

## 12) Windstorms and Tornadoes Hazard Analysis for New York City

### a) Hazard Profile

#### i) Hazard Description

Windstorms are often associated with other storms, such as hurricanes or nor'easters, but may occur independently. High winds can cause downed trees and power lines, flying debris, and building collapses, all of which may lead to power outages, transportation disruptions, damage to buildings and vehicles, and injury or death. Flying debris is the primary cause of damage during a windstorm. While a building may be generally structurally sound, broken glass from windows can cause injuries inside and outside the building and extensive damage to building content.

A tornado is a violent storm with winds up to 300 miles per hour. It appears as a rotating funnel-shaped cloud, gray to black in color, extending toward the ground from the base of a thundercloud. The average tornado moves southwest to northeast at a forward speed of 30 miles per hour, but tornadoes can move in any direction and may vary from stationary to 70 miles per hour. Tornadoes are most frequent east of the Rocky Mountains during spring and summer months between the hours of 3 PM and 9 PM. Tornadoes may also accompany hurricanes. Tornadoes can uproot trees and buildings and turn harmless objects into deadly missiles in a matter of seconds. Tornadoes are especially dangerous because they appear transparent until they begin to pick up debris and dust. These short-lived storms are the most violent of all atmospheric phenomena and, over a small area, are the most destructive. Approximately 800 tornadoes occur across the nation each year, resulting in nearly 80 deaths and 1,500 injuries. Damage paths can exceed one mile wide and 50 miles long.

#### ii) Severity

The Beaufort Wind Scale is a simplified scale to aid in the estimation of wind speed and corresponding typical effects.

Beaufort Wind Scale		
Wind Speed (mph)	Name	Damage
25–31	Strong Breeze	Large branches in motion; whistling in telephone wires; umbrellas used with difficulty
32–38	Near Gale	Whole trees in motion; resistance felt while walking against the wind
39–46	Gale	Twigs break off of trees; wind impedes walking
47–54	Strong Gale	Slight structural damage to chimneys and slate roofs
55–63	Storm	Seldom felt inland; trees uprooted; considerable structural damage

Beaufort Wind Scale		
Wind Speed (mph)	Name	Damage
64–72	Violent Storm	Very rarely experienced; widespread structural damage; roofing peels off buildings; windows broken; mobile homes overturned
73+	Hurricane	Widespread structural damage; roofs torn off homes; weak buildings and mobile homes destroyed; large trees uprooted

**Table 41: Beaufort Wind Scale**

The Fujita Scale (F-Scale) is the standard measurement for rating the strength of a tornado. The NWS bases this scale on an analysis of damage after a tornado to infer wind speeds. On February 1, 2007, the NWS transitioned from the F-Scale to the Enhanced Fujita Scale (EF-Scale). The EF-Scale is considerably more complex and enables surveyors to assess tornado severity with greater precision. Table 42 details both scales.

F-SCALE and EF-SCALE				
F-Scale	3-sec. gust speed (mph)	EF-Scale	3-sec. gust speed (mph)	TYPICAL DAMAGE
<b>F0</b>	45–78	<b>EF0</b>	65–85	Light damage. Some damage to chimneys. Branches broken off trees. Shallow-rooted trees pushed over; signboards damaged.
<b>F1</b>	79–117	<b>EF1</b>	86–109	Moderate damage. Peels surface off roofs. Mobile homes pushed off foundations or overturned. Moving autos blown off roads.
<b>F2</b>	118–161	<b>EF2</b>	110–137	Considerable damage. Roofs torn off frame houses. Mobile homes demolished. Boxcars overturned. Large trees snapped or uprooted. Light-object missiles generated. Cars lifted off ground.
<b>F3</b>	162–209	<b>EF3</b>	138–167	Severe damage. Roofs and some walls torn off well-constructed houses. Trains overturned. Most trees in forest uprooted. Heavy cars lifted off the ground and thrown.
<b>F4</b>	210–261	<b>EF4</b>	168–199	Devastating damage. Well-constructed houses leveled. Structures with weak foundations blown away some distance. Cars thrown and large missiles generated.
<b>F5</b>	262–317	<b>EF5</b>	200–234	Incredible damage. Strong frame houses leveled off foundations and swept away. Automobile-sized missiles fly through the air in excess of 100 meters (109 yards). Trees debarked. Incredible phenomena will occur

**Table 42: Fujita and Enhanced Fujita Scale**

### iii) Probability

Windstorms are a common occurrence in New York City, making them a highly probable hazard. Based on the historic occurrences, New York City experiences a high-wind event at least once a year.

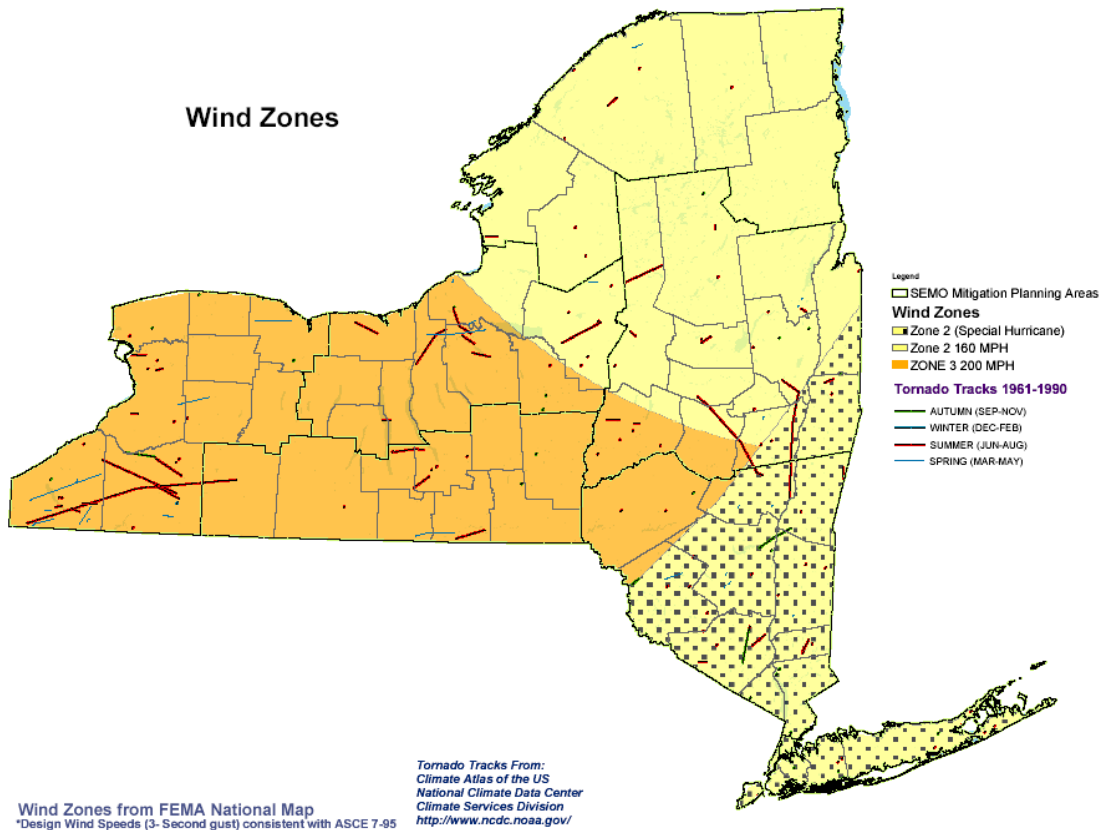
Though infrequent, tornadoes in New York City are not unprecedented. Over the past 22 years, six tornadoes have hit New York City, five of which were scaled F0 or F1. Based on historic frequency, an estimated 27 tornadoes will hit the City every 100 years.

### iv) Location

Windstorms occur in all five boroughs of New York City. Figure 73 and Figure 74 display wind zones throughout the United States and New York State. These wind zones portray the frequency and strength of extreme windstorms.



Figure 73: Wind Zones in the United States (Source: FEMA, 2008)



**Figure 74: Wind Zones in NY State (Source: FEMA, 2008)**

Of the six tornadoes that have affected the City, three were in Staten Island, while Manhattan, Brooklyn, and Queens each experienced one. However, scientists caution that though rare, a tornado is possible anywhere in the City.

#### v) Historic Occurrences

Historic Occurrences of Windstorms and Tornadoes in New York City			
Date	Event	Location(s)	Description
Oct. 5, 1985	Tornado	Queens	<ul style="list-style-type: none"> <li>F1 tornado</li> <li>Ran for 2 miles; width of 50 yards</li> <li>No fatalities; 6 injuries</li> </ul>
Aug. 10, 1990	Tornado	Staten Island	<ul style="list-style-type: none"> <li>F0 tornado</li> <li>Ran for 2 miles; width of 17 yards</li> <li>No fatalities; 3 injuries</li> </ul>
Mar. 2, 1994	High Wind	Citywide	<ul style="list-style-type: none"> <li>High winds of 53 knots</li> </ul>
Aug. 31, 1995	Tornado	Manhattan	<ul style="list-style-type: none"> <li>F1 tornado</li> <li>Ran for 0 miles; width of 10 yards</li> <li>No fatalities; 1 injury</li> <li>Property damages totaled \$30,000</li> </ul>

Historic Occurrences of Windstorms and Tornadoes in New York City			
Date	Event	Location(s)	Description
Oct. 28, 1995	Tornado	Staten Island	<ul style="list-style-type: none"> <li>F1 tornado</li> <li>No fatalities or injuries</li> <li>Estimated damage \$500,000</li> </ul>
Feb. 25, 1996	High Wind	Citywide	<ul style="list-style-type: none"> <li>Intensity unknown</li> <li>1 fatality in Brooklyn due to a fallen tree</li> <li>1 reported injury</li> </ul>
Mar. 19, 1996	High Wind	Citywide	<ul style="list-style-type: none"> <li>High winds of 69 knots</li> <li>No fatalities or injuries</li> </ul>
Oct. 19, 1996	High Wind	Citywide	<ul style="list-style-type: none"> <li>High winds of 80 knots</li> <li>Fallen trees caused 3 fatalities; no additional injuries</li> <li>Power lines and downed trees closed Bayonne Bridge</li> <li>Reported roof ripped off a Bronx building</li> </ul>
Nov. 2, 1997	Wind	Citywide	<ul style="list-style-type: none"> <li>Reported wind gusts 35-40 knots</li> <li>1 fatality; 1 injury</li> </ul>
Nov. 27, 1997	Wind	Manhattan	<ul style="list-style-type: none"> <li>Winds averaged 25 to 35 mph; gusts around 50 mph</li> <li>Balloon handlers lost control of Cat in the Hat balloon at Macy's Thanksgiving Day Parade; caused top of light pole to fall on 4 spectators</li> <li>1 serious and 3 less-serious injuries</li> </ul>
Feb. 4, 1998	High Wind	Manhattan	<ul style="list-style-type: none"> <li>High winds of 50 knots</li> <li>No fatalities; 1 injury reported</li> </ul>
Mar. 18, 1999	Wind	Manhattan	<ul style="list-style-type: none"> <li>High winds 40-47 mph</li> <li>15-foot metal rod to tumbled 22 stories from top of 1 Times Square; injured 3 women</li> </ul>
Dec. 12, 2000	High Wind	Citywide	<ul style="list-style-type: none"> <li>High winds 56 knots</li> <li>Nor'easter</li> <li>1 fatality; 6 injuries</li> </ul>
Sept. 11, 2002	High Wind	Citywide	<ul style="list-style-type: none"> <li>Strongest winds measured 66 mph in Queens</li> <li>Winds lasted at least 6 hours</li> <li>1 fatality; 4 injuries</li> <li>Widespread power outages</li> <li>Construction debris caused injuries</li> </ul>
Sept. 19, 2003	Strong Wind	Bronx	<ul style="list-style-type: none"> <li>Strong winds up to 40 knots</li> <li>Hurricane Isabel</li> <li>No fatalities; 1 injury</li> <li>Downed trees and power lines</li> </ul>
Oct. 15, 2003	High Wind	Queens	<ul style="list-style-type: none"> <li>High winds of 39 knots</li> <li>No fatalities or injuries reported</li> <li>Downed trees and power lines</li> </ul>

Historic Occurrences of Windstorms and Tornadoes in New York City			
Date	Event	Location(s)	Description
			<ul style="list-style-type: none"> <li>reported</li> <li>Property damage estimated at a least \$100,000</li> </ul>
Oct. 27, 2003	Tornado	Staten Island	<ul style="list-style-type: none"> <li>F0 tornado</li> <li>No fatalities or injuries</li> </ul>
Nov. 13, 2003	High Wind	Citywide	<ul style="list-style-type: none"> <li>High winds of 56 knots</li> <li>1 fatality; no injuries reported</li> </ul>
Dec. 1, 2004	High Wind	Brooklyn	<ul style="list-style-type: none"> <li>High winds of 61 knots</li> <li>No fatalities or injuries reported</li> </ul>
Dec. 23, 2004	Strong Wind	Queens	<ul style="list-style-type: none"> <li>High winds of 47 mph</li> <li>1 fatality caused by tree crushing traveling car; no injuries</li> </ul>
Mar. 8, 2005	High Wind	Queens	<ul style="list-style-type: none"> <li>High winds of 50 knots</li> <li>No fatalities; no injuries reported</li> </ul>
Apr. 2, 2005	High Wind	Queens	<ul style="list-style-type: none"> <li>High winds of 50 knots</li> <li>No fatalities and no injuries reported</li> </ul>
Oct. 16, 2005	Strong Wind	Citywide	<ul style="list-style-type: none"> <li>High winds of 31 knots</li> <li>No fatalities or injuries reported</li> <li>Trees downed</li> <li>Windows in a high-rise office building in Manhattan blew out</li> <li>\$17,000 in property damage reported</li> </ul>
Oct. 25, 2005	High Wind	Citywide	<ul style="list-style-type: none"> <li>High winds of 42 knots</li> <li>No fatalities or injuries reported</li> <li>Downed trees City reported</li> <li>Property damaged reported \$35,000</li> </ul>
Nov. 24, 2005	Strong Wind	Citywide	<ul style="list-style-type: none"> <li>High winds of 35 knots</li> <li>No fatalities and 2 injuries resulting from a Macy's Thanksgiving Day parade balloon hitting a lamppost and causing a 30-pound light to fall into the crowd</li> <li>No cost in damages reported</li> </ul>
Jan. 15, 2006	High Wind	Queens	<ul style="list-style-type: none"> <li>High winds of 55 knots</li> <li>No fatalities and 1 injury reported</li> </ul>
Jan. 18, 2006	High Wind	Bronx, Manhattan, Staten Island, Queens	<ul style="list-style-type: none"> <li>High winds of 59 knots</li> <li>No fatalities or injuries reported</li> </ul>
Feb. 17, 2006	High Wind	Brooklyn, Queens, Staten Island	<ul style="list-style-type: none"> <li>High winds of 53 knots</li> <li>No fatalities or injuries reported</li> </ul>
Oct. 20, 2006	High Wind	Staten Island	<ul style="list-style-type: none"> <li>High winds of 50 knots</li> <li>No fatalities or injuries reported</li> </ul>

Historic Occurrences of Windstorms and Tornadoes in New York City			
Date	Event	Location(s)	Description
Jan. 20, 2007	Strong Wind	Citywide	<ul style="list-style-type: none"> <li>High winds of 41 knots</li> <li>Flying construction resulted in no fatalities and 1 injury from debris</li> </ul>
Aug. 8, 2007	Tornado	Brooklyn	<ul style="list-style-type: none"> <li>EF2 tornado</li> <li>Discontinuous path</li> <li>16 homes had moderate to severe roof damage</li> <li>Tornado tore the roof off a car dealership</li> <li>Downed trees reported</li> <li>Event accompanied by severe flooding</li> <li>Federally declared disaster with more than \$7.2 million given in IHP funding from FEMA</li> <li>More than 3,700 residents filed claims at Disaster Assistance Service Centers</li> </ul>

**Table 43: Historic Occurrences of Windstorms and Tornadoes in New York City**

## **b) Vulnerability Assessment**

### **i) Impact to New York City**

High-wind events can pose a serious threat to people and infrastructure. New York City's dense urban environment provides numerous objects that can become flying debris and severely injure people and damage structures. Areas with tall buildings such as Midtown Manhattan, the Financial District, and Downtown Brooklyn are at a greater risk because of increased wind pressures at greater heights. While these structures can withstand strong winds, glass windows pose a fatal threat if broken. Construction sites are also especially vulnerable to high winds. Loose tools and construction materials, cranes, scaffolding, and other building appurtenances may become loose from exposure to high winds.

### **ii) Structural Vulnerability**

Structural vulnerability to wind is related to the building's construction type. Wood structures and manufactured homes are more susceptible to wind damage, while steel and concrete buildings are more resistant. Less than 0.1% of the City's buildings are manufactured housing and 54% are wooden structures. Staten Island has the highest percentage of structure vulnerable to windstorms and tornadoes with 93% of the borough's structures made of wood.

The New York City Construction Code addresses high winds in a dense, high-rise environment. The Construction Code establishes wind-exposure categories to set design requirements for new buildings. These requirements account for location, surroundings,

and occupancy to ensure buildings can withstand extreme wind. For example, buildings along the coastline are subject to higher wind loads, as are buildings more than 300 feet.

**iii) Potential Loss Estimate**

It is difficult to estimate potential losses to specific structures because wind is a citywide hazard. More information regarding New York City's physical and structural vulnerability is located in section 3 on page 12.