



Appendix A

General Hazard Descriptions

The following is a general description for each of the hazards listed below. The complete profile for each hazard can be found in Section 4.3 of the 2016 Union County Multi-Jurisdictional Hazard Mitigation Plan.

General descriptions completed for the following hazards.

1. Dam Failure
2. Drought
3. Earthquake/Geological
4. Erosion–Hurricane/Nor’easter/Tropical Storm
5. Extreme Temperature–Cold
6. Extreme Temperature–Heat
7. Flood
8. Hail
9. Hazardous Materials Release–Fixed Site
10. Hazardous Materials Release–Transportation
11. High Wind–Straight-Line Winds
12. High Wind–Tornado
13. Ice Storm
14. Landslide (non-seismic)
15. Severe Storm–Lightning
16. Severe Storm–Winter Weather
17. Storm Surge–Hurricane/Nor’easter/Tropical Storm
18. Wildfire

D-1 Dam Failure

D-1.1 Definition of Dam Failure Hazard

A dam is defined by the New Jersey Department of Environmental Protection (NJDEP) as any artificial dike, levee, or other barrier, which is constructed for the purpose of impounding water on a permanent or temporary basis, that raises the water level five feet or more above the usual, mean, low water height when measured from the downstream toe-of-dam to the emergency spillway crest or, in the absence of an emergency spillway, the top-of-dam.¹

A dam failure can be defined as the unintended release or surge of impounded water. A failure can cause significant property damage, injury, and in some cases death downstream of where the dam failed. The severity of a dam failure can also vary widely. There is the potential for total collapse of a dam, but less significant failures are more likely as a result of an overtopping (inadequate spillway design, debris blockage), foundation defects, or seepage. Overtopping of a dam during a flood event due to clogged debris has the potential to be catastrophic. In 1972 the Dam Failure in Rapid South Dakota occurred after the Canyon Lake Dam became clogged with debris and the dam was overtopped.²

Figure D-1.1-1
Canyon Lake Dam Failure in 1972
(Source: USGS)



¹ NJDEP. Retrieved from <http://www.nj.gov/dep/>

² USGS. Retrieved from <http://www.usgs.gov/>



D-2.2 Characteristics of Dam Failure

Dam failures can result from a variety of causes including lack of maintenance, seismic activity, improper design or construction, or during large storm events. Significant rainfall can quickly inundate an area and cause floodwaters to overwhelm a reservoir. If the spillway of the dam cannot safely pass the resulting flows, water will begin flowing in areas not designed for such flows and failure may occur.³

Intense storms may produce a flood in a few hours or even minutes for upstream locations. Flash floods can occur within several hours of the beginning of heavy rainfall, and dam failure may occur within hours of the first signs of breaching. Other failures can take much longer to occur, from days to weeks, as a result of debris jams or the accumulation of melting snow.⁴

³ NJDEP. Retrieved from <http://www.nj.gov/dep/>

⁴ FEMA. Retrieved from <http://www.fema.gov/>



D-2 Drought

D-2.1 Definition of Drought Hazard

A drought is an extended dry climate condition when there is not enough water to support urban, agricultural, human, or environmental water needs. It usually refers to a period of below-normal rainfall, but can also be caused by drying bores or lakes, or anything that reduces the amount of liquid water available. Drought is a recurring feature of nearly all the world's climatic regions.

Drought is the result of a decline in the expected precipitation over an extended period of time, typically one or more seasons in length. Meteorological drought is defined solely on the degree of dryness, expressed as a departure of actual precipitation from an expected average or normal amount based on monthly, seasonal, or annual time scales. Hydrological drought is related to the effects of precipitation shortfalls on streamflows and reservoir, lake, and groundwater levels. Agricultural drought is defined principally in terms of soil moisture deficiencies relative to water demands of plant life, usually crops. Socioeconomic drought associates the supply and demand of economic goods or services with elements of meteorological, hydrologic, and agricultural drought. Socioeconomic drought occurs when the demand for water exceeds the supply as a result of weather-related supply shortfall. This may also be called a water management drought.

Figure D-2.1-1
Boy Wheeling Water During Drought
(Source: FEMA)





D-2.2 Characteristics of Drought

Drought produces a complex web of impacts that spans many sectors of the economy and reaches well beyond the area experiencing physical drought. This complexity exists because water is integral to our ability to produce goods and provide services. Impacts are commonly referred to as direct or indirect. Reduced crop, rangeland, and forest productivity; increased fire hazard; reduced water levels; increased livestock and wildlife mortality rates; and damage to wildlife and fish habitat are a few examples of direct impacts. The consequences of these impacts illustrate indirect impacts. For example, a reduction in crop, rangeland, and forest productivity may result in reduced income for farmers and agribusiness, increased prices for food and timber, unemployment, reduced tax revenues because of reduced expenditures, increased crime, foreclosures on bank loans to farmers and businesses, migration, and disaster relief programs.

Drought differs from other natural hazards in three ways. First, the onset and end of a drought are difficult to determine due to the slow accumulation and lingering effects of an event. Second, the lack of an exact and universally accepted definition adds to the confusion of its existence and severity. Third, in contrast with other natural hazards, the impact of drought is less obvious and may be spread over a larger geographic area. These characteristics have hindered the preparation of drought contingency or mitigation plans by many governments.

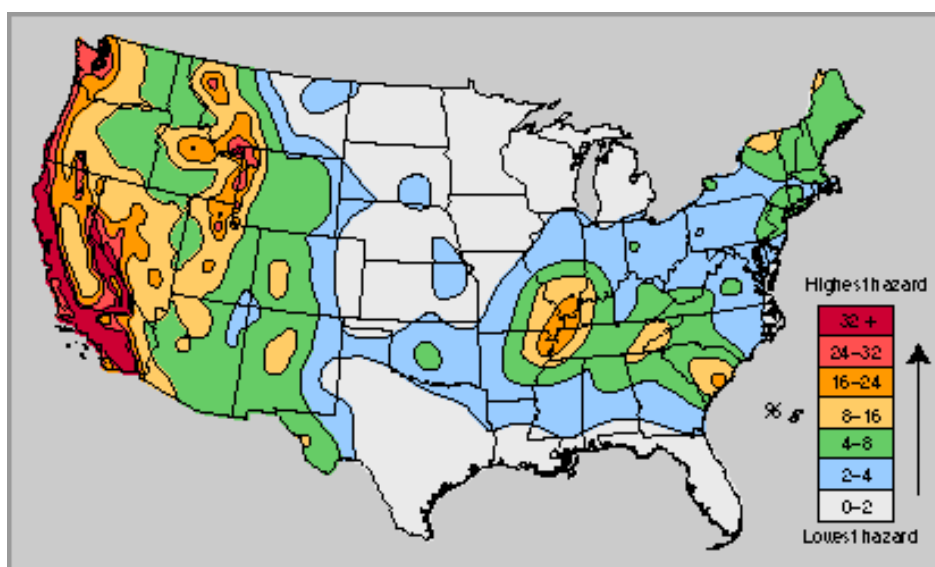
Droughts may cause a shortage of water for human and industrial consumption and cause a decrease in hydroelectric power. Water quality may also decline while the number and severity of wildfires may increase. Severe droughts may result in the loss of agricultural crops and forest products, undernourished wildlife and livestock, lower land values, and higher unemployment.

D-3 Earthquake/Geological

D-3.1 Definition of Earthquake Hazard

An earthquake is "...a sudden motion or trembling caused by an abrupt release of accumulated strain in the tectonic plates that comprise the earth's crust." These rigid plates, known as tectonic plates, are some 50 to 60 miles in thickness and move slowly and continuously over the earth's interior. The plates meet along their edges, where they move away from or pass under each other at rates varying from less than a fraction of 1" up to 5" per year. While this sounds small, at a rate of 2" per year, a distance of 30 miles would be covered in approximately 1 million years.⁵ Figure D-3.1-1 shows a US Geological Survey (USGS) seismic probability map for the continental United States.

Figure D-3.1-1
United States Earthquake Zones
(Source: USGS)



D-3.2 Characteristics of Earthquakes

The vibration or shaking of the ground during an earthquake is described by ground motion. Severity of ground motion generally increases with the amount of energy released and decreases with distance from the fault or epicenter of the earthquake. Ground motion causes waves in the earth's interior, also known as seismic waves, and along the earth's surface, known as surface waves. The following are the two kinds of seismic waves:

- P (primary) waves are longitudinal or compressional waves similar in character to sound waves that cause back-and-forth oscillation along the direction of travel (vertical motion),

⁵ FEMA, 1997.

- with particle motion in the same direction as wave travel. They move through the earth at approximately 15,000 mph.
- S (secondary) waves, also known as shear waves, are slower than P waves and cause structures to vibrate from side-to-side (horizontal motion) due to particle motion at right-angles to the direction of wave travel. Unreinforced buildings are more easily damaged by S waves.
 - Earthquakes are often relatively short duration, but there may be aftershocks and other effects (such as liquefaction) that prolong and exacerbate their effects. The potential for either of these effects depends on local conditions and other technical factors that are not discussed in this Plan.

There is some potential for seismic activity virtually anywhere on the earth. Locations that are close to tectonic faults, however, are much more likely to be impacted by earthquakes than other places. The USGS and other organizations develop maps to indicate the relatively probability of earthquakes in particular areas.

Figure D-3.2-1
Earthquake Damage
(Source: FEMA)





D-4 Erosion

1.1.1

(Incl

uding Hurricane/Nor'easter/Coastal Storm)

D-4.1 Definition of Erosion

Coastal erosion is the wearing away of land or the removal of beach or dune sediments by wave action, tidal currents, wave currents, wind, or drainage. Coastal erosion is a dynamic process that is constantly occurring at varying rates along the coasts and shorelines of the United States. Numerous factors can influence the severity and rate of coastal erosion including human activities, tides, the possibility of rising sea levels, and the frequency and intensity of hurricanes. Strong storms and hurricanes can erode large sections of coastline with a single event. The process of coastal erosion results in permanent changes to the shape and structure of the coastline. Human activities such as poor land use practices and boating activities can also accelerate the process of coastal erosion.

D-4.2 Characteristics of Erosion

Coastal erosion is a dynamic process that is constantly occurring at varying rates along the coasts and shorelines of the United States. Numerous factors can influence the severity and rate of coastal erosion including human activities, tides, the possibility of rising sea levels, and the frequency and intensity of hurricanes. Strong storms and hurricanes can erode large sections of coastline with a single event. The process of coastal erosion results in permanent changes to the shape and structure of the coastline. Human activities such as poor land use practices and boating activities can also accelerate the process of coastal erosion.

Billions of dollars of economic development are potentially threatened by the impacts of coastal erosion. In a report to Congress in the year 2000, the Federal Emergency Management Agency estimated that erosion may cost property owners along the coast \$500 million a year in structural damages and loss of land. The report also stated as many as 87,000 residential homes may be at risk of eroding into the oceans or Great Lakes over the next 60 years.

A range of studies have assessed the susceptibility of the New Jersey coast to erosion. Several of the more significant studies have included a report by the United States Army Corps of Engineers (USACE) in 1971, a study by the NJDEP in 1981, and study by the Rutgers University Institute of Marine and Coastal Sciences in 1996. The 1971 study conducted by the USACE considered economic, ecological, and other variables along with physical measures of shoreline change to determine the severity of New Jersey coastal erosion. The study classified the majority of the New Jersey coastline as critically eroding. A successive study by the NJDEP in 1981 calculated the severity of shoreline erosion (considering only physical factors) and categorized 32.9 % as critically eroding, 18 % as significantly eroding, 38.5 % as moderately eroding and 10.6 % as non-eroding.⁶

In southern New Jersey the Town of Cape May Pont is vulnerable to beach erosion due to waves from the Atlantic Ocean and the Delaware Bay. The Town is roughly a mile long beachfront community

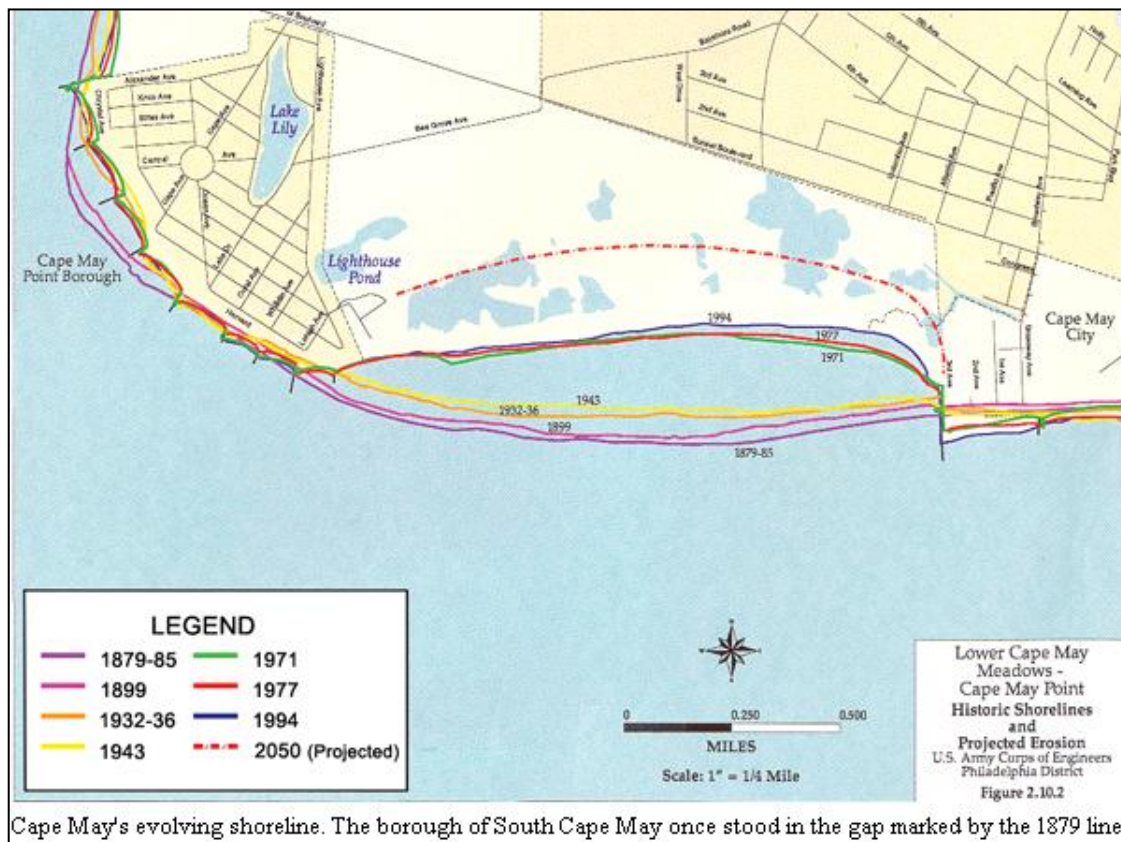
⁶ Future Sea Level Rise and the New Jersey Coast, June 2005



located on the southern tip of New Jersey. Between 1994 and 2002, the USACE installed several Beach Saver Reefs and a Double-T sill (inverted double fabricated parking garage floor) to limit the effects of coastal erosion. The Double T sill was installed to retain sediment behind the structure and create a perched beach.

Since 2002, the USACE has been closely monitoring the project completing numerous surveys including profiles and settlement surveys, sediment samples, and wave and current measurements.⁷ Figure D-4.1-1 shows the past and project shoreline along the Cape May, New Jersey coastline.

Figure D-4.1-1
Cape May, New Jersey Shoreline Map (1879-2050)
(Sources: USACE)



⁷ U.S Army Corps of Engineers – Coastal and Hydraulics Laboratory



D-5 Extreme Temperature–Cold

D- 5.1 Definition of Extreme Temperature (Cold)

The extreme cold hazard can be defined as temperatures that are significantly below normal. The severity of extreme temperature events are measured by temperature, duration and humidity. Most events are of less than a week in duration but can occasionally last for longer periods up to several weeks.

A cold wave is classified as a rapid drop of 20°F, to below between 28°F and 10°F, depending on the time of year and whether the drop occurs in the southern or northern half of the state, within a 24-hour period. When this occurs, outdoor industrial, commercial, agricultural and social activity must be curtailed or additional precautions taken.

D-5.2 Characteristics of Extreme Temperature (Cold)

The consequences of extreme cold on humans are intensified by high winds which increase the rate of heat loss and has the effect of making it feel colder than the actual air temperature. Wind chills can make extreme cold temperatures even more dangerous. Very strong winds combined with temperatures slightly below freezing can have the same chilling effect as a temperature nearly 50°F lower in a calm atmosphere. Arctic explorers and military experts have developed what is called the *wind-chill factor*, which calculates an equivalent calm-air temperature for the combined effects of wind and temperature. In effect, the index describes the cooling power of air on exposed flesh and to a lesser extent a clothed person. Wind-chill temperatures throughout New Jersey annually fall below 0°F a number of times each winter.

At very cold temperatures, the most serious concern is the risk of hypothermia or dangerous overcooling of the body. Extreme cold temperatures combined with high winds can lead to frostbite or freezing of the exposed extremities such as fingers, toes, nose and ear lobes. Hypothermia could be fatal in absence of immediate medical attention.

Cold weather injuries are summarized as follows:

- **Frostnip:** The freezing of the top layers of skin tissue and is normally reversible. It mostly affects the cheeks, earlobes, fingers, and toes. Symptoms include numbness, top layer of skin feeling hard and rubbery, but deeper tissue is soft. Skin becomes waxy.
- **Frostbite:** The actual freezing of the tissue and/or body part. Ice crystals form inside the skin that can destroy the tissues, potential for losing skin or part of a finger, toe, or foot. Frostbite affects the ears, nose, fingers, and toes most often. Superficial frostbite includes all layers of skin, and deep frostbite can include freezing of muscle and/or bone. Symptoms include skin that is white and has a *wooden* feel all the way through.
- **Hypothermia:** The general cooling of the body. When the body drops much below the normal temperature of 98.6°F, serious problems can arise. Severe hypothermia can lead to death. Symptoms of mild hypothermia include uncontrolled shivering, numbness of hands, and the inability to complete tasks with hands. At the point of severe hypothermia shivering stops, a person is unable to walk, and pulse and respiration rates decrease.



D-6 Extreme Temperature–Heat

D- 6.1 Definition of Extreme Temperature (Heat)

Extreme summer heat is the combination of very high temperatures and exceptionally humid conditions. If such conditions persist for an extended period of time, it is called a heat wave.⁸ Heat stress can be indexed by combining the effects of temperature and humidity, as shown in Table D-6.1-1. The index estimates the relationship between dry bulb temperatures (at different humidity) and the skin's resistance to heat and moisture transfer. The higher the temperature or humidity, the higher the apparent temperature.

Table D-6.1-1
Heat Index and Disorders
(Sources: FEMA, 1997; NWS, 1997)

Danger Category		Heat Disorders	Apparent Temperatures (°F)
IV	Extreme Danger	Heatstroke or sunstroke imminent.	>130
III	Danger	Sunstroke, heat cramps, or heat exhaustion likely; heat stroke possible with prolonged exposure and physical activity.	105-130
II	Extreme Caution	Sunstroke, heat cramps, and heat exhaustion possible with prolonged exposure and physical activity.	90-105
I	Caution	Fatigue possible with prolonged exposure and physical activity.	89-90

In the northeastern United States periods of warmer than normal temperatures typically occur several times a summer. Extreme heat waves may occur about once every five years or so where maximum daily temperatures exceed 100°F for an extended period of time. The passing of a cold front usually moderates temperatures after a few days to a week.

D-6.2 Characteristics of Extreme Temperature (Heat)

The main impact of extreme heat is its affect on the human body. In a very hot environment, the most serious concern is heat stroke. In absence of immediate medical attention, heat stroke could be fatal. Heat stroke fatalities do occur every summer. Heat exhaustion and fainting (syncope) are less serious types of illnesses which are not fatal but interfere with a person's ability to work.

⁸ FEMA, 1997.



The major human risks associated with extreme heat can be summarized as follows.

- **Heatstroke:** Considered a medical emergency, heatstroke is often fatal. It occurs when the body's responses to heat stress are insufficient to prevent a substantial rise in the body's core temperature. While no standard diagnosis exists, a medical heatstroke condition is usually diagnosed when the body's temperature exceeds 105°F due to environmental temperatures. Rapid cooling is necessary to prevent death, with an average fatality rate of 15% even with treatment.
- **Heat Exhaustion:** While much less serious than heatstroke, heat exhaustion victims may complain of dizziness, weakness, or fatigue. Body temperatures may be normal or slightly too moderately elevated. The prognosis is usually good with fluid treatment.
- **Heat Syncope:** This refers to sudden loss of consciousness and is typically associated with people exercising who are not acclimated to warm temperatures. Causes little or no harm to the individual.
- **Heat Cramps:** May occur in people unaccustomed to exercising in the heat and generally ceases to be a problem after acclimatization.



D-7 Flood

D-7.1 Definition of Flood Hazard

Flooding is the accumulation of water within a water body (e.g., stream, river, lake, or reservoir) and the overflow of excess water onto adjacent floodplains. As illustrated in Figure D-7.2-1, floodplains are usually lowlands adjacent to water bodies that are subject to recurring floods. Floods are natural events that are considered hazards only when people and property are affected. Nationwide, hundreds of floods occur each year, making them one of the most common hazards in the United States.⁹ There are a number of categories of floods in the United States, including the following:

- Riverine flooding, (river channel, flash floods, alluvial fan floods, ice-jam floods, dam breaks)
- Local drainage or high groundwater levels
- Fluctuating lake levels
- Coastal flooding, including storm surges
- Debris flows
- Subsidence

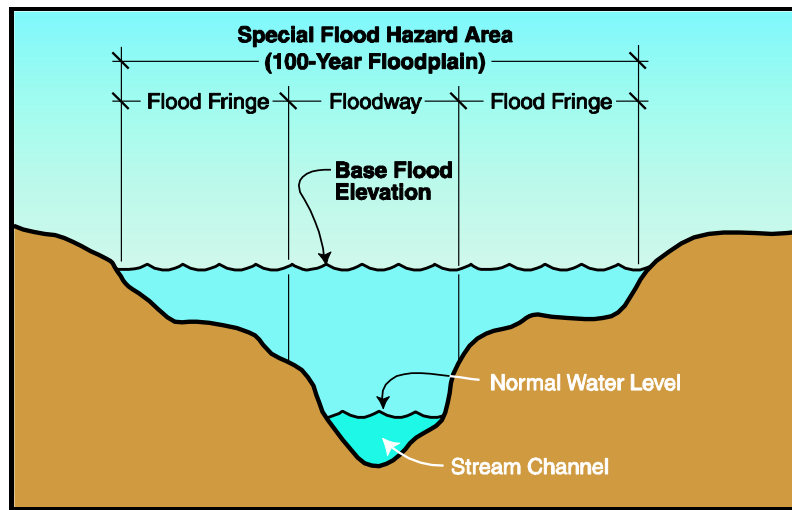
D-7.2 Characteristics of Floods

While there is no sharp distinction between riverine floods, flash floods, alluvial fan floods, ice jam floods, and dam-break floods, these types of floods are widely recognized and may be helpful in considering the range of flood risk and appropriate responses. The most common kind of flooding event is riverine flooding, also known as overbank flooding. Riverine flooding occurs as a result of excess rainfall or rapid snowmelt causing the overflow of rivers, streams, and lakes. This type of flooding occurs when the flow of rainwater runoff is greater than the carrying capacities of the natural drainage systems. There are several types of riverine floods, including headwater, backwater, interior drainage, and flash flooding.

Riverine floodplains range from narrow, confined channels in the steep valleys of mountainous and hilly regions, to wide, flat areas in plains and coastal regions. The amount of water in the floodplain is a function of the size and topography of the contributing watershed, the regional and local climate, and land use characteristics. In steep valleys, flooding is usually rapid and deep, but of short duration, while flooding in flat areas is typically slow, relatively shallow, and may last for long periods of time.

⁹ (FEMA, 1997)

Figure D-7.2-1
Floodplain Definition
(Source: FEMA, August 2001)



Flash floods involve a rapid rise in water level, high velocity, and large amounts of debris, which can lead to significant damage that includes the tearing out of trees, undermining of buildings and bridges, and scouring new channels. The intensity of flash flooding is a function of the intensity and duration of rainfall, steepness of the watershed, stream gradients, watershed vegetation, natural and artificial flood storage areas, and configuration of the streambed and floodplain. Dam failure and ice jams may also lead to flash flooding.

Alluvial fan floods occur in the deposits of rock and soil that have eroded from mountainsides and accumulated on valley floors in the pattern of a fan. Alluvial fan floods often cause greater damage than overbank flooding due to the high velocity of the flow, amount of debris, and broad area affected. Human activities may exacerbate flooding and erosion on alluvial fans via increased velocity along roadways acting as temporary drainage channels or changes to natural drainage channels from fill, grading, and structures.

Ice jam flood occur when an upstream part of a river thaws first (possibly because it flows away from the equator), and the ice gets carried downstream into the still-frozen part. Masses of ice can become lodged under bridges and other weirs, causing an ice dam, flooding areas upstream of the jam. After the ice dam breaks apart, the sudden surge of water that breaks through the dam can then flood areas downstream of the jam. While this usually occurs in spring, it can happen as winter sets in when the downstream part becomes frozen first. Dam-break floods may occur due to structural failures (e.g., progressive erosion), overtopping or breach from flooding, or earthquakes.

Local drainage floods may occur outside of recognized drainage channels or delineated floodplains for a variety of reasons, including concentrated local precipitation, a lack of infiltration, inadequate facilities for drainage and stormwater conveyance, and/or increased surface runoff. Such events often occur in flat areas, particularly during winter and spring where the ground is frozen. Drainage floods are found also in urbanized areas with large impermeable surfaces. High groundwater flooding is a seasonal occurrence in some areas, but may occur in other areas after prolonged periods of above-average precipitation.

D-8 Hail

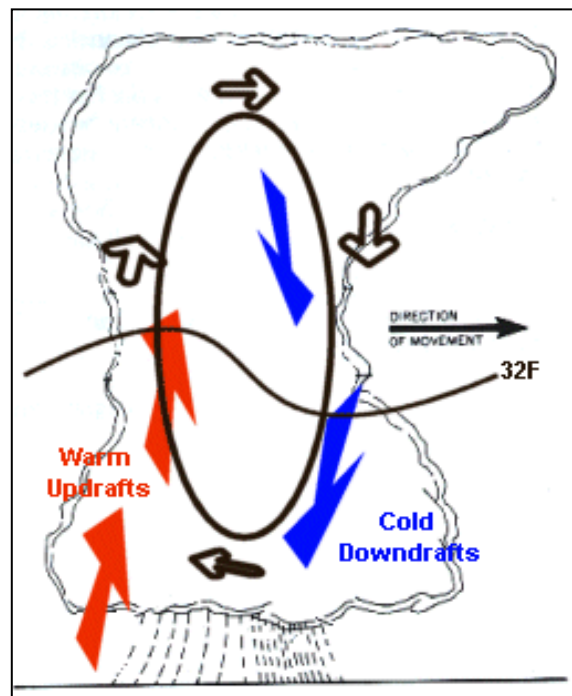
D-8.1 Definition of Hailstorm Hazard

Hail is defined as balls or pieces of ice falling as precipitation from a thunderstorm. Known as hailstones, these ice balls typically range from 5 mm-50 mm in diameter on average, with much larger hailstones forming in severe thunderstorms. The size of hailstones is a direct function of the severity and size of the storm.

D-8.2 Characteristics of Hail

Hail is an outgrowth of severe thunderstorms and develops within a low-pressure front as warm air rises rapidly in to the upper atmosphere and is subsequently cooled, as shown in Figure D-8.2-1, leading to the formation of ice crystals. These are bounced about by high-velocity updraft winds and accumulate into frozen droplets, falling as precipitation after developing enough weight.¹⁰ The National Weather Service (NWS) defines severe thunderstorms as those with downdraft winds in excess of 58 mph and/or hail at least .75" in diameter. While only about 10% of thunderstorms are classified as severe, all thunderstorms are dangerous because they produce numerous dangerous conditions, including one or more of the following: hail, strong winds, lightning, tornadoes, and flash flooding.

Figure D-8.2-1
How Hail Is Formed
(Source: NOAA)



¹⁰ FEMA, 1997.



Hailstorms occur most frequently during the late spring and early summer. During this period, extreme temperature changes occur from the surface up to the jet stream, resulting in the strong updrafts required for hail formation.

The size of hailstones varies and is related to the severity and size of the thunderstorm that produced it. The higher the temperatures at the earth's surface, the greater the strength of the updrafts, and the greater the amount of time the hailstones are suspended, giving the hailstones more time to increase in size. Hailstones vary widely in size, as shown in Table D-8.2-1. Note that penny size (.75" in diameter) or larger hail is considered severe.

Table D-8.2-1
Estimating Hail Size
(Source: NOAA)

Size	Inches in Diameter
Pea	.25 inch
Marble/mothball	.50 inch
Dime/Penny	.75 inch
Nickel	.875 inch
Quarter	1 inch
Ping-Pong Ball	1.5 inches
Golf Ball	1.75 inches
Tennis Ball	2.5 inches
Baseball	2.75 inches
Tea Cup	3 inches
Grapefruit	4 inches
Softball	4.5 inches

Figure D-8.2-2
Large Hailstone
(Source: NOAA)





D-9 Hazardous Materials Release—Fixed Site

D-9.1 Definition of the Hazardous Materials Release—Fixed Site Hazard

Hazardous materials come in the form of explosives, flammable and combustible substances, poisons, and radioactive materials. These substances are most often released as a result of transportation accidents or because of chemical accidents in plants. Hazardous materials in various forms can cause death, serious injury, long-lasting health effects, and damage to buildings, homes, and other property. Many products containing hazardous chemicals are used and stored in homes routinely. These products are also shipped daily on the nation's highways, railroads, waterways, and pipelines. This section deals those hazardous materials that occur at facilities are which are known as fixed site. The next section, D-10 deals with hazardous materials as they relate to transportation routes (off-site).

D-9.2 Characteristics of Hazardous Materials Release—Fixed Site

Varying quantities of hazardous materials are manufactured, used, or stored at an estimated 4.5 million facilities in the United States—from major industrial plants to local dry cleaning establishments or gardening supply stores. Although there are a number of Federal laws that regulate hazardous materials, including: the Superfund Amendments and Reauthorization Act of 1986 (SARA), the Resource Conservation and Recovery Act of 1976, the Hazardous Materials Transportation Act, the Occupational Safety and Health Act, the Toxic Substances Control Act, and the Clean Air Act, accidents can and do happen.

Incidents related to the release of hazardous materials can occur as a result of human carelessness, technological failure, intentional acts, and natural hazards. When caused by natural hazards, these incidents are known as secondary hazards, whereas intentional acts are terrorism. Hazardous materials releases, depending on the substance involved and type of release, can directly cause injuries and death and contaminate air, water, and soils. While the probability of a major release at any particular facility or at any point along a known transportation corridor is relatively low, the consequences of releases of these materials can be very serious.

In 1986, Congress passed the SARA of 1986. Title III of this legislation requires that each community establish a Local Emergency Planning Committee (LEPC) to be responsible for developing an emergency plan for preparing for and responding to chemical emergencies in that community. This emergency plan must include the following: an identification of local facilities and transportation routes where hazardous material are present; the procedures for immediate response in case of an accident (this must include a community-wide evacuation plan); a plan for notifying the community that an incident has occurred; the names of response coordinators at local facilities; and a plan for conducting exercises to test the plan. The plan is reviewed by the State Emergency Response Commission and publicized throughout the community. The LEPC is required to review, test, and update the plan each year.

The paragraphs below briefly describe these sources.



Right to Know Hazardous Substance List (RTKHSL) The 2007 RTKHSL contains 2,455 hazardous substances and can be found on the State of New Jersey [Department of Health and Senior Services website](#).

The Right-to-Know Network. (RTK) The Right-to-Know (RTK) Network contains data related to hazardous materials that has been compiled from various EPA databases. Several databases from the RTK site include the following:

Toxic Release Inventory (TRI). Releases and transfers of toxic chemicals from large facilities. See Occurrences of Hazardous Materials Release—Fixed Site for additional details about the TRI database and releases for Union County.

Comprehensive Environmental Response, Compensation, and Liability Information System. Information on potential and actual Superfund Sites. The majority of the sites listed for Union County are labeled as having an EPA status of “No further Remedial Action Planned” on the National Priority List.

Emergency Response Notification System. Toxic Chemicals and spills reported to the National Response Center. See past Occurrences of Hazardous Materials Release—Transportation for additional details about this database and a list of past transportation accidents in Union County.

Facility Registry System (FRS). Names, addresses, and ID numbers of all facilities regulated by the EPA.

Resource Conservation and Recovery Act information (RCRAInfo) is Environmental Protection Agency’s (EPA’s) comprehensive information system, providing access to data supporting the Resource Conservation and Recovery Act (RCRA) of 1976 and the Hazardous and Solid Waste Amendments (HSWA) of 1984. RCRAInfo replaces the data recording and reporting abilities of the Resource Conservation and Recovery Information System (RCRIS) and the Biennial Reporting System (BRS). The RCRAInfo system allows tracking of many types of information about the regulated universe of RCRA hazardous waste handlers. RCRAInfo characterizes facility status, regulated activities, and compliance histories and captures detailed data on the generation of hazardous waste from large quantity generators and on waste management practices from treatment, storage, and disposal facilities.

Each of the databases listed can be queried from the following website: <http://www.rtknet.org/>

Table 5-X provides a summary of the waste generated in Union County for the years 2003, 2005 and 2007 from the EPA’s RCRAInfo database. The table identifies federal tons managed and generated for each of these reporting years. The database identifies the total and federal waste generated. Federal waste includes only those wastes that have a federal EPA waste code – those that do not are wastes regulated by an individual state only.





Table 5-X

Hazardous Waste—Tons Generated and Tons Managed by Municipality: Union County, 2005–2007
(Source: RCRAInfo Hazardous Waste Data, December, 2012)

Municipality	# of Facilities	2003 Federal Tons Generated	Federal Tons Managed	# of Facilities	2005 Federal Tons Generated	Federal Tons Managed	# of Facilities	2007 Federal Tons Generated	Federal Tons Managed
Berkeley Heights, Township of	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00
Clark, Township of	6	131.01	131.01	8	341.30	341.31	8	188.49	188.49
Cranford, Township of	1	12.03	12.03	2	7.71	7.71	1	9.62	9.62
Elizabeth, City of	9	12,076.64	20,465.70	15	9,032.81	12,788.33	8	7,928.98	10,708.78
Garwood, Borough of	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00
Hillside, Township of	1	3.70	3.70	1	5.40	5.40	2	206.78	30.08
Industrial Hillside	1	468.80	468.80	1	247.40	494.80	0	0.00	0.00
Kenilworth, Borough of	1	68.49	65.13	4	295.87	295.87	1	150.29	150.29
Linden, City of	21	16,234.92	41,869.36	17	17,730.04	46,025.01	18	25,035.19	56,606.75
Mountainside, Borough of	1	76.33	76.33	1	39.58	39.58	2	35.35	35.35
Murray Hill	3	17.31	18.21	1	14.74	14.74	1	5.27	5.67
Plainfield, City of	2	47.02	47.02	0	0.00	0.00	0	0.00	0.00
Rahway, City of	3	10,785.54	10,785.54	2	8,225.49	8,225.49	5	7,050.92	7,050.92
Roselle, Borough of	1	298.14	298.14	1	250.70	250.70	2	219.11	226.62
Roselle Park, Borough of	1	9.25	9.25	1	21.44	21.44	0	0.00	0.00
Springfield, Township of	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00
Summit, City of	4	371.68	370.70	2	9.29	9.29	3	150.80	150.80
Union, Township of	7	2,022.24	63,551.34	5	1,458.09	60,006.82	8	1,203.57	52,604.65
Vauxhall	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00
Total	62	42,623.09	138,172.25	61	37,679.86	128,526.49	59	42,184.36	127,768.01



D-10 Hazardous Materials Release–Transportation

D-10.1 Definition of the Hazardous Materials Release–Transportation Hazard

Hazardous materials release-transportation incidents refer to uncontrollable releases of hazardous materials during transport, which pose a risk to the health, safety, property, and the environment. Small-scale incidents—those that require a response and implementation of evacuation procedures or other protective actions—are somewhat common along major US highways, but can also occur through other modes of transportation including rail, water transport (shipping and ferries), air, and pipelines.

D-10.2 Characteristics of Hazardous Materials Release–Transportation

As described in section D-9, hazardous materials come in the form of explosives, flammable and combustible substances, poisons, and radioactive materials. These substances are most often released as a result of transportation accidents or because of chemical accidents in plants. Hazardous materials in various forms can cause death, serious injury, long-lasting health effects, and damage to buildings, homes, and other property. Many products containing hazardous chemicals are used and stored in homes routinely. These products are also shipped daily on the nation's highways, railroads, waterways, and pipelines.

Data collected by the United States Department of Transportation (USDOT) in Table D-10.2-1 below shows that transportation related hazardous materials incidents are much more likely to occur on highways than through any other mode of transportation.

Table D-10.2-1
Hazardous Material Incidents by Transportation Mode Totals, 1998-2007
(Source: Hazardous Materials Information System, USDOT)

Mode of Transportation	Number of Incidents	Associated Deaths	Associated Injuries	Damages
Air	13,558	0	152	\$2,486,833
Highway	146,425	124	1,542	\$446,482,507
Railway	8,633	17	1,101	\$176,044,545
Water	280	0	20	\$3,862,240
Total	168,896	141	2,815	\$628,876,125

A one-mile radius around major transportation routes is often delineated as areas of risk if a hazardous materials incident occurs on a roadway. This demonstrates that residents and businesses near these roadways are also at risk, as chemical spills on transportation routes can impact the immediate vicinity via land, water, or air. However, incidents are not contained to these areas. There are often secondary impacts on the community following such an incident, including significant traffic congestion due to closed roadways.



D-11 High Winds–Straight-Line Winds

1.1.2 (Includes Hurricane/Nor'easter/Tropical Storm/and Other Severe Storm)

D-11.1 Definition of the Wind Hazard

Wind is the uneven horizontal movement of air resulting from the irregular heating of the earth's surface. It can range from local breezes produced by heat from land surfaces and lasting tens of minutes to powerful global winds resulting from solar heating of the earth. Severe winds typically result from hurricanes, nor'easters, tropical storms, tornadoes, thunderstorms, or winter storms.

Hurricanes, tropical storms, and typhoons, collectively known as tropical cyclones, are among the most devastating naturally occurring hazards in the United States. They present flooding, storm surge, and high wind hazards to the communities that they impact. A hurricane is defined as a low-pressure area of closed circulation winds that originates over tropical waters. A hurricane begins as a tropical depression with wind speeds below 39 mph. As it intensifies, it may develop into a tropical storm, with further development producing a hurricane. Table D-11.1-1 below identifies the criteria for each stage of development.

Table D-11.1-1
Hurricane Development
(Source: NOAA-Hurricane Basics)

Stage of Development	Criteria
Tropical Depression (development)	Maximum sustained surface wind speed is < 39 mph
Tropical Storm	Maximum sustained surface wind speed ranges from 39 mph- <74 mph
Hurricane	Maximum sustained surface wind speed is at least 74 mph
Tropical Depression (dissipation)	Decaying stages of a cyclone in which maximum sustained surface wind speed has dropped below 39 mph

Hurricanes develop from tropical cyclones, which are any type of tropical system that achieves a rotation to it. Three types of tropical cyclones that increase in intensity follow:

1. Tropical Depression. A tropical system that is made up of a large cluster of thunderstorms and has wind speeds between 23 mph and 39 mph. If a tropical depression gathers strength, it can become a tropical storm.
2. Tropical Storm. Any type of tropical system with a notable rotation and wind speeds between 39 mph and 74 mph. When a tropical storm forms, the National Hurricane Center (NHC) assigns it a predetermined name. If a tropical storm continues to gather strength, it will become a hurricane.
3. Hurricane. When a tropical cyclone gains winds in excess of 74 mph, the storm is considered a hurricane. Hurricanes are made up of different sections, all with different wind intensity.



A nor'easter is an intense low pressure system that typically occurs during the winter months and affects the coastal areas of the northeast United States and Atlantic Canada. More specifically, it describes a low pressure area, where the center of rotation is just off the coast and whose leading winds in the left forward quadrant rotate onto land from the northeast. The precipitation pattern is similar to other extra-tropical storms. These events can also cause coastal flooding, coastal erosion, and gale force winds.

D-11.2 Characteristics of Wind

Hurricanes and tropical storms are categorized based on their wind speed. Both bring strong winds and are characterized by torrential rain that often results in widespread damage. Hurricanes can produce both extreme high winds and heavy rains. Tropical storms are most often associated with heavy rains that have the potential to produce severe flooding.

Table D-11.2-1
Saffir/Simpson Hurricane Scale
(Source: NOAA)

Saffir-Simpson Hurricane Scale		
Category	Wind Speed	
	mph	knots
5	≥156	≥135
4	131-155	114-134
3	111-130	96-113
2	96-110	84-95
1	74-95	65-83
Non-Hurricane Classifications		
Tropical Storm	39-73	34-64
Tropical Depression	0-38	0-33

As shown in Table D-11.2-1, the Saffir/Simpson Hurricane Scale is used to classify storms by numbered categories. Hurricanes are classified as Categories 1 through 5 based on central pressure, wind speed, storm surge height, and damage potential.



Hurricane winds blow in a large spiral around a relative calm center known as the *eye*. The eye is generally 20 to 30 miles wide, and the storm may extend outward 400 miles. As a hurricane approaches, the skies will begin to darken and winds will grow in strength. As a hurricane nears land, it can bring torrential rains, high winds, storm surges, and severe flooding. A single hurricane can last for more than two weeks over open waters and can run a path across the entire length of the eastern seaboard. August and September are peak months during the hurricane season that lasts from June 1 through November 30.

High winds from Hurricanes and Tropical Storms are capable of imposing large lateral (horizontal) and uplift (vertical) forces on buildings. Residential buildings can suffer extensive wind damage when they are improperly designed and constructed and when wind speeds exceed design levels. The effects of high winds on a building will depend on several factors:

- Wind speed (sustained and gusts) and duration of high winds
- Height of building above the ground
- Exposure or shielding of the building (by topography, vegetation, or other buildings) relative to wind direction
- Strength of the structural frame, connections, and envelope (walls and roof)
- Shape of building and building components
- Number, size, location, and strength of openings (windows, doors, vents)
- Presence and strength of shutters or opening protection
- Type, quantity, velocity of windborne debris

Proper design and construction of residential structures, particularly those close to water or near the coast, demand that every factor mentioned above be addressed. Failure to do so may result in building damage or destruction by wind.

Figure D-11.1-1
Strong Wind Effects
(Source: FEMA)





D-12 High Wind–Tornado

D-12.1 Definition of Tornado Hazard

A tornado is a rapidly rotating funnel (or vortex) of air that extends toward the ground from a cumulonimbus cloud. Most tornadoes do not touch the ground, but when the lower tip of a tornado touches the earth, it can cause extensive damage. Tornadoes often form in convective cells such as thunderstorms or at the front of hurricanes. Tornadoes may also result from earthquake induced fires, wildfires, or atomic bombs.¹¹ The formation of tornadoes from thunderstorms is explained in Figure D-12.2.

D-12.2 Characteristics of Tornadoes

Tornadoes in the dissipating stage can appear like narrow tubes, or ropes, twisting into all manner of curls, twists, and s-shapes. These tornadoes, such as the one pictured in Figure D-12.2-2, are *roping out*, or becoming a *rope tornado*. Multiple-vortex tornadoes can appear as a family of swirls circling a common center, or may be completely obscured by condensation, dust, and debris, appearing to be a single funnel. In addition to these appearances, tornadoes may be obscured completely by rain or dust. These tornadoes are especially dangerous, as even experienced meteorologists might not spot them.

As shown in the following table, tornadoes are measured by the Fujita Scale, an empirical system that determines the severity by observed damages (last column).

Table D-12.2-1
The Fujita Tornado Scale
(Source: FEMA 1997)

Category	Wind Speed	Description of Damage
F0	40 mph-72 mph	Light damage. Some damage to chimneys; break branches off trees; push over shallow-rooted trees; damage to sign boards.
F1	73 mph-112 mph	Moderate damage. The lower limit is the beginning of hurricane speed. Roof surfaces peeled off; mobile homes pushed off foundations or overturned; moving autos pushed off roads.
F2	113 mph-157 mph	Considerable damage. Roofs torn off frame houses; mobile homes demolished; boxcars pushed over; large trees snapped or uprooted; light-object missiles generated.
F3	158 mph-206 mph	Severe damage. Roofs and some walls torn off well-constructed houses; trains overturned; most trees in forest uprooted; cars lifted off ground and thrown.
F4	207 mph-260 mph	Devastating damage. Well-constructed houses leveled; structures with weak foundations blown off some distance; cars thrown and large missiles generated.

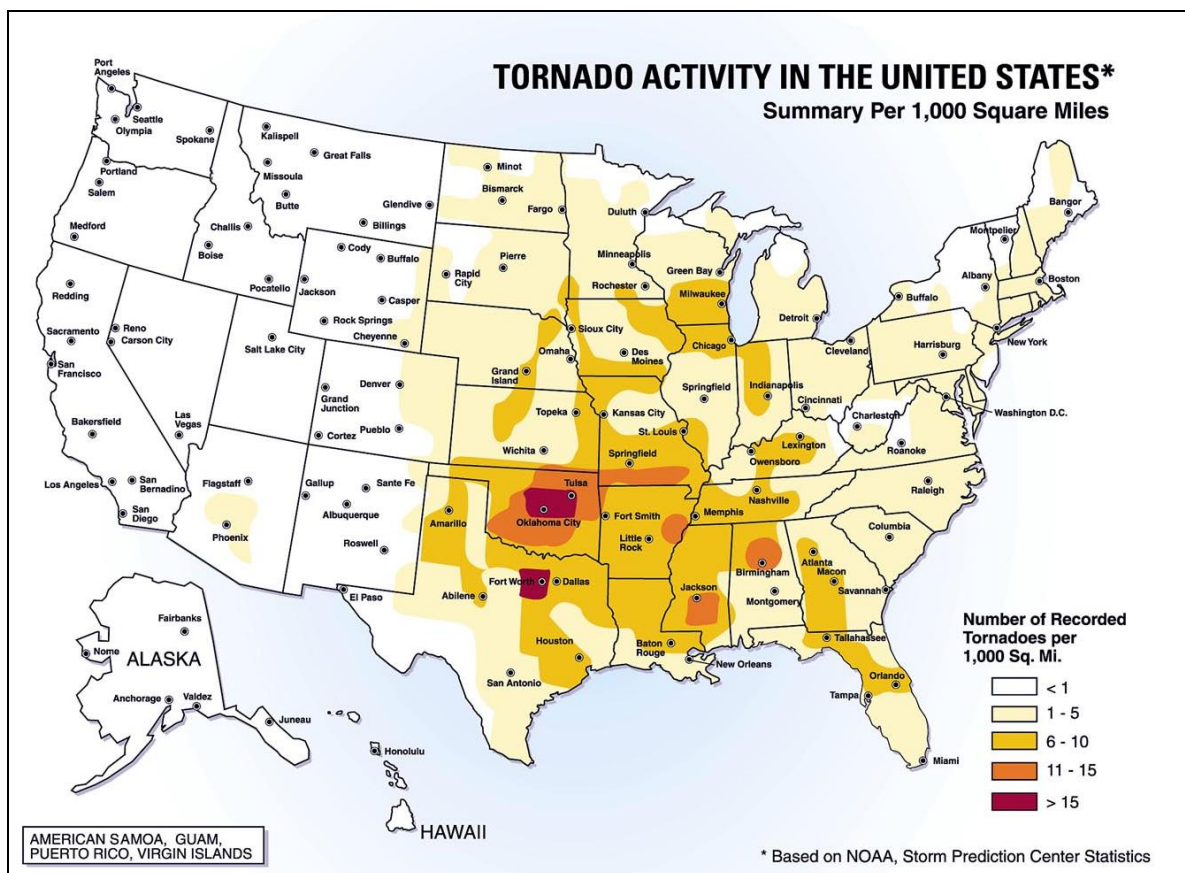
¹¹ FEMA, 1997.



Category	Wind Speed	Description of Damage
F5	261-318 mph	Incredible damage. Strong frame houses lifted off foundations and carried considerable distance to disintegrate; automobile-sized missiles fly through the air in excess of 100-yards; trees debarked.

Figure D-12.2-1 illustrates the frequency of tornado strikes in the United States per 1,000 square miles. While tornadoes can occur in any month and at all hours of the day or night, they occur with greatest frequency during the late spring and early summer months during late afternoon and early evening hours.

Figure D-12.2-1
Historic Tornado Activity in the United States,
Summary per 1,000 Square Miles
(Source: NOAA)



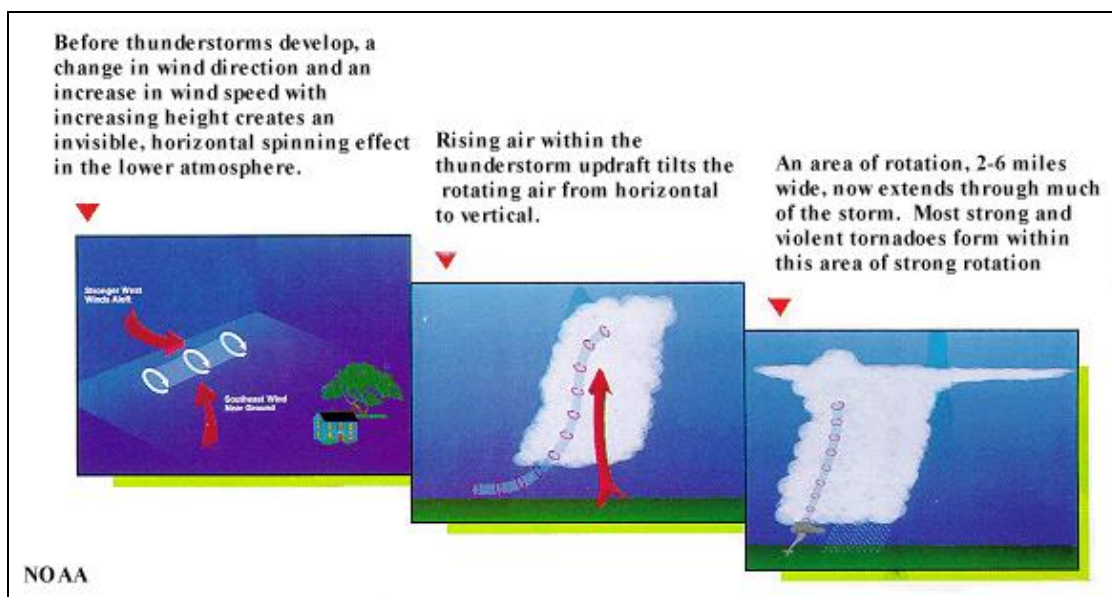
The severity and duration of tornadoes is a function of several factors, including weather conditions, topography and the F class of the event. As noted earlier, tornado severity is measured with the Fujita scale, an empirical system that classifies events after they occur. In some cases there are anomalous patterns for various reasons (including the reliability and completeness of reporting), but generally speaking smaller events are more probable, larger (more severe) ones are less likely.



Tornado duration is usually relatively short, varying from a matter of seconds to several minutes on the ground, although in rare cases they can last significantly longer. The path width of a single tornado generally is less than 0.6 miles. The path length of a single tornado can range from a few hundred yards to miles. A tornado typically moves at speeds between 30 and 125 mph and can generate internal winds exceeding 300 mph.

Most tornadoes take on the traditional appearance of a narrow funnel, a few hundred yards across, with a small cloud of debris near the ground. Tornadoes can appear, however, in all manner of shapes and sizes.

Figure D-12.2-2
Formation of Tornadoes
(Source: NOAA)



Small, relatively weak landspouts might only be visible as a small swirl of dust on the ground. While the condensation funnel may not extend all the way to the ground, if associated surface winds are greater than 40 mph (64 km/h), it is considered a tornado. Large single-vortex twisters, often violent, can look like a large wedge stuck into the ground, and are known as *wedge tornadoes* or *wedges*. Wedges can be so wide that they appear to be a block of dark clouds. Even experienced storm observers may not be able to tell the difference between a low-hanging cloud and a wedge tornado from a distance.

Table 5-X

Fujita Tornado Measurement Scale

(Source: NOAA)

Category	Wind Speed	Examples of Possible Damage
F0	Gale	Light damage. Some damage to chimneys; break branches of trees; push over shallow rooted trees; damage to sign boards.



	(40 mph-72 mph)	
F1	Moderate (73 mph-112 mph)	Moderate damage. Peel surface off roofs; mobile homes pushed off foundations or overturned; moving autos pushed off roads.
F2	Significant (113 mph-157 mph)	Considerable damage. Roofs torn off frame houses; mobile homes demolished; boxcars pushed over; large trees snapped or uprooted; light-object missiles generated.
F3	Severe (158 mph-206 mph)	Severe damage. Roofs and some walls torn off well constructed houses; trains overturned; most trees in forest uprooted; cars lifted off ground and thrown.
F4	Devastating (207 mph-260 mph)	Devastating damage. Well-constructed houses leveled; structures with weak foundations blown off some distance; cars thrown and large missiles generated.
F5	Incredible (261 mph-318 mph)	Incredible damage. Strong frame houses lifted off foundations and carried considerable distance to disintegrate; automobile sized missiles fly through air in excess of 100 yards; trees debarked; incredible phenomena will occur.

In February of 2007 the F-Scale was replaced with a more accurate Enhanced Fujita Scale (Enhanced F-scale). It was the Jarrell, Texas tornado of May 27, 1997 and the Oklahoma City/Moore tornado of May 3, 1999 that brought to the forefront the problem that perhaps the wind estimates were too high in the F-Scale. The changes to the original scale were proposed by a committee of meteorologist and engineers searching for a more accurate method of assessing the magnitude of tornadoes. The modifications made to the F-scale were limited to ensure that the new Enhanced F-scale could continue to support the original tornado database found within the NDCD.

The Enhanced F-scale is a set of wind estimates (not measurements) based on observed damages after a tornado. Its uses three-second gusts estimated at the point of damage based on a judgment of eight levels of damage to 28 indicators that include various commercial and residential building types, transmission towers, poles, and trees.

Similar to the original scale, the new Enhanced F-scale includes five classes ranging from EF0 to EF5.¹² The wind speeds from the Fujita Scale were used as basis for development of the Enhanced F-scale. The following Table displays the wind speed ranges for the original Fujita Scale, the derived wind speeds (Enhanced F-scale), and the new Enhanced F-scale currently in use since February of 2007.

¹² NOAA - Enhanced F-scale



Table 5-X

Wind Speed Comparison of the Fujita Scale and Enhanced Fujita Scale

(Source: NOAA – National Weather Service)

Fujita Scale			Derived EF Scale		Operational EF Scale	
F Number	Fastest 1/4-mile (mph)	3 Second Gust (mph)	EF Number	3 Second Gust (mph)	EF Number	3 Second Gust (mph)
0	40-72	45-78	0	65-85	0	65-85
1	73-112	79-117	1	86-109	1	86-110
2	113-157	118-161	2	110-137	2	111-135
3	158-207	162-209	3	138-167	3	136-165
4	208-260	210-261	4	168-199	4	166-200
5	261-318	262-317	5	200-234	5	Over 200



D-13 Ice Storm

D-13.1 Definition of Ice Storm Hazard

An ice storm is defined as a storm characterized by falling freezing liquid precipitation. The term ice storm is used to describe occasions when damaging accumulations of ice are expected during freezing rain situations. The frozen precipitation falls as freezing rain and forms ice accumulations usually greater than .25" thick that potentially cause extremely dangerous driving conditions and significant damage. Significant accumulations of ice can pull down trees and utility lines resulting in loss of power and communication.

When ice accumulations are anticipated to exceed .50" to .25" (depending on the state) the NWS will issue an ice storm warning.

Figure D-13.1-1
Split Tree Caused by Ice Storm
(Source: FEMA)



D-13.2 Characteristics of Ice Storms

Although snow is the weather phenomenon most commonly associated with winter, ice storms are a much greater winter menace. The freezing rain that coats all objects in a sheath of ice can cause power outages, structural damage, damaging tree falls. Ice storms occur when rain droplets fall through freezing air and but do not freeze until they touch objects such as trees, roads, or structures. A clear icy sheath, known as a glaze, forms around branches, structures and wires and has been known to bring down high-tension utility, radio, and television transmission towers. Communications and power can be disrupted for days while utility companies work to repair the extensive damage. Even small accumulations of ice may cause extreme hazards to motorists and pedestrians.¹³

¹³ NWS. Retrieved from <http://www.nws.noaa.gov/>



When air temperatures are only slightly below freezing at the surface, elevated structures such as bridges and overpasses will freeze first. This can make driving conditions extremely hazardous. As the surface temperature lowers to around 30°F or lower, the freezing rain will begin coating all objects.



D-14 Landslide (non-seismic)

D-14.1 Definition of Landslide Hazard

A landslide is a natural geologic process involving the movement of earth materials down a slope, including rock, earth, debris, or a combination of these, under the influence of gravity. However, there are a variety of triggers for landslides such as: a heavy rainfall event, earthquakes, or human activity. The rate of landslide movement ranges from rapid to very slow. A landslide can involve large or small volumes of material. Material can move in nearly intact blocks or be greatly deformed and rearranged. The slope may be nearly vertical or fairly gentle.¹⁴

D-14.2 Characteristics of landslides

Landslides are usually associated with mountainous areas but can also occur in areas of generally low relief. In low-relief areas, landslides occur due to steepening of slopes: as cut and fill failures (roadway and building excavations), river bluff failures, collapse of mine waste piles, and a wide variety of slope failures associated with quarries and open-pit mines.¹⁵



Figure D-14.2-1
Small Landslide In a
Residential Area In
New Jersey

¹⁴ Delano and Wilshusen, 2001.

¹⁵ USGS, Landslide Types and Process, 2004.



D-15 Severe Storm–Lightning

D-15.1 Definition of Lightning

Lightning is a powerful natural electrostatic discharge produced during a thunderstorm. This abrupt electric discharge is accompanied by the emission of visible light and other forms of electromagnetic radiation. The electric current passing through the discharge channels rapidly heats and expands the air into plasma producing acoustic shock waves (thunder) in the atmosphere.

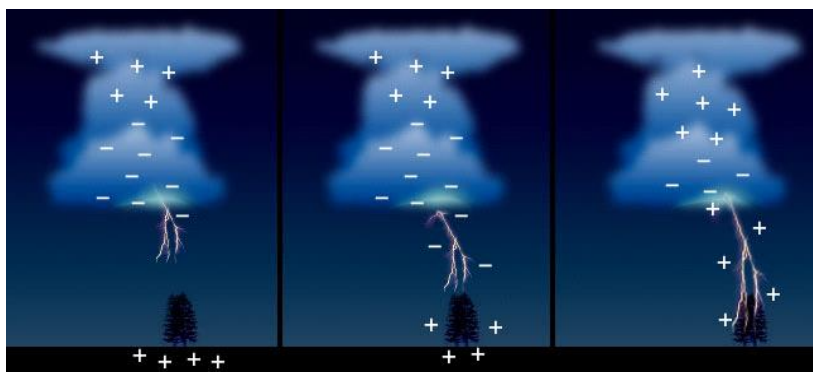
Lightning, which occurs during all thunderstorms, can strike anywhere. Generated by the buildup of charged ions in a thundercloud, the discharge of a lightning bolt interacts with the best conducting object or surface on the ground. The air in the channel of a lightning strike reaches temperatures higher than 50,000°F. The rapid heating and cooling of the air near the channel causes a shock wave, which produces thunder.

D-15.2 Characteristics of Lightning

Lightning typically occurs as a by-product of a thunderstorm. The action of rising and descending air in a thunderstorm separates positive and negative charges, with lightning the result of the buildup and discharge of energy between positive and negative charge areas. Water and ice particles may also affect the distribution of the electrical charge. In only a few millionths of a second, the air near a lightning strike is heated to 50,000°F, a temperature hotter than the surface of the sun. Thunder is the result of the very rapid heating and cooling of air near the lightning that causes a shock wave.

Figure D-15.2-1
Formation of Lightning

(Source: University Corporation for Atmospheric Research)



The hazard posed by lightning is significantly underrated. High winds, rainfall, and a darkening cloud cover are the warning signs for possible cloud-to-ground lightning strikes. While many lightning casualties happen at the beginning of an approaching storm, more than half of lightning deaths occur after a thunderstorm has passed. The lightning threat diminishes after the last sound of thunder, but may persist for more than 30 minutes. When thunderstorms are in the area, but not overhead, the



lightning threat continues to exist. Lightning has been known to strike more than 10 miles from the storm in an area with clear sky above.

Lightning is the most dangerous and frequently encountered weather hazard that most people in the United States experience annually. Lightning is the second most frequent killer in the United States, behind floods and flash floods, with nearly 100 deaths and 500 injuries annually. These numbers are likely to underestimate the actual number of casualties because of the under reporting of suspected lightning deaths and injuries. Cloud-to-ground lightning can kill or injure people by either direct or indirect means.

According to the National Oceanic and Atmospheric Administration (NOAA), an average of 20 million cloud-to-ground flashes has been detected every year in the continental United States. About half of all flashes have more than one ground strike point, so at least 30 million points on the ground are struck on average each year. In addition, there are roughly five to 10 times as many cloud-to-cloud flashes as there are to cloud-to-ground flashes.¹⁶

Figure D-15.2-2
Lightning Bolt in Night Sky
(Source: FEMA)



Cloud-to-ground lightning is nearly always associated with thunderstorms and related weather phenomena. Thunderstorms occur in most warm and hot months, and occasionally at other times as well. The entire planning area is subject to the lightning hazard. While the duration of individual lightning strikes is only milliseconds, the duration of thunderstorms that create the lightning ranges from very short periods (15 minutes or less) to long periods when the storms are relatively stationary.

Damages from lightning hazards are generally limited to those related to power surges and contact with electrical equipment. In some cases ungrounded structures are hit by lightning and experience damage, either as a direct result of the lightning or via fires secondary to the hazard. There are also reports of

¹⁶ NOAA. July 7, 2003.



brushfires being started by lightning, although these are usually relatively small and quickly contained. No reliable database or information exists to determine the cost of recovery from lightning.



D-16 Severe Storms–Winter Weather

D-16.1 Definition of the Winter Weather Hazard

Winter weather can produce storm events where the dominant type of precipitation only occur at cold temperatures, such as snow or sleet, or a rainstorm where ground temperatures are cold enough to allow ice to form (i.e. freezing rain). In temperate continental climates, these storms are not restricted to the winter season, and may occur in the late autumn and early spring. Also, there are very rare occasions when they form in summer, although it would have to be an abnormally cold summer, such as the summer of 1816 in the northeast United States. In many locations in the northern hemisphere, the most powerful winter storms usually occur in March and, in regions where temperatures are cold enough, April.

The following descriptions provide the commonly used definitions of winter storms:

- **Winter storm.** A storm with significant snowfall, ice, and/or freezing rain; the quantity of precipitation varies by elevation.
 - Non-mountainous areas - heavy snowfall is 4" or more in a 12-hour period, or 6" or more in a 24-hour period
 - Mountainous areas-12" or more in a 12-hour period or 18" or more in a 24-hour period
- **Blizzard.** A storm with considerable falling and/or blowing snow combined with sustained winds or frequent gusts of 35 mph or greater that frequently reduces visibility to less than one-quarter mile.

D-16.2 Characteristics of Winter Weather

Winter weather typically forms along a front generally following the meandering path of the jet stream. These storms, called mid-latitude cyclones or extra-tropical cyclones, differ from hurricanes, in that they move from west to east as opposed to east to west. These weather patterns carry cold air from Canada and the Rockies into the southern United States.

Winter storms vary in size and strength and include heavy snowstorms, blizzards, freezing rain, sleet, ice storms and blowing and drifting snow conditions. Extremely cold temperatures accompanied by strong winds can result in wind chills that cause bodily injury such as frostbite and death. Severe winter and ice storms can cause unusually heavy rain or snowfall, high winds, extreme cold, and ice storms throughout the continental United States.

NOAA describes the jet streams that carry storm systems across the United States as narrow bands of strong wind in the upper atmosphere that follow the boundaries between hot and cold air masses. These boundaries are most pronounced during the winter months, when the jet streams travel to their southernmost position over the United States and surrounding water.



The trajectory of the storm center, whether it passes close to the New Jersey coast or at a distance, largely determines both the intensity and the duration of the snowfall over the state. The zone of heaviest snowfall across New Jersey usually occurs in the southwest-to-northeast strip about 150 miles wide, approximately parallel to the path of the storm center, and about 125 and 175 miles northwest of it. If the center passes well offshore, only the southern part of New Jersey receives substantial snowfall. When the track passes close to shore, warm air from the ocean is drawn into the surface circulation, resulting in rain falling over southern New Jersey and snow over the rest of the state. Often, a passing storm center brings rain to the south, mixed precipitation to central sections and snow to the north.

Winter storm occurrences tend to be very disruptive to transportation and commerce. Trees, cars, roads, and other surfaces develop a coating or glaze of ice, making even small accumulations of ice extremely hazardous to motorists and pedestrians. The most prevalent impacts of heavy accumulations of ice are slippery roads and walkways that lead to vehicle and pedestrian accidents; collapsed roofs from fallen trees and limbs and heavy ice and snow loads; and felled trees, telephone poles and lines, electrical wires, and communication towers. As a result of severe ice storms, telecommunications and power can be disrupted for days. Such storms can also cause exceptionally high rainfall that persists for days, resulting in heavy flooding.



D-17 Storm Surge (Including Hurricane/Nor'easter/Coastal Storm)

D-17.1 Definition of Storm Surge Hazard

Storm Surge is defined as the onshore rush of sea or lake water caused primarily by the high winds that are associated with a landfalling hurricane, typhoon, or tropical cyclone and secondarily by the low pressure of the storm. Storm surge is simply water that is pushed toward the shore by the force of the winds swirling around the storm. This advancing surge combines with the normal tides to create the hurricane storm tide, which can increase the mean water level 15 feet or more. In addition, wind driven waves are superimposed on the storm tide. This rise in water level can cause severe flooding in coastal areas, particularly when the storm tide coincides with the normal high tides.¹⁷

D-17.2 Characteristics of Storm Surge

Storm surges are characterized by several factors that allow the displacement of water from oceans, bays or rivers to travel so far inland. Much of the coastlines along the Atlantic and Gulf Coast lie less than 10' above mean sea level. These coastal areas are also densely populated making the danger from storm tides a major concern to life and property. As shown in Figure D-17.2-1, the level of surge in a particular area is also determined by the slope of the continental shelf. A shallow slope off the coast will allow a greater surge to inundate coastal municipalities.

Municipalities with a steeper continental shelf will not see as much surge inundation, although large breaking waves can still present major problems. Storm tides, waves, and currents in confined harbors have the potential to severely damage ships, marinas, and pleasure boats.¹⁸

Figure D-17.2-1
Storm Surge
(Source: NOAA)



¹⁷ NOAA. Retrieved from <http://www.noaa.gov/>

¹⁸ NOAA. Retrieved from <http://www.noaa.gov/>

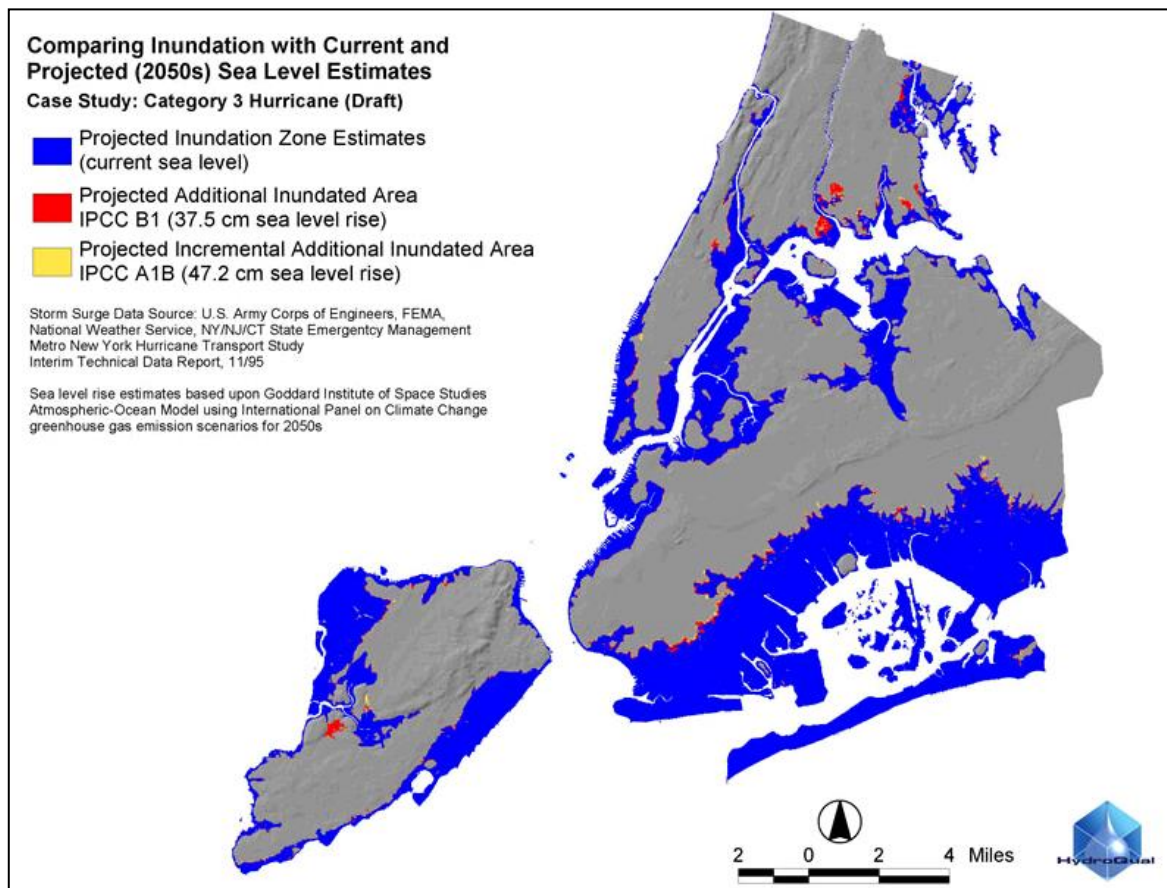


One tool used to evaluate the threat from storm surge is the Sea, Lake and Overland Surges from Hurricanes (SLOSH) Model. SLOSH is a computerized model run by the NHC to estimate storm surge heights and winds resulting from historical, hypothetical, or predicted hurricanes by taking into account

- Pressure
- Size
- Forward speed
- Track
- Winds

Graphical output from the model displays color coded storm surge heights for a particular area in feet above the model's reference level, the National Geodetic Vertical Datum, which is the elevation reference for most maps. Emergency managers often use the data produced from the SLOSH model to assist with determining which areas must be evacuated in advance of an approaching hurricane. Figure D-17.2-2 identifies the inundation zone for New York City with current and projected sea level rise for a Category 3 Hurricane on a worst-case track slightly west of the City.

Figure D-17.2-2
New York City Inundation Zones for a Category 3 Hurricane
(Sources: New York City Department of Environmental Protection, Goddard Institute for Space Studies)



D-18 Wildfire

D-18.1 Definition of Wildfire Hazard

A wildfire, also known as a forest fire, vegetation fire, grass fire, brush fire, or hill fire, is an uncontrolled fire often occurring in wildland areas, which can also consume houses or agricultural resources. Common causes include lightning, human carelessness, and arson. Wildfires are fueled by naturally occurring or non-native species of trees, brush, and grasses. Topography, fuel, and weather are the three principal factors that impact wildfire hazards and behavior.

Figure D-18.1-1
Urban Interface Fire
(Source: NOAA)



D-18.2 Characteristics of Wildfires

Wildfires often begin unnoticed, spread quickly, and are usually signaled by dense smoke that may fill the area for miles around. As mentioned, wildfires can be human-caused through acts such as arson or campfires, or can be caused by natural events such as lightning. Wildfires can be categorized into three types:

1. Wildland fires occur in very rural areas and are fueled primarily by natural vegetation.
2. Interface fires occur in areas where homes or other structures are endangered by the wildfires. The fires are fueled by both natural vegetation and man-made structures. These are often referred to as Wildland Urban Interface fires.
3. Firestorms occur during extreme weather (e.g., high temperatures, low humidity, and high winds) with such intensity that fire suppression is virtually impossible. These events typically burn until the conditions change or the fuel is exhausted.



The following three factors contribute significantly to wildfire behavior:

Fuel: The type of fuel and the fuel loading (measured in tons of vegetative matter per acre) have a direct impact on fire behavior. Fuel types vary from light fuels (grass) to moderate fuels (southern rough) to heavy fuels (slash). The type of fuel and the fuel load determines the potential intensity of the wildfire and how much effort must be expended to contain and control it.

Weather: The most variable factor affecting wildfire behavior is weather. Important weather variables are precipitation, humidity, and wind. Weather events ranging in scale from localized thunderstorms to large cold fronts can have major effects on wildfire occurrence and behavior. Extreme weather, such as extended drought and low humidity can lead to extreme wildfire activity.

Topography; Topography can have a powerful influence on wildfire behavior. The movement of air over the terrain tends to direct a fire's course.

Figure X

Wildfire Intensity Scale

(Source: Colorado State Forest Service, Wildfire Risk Assessment, 2013)

Fire Intensity Class	Description of Fire Behavior and Potential Effects	General Preparedness Recommendations
1	Very small, discontinuous flames, usually less than 1 foot in length; very slow spread rate; no spotting. Fires suppressible by lay-firefighters without specialized tools. Very little potential for harm or damage. Fires of this intensity occur on the flanks and rear of large fires, and near the beginning and end of burning periods. These fires are relatively rare due to their slow spread rate and easy control.	Basic preparedness measures will better protect your home and property.
2	Small flames, usually less than two feet long; small amount of very short range spotting possible. Fires easily suppressed by trained hand crews with protective equipment and firefighting tools. Little potential for harm or damage. This intensity class can occur at the head of a fire in a mild fire environment or on the flanks and rear of fires in more severe fire environments. This intensity class is very common, especially on fires not being actively suppressed.	Increasing potential to cause harm or damage to life and property. Increased preparedness measures may be needed to better protect your home and property. This is an important consideration in a scenario where sufficient firefighting resources are not available to protect your home or property.



Fire Intensity Class	Description of Fire Behavior and Potential Effects	General Preparedness Recommendations
3	<p>Flames up to 8 feet in length; short-range spotting is possible. Hand crews will find these fires difficult to suppress without support from aircraft or engines, but dozers and plows are generally effective. Increasing potential to cause harm or damage. This intensity class occurs at</p> <p>the head and flanks of fires in moderate fire environments, or near the rear of fires in heavy fuel. This intensity class is common.</p>	<p>Increasing potential to cause harm or damage to life and property.</p> <p>Increased preparedness measures may be needed to better protect your home and property. This is an important consideration in a scenario where sufficient firefighting resources are not available to protect your home or property.</p>
4	<p>Large flames, up to 30 feet in length; short-range spotting common; medium-range spotting possible. Direct attack by hand crews and equipment is generally ineffective, indirect attack may be effective. Moderate potential for harm or damage. This intensity class is generally observed at the head of fires in moderate fire environments or near the head and flank of fires in moderate to severe fire environments. This intensity class is relatively common.</p>	<p>Significant potential for harm or damage to life and property.</p> <p>Extensive preparedness measures may be needed to better protect your home and property. This is an important consideration in a scenario where sufficient firefighting resources are not available to protect your home or property.</p>
5	<p>Very large flames up to 150 feet in length; copious short-range spotting, frequent long-range spotting; strong fire-induced winds. Indirect attack marginally effective at the head. Great potential for harm or damage. This intensity class is usually observed near the head of fires in severe fire environments. Despite the high spread rate, this intensity class is relative infrequent due to the rarity of the fire environment and spread direction.</p>	<p>Significant potential for harm or damage to life and property.</p> <p>Similar to the previous category, extensive preparedness measures may be needed to better protect your home and property. This is an important consideration in a scenario where sufficient firefighting resources are not available to protect your home or property.</p>



Fire Intensity Class	Description of Fire Behavior and Potential Effects	General Preparedness Recommendations
6	Extraordinary flame size, greater than 150 feet in length; copious spotting; very strong fire-induced winds. Conditions supporting this behavior are rare and short-lived. All suppression efforts are ineffective. Great potential for harm or damage. This intensity class is usually observed near the head of fires in severe fire environments. Despite the high spread rate, this intensity class is relative infrequent due to the rarity of the fire environment and spread direction.	Great potential for harm or damage to life and property. Extensive preparedness measures may be needed to better protect your home and property.



This page is intentionally blank.