15. Winter Storms

A. Hazard Profile

i. Hazard Description

New York City winters usher in heavy snow and ice. Heavy snow generally means snowfall accumulating to four inches or more in depth in 12 hours or less, or snowfall accumulating to six inches or more in depth in 24 hours or less. According to the National Climatic Data Center, the city averages 26.7 inches of snowfall annually. While snow and ice are the defining features of New York City's winter storms, wind gusts and frigid temperatures (see Section 10. Extreme Temperatures) can also accompany these weather events.

The primary types of wintry precipitation are snow, sleet and freezing rain. Snow is precipitation in the form of ice crystals, mainly of intricately branched, hexagonal form and often agglomerated into snowflakes, formed directly from the freezing of the water vapor in the air. Sleet is defined as pellets of ice composed of frozen or mostly frozen raindrops or refrozen partially melted snowflakes. Freezing rain is precipitation that falls as rain, but freezes on contact with the surface, forming a glaze of ice. All types of wintry precipitation contribute to hazardous travel conditions, although freezing rain is the most treacherous.

There are different types of winter storms. The storms that can affect New York City are described in Figure 3.15.101 and below:

- **Snow showers** are brief, intense periods of snowfall resulting in accumulations of one inch or less.
- A **blizzard** is a severe snowstorm with winds of 35 miles per hour (mph) or greater and snow and blowing snow, reducing visibility to less than 1/4 mile for three hours or longer.
- A **snowsquall** has moderate to heavy snowfall accompanied by strong, gusty winds and, sometimes, lightning.
- **Thundersnow events** are accompanied by thunder and lightning.
- **Ice storms** occur when freezing rain results in dangerous accumulations of ice, usually 1/4 inch or greater.

Figure 3.15.101: Winter Weather Definitions

Snow	Precipitation in the form of ice crystals that form directly from the freezing of water vapor in the air.
Snow Showers	Snow that falls at varying intensities for brief periods with accumulations of one inch or less.
Blizzard	The following conditions prevail for at least three hours: - Sustained winds or frequent gusts to 35 miles an hour or greater. -Blowing snow which may reduce visibility to a 1/4 of a mile.
Snow Squalls	An intense, but brief period of moderate to heavy snowfall, accompanied by strong, gusty surface winds and possibly lighting. Snow accumulation may be significant.
Thundersnow	A snowstorm that includes thunder and lightning. Thundersnow can be occur when there is relatively strong instability and abundant moisture such as above a warm front.
Ice Storms	Freezing rain which can accumulate to a quarter of an inch or greater.

The impacts of winter storms can be significant, with snow and ice compromising public safety and health and the functioning of infrastructure and services. Ice storms can have a greater impact on New York City than heavy snowfall because these storms develop quickly and have a greater chance of downing overhead power and telecommunications lines, resulting in loss of power and communication ability. Accumulations of ice make walking and driving extremely dangerous. In addition, ice accumulations can make roads impassable and affect rail beds and the mass transit switch system. Winter storms in general can be especially hazardous for people who work outdoors, those who are homeless, those without adequate home heat, and at-risk populations such as seniors and children.

ii. Severity

The severity of a winter storm depends on several factors including temperature, wind speed, type of precipitation, and rate of deposition. The time of year a storm hits also affects its severity. For example, a storm that occurs during the early winter months, when trees still have leaves, may result in more downed trees and power lines because the leaves hold the accumulation of snow and ice.

The severity of a winter storm can be classified by meteorological measurements and societal impacts. The Northeast Snowfall Impact Scale (NESIS), (see Figure 3.15.102) characterizes and ranks high-impact Northeast snowstorms—those with large areas of snowfall accumulations of 10 inches and greater—and was developed because of the transportation and economic impacts Northeast snowstorms can have on the rest of the country.

Figure 3.15.102: Northeast Snowfall Impact Scale (NEIS)

CATEGORY	DESCRIPTION
1	Notable
2	Significant
3	Major
4	Crippling
5	Extreme

The NESIS index differs from other meteorological indices in that it uses population information in addition to meteorological measurements to give an indication of a storm's societal impact. NESIS scores are a function of the area affected by the snowstorm, the amount of snow, and the number of people living in the path of the storm. The snowfall and population information are combined in an equation that calculates a NESIS score, which varies from around one for smaller storms to over 10 for extreme storms, with largest NESIS values resulting from storms producing heavy snowfall over large areas that include major metropolitan centers. The raw score is then converted into one of the five NESIS categories: Notable, Significant, Major, Crippling, and Extreme. Since 1798, New York City has experienced 19 snowstorms with snowfall totaling 16 inches or greater. According to NESIS, of these 19 storms, one was Extreme, five were Crippling, five were Major, three were Significant, and one was Notable. The remaining 12 historical snowstorms did not qualify for a NESIS rank.

iii. Probability

Winter storms are frequent occurrences in New York City. Based on historical frequency, it is probable that New York City will experience a winter storm with 16 inches or more of snow approximately once every nine years. Thundersnow events are rare in New York City—there have been only two reported events—and less likely to occur in the winter months than they are during months of warmer weather.

iv. Location

All areas of New York City are susceptible to winter storms. However, during these events, snowfall totals can vary widely across the city. For example, during the winter storm on December 26 and 27, 2010, snowfall ranged from 13 inches in Queens to 29 inches in Staten Island (see Table 3.15.70).

Table 3.15.70: Inches of Measured Snowfall December 26 and 27, 2010 (Source: National Weather Service)

Great Kills	Central Park	LaGuardia Airport	Kennedy Airport
29.0	20.0	13.0	15.6

v. Historic Occurrences

Table 3.15.71, below, identifies major winter storms in New York City from 1798 to 2013. Between 1953 and 2013 there have been three presidential disaster declarations for winter snowstorms and blizzards in New York City.

Table 3.15.71: Selected Major Winter Storms in New York City 1798 to 2013

Date	Name	Total (inches)	NESIS	Comments
November 19 to 21, 1798	The Long Storm	~18	N/A	• Snow from Maryland to Maine
January 26 to 28, 1805	N/A	~24	N/A	• 48 hours of continuous snow
January 14 to 16, 1831	The Great Snow-storm	~15	N/A	• Rivals the "Storm of the Century" of 1993 for expansiveness of coverage
January 26 to 28, 1836	The Big Snow	~15	N/A	• Interior sections see widespread 30- to 40-inch tallies
March 12 to 14, 1888	The Blizzard of '88	21	4	• Extreme blizzard conditions leave behind more than 50 inches of snow in some areas of Connecticut and the Hudson Valley
March 16 to 18, 1892	St. Patrick's Day Snowstorm	15.4	N/A	• Largest snowstorm on record for many areas of the South
February 17 to 18, 1893	N/A	17.8	N/A	• Follows a warm spell when temperatures reached as high as 54°F
February 25 to 27, 1894	N/A	15.2	N/A	• Before the storm, temperatures start out around 0°F before rising to just above freezing
February 12 to 13, 1899	The Blizzard of 1899	16	4	• Temperatures in the single digits for most of the storm
February 4 to 7, 1920	N/A	17.5	N/A	• Parts of Westchester receive more than 20 inches of snow
January 22 to 24, 1935	N/A	17.5	N/A	• Snow from Gulf Coast to Maine
March 7 to 8, 1941	N/A	18.1	N/A	• Quick drop-off of snow toward the coast with parts of New Jersey and Eastern Suffolk reporting less than 10 inches
December 26 to 27, 1947	Big Snow	26.4	2	• Worst blizzard since 1888 and record-holder until 2006
December 19 to 20, 1948	N/A	16	N/A	• 20-hour duration • Widespread totals of 12 to 18 inches across the metropolitan area
December 11 to 12, 1960	N/A	15.2	3	• 20.4 inches of snow recorded at Newark, NJ • 17 inches at the Battery, NYC
February 3 to 4, 1961	N/A	17.4	4	• Storm follows prolonged cold period (16 days of tempera-tures in the teens and 20s) • JFK Airport records 24 inches
February 6 to 7, 1967	N/A	15.2	2	• Blizzard conditions produce totals of more than 20 inches of snow in parts of New Jersey
February 9 to 10, 1969	Lindsay Storm	15.3	2	• Mayor John Lindsay receives criticism after sections of New York City remained unplowed for a week

Date	Name	Total (inches)	NESIS	Comments
February 5 to 7, 1978	Blizzard of '78	17.7	3	• Long Island and New England hardest hit • Near hurricane-strength winds • Thundersnow reported • 36-hour storm duration
February 19, 1979	President's Day Snowstorm I	12.2	N/A	• Fast-moving snowstorm brings 12.2 inches of snow to the city • Heaviest snowfall ranged from 18.7 to 20 inches in Washington, D.C. and Baltimore, MD
February 11 to 12, 1983	Megalopolitan Snowstorm	17.6	4	• Occurs during one of the strongest El Niños of the 20th century
March 12 to 14, 1993	Storm of the Century	12.2	N/A	• Tremendous snowfall leaves 13 inches of snow in Birmingham, AL, and 36 inches in Syracuse, NY • Dozens of tornadoes reported in the South • Storm ranks as one of the most deadly and costly weather events in the 20th century
January 7 to 8, 1996	Blizzard of 1996	20.2	5	• Snow accumulation of more than 30 inches across portions of New Jersey • New York City schools closed for the first time since Blizzard of '78 • Federally declared disaster (DR-1083), with $21.3 million in eligible damages for all affected counties
February 16 to 17, 2003	Presidents' Day Snowstorm II	19.8	4	• 25.6 inches of snow recorded at JFK Airport • Federally declared disaster (EM-3184), with $33.7 million in Public Assistance (PA) funds authorized for New York City and 17 counties
February 11 to 12, 2006	Blizzard of 2006	26.9	3	• Largest snowstorm in New York City history • Thundersnow reported
December 26 to 27, 2010	Blizzard of 2010	20	3	• New York Airports close • Public transportation severely hampered • Delayed snow removal • 8,000 customers lose power in New York City • Federally declared disaster (DR-1957), with $37.7 million in PA funds made available for New York City ($30.6 million in Emergency Work and $7.4 Million in Permanent Work)
February 25 to 26, 2010	N/A	20.9	3	• Extensive damages and power outages from wet snow North of the New York City • 3rd major Eastern snowstorm in February • Fallen tree causes 1 fatality • Causes major flight delays at New York City airports
January 26 to 27, 2011	N/A	19	1	• Snowfall rates of over 3 inches per hour • New York City public schools close

According to the National Weather Service (NWS), the five snowstorms with the greatest snowfall in New York City were:

(1) 26.9 inches on February 11 to 12, 2006

(2) 26.4 inches on December 26 to 27, 1947

(3) 21 inches on March 12 to 14, 1888

(4) 20.9 inches on February 25 to 26, 2010

(5) 20 inches on December 26 to 27, 2010

B. Vulnerability Assessment

i. Social Environment

A major winter storm affects the health, safety, and daily routine of New Yorkers and causes significant economic losses for businesses and City government.

The public's risk from winter storms varies by population group. Among the people most at risk are laborers or individuals who spend time outdoors, and the homeless. Also at greater risk are seniors, children, persons in poor physical health, and those without adequate heat in their homes. The ability to tolerate colder weather is contingent on age. Older individuals have decreased thermoregulatory ability and also have difficulty compensating for sudden temperature change. At the other end of the age scale, children lose body heat much faster than adults. In addition, underweight individuals lose body heat at a faster rate than those with greater body weights.

Public health concerns during winter storms include frostbite, hypothermia, exacerbation of pre-existing respiratory and cardiovascular conditions, and carbon monoxide poisoning (due to poorly ventilated gas ranges and kerosene space heaters or, in the case of power outages, generators or grills used indoors). Health risks may also include slips and other injuries related to icy, snowy streets; back injuries from strenuous shoveling; and electrocution from contact with a downed power line.

Accumulations of snow and ice can affect public safety in other ways. The collapse of building roofs and the downing off trees and power lines can put people at risk. When heavy snow and ice disrupt the city's infrastructure and services, commuters and travelers can be stranded, the flow of supplies can be impeded, and emergency and medical services can be impaired. The greatest danger during winter storms in New York City is the risk of automobile accidents. Even small accumulations of ice on roadways can be extremely dangerous to motorists and pedestrians.

During and after winter storms, the loss of business and the challenge of snow removal and repairs can have a severe economic impact on New York City. Commercial and financial businesses may see revenue and productivity losses, although this is usually short-term. Government services may also be affected. A large snowstorm will significantly increase costs to City agencies. The Department of Sanitation (DSNY), Department of Transportation (DOT), and Department of Parks & Recreation (DPR) will incur additional costs related to snow and ice removal and pothole repair.

There are no standard loss estimation models or methodologies for winter storms. Potential losses from winter storms are, in most cases, indirect and therefore difficult to quantify. In May 1994, the New York City Office of the Comptroller conducted a study of the fiscal and economic impact of the winter of 1993 to 94. The study revealed that the winter's unseasonably cold and snowy weather cost the City about $50 million more than a normal winter ($76 million when adjusted for inflation to 2008 dollars). Of this, $35.7 million was from additional costs to City agencies (DSNY, DOT, and DPR) and snow-related claims against the City. The other $14.7 million was from lost City revenues, such as parking meters and towing fees, and lost savings from the City's energy plan.

More recently, the blizzard on December 26 and 27 of 2010 is estimated to have cost the City of New York over $68 million. The Metropolitan Transportation Authority lost $30 million due to overtime expenses and lost ridership revenue. Furthermore, holiday and weekend pay for workers called in to operate buses, subways, railroads, and crossings totaled $14 million. Total costs related to the storm were reported to exceed $38.8 million, which was the entire City's snow

budget for the year. A majority of the costs were due to overtime pay for DSNY workers.

ii. Built Environment

Winter storms can affect both buildings and infrastructure. Accumulations of snow and ice can cause roofs to collapse and knock down trees and power lines.

Structural damage or building collapses because of snow are very rare in New York City. However, buildings with flat rooftops may be at greater risk than other buildings. This is because snow can more easily accumulate on flat roofs and cause damage, even to the point of jeopardizing the building's structural soundness. As the snow melts, it can collect in depressed or recessed areas of a flat roof—a condition commonly called "ponding"—because the water cannot easily travel off the surface. This additional weight, or load, can lead to leaks, roof damage, or even building collapse.

Chapter 16 of the New York City Building Code governs the structural design of buildings and provides minimum design loads, load combinations, and procedures for determining snow loads. The Department of Buildings bases snow loads on New York City regional climate value for ground snow load and incorporates thermal factors for heated and unheated buildings. There are also provisions for snowdrifts caused by parapets and adjacent buildings.

Ice storms can also have a significant impact on infrastructure and transportation. Ice can disrupt communication and power for days while utility companies repair damage. In addition, ice accumulations can affect rail beds and the public transit switch system. Bridges and overpasses are particularly dangerous because they freeze before other surfaces. Fire hydrants could also be snowed in, compromising the ability of the Fire Department of New York to suppress fires.

iii. Natural Environment

Heavy accumulations of ice can bring down trees. In addition, when snow and ice melts, it creates runoff that flows into the city's sewer system. The increased volume of runoff combined with sanitary waste may exceed the capacity of the City's wastewater treatment plants. When the plants cannot handle the excess volume, untreated wastewater is discharged into local waterways (see section 18. Infrastructure Failures).

iv. Future Environment

According to the New York City Panel on Climate Change, climate change projections indicate that in the future snowfall will decline in frequency and the length of snow seasons will likely decrease. Nevertheless, the intensity of snowfall per storm is highly uncertain, and it is unknown whether the frequency and intensity of ice storms and freezing rain will change.

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