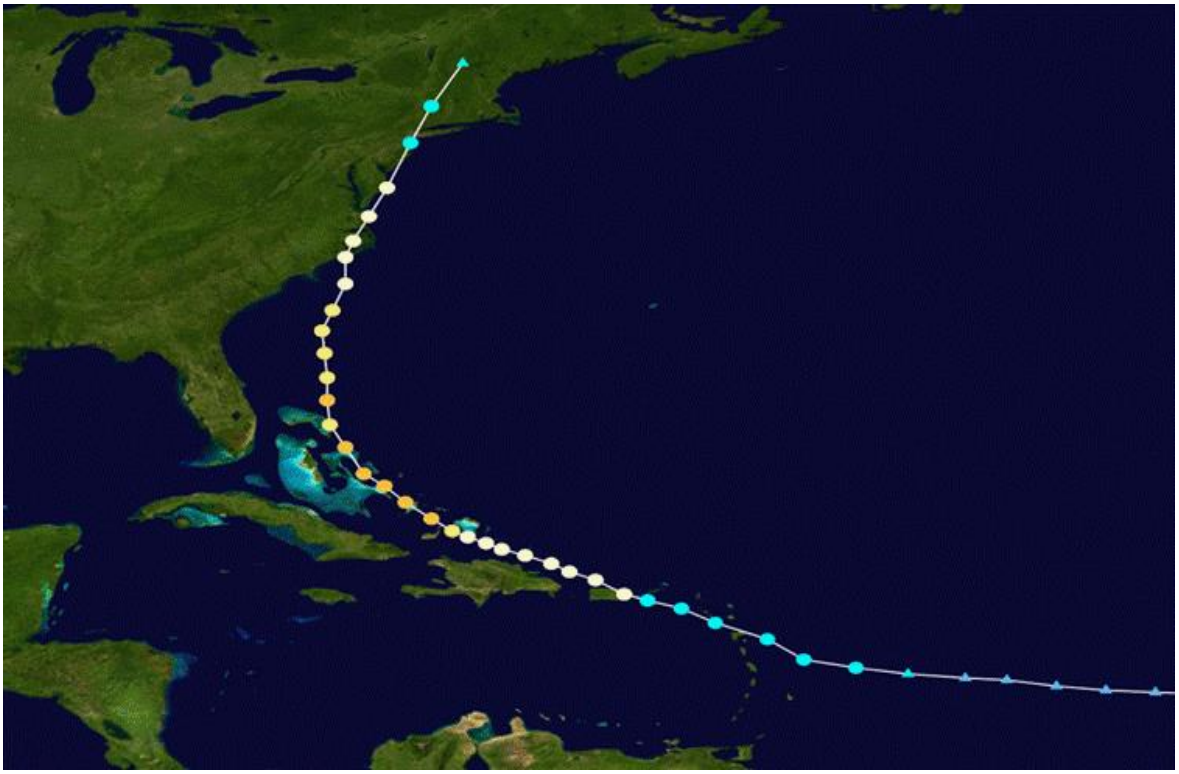
Figure 3.12j: Hurricane Irene Evacuation Zone A, B, and C for New York City



Source: NYC Hurricane

Hurricane Irene was a huge and prevailing Atlantic hurricane leaving extensive flood and wind damages. **Figure 3.12k** displays the storm's path as it plowed along the Caribbean, the United States East Coast, and as far north as Canada. Hurricane Irene cost New York City alone, an estimated $100 million in damages. More than 8,000 residents were approved for $13.6 million in federal disaster assistance to help with the recovery.

Figure 3.12k: Hurricane Irene Storm Track



Source: National Hurricane Center. Track of Hurricane Irene, August 20 through 29, 2011

Sandy- 2012[3]

Hurricane Sandy made landfall on October 29, 2012, impacting the southeastern region of the State of New York with storm surge, high waves, and wind. By the time Hurricane Sandy had reached the State it had downgraded to a post-tropical cyclone. Water levels rose along the entire east coast with the highest storm surges and greatest inundation levels occurring in New Jersey, New York, and Connecticut greatly affecting the New York metropolitan area.

Source: New York State DHSES, Brooklyn, NY- The Seagate Community Hurricane Sandy damage

In Kings Point, along the western

[3] Source: Tropical Cyclone Report Hurricane Sandy (AL182012). 12 February2013

end of Long Island Sound, the highest storm surge recorded in New York was 12.65 ft. above the normal tide level. Other recorded storm surges that reached above normal tide levels ranging anywhere from 9.40 ft. to 9.56ft were found on the northern side of Staten Island (Bergen Point West Reach) and the southern tip of Manhattan (the Battery).

Record storm tides (the combination of the storm and astronomical tide) were measured in the New York City area. At the Battery (where water level records go back to 1920), the storm tide reached 14.06 ft. above Mean Lower Low Water (MLLW), which was 4.36 ft. higher than the previous record set in December 1992. This storm tide was also 4.55 ft. higher than what occurred when Tropical Storm Irene affected the region in 2011. The storm tides of 14.58 ft. above MLLW at Bergen Point West Reach and 14.31 ft. above MLLW at Kings Point were 4.37 ft. and 2.00 ft. higher, respectively, than their previous highest levels set in Irene.

The following inundations, expressed above ground level, were prevalent along the coast due to the storm tide:

- Staten Island and Manhattan 4-9 ft.
- Brooklyn and Queens 3-6 ft.
- The Bronx and Westchester County 2-4ft.
- Long Island (Nassau and Suffolk Counties) 3-6 ft.
- Hudson River Valley 3-5 ft.

Surveyed high-water marks from USGS indicate that the highest water levels in New York occurred on Staten Island. The highest direct measurement of inundation was 7.9 ft. above ground level, in the Oakwood neighborhood of Staten Island. A direct measurement of 4.7 ft. above ground level was made at One World Trade Center in the Financial District in Lower Manhattan. Higher inundation values likely occurred in other parts of Manhattan that are at lower elevations.

In preparation the City issued the second-ever mandatory evacuation of coastal areas on October 28, 2012. The evacuation encompassed residents living in Evacuation Zone A, which was updated to include:

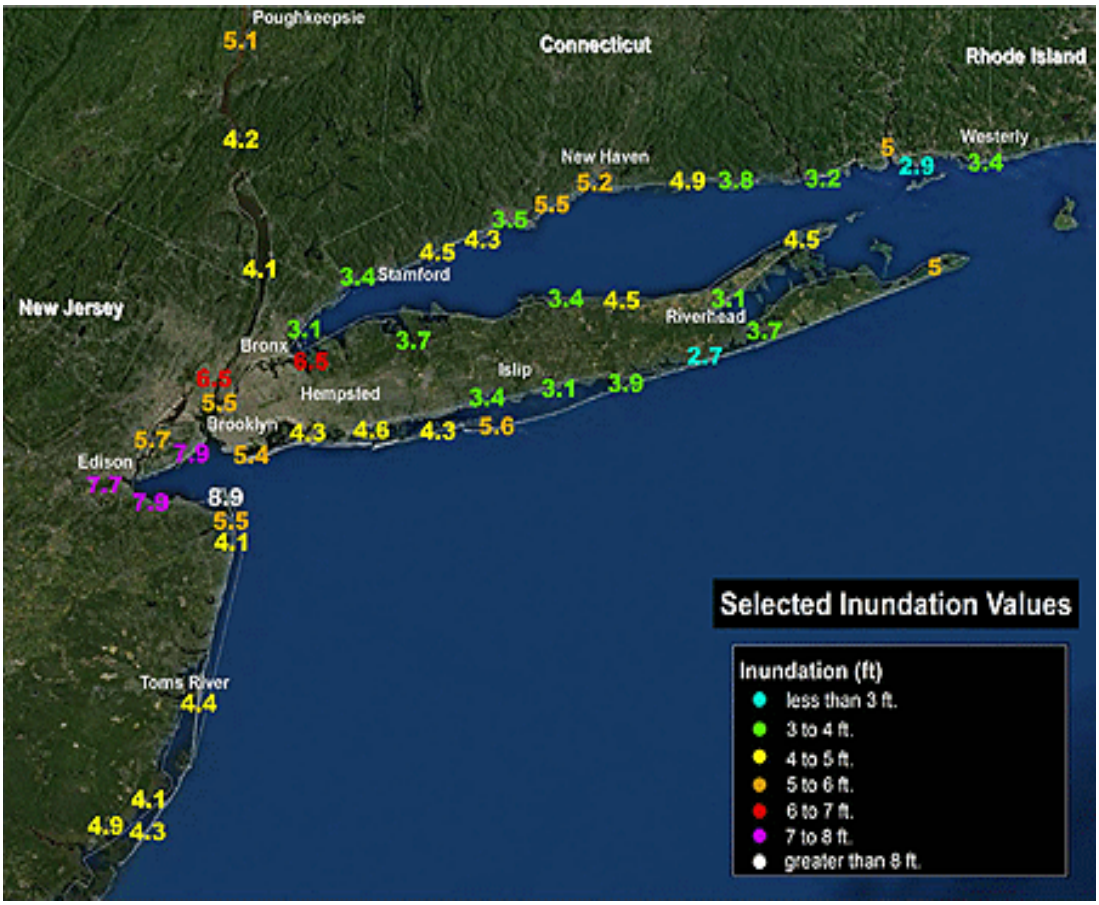
- Coney Island
- Manhattan Beach
- Red Hook and areas along the East River in Brooklyn
- All of the Rockaways
- Hamilton Beach & Broad Channel in Queens
- Nearly all coastal areas of Staten Island
- City Island
- Small areas of Throgs Neck & South Bronx
- Battery Park City
- The West Side waterfront and
- Lower East Side
- East Village in Manhattan.

Destruction amongst many communities particularly of those found near the southern shores was widespread after Hurricane Sandy made landfall, effecting residences,

businesses, vehicles, and other property. The fishing industry suffered severe losses with damage caused to their docks, marinas, dining, and fishing plants. Sandy destroyed more than 65,000 boats and about $650 million in marine-related damages to New York, New Jersey, and Connecticut.

Below **Figure 3.12l** presents the storm inundation values from Hurricane sandy. The inundation levels ranged between four to five feet; however Nassau County reached levels that exceeded six feet.

Figure 3.12l: Hurricane Sandy Inundation Levels

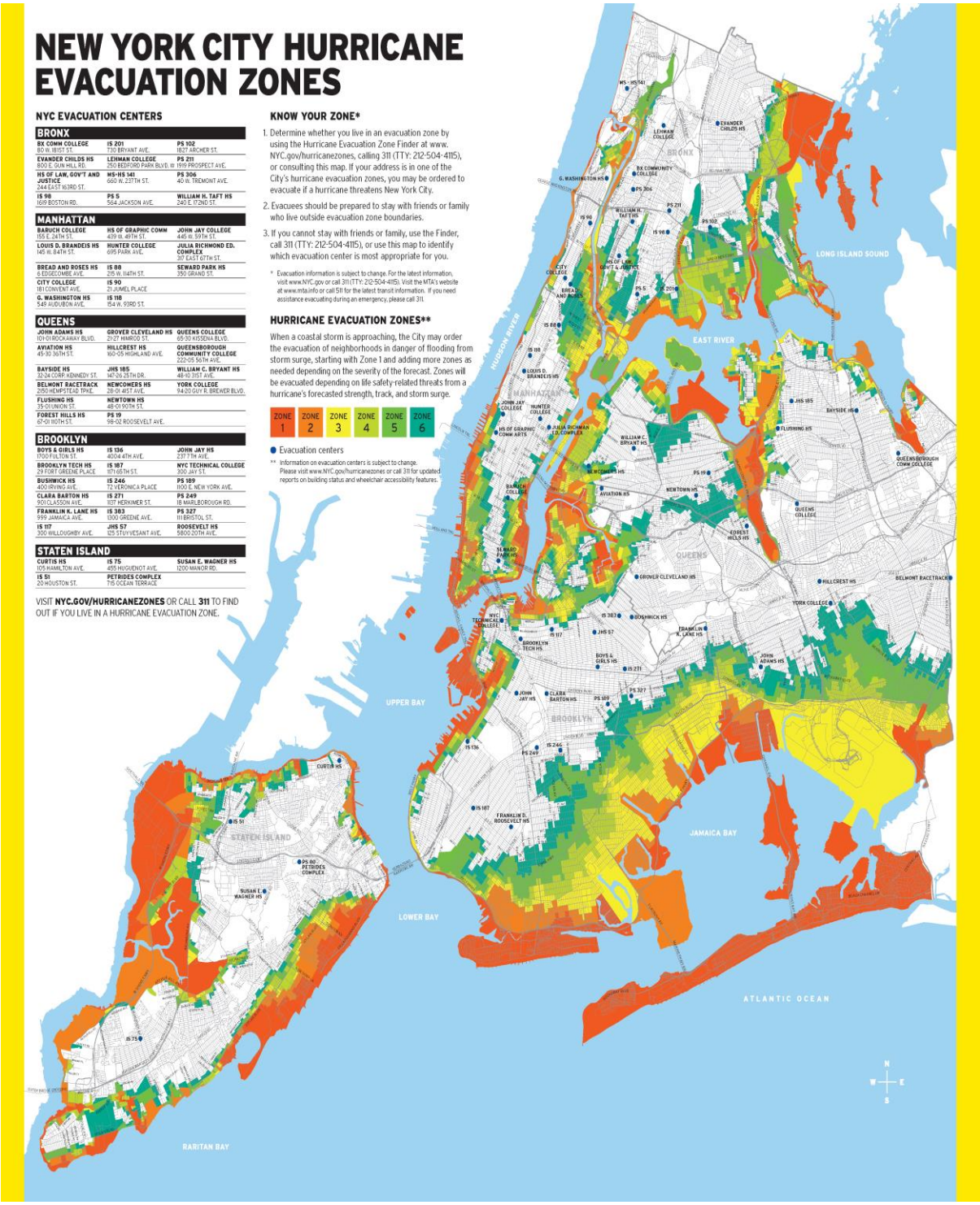


Source: NHC Tropical Cyclone Report—Hurricane Sandy

Since Hurricane Irene and Hurricane Sandy, evacuation zones for the City of New York have been updated. The final updates were made in June of 2013 and announced by the City of New York which included evacuation zones for 600,000 more residents who were not covered in previous zoning systems. According to the City's contingency plan there are now six evacuation zones found in this coastal region. The old alphabetical zoning technique has been replaced with a new numerical system, and will now include emergency evacuation zones for 37 percent of New Yorkers.

Found below in **Figure 3.12m** is a map that displays the new zoning areas and evacuation centers for New York City.

Figure 3.12m: New York City Hurricane Evacuation Zones



Source: Metro, September 2013

Probability of Future Hurricane (Tropical/ Coastal Storms) Events

Using the historical occurrence, or more specific documentation if available, a *future probability and average annual losses* analysis was determined for hurricane events. The number of years recorded was divided by the number of occurrences, resulting in a simple past-determined recurrence interval. If the hazard lacked a definitive historical record, the probability was assessed qualitatively based on county history or other supporting data.

From the historical records found in **Table 3.12d**, the following can be expected on average in a typical year in New York State:

- 3.23 hurricane events
- Nearly $1.5 million in property and crop damage
- 1 Injuries
- .24 Fatalities

Based on hurricane probability models derived from historical frequency, Suffolk County has the highest chance of being impacted by a hurricane during any given season. The following table illustrates the top three counties with the highest probability for future occurrences. From previous occurrences of hurricane related hazard events (described in **Table 3.12.e**), the counties with the highest probability of future occurrences, based on recurrence interval, are Suffolk (21%), Nassau (19%), and Bronx (17%).

Table 3.12e: Percentage Probability of Future Occurrences, by County

County	Future Probability (%)
Suffolk	21
Nassau	19
Bronx	17

Source: SHELDUS *Future Probability equals the number of events divided by the number of years of record [52], expressed as a percentage.

Since 1970, records show an escalation in the intensity of tropical cyclone activity in the North Atlantic, which scientist suggests correlates to the increase in sea surface temperatures. This is also true for other regions where increased intensity in tropical cyclone activity is now greater. Intensified storm surges have caused more threats to coastal areas due to increased sea levels producing more substantial storm damage. The change in climatic temperatures has also been associated with heavy rains extending hundreds of miles inland further increasing flood risk. **Section 3.4- Climate Change,** provides more in depth information on the effects that climate change has on hurricanes and other identified hazards within the 2014 update.

3.12.2 Assessing Hurricane (Tropical/ Coastal Storms) Vulnerability and Estimating Potential Losses by Jurisdiction

Although the State experiences some economic impacts from hurricane and tropical storms, the greatest vulnerability is found in hazard areas relating to flood, winter weather, and wind events. Throughout the State of New York people, property, and crops are susceptible to storm related damages, loss of lives, as well as injuries.

From 1960 to 2012, based on historical data, the property damage for New York State is estimated at $55,620,500 and an additional $37,100,000 in crop damages. According to SHELDUS, the total loss of life was 15 for the State as a result of hurricane events, with an additional 75 persons injured. Suffolk, Orange, and Nassau Counties, were the top three areas affected by fatalities within New York State.

Table 3.12f provides the estimated population for individual counties that are most susceptible to hurricane and storm damage based on historical frequency. These estimates were extracted from the most recent data available on SHELDUS (**Table 3.12d)**.

Table 3.12f: Estimated Population for Counties Most Susceptible to Damage

Estimated Population For Counties Most Susceptible to Damage				
County	**2010**	**2011**	**2012**	**Number of Events**
Suffolk	1,493,350	1,498,816	1,499,273	11
Nassau	1,339,532	1,344,436	1,349,233	10
Bronx	1,385,108	1,392,002	1,408,473	9
Total	**4,220,000**	**4,237,265**	**4,258,991**	**30**

Sources: SHELDUS, American Fact Finder

Local Plan Integration/ Risk Assessments

Since August of 2013, 56 FEMA-approved local hazard mitigation plans (LHMP) have been reviewed for the 2014 Update. The State's planning team had the opportunity to review local county risk assessments to help the State better understand its vulnerability in terms of the jurisdictions most threatened by classified hazards. In its analysis, the State of New York reviewed the processes of local governments and how their hazards were ranked based on their jurisdictions and the potential losses (i.e., people, buildings, and dollar values) associated with the hazards of greatest concern.

Where data was available, the State extracted the ranking impact information from the LHMP hazard analysis. This ranking feature is based on a combination of probability, severity, and extent of the hazard and was determined to be the best measure of overall risk in the plans. This ranking was either numeric or described in terms of high, moderately high, moderate, or low. In cases where this information was not available,

ranking values were not determined yet considered if identified in the individual county local plans.

For the sake of the 2014 Update, a proper analysis and summary of the data was required. During the review of the local plan risk assessments, all rankings used were based on the New York HAZNY ranking system, and measured on a scale rating from 44 (low) to 400 (high). This analysis revealed that selected county-level plans did include manmade hazards in their analysis, but the State hazard mitigation plan's 2014 Update focused solely on natural hazards.

The local risk assessment summary allowed for an analysis of which hazards are of high concern to particular counties. **Table 3.2a** in **Section 3.2** lists all the hazards and the number of counties that ranked them at each of the scale levels: High, Moderately High, Moderate, Moderately Low and Low. As indicated previously, four of the local plans ranked hurricane events as a high hazard. In addition, eight counties ranked it as moderately high, three moderate, twelve moderately low, and two counties ranked it as a low hazard. **Table 3.11g** displays the highest ranked county hazard impacts and the high and / or moderately high ranked risk assessment scores for Hurricane.

Table 3.12g: Summary of Hurricane Hazard Impacts and Rankings by County

Local County Hurricane Hazard Impacts		
Highest Occurrences	**Highest Fatalities**	**Highest Property Damage**
Suffolk	Suffolk	Suffolk
Nassau	Orange	Nassau
Bronx	Nassau	Putnam
Kings	Kings	Rockland
Putnam	Westchester	Bronx

Source: SHELDUS

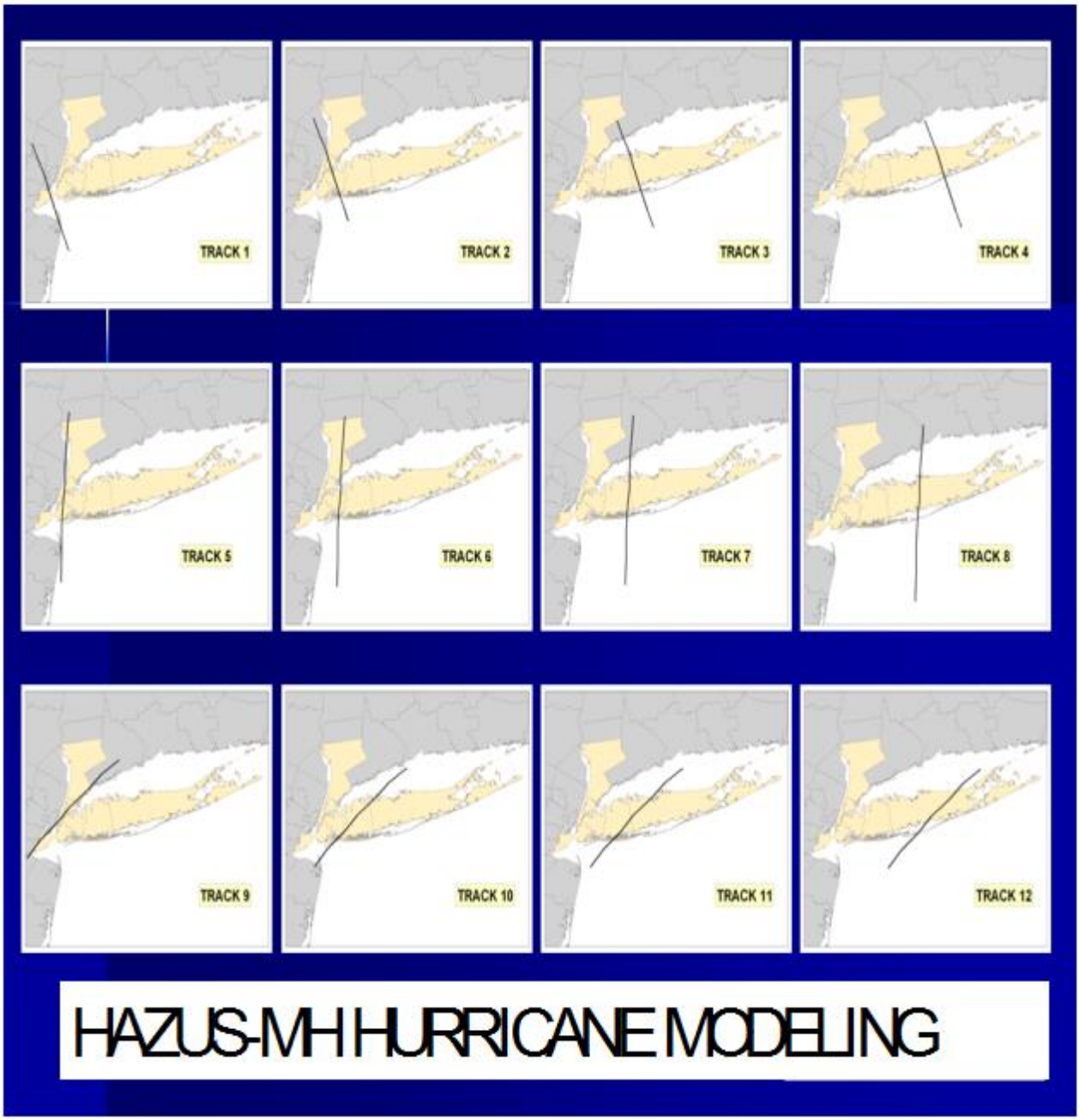
Local County Hurricane Hazard Rankings	
High	**Moderately High**
Fulton, Montgomery, Saratoga, and Suffolk	Delaware, Nassau, Niagara, Orleans, Rensselaer, Schoharie, Ulster, and Westchester

Source: LHMP

Hazus-MH 2.1- MH2 Analysis

Figure 3.12n demonstrates using Hazus-MH 2.1 the potential Hurricane tracks/paths that could pass through New York State.

Figure 3.12n: Hurricane Storm Modeling Tracks

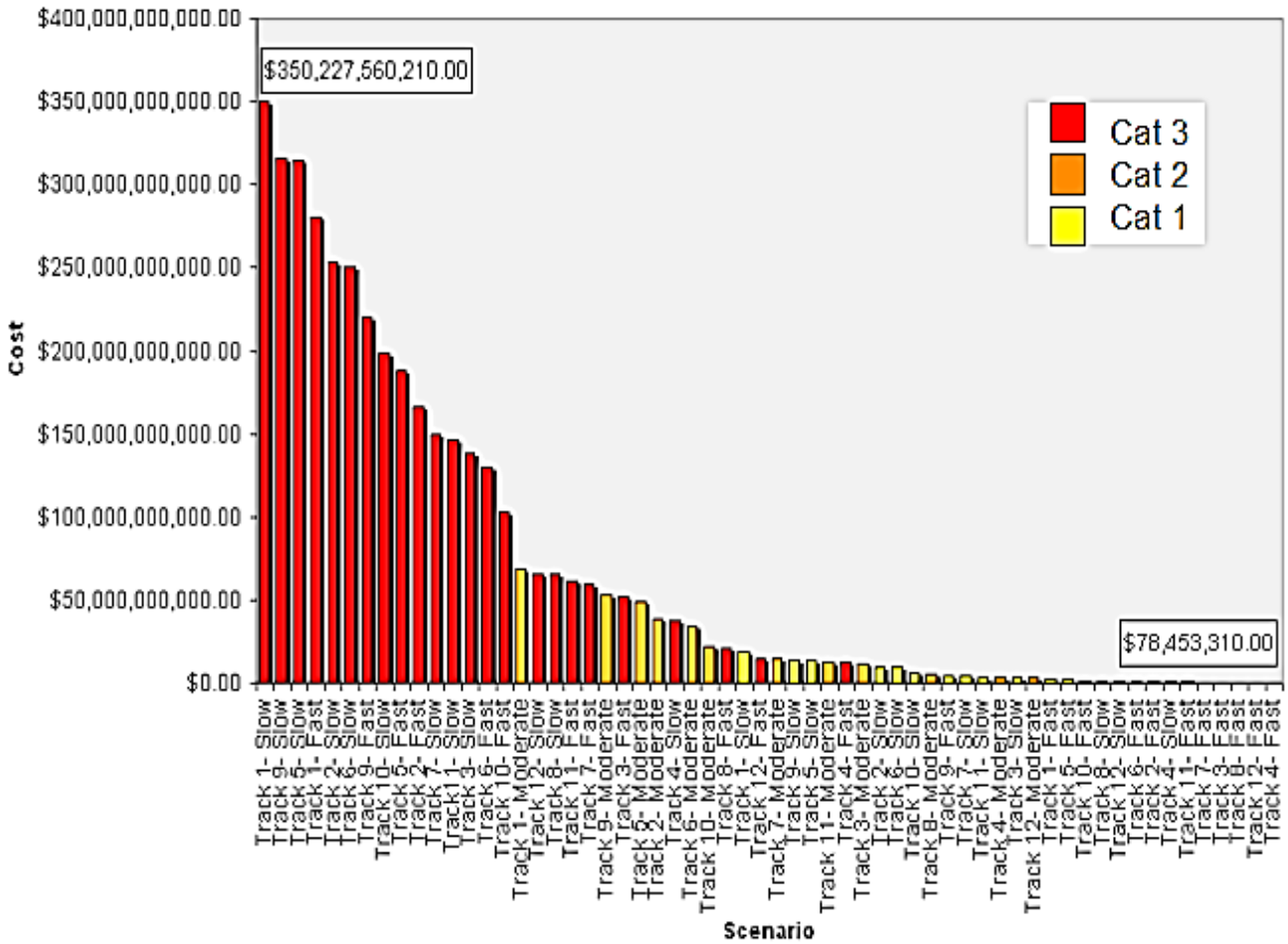


Source: Hazus-MH 2.1

The following **Figures 3.12o** through **3.12r** are indicative of the results of a particular category hurricane relative to a specific hurricane track and speed. These Figures were created using a cumulative numbers generated from Hazus-MH 2.1 runs. Each Figure compliments **Figure 3.12n (Storm Track Models)**. (NOTE: These estimates are based on wind damage.)

Figure 3.12o portrays the total economic losses based on various hurricane tracks, category levels and speeds (slow, moderate, or fast). For example, if a Track 1 (refer to **Figure 3.12n**), Category 3 hurricane traveling at a slow speed would result in an estimated 350 billion dollars in economic losses for the affected coastal county areas. This loss estimate does not take into account areas outside the coastal counties and is for wind damage only. This test run accounts for the coastal Counties of Nassau, Suffolk, Westchester, and those comprising New York City.

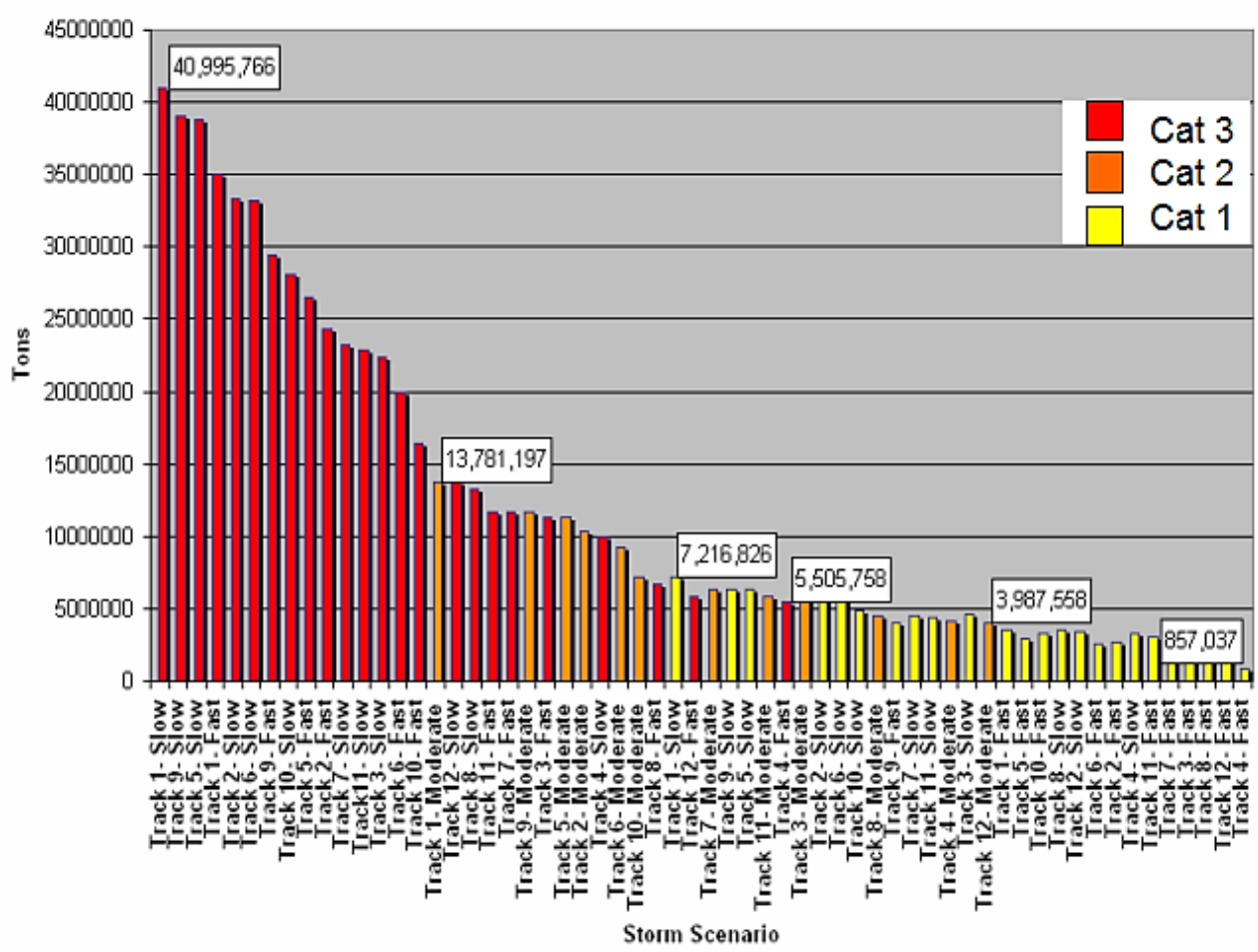
Figure 3.12o: Indicating Total Economic Loss per Category, Track, and Speed



Source: Hazus-MH 2.1

Figure 3.12p portrays the total debris in tons that would have to be addressed after a given hurricane event. For this graph debris is broken up into 3 categories: 1) Brick/Wood, 2) Reinforced Concrete/Steel, and 3) Trees. Similar to the pervious example, a track 1 Category 3 hurricane moving slowly would produce an estimated 41 million tons in one storm. Because debris removal plans are pertinent to recovery efforts, many local jurisdictions have emergency debris management plans in place and the State created the Traffic Infrastructure Group (TIG) to bring together those agencies like the State Police, DOT, Thruway Authority and State Parks with resources and expertise in removing vegetative debris from roadways. As well, NYSOEM and FEMA offer Debris Removal Workshops for Local Governments.

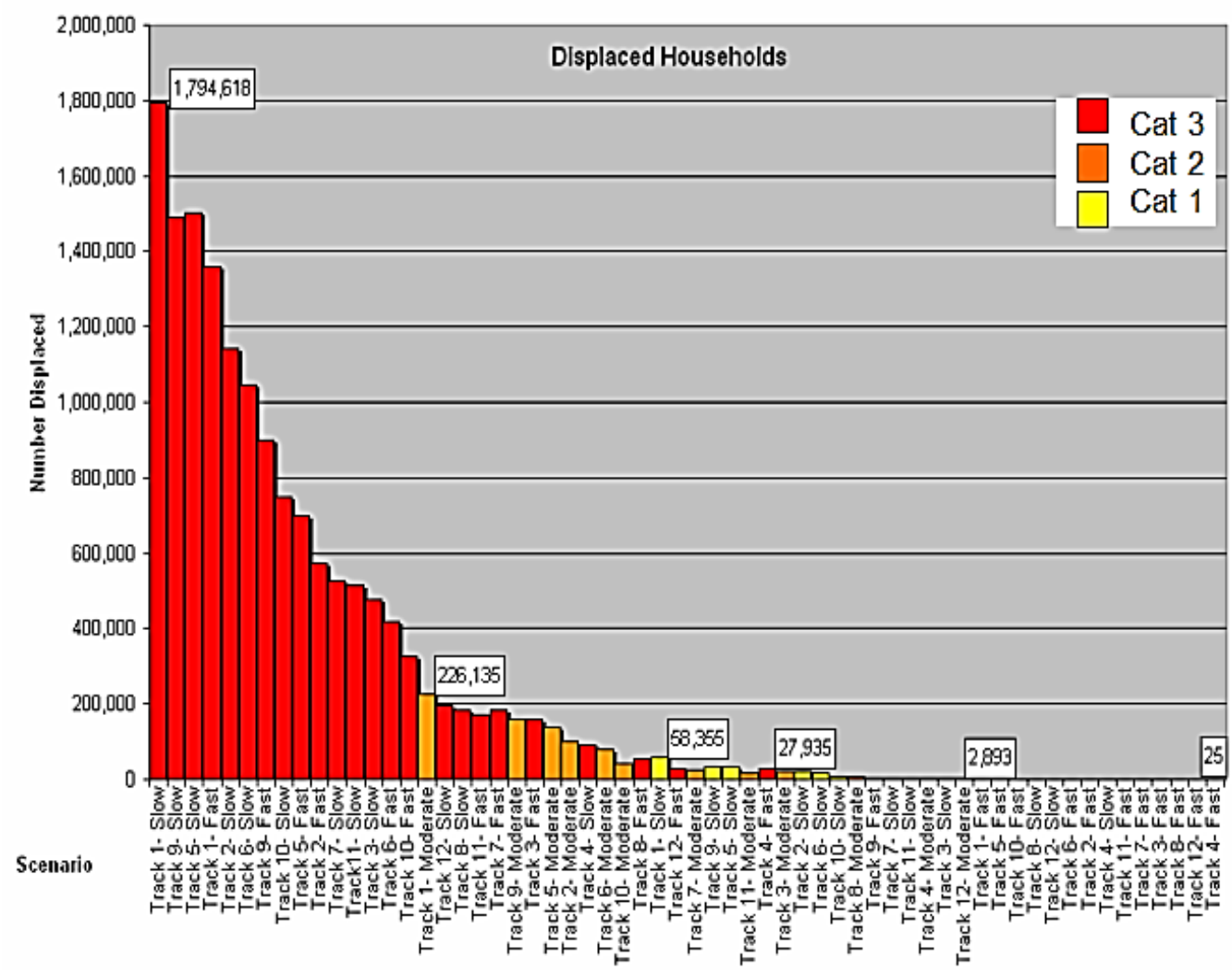
Figure 3.12p: Indicating Total Debris in Tons per Category, Track, and Speed



Source: Hazus-MH 2.1

Figure 3.12q illustrates the number of displaced households relative to a particular hurricane event. Per the previous examples, a track 1 Category 3 hurricane moving slowly could affect or displace an estimated 1.8 million households.

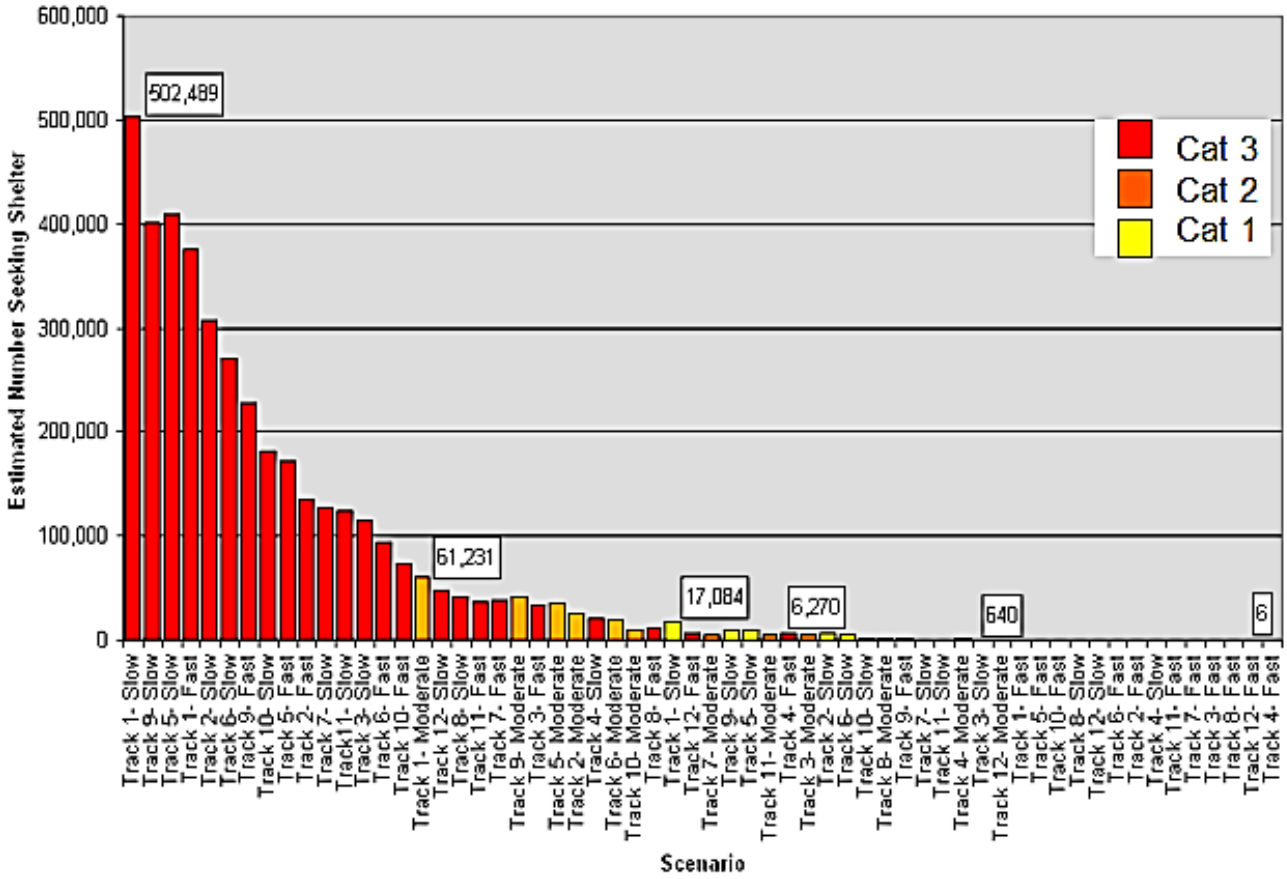
Figure 3.12q: Displaced Households



Source: Hazus-MH 2.1

Figure 3.12r portrays the short-term shelter needs for the affected areas. Again, to reference the previous example, a track 1 Category 3 slow-moving hurricane could result in the need for immediate short-term sheltering for roughly 500,000 people.

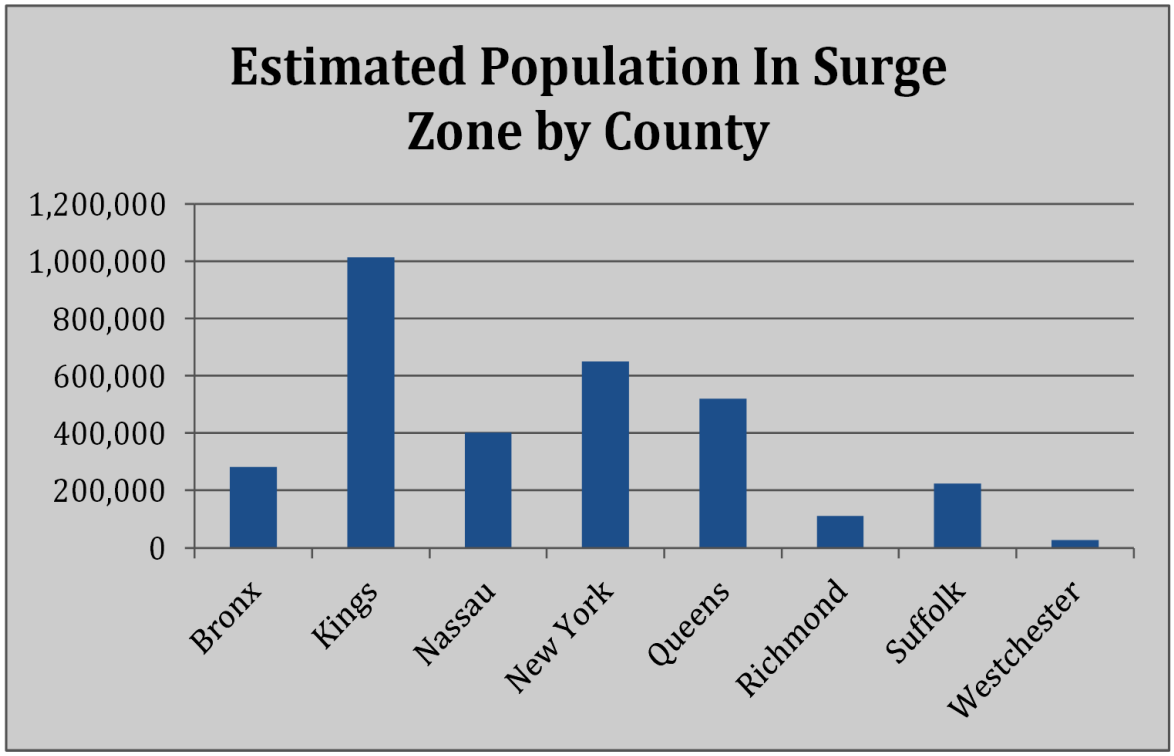
Figure 3.12r: Total Short-Term Shelter Needs per Category, Track, and Speed



Source: Hazus-MH 2.1

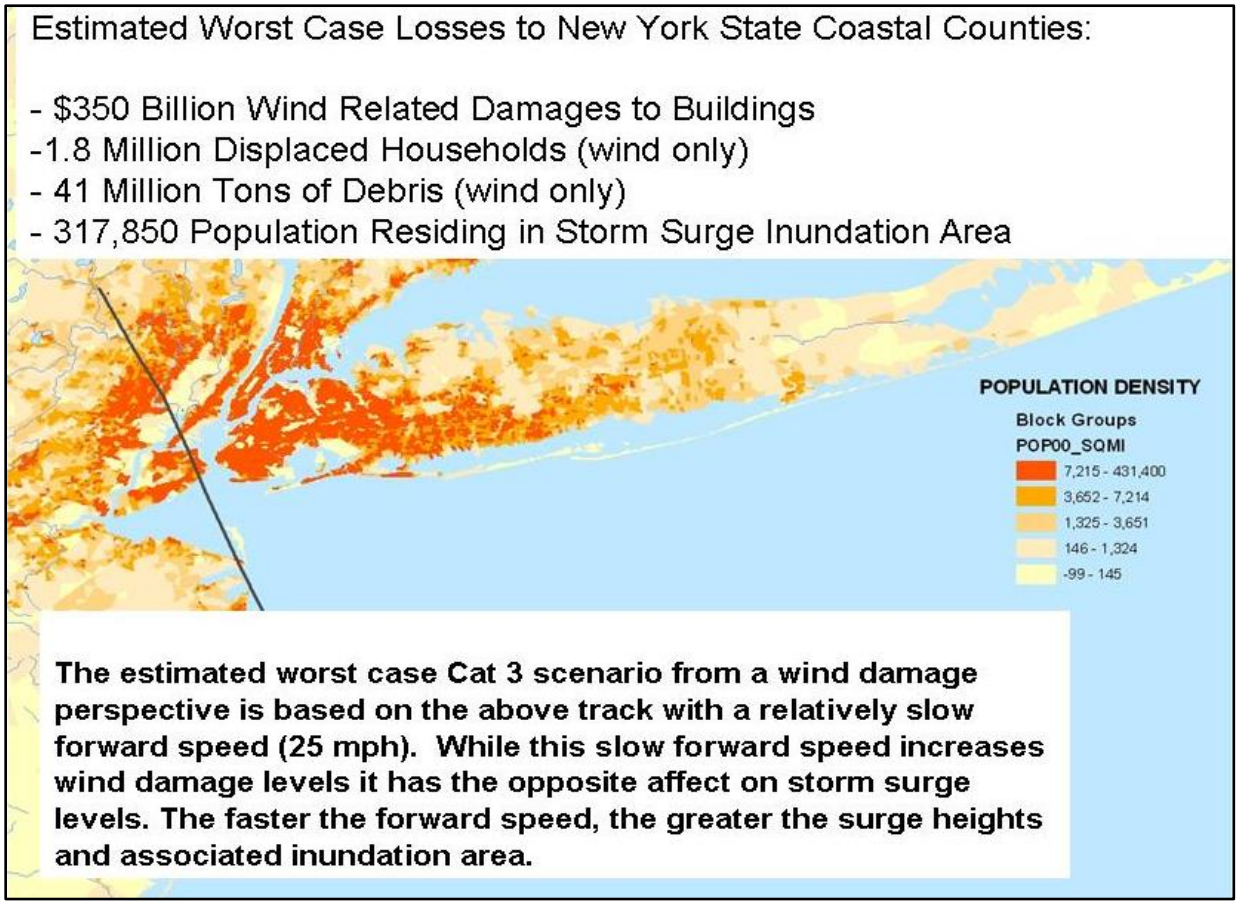
Figure 3.12s portrays the population within in a track 1 storm surge inundation area broken up by jurisdiction. The total estimated population is 317,850 people spread throughout 9 coastal jurisdictions.

Figure 3.12s: Population in Storm Surge Zone by County



Source: Hazus-MH 2.1

Figure 3.12t: Estimated Worst Case Losses to New York State Coastal Counties



Source: Hazus-MH 2.1

A combination of many aspects of predictive measures can be used in the future to determine the multiple needs of affected people during the course of a storm event. Through continuous research and data collection, New York State can prepare in advance to dramatically reduce the risk to its residents.

Table 3.12h provides the breakdown of annualized losses, extracted from the Hazus-MH 2.1 probabilistic hurricane run. The top counties with the highest total annualized losses include: New York, Kings, Queens, Nassau, and Suffolk.

Table 3.12h: Hurricane Annualized Losses by County

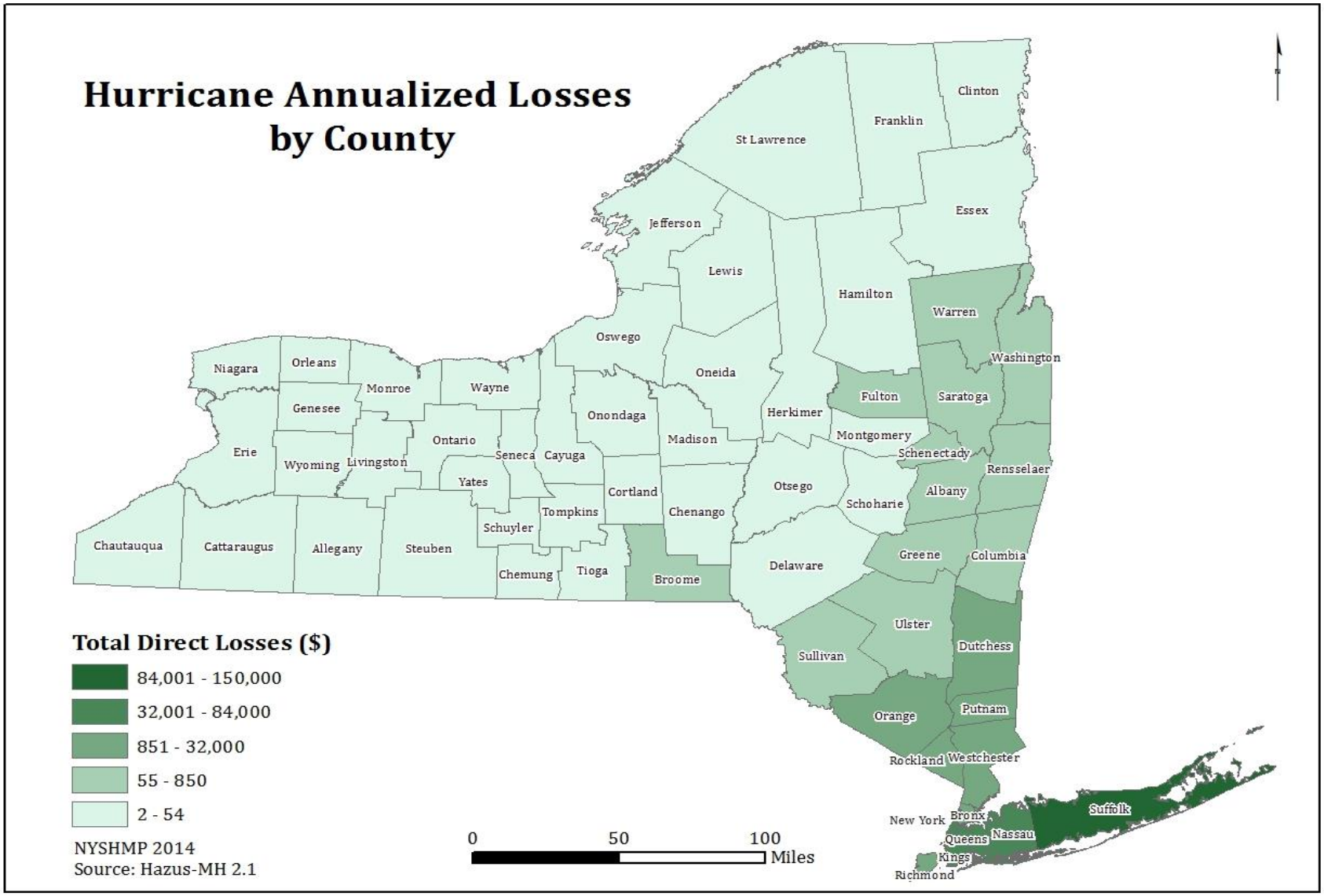
County	Structural Damage	Contents Damage	Inventory Loss	Relocation Loss	Capital Related Loss	Wages Loss	Rental Income Loss	Total Loss
Albany	$476	$144	$1	$22	$2	$6	$14	$666
Allegany	$5	$2	$0	$0	$0	$0	$0	$7
Bronx	$22,644	$4,710	$32	$1,391	$160	$186	$1,328	$30,451
Broome	$52	$21	$0	$1	$0	$0	$1	$76
Cattaraugus	$6	$1	$0	$0	$0	$0	$0	$8
Cayuga	$7	$2	$0	$0	$0	$0	$0	$10
Chautauqua	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Chemung	$13	$5	$0	$0	$0	$0	$0	$18
Chenango	$13	$7	$0	$0	$0	$0	$0	$21
Clinton	$18	$4	$0	$1	$0	$0	$0	$24
Columbia	$263	$84	$1	$17	$1	$3	$7	$376
Cortland	$5	$1	$0	$0	$0	$0	$0	$7
Delaware	$28	$5	$0	$2	$0	$0	$1	$36
Dutchess	$1,565	$345	$3	$107	$10	$16	$46	$2,092
Erie	$37	$8	$0	$1	$0	$0	$1	$47
Essex	$24	$13	$0	$1	$0	$0	$0	$38
Franklin	$6	$3	$0	$0	$0	$0	$0	$9
Fulton	$39	$20	$0	$1	$0	$0	$1	$61
Genesee	$3	$1	$0	$0	$0	$0	$0	$5
Greene	$102	$42	$0	$4	$0	$1	$2	$151
Hamilton	$5	$3	$0	$0	$0	$0	$0	$8
Herkimer	$14	$5	$0	$1	$0	$0	$0	$20
Jefferson	$3	$1	$0	$0	$0	$0	$0	$4
Kings	$49,019	$10,807	$116	$3,028	$381	$517	$2,871	$66,738
Lewis	$2	$1	$0	$0	$0	$0	$0	$3
Livingston	$5	$2	$0	$0	$0	$0	$0	$7
Madison	$8	$3	$0	$0	$0	$0	$0	$11
Monroe	$39	$13	$0	$1	$0	$0	$1	$54
Montgomery	$32	$10	$0	$2	$0	$0	$1	$46
Nassau	$51,162	$15,509	$125	$3,909	$614	$781	$1,646	$73,745
New York	$31,746	$5,037	$32	$1,744	$349	$359	$1,810	$41,076
Niagara	$6	$1	$0	$0	$0	$0	$0	$8
Oneida	$30	$9	$0	$1	$0	$0	$1	$40
Onondaga	$36	$9	$0	$1	$0	$0	$1	$46

County	Structural Damage	Contents Damage	Inventory Loss	Relocation Loss	Capital Related Loss	Wages Loss	Rental Income Loss	Total Loss
Ontario	$8	$2	$0	$0	$0	$0	$0	$11
Orange	$1,654	$621	$3	$81	$9	$15	$39	$2,422
Orleans	$2	$0	$0	$0	$0	$0	$0	$2
Oswego	$7	$4	$0	$0	$0	$0	$0	$11
Otsego	$27	$11	$0	$1	$0	$0	$0	$40
Putnam	$1,010	$231	$2	$66	$5	$9	$25	$1,348
Queens	$48,823	$11,494	$86	$3,198	$319	$414	$2,514	$66,848
Rensselaer	$320	$103	$0	$17	$1	$3	$9	$454
Richmond	$7,810	$1,865	$11	$545	$60	$78	$330	$10,699
Rockland	$2,943	$1,065	$6	$164	$21	$32	$74	$4,305
Saint Lawrence	$3	$1	$0	$0	$0	$0	$0	$4
Saratoga	$289	$143	$0	$9	$1	$1	$5	$448
Schenectady	$202	$82	$0	$8	$1	$1	$5	$298
Schoharie	$33	$14	$0	$1	$0	$0	$1	$50
Schuyler	$3	$1	$0	$0	$0	$0	$0	$4
Seneca	$3	$1	$0	$0	$0	$0	$0	$5
Steuben	$12	$5	$0	$0	$0	$0	$0	$18
Suffolk	$101,475	$37,701	$378	$8,210	$1,136	$1,463	$3,176	$153,539
Sullivan	$169	$81	$0	$6	$0	$1	$3	$260
Tioga	$11	$4	$0	$0	$0	$0	$0	$16
Tompkins	$11	$4	$0	$0	$0	$0	$0	$16
Ulster	$571	$234	$1	$25	$2	$4	$13	$850
Warren	$75	$39	$0	$2	$0	$0	$1	$117
Washington	$92	$36	$0	$5	$0	$1	$2	$137
Wayne	$5	$2	$0	$0	$0	$0	$0	$8
Westchester	$15,356	$5,150	$25	$917	$137	$180	$584	$22,350
Wyoming	$3	$1	$0	$0	$0	$0	$0	$4
Yates	$3	$1	$0	$0	$0	$0	$0	$4

Source: Hazus-MH 2.1, Values are in thousands of dollars

Figure 3.12u shows total annualized losses by county for New York from a Hazus-MH 2.1®*MH* probabilistic hurricane hazard run. The annualized loss total is the sum of direct building losses from capital stock and income losses. Suffolk, Nassau, New York, Kings, and Queens Counties make up the top five counties with the highest annualized losses.

Figure 3.12u: Hurricane Annualized Losses by County



Hazus-MH 2.1 was used to provide hurricane building and transportation loss estimates for the State of New York. **Table 3.12i** provides building inventory value for the counties of New York. The loss estimate results use this default data to generate loss estimates; values are in millions of dollars. **Table 3.12j** list direct economic building losses for a probabilistic 100- year hurricane event; values are represented in thousands of dollars.

Table 3.12i Building Inventory Value (millions of dollars)

County	Residential	Non Residential	Total
Albany	$18,615	$9,473	$28,088
Allegany	$2,508	$747	$3,255
Bronx	$66,088	$16,837	$82,925
Broome	$10,978	$4,475	$15,453
Cattaraugus	$4,580	$1,711	$6,292
Cayuga	$4,286	$1,386	$5,672
Chautauqua	$8,034	$3,218	$11,252
Chemung	$4,352	$1,918	$6,271
Chenango	$2,403	$1,001	$3,404
Clinton	$3,862	$1,555	$5,417
Columbia	$4,269	$1,254	$5,523
Cortland	$2,416	$1,049	$3,466
Delaware	$3,069	$859	$3,929
Dutchess	$18,637	$5,327	$23,964
Erie	$60,331	$22,488	$82,819
Essex	$2,512	$659	$3,171
Franklin	$2,511	$784	$3,295
Fulton	$3,136	$961	$4,098
Genesee	$3,301	$1,572	$4,874
Greene	$3,242	$776	$4,019
Hamilton	$777	$120	$897
Herkimer	$3,411	$1,085	$4,496
Jefferson	$6,251	$1,976	$8,228
Kings	$132,670	$37,601	$170,272
Lewis	$1,576	$381	$1,958
Livingston	$3,338	$1,183	$4,521
Madison	$3,665	$1,216	$4,882
Monroe	$45,990	$17,076	$63,067
Montgomery	$2,470	$1,004	$3,475
Nassau	$111,337	$36,901	$148,238
New York	$114,968	$83,932	$198,901
Niagara	$13,437	$4,511	$17,949
Oneida	$12,862	$4,368	$17,230
Onondaga	$27,936	$12,253	$40,190
Ontario	$6,102	$2,396	$8,498
Orange	$22,097	$7,794	$29,892
Orleans	$2,239	$751	$2,990
Oswego	$5,932	$2,020	$7,953
Otsego	$3,392	$1,057	$4,450
Putnam	$7,746	$1,499	$9,246
Queens	$130,195	$28,411	$158,606

County	Residential	Non Residential	Total
Rensselaer	$8,846	$2,825	$11,671
Richmond	$32,372	$6,519	$38,892
Rockland	$20,466	$6,625	$27,091
Saint Lawrence	$5,390	$1,606	$6,996
Saratoga	$11,741	$3,408	$15,149
Schenectady	$9,138	$5,606	$14,745
Schoharie	$1,814	$455	$2,270
Schuyler	$972	$352	$1,325
Seneca	$1,800	$583	$2,383
Steuben	$5,060	$1,996	$7,057
Suffolk	$118,835	$39,844	$158,680
Sullivan	$6,175	$1,498	$7,674
Tioga	$2,512	$722	$3,234
Tompkins	$5,109	$1,950	$7,060
Ulster	$11,496	$3,922	$15,418
Warren	$4,410	$1,550	$5,961
Washington	$3,048	$821	$3,869
Wayne	$5,272	$2,177	$7,449
Westchester	$67,540	$23,665	$91,206
Wyoming	$2,197	$831	$3,028
Yates	$1,530	$546	$2,076
Total	**$1,213,244**	**$433,086**	**$1,646,360**

Source: Hazus-MH 2.1, values are in millions of dollars

Table3.12j: Direct Economic Building Losses for 100- Year Hurricane Events

Direct Economic Building Losses for 100-Year Hurricane Events (value in thousands of dollars)								
County	Building Damage	Contents Damage	Inventory Loss	Relocation Loss	Capital Related Loss	Wages Losses	Rental Income Loss	Total Loss
Albany	4,834	1,982	0	8	0	0	0	**6,823**
Allegany	0	0	0	0	0	0	0	**0**
Bronx	899,150	95,457	288	46,143	3,707	4,598	54,470	**1,103,812**
Broome	52	21	0	1	0	0	1	**76**
Cattaraugus	0	0	0	0	0	0	0	**0**
Cayuga	0	0	0	0	0	0	0	**0**
Chautauqua	0	0	0	0	0	0	0	**0**
Chemung	0	0	0	0	0	0	0	**0**
Chenango	13	7	0	0	0	0	0	**21**
Clinton	0	0	0	0	0	0	0	**0**
Columbia	1,899	555	0	1	0	0	0	**2,456**
Cortland	5	1	0	0	0	0	0	**7**
Delaware	28	5	0	2	0	0	1	**36**
Dutchess	15,654	274	0	23	0	0	13	**15,964**
Erie	0	0	0	0	0	0	0	**0**
Essex	0	0	0	0	0	0	0	**0**
Franklin	0	0	0	0	0	0	0	**0**
Fulton	0	0	0	0	0	0	0	**0**
Genesee	0	0	0	0	0	0	0	**0**
Greene	481	381	0	0	0	0	0	**863**
Hamilton	0	0	0	0	0	0	0	**0**
Herkimer	14	5	0	1	0	0	0	**20**
Jefferson	3	1	0	0	0	0	0	**4**
Kings	1,595,963	161,897	1,053	79,937	7,664	11,660	96,875	**1,955,048**
Lewis	2	1	0	0	0	0	0	**3**

Direct Economic Building Losses for 100-Year Hurricane Events (value in thousands of dollars)								
County	**Building Damage**	**Contents Damage**	**Inventory Loss**	**Relocation Loss**	**Capital Related Loss**	**Wages Losses**	**Rental Income Loss**	**Total Loss**
Livingston	0	0	0	0	0	0	0	**0**
Madison	8	3	0	0	0	0	0	**11**
Monroe	0	0	0	0	0	0	0	**0**
Montgomery	65	32	0	1	0	0	0	**97**
Nassau	275,295	13,268	33	4,942	82	29	3,715	**297,364**
New York	1,642,719	168,206	322	81,424	13,599	10,960	94,421	**2,011,652**
Niagara	0	0	0	0	0	0	0	**0**
Oneida	30	9	0	1	0	0	1	**40**
Onondaga	36	9	0	1	0	0	1	**46**
Ontario	0	0	0	0	0	0	0	**0**
Orange	15,620	5,876	0	19	0	0	17	**21,532**
Orleans	0	0	0	0	0	0	0	**0**
Oswego	7	4	0	0	0	0	0	**11**
Otsego	27	11	0	1	0	0	0	**40**
Putnam	13,233	289	0	44	0	0	49	**13,614**
Queens	997,657	88,548	463	45,185	2,876	3,454	53,130	**1,191,313**
Rensselaer	5,065	1,687	0	5	0	0	1	**6,758**
Richmond	335,440	28,601	194	15,290	1,987	3,012	14,312	**398,836**
Rockland	47,851	15,049	0	249	0	0	262	**63,411**
Saint Lawrence	0	0	0	0	0	0	0	**0**
Saratoga	2,729	2,113	0	1	0	0	0	**4,843**
Schenectady	1,621	1,204	0	2	0	0	0	**2,827**
Schoharie	129	124	0	0	0	0	0	**253**
Schulyer	0	0	0	0	0	0	0	**0**
Seneca	0	0	0	0	0	0	0	**0**
Steuben	0	0	0	0	0	0	0	**0**
Suffolk	93,073	18,662	0	211	0	0	171	**112,117**
Sullivan	653	626	0	0	0	0	0	**1,279**
Tioga	11	4	0	0	0	0	0	**16**
Tompkins	11	4	0	0	0	0	0	**16**
Ulster	4,428	2,233	0	3	0	0	1	**6,666**
Warren	387	436	0	0	0	0	0	**824**
Washington	1,681	730	0	1	0	0	1	**2,413**
Wayne	0	0	0	0	0	0	0	**0**
Westchester	272,290	72,282	22	7,810	5	2	7,828	**360,240**
Wyoming	0	0	0	0	0	0	0	**0**
Yates	0	0	0	0	0	0	0	**0**

Source: Hazus-MH 2.1, values are in thousands of dollars

Table 3.12k provides estimates for building-related economic loss for property and business interruption. Residential occupancies make up the most significant percentage of losses, at over 96% of total losses. Values are in thousands of dollars.

Table 3.12k Hurricane Building Loss Estimates by Building Occupancy

Building Loss Estimates by Occupancy (thousands of dollars)						
Category	**Area**	**Residential**	**Commercial**	**Industrial**	**Other**	**Total**
Property Damage	Building	$374,398	$11,127	$1,673	$2,144	$389,343
	Content	$105,739	$693	$63	$17	$106,513
	Inventory	$0	$8	$13	$2	$23
	Subtotal	**$480,137**	**$11,828**	**$1,749**	**$2,164**	**$495,878**
Business Loss	Income	$0	$5	$0	$0	$5
	Relocation	$7,971	$178	$9	$11	$8,169
	Rental	$8,171	$2	$0	$0	$8,173
	Wage	$0	$2	$0	$0	$2
	Subtotal	**$16,142**	**$188**	**$9**	**$11**	**$16,349**
Total		**$496,279**	**$12,016**	**$1,758**	**$2,175**	**$512,227**

Source: Hazus-MH 2.1

Saratoga County's local hazard mitigation plan (LHMP) provides an example of how Hazus-MH 2.0 can be used to determine the impact on general building stock. The county's vulnerability assessment using Hazus is documented in the proceeding pages; however, the complete LHMP can be reviewed at Saratoga County's website[4]

[4] http://www.saratogacountyny.gov/departments.asp?did=97

GENERAL BUILDING STOCK

The 2000 U.S. Census data identifies 78,165 households in Saratoga County. The U.S. Census data identified 86,701 housing units in Saratoga County in 2000. U.S. Census defines household as all the persons who occupy a housing unit, and a housing unit as a house, an apartment, a mobile home, a group of rooms, or a single room that is occupied (or if vacant, is intended for occupancy) as separate living quarters. Therefore, you may have more than one household per housing unit. The median price of a single family home in Saratoga County was estimated at $120,400 in 2000 (U.S. Census, 2000).

Saratoga County's HAZUS-MH MR3 most recent hazard mitigation plan is available for review at http://www.saratogacountyny.gov/departments.asp?did=97

The data in HAZUS-MH MR3 estimates a total building replacement value (structure and content) of greater than $24.8 billion for Saratoga County. Approximately 90.7% of the buildings and 69.5% of the building stock structural value are associated with residential housing. **Table 3.12l** presents Building Stock Statistics by Occupancy Class for Saratoga County, based on HAZUS-MH provided data.

Table 3.12l: Building Stock Replacement Value by Occupancy Class

Location (Municipality)	Total	Residential	Commercial	Industrial
Town of Ballston	$981,429,000	$705,548,000	$154,102,000	$58,466,000
Village of Ballston Spa	$670,215,000	$436,695,000	$155,816,000	$29,230,000
Town of Charlton	$448,009,000	$394,007,000	$27,839,000	$10,014,000
Town of Clifton Park	$4,633,011,000	$3,367,323,000	$1,015,472,000	$119,530,000
Town of Corinth	$301,704,000	$268,066,000	$18,506,000	$8,372,000
Village of Corinth	$280,235,000	$159,019,000	$54,396,000	$25,254,000
Town of Day	$311,923,000	$263,208,000	$17,014,000	$16,463,000
Town of Edinburg	$350,033,000	$322,793,000	$11,226,000	$4,773,000
Town of Galway	$472,152,000	$420,467,000	$26,290,000	$7,989,000
Village of Galway	$24,657,000	$18,736,000	$2,113,000	$118,000
Town of Greenfield	$683,176,000	$549,795,000	$76,486,000	$24,553,000
Town of Hadley	$202,491,000	$181,094,000	$12,852,000	$3,103,000
Town of Halfmoon	$1,943,765,000	$1,405,643,000	$413,701,000	$79,312,000
Town of Malta	$1,477,322,000	$1,132,409,000	$238,491,000	$67,653,000
City of Mechanicville	$487,845,000	$368,191,000	$90,735,000	$9,766,000
Town of Milton	$1,176,294,000	$865,010,000	$162,954,000	$69,392,000
Town of Moreau	$993,509,000	$719,329,000	$192,946,000	$36,511,000
Town of Northumberland	$406,959,000	$352,122,000	$34,178,000	$9,817,000
Town of Providence	$187,863,000	$151,942,000	$13,726,000	$6,948,000
Village of Round Lake	$68,688,000	$44,542,000	$19,788,000	$1,422,000
Town of Saratoga	$397,328,000	$313,194,000	$44,499,000	$16,798,000
City of Saratoga Springs	$4,825,875,000	$2,659,812,000	$1,279,612,000	$168,138,000
Village of Schuylerville	$141,009,000	$88,076,000	$32,779,000	$5,073,000
Village of South Glens Falls	$328,997,000	$230,861,000	$75,933,000	$3,349,000
Town of Stillwater	$551,522,000	$423,924,000	$61,986,000	$42,977,000
Village of Stillwater	$147,913,000	$116,644,000	$14,529,000	$4,471,000
Village of Victory	$48,021,000	$37,775,000	$3,410,000	$1,110,000
Town of Waterford	$780,046,000	$560,956,000	$68,312,000	$132,677,000
Village of Waterford	$218,964,000	$159,687,000	$32,253,000	$2,945,000
Town of Wilton	$1,294,768,000	$914,295,000	$292,597,000	$28,801,000
Saratoga County	**$24,835,723,000**	**$17,631,163,000**	**$4,644,541,000**	**$995,025,000**

Source: HAZUS-MH MR3, 2007

Note (1): The valuation of general building stock and the loss estimates determined in Saratoga County were based on the default general building stock database provided in HAZUS-MH MR3. The general building stock valuations provided in HAZUS-MH MR3 are Replacement Cost Value from R.S. Means as of 2006.

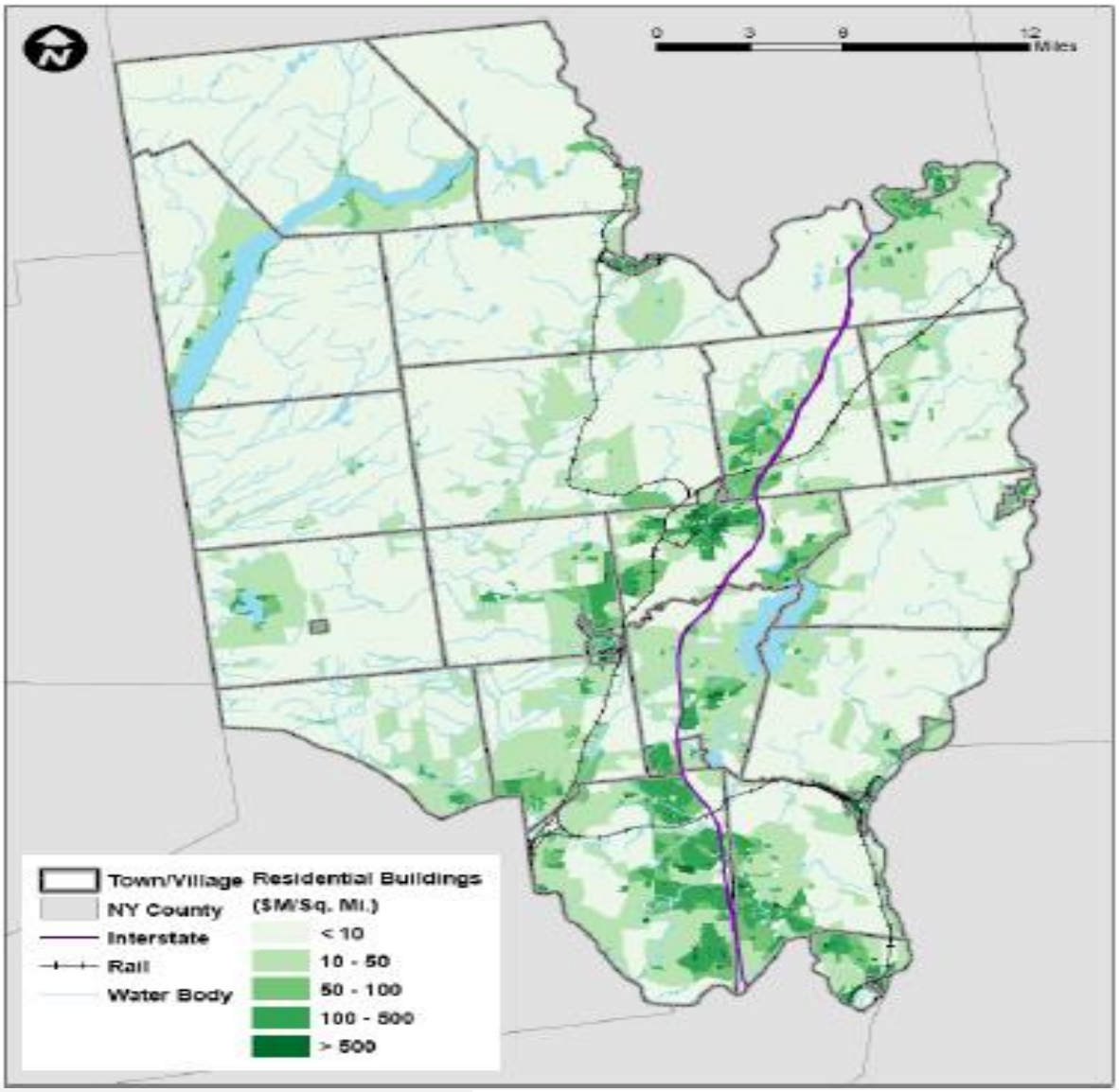
Note (2): Value reflects the replacement cost for building structure and contents. Generally, contents for residential structures are valued at about 50 percent of the building's value. For commercial facilities, the value of the content is generally about equal to the building's structural value. Building stock is generated by using 2000 U.S. Census data. Total is total of all building classes (Residential, Commercial, Industrial, Agricultural, Religious, Government and Education).

The 2000 Census data identify that the majority of housing units (60.6%) in Saratoga County are single-family detached units. The 2005 U.S. Census Bureau's County Business Patterns data identified 4,864 business establishments employing 63,795 people in Saratoga County. The majority (54.8%) of these establishments employed between one and four employees.

Figure 3.12v through **Figure 3.12x** show the distribution and exposure density of residential, commercial and industrial buildings in Saratoga County. Exposure density is the dollar value of structures per unit area, including building content value. Generally, contents for residential structures are valued at about 50 percent of the building's value. For commercial facilities, the value of the content is generally about equal to the building's structural value. The densities are shown in units of $1,000 ($K) per square mile.

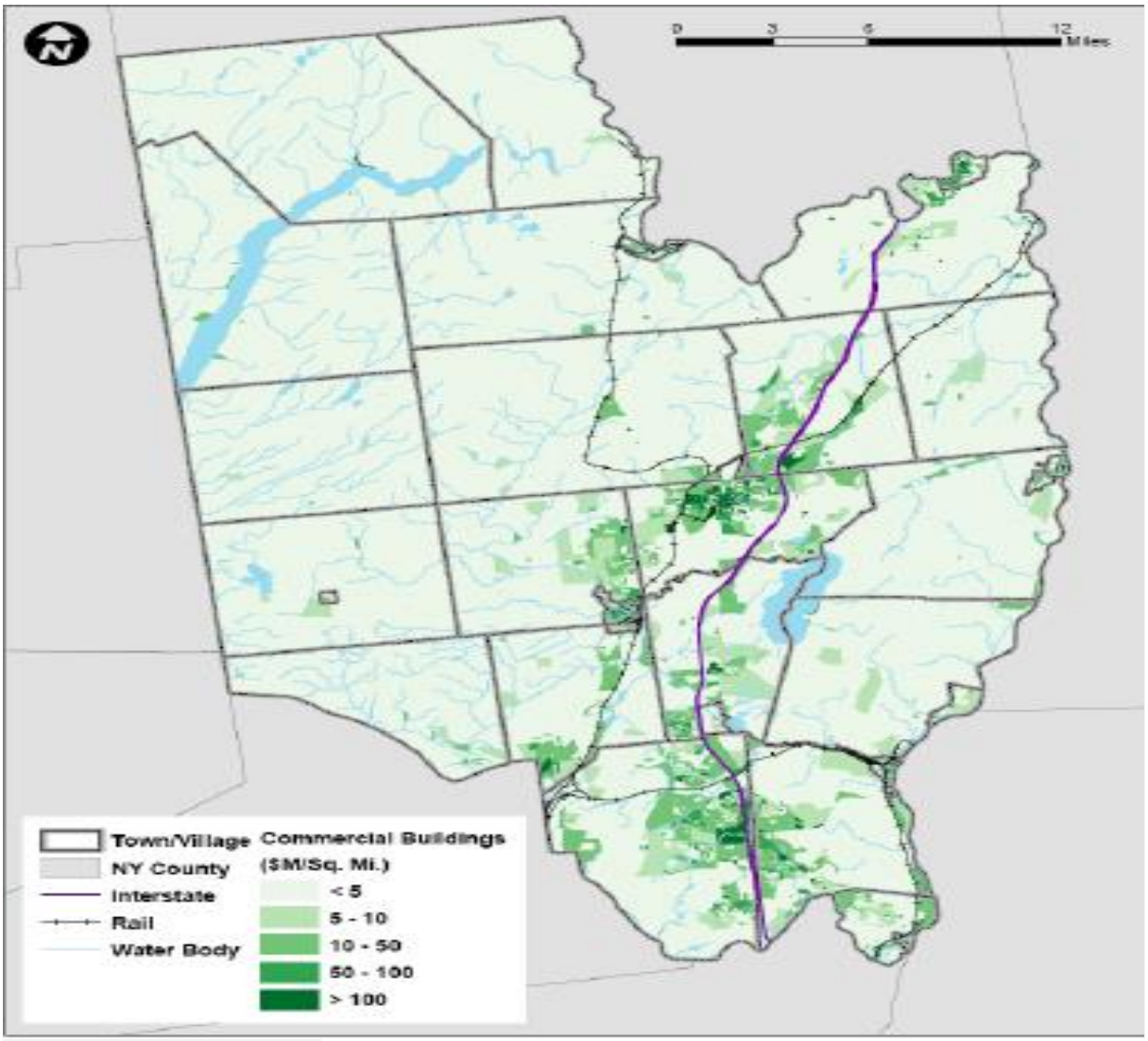
Viewing exposure distribution maps such as **Figures 3.12v through 3.12x** can assist communities in visualizing areas of high exposure and in evaluating aspects of the study area in relation to the specific hazard risks.

Figure 3.12v: Distribution of Residential Building Stock Replacement Value in Saratoga County



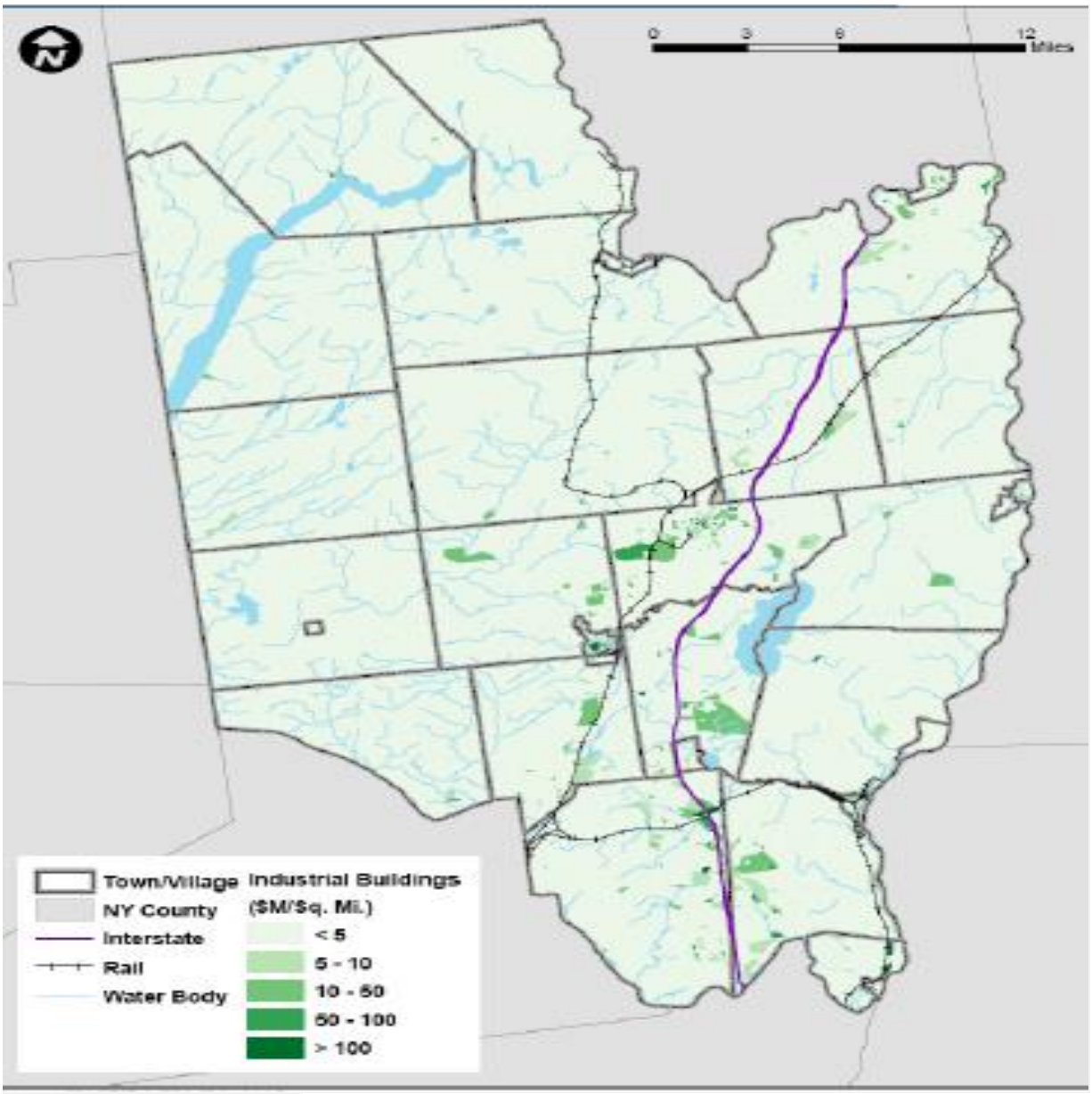
*Source: HAZUS-MH 2.1, (*As of October 2013)

Figure 3.12w: Distribution of Commercial Building Stock Replacement Value in Saratoga County



Source: HAZUS-MH MR3, 2007

Figure 3.12x: Distribution of Industrial Building Stock Replacement Value in Saratoga County



Source: HAZUS-MH MR3, 2007

Development in hazard prone areas

The national trend that sees ever-increasing development along the coastline has also been evident in New York State. Accordingly, thousands of New Yorkers and businesses now exist in areas that are vulnerable to hurricanes and tropical storms.

For the State 2014 Update, 2010 Census data was used in the preparation of the risk assessment. The latest Census estimates (July 1, 2009), show that New York State as a whole experienced a 96.6% population growth between the years of 2000 and 2010. Records indicate that although there was a significant increase in population, this was not evenly distributed throughout the State. According to data found in **Table 1a** in **Section 1** of the 2014 Update, Saratoga County, accounted for a 9.5% population gain.

At the local level, jurisdictions have recognized their susceptibility of the occurrence of hurricane events. Although some counties seem to have higher occurrences than others the mitigating trend appears to be strictly enforcing building codes and instituting new measures that would call for the use of hurricane resistant materials, hurricane clips, and wind shutters. For Instance, Westchester County has assessed their risk and exposure and although the likelihood of a hurricane hitting Westchester is moderately high their exposure is very high.

3.12.3 Assessing Hurricane (Tropical/ Coastal Storms) Vulnerability and Estimating Potential Losses of State Facilities

A project to produce a statewide inventory of facilities was initiated in August 2013, with a projected completion date for the pilot phase of mid-2014. The pilot will identify and assess one category of state critical infrastructure, developing the methodology for what is anticipated to be a multi-year project. The methodology will include analysis of vulnerability and estimated potential losses to state facilities from future hazard events. **Section 3.1.8** provides a comprehensive description of the status of the statewide facilities inventory project.

Table 3.12m exhibit the total number of state buildings and their replacement value as of 2012 based on varying surge zones. According to the SLOSH model, if a category 1 hurricane makes landfall, the State of New York is susceptible to $346,288,919 in damages. Conversely, a category 4 hurricane will potentially damage 509 State buildings with an estimated cost of $653,087,513.

Table 3.12m: State Building Exposure in Hurricane Surge Zones

State Buildings Exposure		
Surge Zone	**No. of Buildings**	**Replacement Value**
Cat 1	**263**	**$ 346,288,919**
Cat 2	**350**	**$ 396,119,923**
Cat 3	**463**	**$ 530,070,230**
Cat 4	**509**	**$ 653,087,513**

Source: SHELDUS/ (Category 2-4 Inclusive of Proceeding Storm Surge)

The data below displays the results of a wind-hazard vulnerability assessment and loss analysis for State facilities. The results present a gross estimate of potential wind losses to those identified vulnerable State facilities in terms of dollar value of exposed property. The wind hazard vulnerability analysis and loss estimation methodology was supported by GIS and Hazus-MH 2.1 technology and involved collaboration with key State agencies that resulted in the identification of two State databases that provide key facility information.

The NYS Offices of General Services (OGS) fixed asset database and Office of Information Technology Services (OITS) database included fields that provide coordinate location information and building replacement value in dollars. The analysis process involved the creation of a GIS mapping layer showing facility location using the coordinate information and overlaid on a wind hazard layer developed using the 100-Year Peak Gust Wind Speed Probability map data.

Figure 3.12y shows New York's probabilistic 100-year peak gust wind speed from a hurricane event. GIS analysis show that 3,785 buildings are within the high peak gust wind zones (74– 110 miles per hour), with a total replacement cost of $2,425,867,307 dollars. However, value is reflective of 3,093 buildings, because replacement value data is not available for all buildings. **Table 3.12m** refers to susceptible populations found in the 100-Year Peak Gust Zones found in the map following.

Table 3.12n: Population in 100-Year Peak Gust Zones

Population in 100-Year Peak Gust Zones	
Wind Speed Zones (mph)	**Population**
91-110 (Red)	1,974,031
74-90 (Orange)	10,253,673
53-73 (Yellow)	1,912,605
37-52 (Green)	1,684,894
24-36 (Blue)	2,985,444

Figure 3.12y: 100-Year Peak Gust Wind Probability

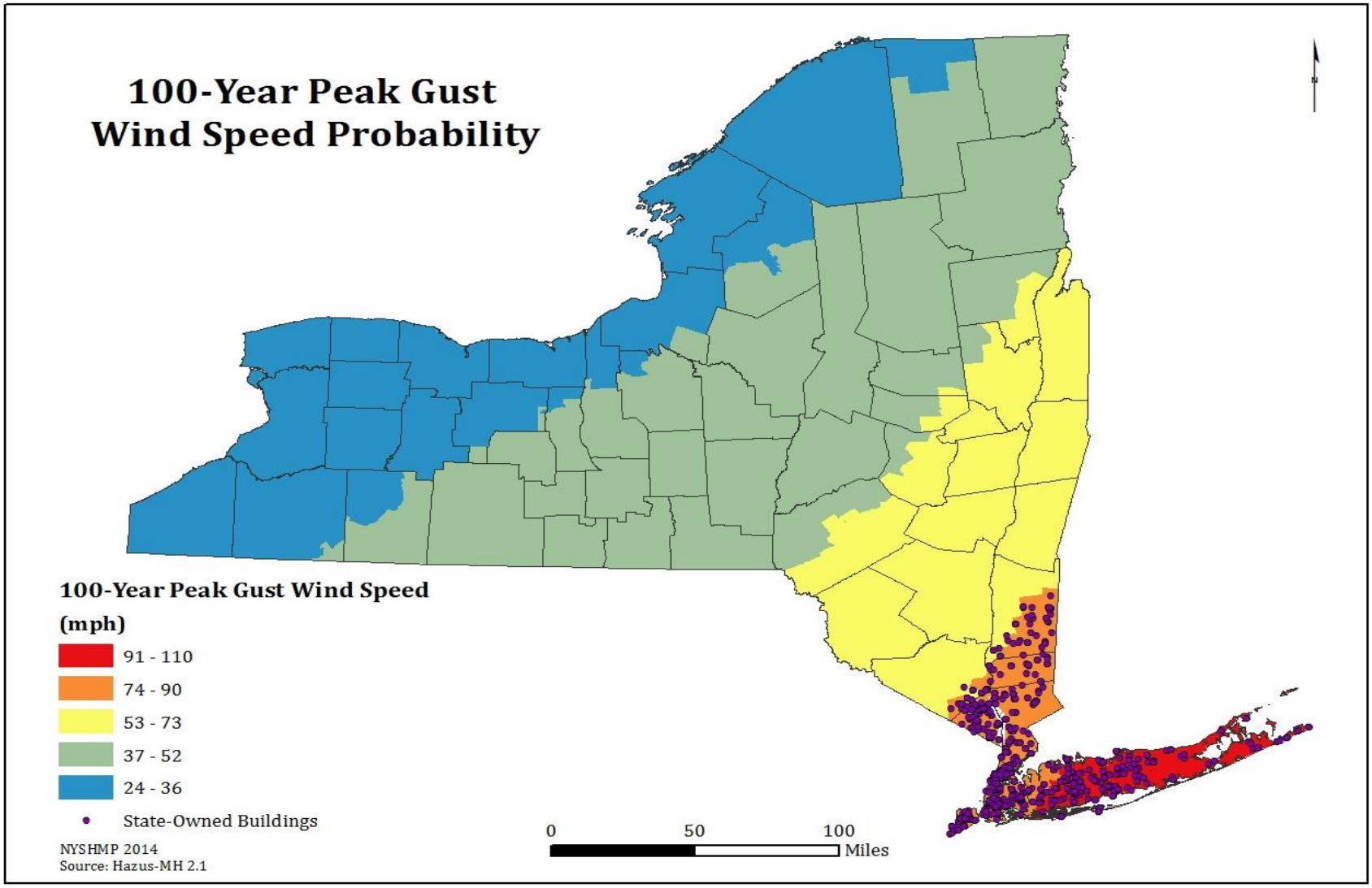


Table 3.12o details the GIS analysis results from the state-owned buildings in the high peak gust wind zone of 74 to 110 miles per hour categories. The table provides the name of the agency that owns the buildings, the total count of buildings, and replacement cost in the high peak gust wind hazard zones.

Table 3.12o: State-Owned Buildings and Replacement Cost

Agency	Number of Buildings	Replacement Cost ($)
Office of General Services (OGS)	9	$ 122,193,519.00
Department of Health (DOH)	27	$ 67,761,389.00
Office of Information Technology Services (OITS)	293	$ 329,045,358.00
Office of Parks, Recreation and Historic Preservation (OPRHP)	1,840	$ 504,287,400.00
Department of Environmental Conservation (DEC)	54	$ 10,534,440.00
Office of Mental Health (OMH)	228	$ 773,237,304.00
Office For People With Developmental Disabilities (OPWDD)	426	$ 394,705,144.00
Division of State Police (DSP)	5	$ 4,874,743.00
Department of Military and Naval Affairs (DMNA)	39	$ 113,149,168.00
Department of Transportation (DOT)	147	$ 68,353,325.00
Office of Child and Family Services (OCFS)	21	$ 24,645,931.00
Dormitory Authority of the State of New York (DASAS)	2	$ 5,631,127.00
Department of Labor (DOL)	2	$ 7,448,928.00
Total	**3,093**	**$ 2,425,867,776.00**

Source: Hazus-MH 2.1, NYSOGS

Figure 3.12z shows State buildings that are at risk from hurricane storm surge based on NOAA's SLOSH inundation model projections. Based on map observations, there are a number of state owned buildings found within the Queens, Kings, Bronx, and New York Counties. There are roughly a total of 349 state owned facilities, Queens- 112, Kings- 102, Bronx- 74, and New York- 61 found amongst the four counties. A vast majority of the state-owned building vulnerabilities occur at category two, three, and four hurricane storm surges.

Figure 3.12z: State Buildings in Storm Surge Zones

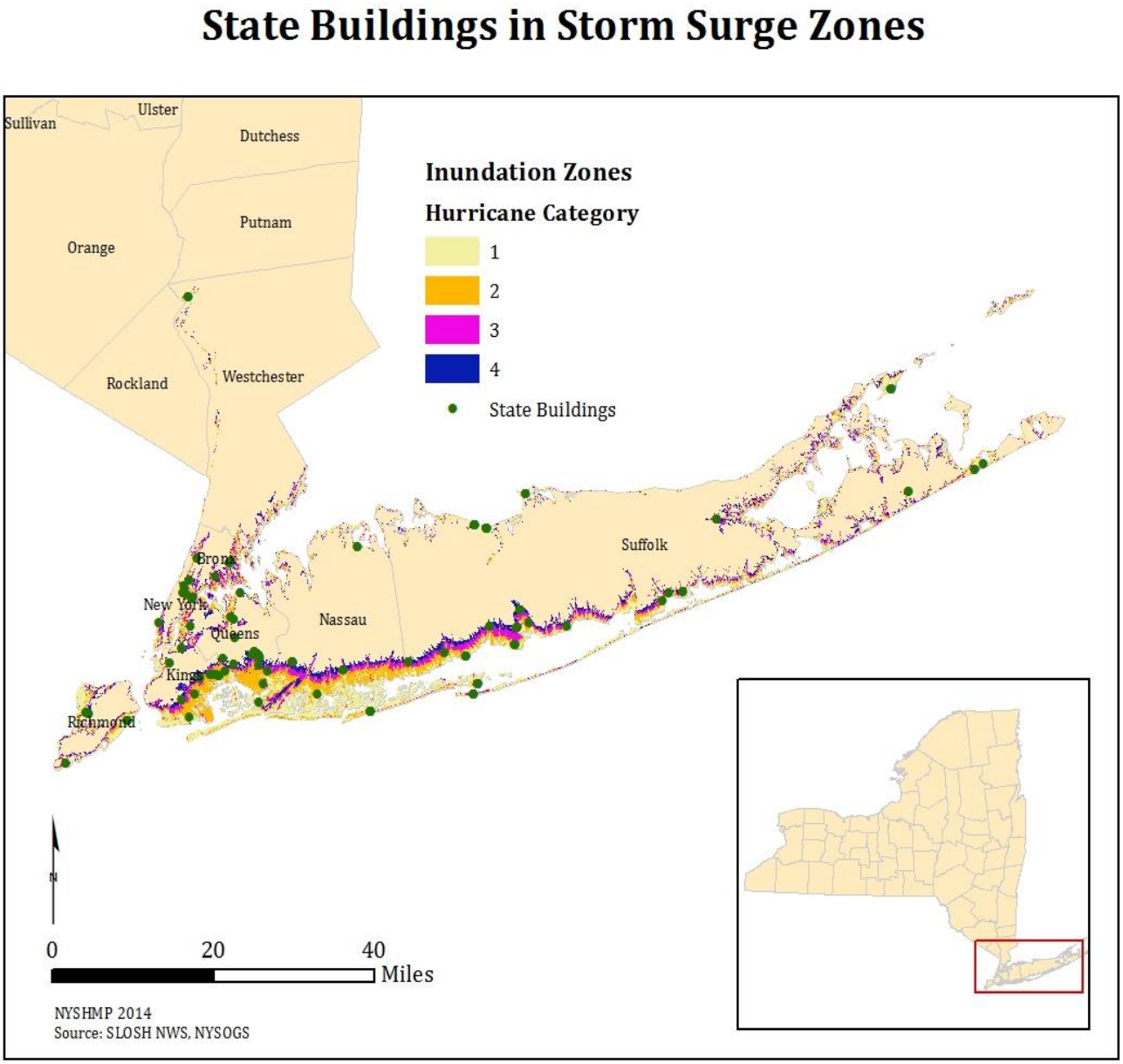


Table 3.12p details the GIS analysis results from the state-owned buildings in the storm surge zone. The table provides the name of the agency that owns the buildings, the total count of buildings, and replacement cost in the high peak gust wind hazard zones.

Table 3.12p: State Building Exposure in Hurricane Surge Zones

Agency	Number of Buildings	Replacement Cost ($)
Office of General Services (OGS)	2	$ 60,024,059.00
Department of Health (DOH)	1	$ 17,116,294.00
Department of Corrections and Community Supervision (DOCCS)	3	$ 24,722,629.00
Office of Parks, Recreation and Historic Preservation (OPRHP)	359	$ 138,643,712.00
Department of Environmental Conservation (DEC)	8	$ 2,622,073.00
Office of Mental Health (OMH)	47	$ 254,738,080.00
Office For People With Developmental Disabilities (OPWDD)	69	$ 126,508,892.00
Division of State Police (DSP)	1	$ 663,990.00
Department of Military and Naval Affairs (DMNA)	5	$ 26,178,541.00
Department of Transportation (DOT)	13	$ 994,864.00
Dormitory Authority of the State of New York (DASAS)	1	$ 874,379.00
Total	**509**	**$ 653,087,513.00**

Source: HAZUS-MH 2.1, NYSOGS

3.12.4 Data Limitations and Other Key Documents

The Mitigation Plan Development Team researched the Wind Event Hazard and its effects on New York State. Contents of this section resulted from research and outreach including, but not limited to, the following sources:

- New York City Office of Emergency Management, www.nyc.gov/html/oem/html/hazards/storms_terms.shtml
- The Federal Emergency Management Agency (FEMA), www.fema.gov
- The National Hurricane Center (NHC), www.nhc.noaa.gov
- The National Climatic Data Center (NCDC), www.ncdc.noaa.gov
- CNN; http://www.cnn.com/2013/07/13/world/americas/hurricane-sandy-fast-facts
- Daily News; http://www.nydailynews.com/new-york/great-hurricane-1938-article-1.1194501#ixzz2e1W4Ckuu
- SHELDUS, the Spatial Hazard Events and Loss Database for the United States
- Metro. Hurricane evacuation maps place 600,000 more New Yorkers in flood Zones. http://www.metro.us/newyork/news/local/2013/06/18/hurricane-evacuation-maps-place-600000-more-new-york-in-zones/

Please note: *data obtained from the Spatial Hazard Events and Losses Database for the United States (SHELDUS™) is a county-level hazard data set for the U.S. for 18 different natural hazard event types such thunderstorms, hurricanes, floods, and tornados. For each event the database includes the beginning date, location (county and state), property losses, crop losses, injuries, and fatalities that affected each county. The data derives from the national data source, National Climatic Data Center's monthly Storm Data publications. Using the latest release of SHELDUS™ 12.0, the database includes every loss causing and/or deadly event between 1960 through 1992 and from 1995 onward. Between 1993 and 1995, SHELDUS™ reflects only events that caused at least one fatality or more than $50,000 in property or crop damages.*