

SECTION 10:

WINDSTORMS

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SECTION 10: WINDSTORMS

Why are Windstorms a Threat to the City of Newport Beach?

Severe windstorms can pose a significant risk to property and life in the region by creating conditions that disrupt essential systems such as public utilities, telecommunications, and transportation routes. High winds can and do occasionally cause damage to local homes and businesses. This section discusses the specific hazards associated with unusual and potentially damaging wind activity based on historic records and scientific data.

Definitions and Setting

Wind is air that is in motion relative to the earth. It generally has both horizontal and vertical components, but the horizontal component generally dominates (National Research Council, Committee on Natural Disasters – NRC, CND, 1993). Due to friction, wind speed drops off at the ground surface, with approximately 50% of the transition in wind speed due to frictional forces exerted by the ground surface occurring in the first six feet above the ground. As a result, “near-surface wind is the most variable of all meteorological events” (NRC, CND, 1993), and it generally consists of a combination of high-frequency oscillations in both speed and direction superimposed on a more consistent flow with a prevailing speed and direction. With an increase in wind speed, the high-frequency oscillations can become more abrupt and of greater amplitude – these are referred to as wind gusts. Because wind speeds vary as a function of height, time and the terrain upwind, it is difficult to obtain a value that is representative of the wind speeds over a large region. The general convention for measuring wind speed is at a height of 33 feet (10 m), in flat, open terrain, such as that provided by an airport field. Temporal variations are taken into account by averaging speed and direction over a given time, typically 1-minute averages for sustained wind, and 2- to 5-second averages for peak or extreme winds. The mean annual wind speed for the contiguous 48 states is 8 to 12 miles per hour (mph), with most areas of the country frequently experiencing 50-mph winds (NRC, CND, 1993).

To better appreciate the impact that wind has on the sea and land, and the wind speeds required to move different objects, refer to the Beaufort scale in Table 10-1. This scale was developed by Sir Francis Beaufort in 1805 to illustrate and measure the effect that varying wind speed can have on sea swells and structures. Note that the highest wind speeds in the Beaufort scale approach the lowest wind speed on the Fujita scale presented in Table 10-2.

Types of High Winds in Southern California

Santa Ana Winds

Most incidents of high wind in southern California are the result of ***Santa Ana wind*** conditions. Santa Ana winds are generally dry, often dust-bearing, winds that blow from the east or northeast toward the coast, and offshore (Figure 10-1). These winds commonly develop when a region of high atmospheric pressure builds over the Great Basin – the arid high plateau that covers most of Nevada and parts of Utah, between the Sierra Mountains on the west and the Rocky Mountains to the east. Clockwise circulation around the center of this high-pressure area forces air downslope from the plateau. As the air descends toward the California coast, it may warm at a rate of about 5 degrees Fahrenheit per 1,000 feet elevation, although this does not always happen. Since the air originates in the high deserts of Utah and Nevada, it starts out already very low in moisture; if heated, it dries out even further. The wind picks up speed as it hits the passes and canyons in the coastal ranges of southern California, blowing with exceptional speed through the Santa Ana Canyon (from where these strong winds derive their name). Forecasters at the National Weather Service usually reserve the use of “Santa Ana”

winds for those with sustained speeds over 25 knots (1 knot = 1.15 mph); as they move through passes and canyons, these winds may reach speeds of 35 knots, with gusts of up to 50 to 60 knots (see Table 10-1).

Table 10-1: The Beaufort Scale

Beaufort Force	Wind Speed (mph/ knots)	Wind Description – State of Sea – Effects on Land
0	< 1; < 1	Calm – Mirror-like – Smoke rises vertically.
1	1 - 3 / 1 - 3	Light – Scaly ripples; no foam crests – Smoke drifts show direction of wind, but wind vanes do not.
2	4 - 7 / 4 - 6	Light Breeze – Small but pronounced wavelets; crests do not break – Wind vanes move; leaves rustle; you can feel wind on face.
3	8 - 12 / 7 - 10	Gentle Breeze – Large wavelets; crests break; glassy foam; a few whitecaps – Leaves and small twigs move constantly; small, light flags are extended.
4	13 - 18 / 11 - 16	Moderate Breeze – Small (1-4 ft) waves; numerous whitecaps – Wind lifts dust and loose paper; small tree branches move.
5	19 - 24 / 17 - 21	Fresh breeze – Moderate (4-8 ft) waves taking longer to form; many whitecaps; some spray – Small trees with leaves begin to move.
6	25 - 31 / 22 - 27	Strong Breeze – Some large (8-13 ft) waves; crests of white foam; spray – Large branches move; wires whistle.
7	32 - 38 / 28 - 33	Near Gale – Sea heaps up; waves 13-20 ft; white foam from breaking waves blows in streaks with the wind – Whole trees move; resistance felt walking into the wind.
8	39 - 46 / 34 - 40	Gale – Moderately high (13-20 ft) waves of greater length; crests break into spin drift, blowing foam in well-marked streaks; Twigs and small branches break off trees; difficult to walk.
9	47 - 54 / 41- 47	Strong Gale – High waves (20 ft) with wave crests that tumble; dense streaks of foam in wind; poor visibility from spray – Slight structural damage; shingles blow off roofs.
10	55 - 63 / 48 - 55	Storm – Very high (20-30 ft) waves with long, curling crests; sea surface appears white from blowing foam; heavy tumbling of sea; poor visibility – Trees broken or uprooted; considerable structural damage.
11	64 – 73 / 56 - 63	Violent Storm – Waves high enough (30-45 ft) to hide small and medium-sized ships; sea covered with patches of white foam; edges of wave crests blown into froth; poor visibility – Seldom experienced inland; considerable structural damage.
12	> 74 / > 64	Hurricane – Sea white with spray; foam and spray render visibility almost non-existent; waves over 45 ft high – Widespread damage; very rarely experienced on land.

Sources: www.spc.noaa.gov/faq/tornado/beaufort.html; <http://www.stormfax.com/beaufort.htm>

Santa Ana winds are common in the southern California area, occurring on a yearly basis in the region, typically in the fall through early spring. For the most part these winds are a nuisance, bringing dust indoors, breaking tree branches, and causing minor damage. For people with respiratory conditions, however, Santa Ana winds often mean headaches, sinus pain, difficulty breathing, and even asthma attacks. Strong Santa Ana winds can cause extensive damage to trees, utility poles, vehicles and structures, and can even be deadly. In 2003, for example, two deaths were blamed on these strong winds: a downed tree struck and killed a woman in San Diego, and a passenger in a vehicle was struck by a flying pickup truck cover ([http://cbsnews.com/January 8, 2003 article](http://cbsnews.com/January%208,%202003%20article)). Wildfires in southern California often occur during Santa Ana wind conditions, when the air humidity is low to very low. Because the winds fan and help spread these fires, Santa Ana wind conditions always are serious concerns to fire fighters.

Thunderstorm-Related Tornadoes

A variety of mechanisms give rise to **thunderstorms**, but most often these develop when warm, moist air meets a cold front, producing strong winds, and sometimes tornadoes and hail. More than 100,000 thunderstorms occur every year in the United States, and more than 10,000 of these are considered severe, resulting in annual property losses in excess of \$1 billion (National Research Council’s Committee on Natural Disasters, 1993). Most of these occur in the central Great Plains and the southeastern coastal states, but thunderstorms do occur in every state. A thunderstorm is officially labeled as severe if: 1) it produces a tornado, 2) has winds in excess of 58 mph, or 3) produces surface hail greater than 0.75 inch in diameter. An exceptionally severe thunderstorm can generate several tornadoes and downbursts.

Tornadoes are “violently rotating columns of air extending from a thunderstorm to the ground (<http://www.nssl.noaa.gov/edu/safety/tornadoguide.html>; Figure 10-2). Although tornadoes occur in many parts of the world, they are most common in the Central Plains of the United States, east of the Rocky Mountains, where they often occur during the spring and summer months. In the spring, tornadoes often form where warm, moist air from the east meets hot, dry air from the west (this boundary is called a “dryline”). In the winter and early spring, tornadoes can also develop when strong frontal weather systems originating in the central states move eastward. Thunderstorms, and associated tornadoes, also form at the range front, where near-ground air is forced to move “upslope” along the ascending mountain slopes. In California, tornadoes are occasionally generated by strong storms. Although the number of tornadoes reported in California is only a fraction of those reported in the central states, California does get its share of these strong winds. In the 30 years between 1959 and 1988, 133 tornadoes were reported in California, for an average of 4 tornadoes a year (NRC-CND, 1993).

Figure 10-1: View From Space of Smoke from the October 2003 Fires in Southern California, Carried Offshore by Strong Santa Ana Winds



Source: Image by Jacques Descloitres, MODIS Rapid Response Team at NASA/GSFC, obtained from the archives at <http://visibleearth.nasa.gov/>

Figure 10-2: View of a Tornado



Source: <http://www.photolib.noaa.gov/700s/nssl0123.jpg>

Tornadoes can also accompany tropical storms and hurricanes as they move on land, where they usually occur ahead of the path of the storm center as it comes onshore (<http://www.nssl.noaa.gov/edu/safety/tornadoguide.html>). Weak tornadoes that form over warm water are called **waterspouts**. Occasionally, waterspouts can move on land and become tornadoes. **Funnel clouds** are cone-shaped or needle-like clouds that extend downward from the main cloud base but do not touch the ground surface. If a funnel cloud touches the ground, it becomes a tornado; if it touches or moves across water, it is a waterspout. Waterspouts that have moved onto land are more often reported in southern California in the fall and winter, but some have also been reported in the spring. A few of these have historically caused significant damage. For instance, on April 6, 1926, a waterspout that came on land at National City, near San Diego, unroofed several homes and injured eight people; one on February 12, 1936 unroofed two homes, blew down five oil derricks and injured six people.

To measure the intensity, area and strength of a tornado, in 1973 Dr. Ted Fujita (then with the University of Chicago) and Allen Pearson (at the time director of the National Severe Storm Forecast Center) introduced the Fujita-Pearson Tornado Intensity Scale (see Table 10-2). An improvement over the scale first published by Dr. Fujita in 1971, this scale compared the estimated wind velocity with the corresponding amount of damage to human-built structures and vegetation (a component first introduced by Fujita) and the width and length of the tornado path (the component added by Pearson). The scale classified tornadoes into six levels (from F0 to F5) with larger numbers indicating more damaging and larger tornadoes (the Fujita scale smoothly divided wind speed between the highest Beaufort level and Mach 1.0 into 12 levels – F0 through F12, but recognized that an F6 tornado would be inconceivable, and indeed no tornado above F5 has ever been measured.

Table 10-1: The Fujita-Pearson Tornado Damage Scale

Scale	Wind Speed Estimate (mph)	Average Damage Path Width (feet)	Typical Damage
F0	40 - 72	30 - 150	Light damage (gale tornado). Some damage to chimneys and television antennas; twigs and branches break off trees; winds push over shallow-rooted trees; sign boards are damaged.
F1	73 – 112	100 - 500	Moderate damage (weak tornado). Winds peel off roofs; windows break; light trailer homes are pushed off their foundations or overturned; some trees are uprooted or snap; moving autos are pushed off the road; attached garages may be destroyed. Hurricane speed starts at 74 mph.
F2	113 – 157	360 - 820	Considerable damage (strong tornado). Roofs are torn off frame houses, leaving strong walls upright; weak rural buildings are demolished; trailer homes are destroyed; large trees snap or are uprooted; railroad boxcars are pushed over; light objects become airborne missiles; cars are blown off highways.
F3	158 – 206	650 – 1,650	Severe damage (severe tornado). Roofs and some walls are torn off well-constructed frame structures; some rural buildings are completely demolished; trains are overturned; steel-framed hangars and warehouse-type structures are torn; cars are lifted off the ground; most trees are uprooted, snapped or leveled.
F4	207 – 260	1,300 – 3,000	Devastating damage (devastating tornado). Well-constructed frame houses are leveled, leaving piles of debris; steel structures are badly damaged; trees are de-barked by small flying objects; cars and trains are thrown some distances or roll considerable distances; large objects become missiles.
F5	261 – 318	~ 3,600	Incredible damage (incredible tornado). Strong, whole-frame houses are lifted off their foundations and carried considerable distances; steel-

Scale	Wind Speed Estimate (mph)	Average Damage Path Width (feet)	Typical Damage
			reinforced concrete structures are badly damaged; automobile-sized missiles are generated and carried through the air >100 meters; trees are debarked.
F6	319 –379		Inconceivable damage: These winds are unlikely. Should a tornado with maximum speed in excess of F5 occur, the extent and type of damage may not be conceived. A number of airborne missiles, such as refrigerators, water heaters, storage tanks, automobiles, etc. create serious secondary damage on structures.

The Fujita-Pearson scale was used to classify all tornadoes reported after its introduction in 1973, in addition to retroactively classify all tornadoes reported since 1950 that were listed in the National Oceanic and Atmospheric Administration’s (NOAA) national tornado database.

Fujita’s wind estimates have since been found to be inaccurate, with the original wind speed estimates higher than the wind speeds actually required to incur the damage described in each category, especially for tornadoes classified as F3 or larger. In response to these criticisms, a new **Enhanced Fujita (EF) scale** for tornado damage was developed between 2004 and 2006. The EF scale, which was officially implemented in the United States on February 1, 2007, is considered an improvement over the old scale: engineers and meteorologists estimated the wind speeds in the new scale (although actual speed winds have not been empirically measured), and records of past tornadoes were reviewed to better equate the wind speeds with the storm damage reported. The new scale also includes more types of structures and vegetation in the damage assessment, and better accounts for differences in construction quality. Similar to the original Fujita scale, the EF scale has six levels of tornado damage, EF-0 to EF-5 (see Table 10-3). A researcher assigning a level of damage to a tornado using the EF scale needs to refer to a list of 28 different damage indicators (DI) or types of structures and vegetation, and then the degree of damage (DoD) for each. Damage indicators include barns or farm outbuildings, residences, manufactured homes (with distinctions made for single-wide and double-wide), apartments, masonry buildings, strip malls, automobile lots, elementary schools, low-, middle- or high-rise buildings (each a different category of indicator), electrical transmission lines, free-standing towers, and softwoods or hardwood trees. The new scale is likely to be modified or updated as new tornado data become available.

Table 10-3: Enhanced Fujita Scale

Scale	Wind Speed Estimate		Relative Frequency (%)
	mph	Km/h	
EF-0	65 - 85	105 - 137	53.5
EF-1	86 - 110	138 - 178	31.6
EF-2	111- 135	179 – 218	10.7
EF-3	136 – 165	219 – 266	3.4
EF-4	166 – 200	267 – 322	0.7
EF-5	> 200	> 322	< 0.1

Macrobursts and Microbursts

Storm researcher Dr. Ted Fujita first coined the term “**downburst**” to describe a strong, straight-direction surface wind in excess of 39 miles per hour (mph) caused by a small-scale, strong downdraft from the base of a thundershower and thunderstorm cell. Unlike tornadoes,

the origin of a downburst is downward-moving air from a thunderstorm's core (as opposed to the upward movement of air associated with tornadoes). Downbursts are further classified into macrobursts and microbursts.

Macrobursts are downbursts with winds up to 117 mph that spread across a path greater than 2.5 miles wide at the surface, and which last from five to 30 minutes. **Microbursts** are confined to smaller areas, less than 2.5 miles in diameter from the initial point of downdraft impact. An intense microburst can result in winds near 170 mph but often lasts less than five minutes. Like tornadoes, microbursts can do significant damage: When a microburst hits a tree, the winds strip the limbs and branches off it; a microburst that hits a house has the potential to flatten the structure. After striking the ground, a powerful outward-running gust can generate significant damage along its path. Damage associated with a microburst appears to have been caused by a tornado, except that the damage pattern away from the impact area is characteristic of straight-line winds, rather than the twisted pattern typical of tornado damage.

Microbursts are particularly dangerous to aircraft landing or taking off, and have caused several planes to crash, with resultant loss of life. Microbursts have also been responsible for capsizing and sinking ships, causing structural damage in many communities, lifting roofs off structures, downing electrical lines, and generally causing millions of dollars in damage. Most of the microbursts reported have occurred in the northeastern and central parts of the United States, including New York, New Jersey, Massachusetts, Ohio, and Kansas, but microbursts have also been reported in Arizona and Utah (http://en.wikipedia.org/wiki/Microburst#Danger_to_aircraft), and in southern California. On March 29, 1998, in a Lake Elsinore neighborhood, an apparent microburst uprooted a tree and ripped two 20-foot sections of roofing tiles from a home. A funnel cloud was also spotted that afternoon near Dulzura, to the east-southeast of San Diego. On August 12, 2012, also in the Lake Elsinore area, a microburst knocked down several power poles and trees, and damaged the roofs of several houses (<http://latimesblogs.latimes.com/lanow/2012/08/microburst-blamed-tornado-type-activity-riverside-county.html>; <http://www.pe.com/localnews/riversidecounty/riverside/riverside-headlines-index/20120812-lake-elsinore-tornado-touches-down-more-expected.ece?ssimg=677704#ssStory677446>).

Historic Southern California Windstorms

As mentioned above, Santa Ana winds are common in the southern California area, with Santa Ana conditions expected yearly in the region, generally in the fall through early spring. Some of the strong winds in the winter are associated with storms emanating from Alaska and Canada. The desert areas are also subject to high winds associated with short-duration tropical thunderstorms emanating from the south. These storms typically occur in the summer months, between July and September.

Some of the most severe windstorms reported in southern California between 1858 and November 2013 (the more recent entries in the NOAA database as of the writing of this document) are listed in Table 10-4 below (<http://www.ncdc.noaa.gov/stormevents/listevents.jsp>; <http://www.wrh.noaa.gov/sgx/document/weatherhistory.pdf>). Some of these events are also discussed in other sections of the report because they were accompanied by other hazards, such as flooding or wildfires. Those winds that are clearly Santa Ana windstorms are highlighted in yellow, whereas strong winds that specifically impacted the Newport Beach area and vicinity are in **bold**. Note that many of the Santa Ana windstorm entries mention wildfires. Please note that this list, although extensive, is likely not complete, as it may omit windstorms that caused extensive damage locally.

Table 10-4: Major Southern California Windstorms (1858- November 2013)

(Santa Ana winds are highlighted in yellow;
 windstorms that impacted the Newport Beach area, including vicinity, are in bold letters)

Date	Location and Damage
October 2, 1858	Category I hurricane hits San Diego. Winds to 75 mph are estimated based on the extensive damage to property reported.
August 11-12, 1873	Tropical storm with strong winds hits San Diego, damaging roofs and felling trees.
November 13, 1880	Severe Santa Ana winds and sandstorms cause extensive damage in southern California.
February 24, 1891	Strong and continuous storm-related winds blowing at 40 mph cause boats to smash on shore and a roof was lifted off a warehouse.
January 27, 1916	Strong winds measured in San Diego, with peak winds at 54 mph; maximum gust to 62 mph, and average wind speeds for the day of 26.2 mph.
January 10, 1918	Strong offshore winds; skies full of dust, with visibility limited to 300 yards. At noon, visibility was only a few miles. Peak wind of 31 mph reported in San Diego at 6:38 am.
November 25, 1918	Strong windstorm produced a 96-mph gust at Mt. Wilson.
May 23, 1932	Strong winds and low humidity; 12 serious brush fires, blackening nearly 2,000 acres in San Diego Count. The biggest fire was in Spring Valley.
March 5, 1933	Strong east winds. A fire that started in the De Luz area spread rapidly westward, impacting more than 800 acres.
September 24-25, 1939	Tropical storm that lost hurricane status shortly before moving onshore at San Pedro had sustained winds of 50 mph. At least 48 people died from sinking boats.
February 11, 1946	Icy cold winds in the mountains of San Diego with gusts to 72 mph.
January 10, 1949	Cold winter storm with gusts to 75 mph in the mountains of San Diego County; gusts to 40 mph in San Diego. Winds cause plane crash near Julian that kills 5 and injures 1.
April 13, 1956	Strong storm-related winds hit Chula Vista causing roof damage to 60 homes and one school. Trees uprooted, TV antennas toppled and windows shattered. Flying glass injures 2. Fish sucked out of San Diego Bay and deposited on the ground. Possible tornado.
November 21-22, 1957	Extremely destructive Santa Ana winds produce a 28,000-acre brush fire west of Crystal Lake.
November 5-6, 1961	Strong Santa Ana winds fan fires in Topanga Canyon, Bel Air and Brentwood; 103 firemen are injured; \$100 million in economic losses, including 484 buildings (mostly residential) and 6,090 acres scorched.
September 26, 1963	Santa Ana winds with gusts over 50 mph in the mountains of San Diego County; hottest heat wave on record for the mountains in west San Diego County.
November 19-20, 1963	Strong storm winds topple power lines and hundreds of trees.
December 2-3, 1966	Strong storm winds cause power outages.
January 18-28, 1969	Strong storm winds cause power outages and falling trees; 4 killed by downed trees.
February 20-25, 1969	Strong storm winds cause telephone, power and gas outages.
September 26-29, 1970	Gusts to 60 mph in Cuyamaca Rancho State Park. Fires from Cuyamaca to Alpine, including the Laguna Fire, resulted in 400 homes destroyed, 185,000 acres burned, and 8 killed.
February 10-11, 1973	Strong storm-related winds clocked at 57 mph in Riverside, 46 mph in Newport Beach. More than 200 trees uprooted in the community of Pacific Beach in San Diego County alone.
March 25, 1975	Wind gust of 101 mph measured at Sandberg, a community north of the Los Angeles National Forest.
February 4-10, 1976	Strong storm winds with gusts to 64 mph in Palmdale.

Date	Location and Damage
September 10, 1976	Hurricane Kathleen brought to the SW the highest sustained winds associated with an eastern Pacific tropical cyclone; sustained winds of 57 mph at Yuma, Arizona.
November 30 – December 1, 1982	Widespread strong winds associated with a big storm result in 1.6 million homes without power.
March 26, 1984	Winds to 60-90 mph in the Mojave Desert cause power outages and road closures. Car had its windows blown out; another had a door ripped off. Peak wind of 103 mph at Mojave; 66 mph in Daggett.
March 1, 1985	Strong storm winds struck San Diego County toppling trees and antennas, and causing numerous power outages.
November 23, 1986	Strong Santa Ana winds hit Los Angeles, its foothills and mountains. Gusts to 54 mph recorded; gusts to 70 mph estimated. An unfinished house in Glendale is blown to bits; numerous beach rescues needed for sailors and windsurfers. Two sailboat masts were snapped in a boat race at the Channel Islands.
January 20, 1987	Wind gusts to 80 mph below Cajon Pass, 70 mph in San Bernardino, 60 mph in Mt. Laguna, and 40 mph at El Toro. Winds cause thick dust clouds; trucks blown over; trees toppled. 100 power poles downed in the Inland Empire. Numerous power outages force school closures. Brush fires started.
February 23-24, 1987	Storm winds to 50 mph in Mt. Laguna; gusts to 34 mph in San Diego.
March 15, 1987	Widespread strong storm winds; winds of 25-35 mph sustained all day, gusts to 40 mph in San Diego. Result in power outages all over the San Diego metropolitan area; motor homes toppled in the desert; light standard fell over onto cars in Coronado; boats flipped over in harbors; a 22-foot boat turned over at Mission Beach jetty; Catalina cruise ships delayed, stranding 1,200 tourists there.
November 18, 1987	Strong Pacific storm brought gale-force winds along the coast with winds exceeding 40 mph; downed trees and caused power outages.
December 12-13, 1987	Strong Santa Ana winds in San Bernardino, with 60-80 mph gusts there. 38-mph winds recorded in San Diego. 80 power poles blown down within ½-mile stretch in Fontana and Rancho Cucamonga; downed tree limbs damaged cars, homes and gardens; 1 injured when tree fell on truck; power poles and freeway signs damaged; parked helicopter blown down a hillside in Altadena; trees downed and power outages in San Diego County. In Spring Valley, 1 dead when eucalyptus tree fell on truck.
December 15, 1987	Strong storm winds of 100 mph at Wheeler Ridge, 80 mph in San Bernardino County; up to 70-mph gusts at Point Arguello; 60-mph gusts in Orange County and the San Gabriel Mountains. One truck overturned.
December 17, 1987	Strong Alaska storm brought strong winds to the area; boats broke free of moorings at Shelter Island in San Diego.
January 17, 1988	Major Pacific storm produced 64-mph gusts in San Diego, with the highest wind on record at Lindbergh Field. Trees uprooted in San Diego; boats damaged in San Diego harbor; apartment windows ripped out in Imperial Beach, where damage was estimated at \$1 million. San Diego Zoo closed for first time in 72 years due to damage; kelp beds damaged.
January 21-22, 1988	Strong offshore winds following major Pacific storm with gusts to 80 mph at the Grapevine, 60 mph in Ontario, and 80 mph in San Diego County. Power poles, road signs and big rigs knocked down in the Inland Empire. In San Diego County, 6 injured; roofs blown off houses, trees toppled, and crops destroyed. Barn demolished and garage crushed by tree in Pine Valley; 20 buildings damaged or destroyed at Viejas; avocado and flower crops destroyed at Fallbrook and Encinitas, respectively, with 5 greenhouses damaged in Encinitas.

Date	Location and Damage
February 16-19, 1988	Very strong Santa Ana winds with gusts to 90 mph in Newport Beach, 70+ mph in the San Gabriel Mountain foothills; gusts to 76 mph at Monument Peak – Mt. Laguna; 63 mph at Ontario, and 50 mph at Rancho Cucamonga. Numerous trees and power lines downed resulting in power outages along the foothills of the San Gabriel and San Bernardino Mountains. Mobile home overturned and shingles torn off roofs in Pauma Valley; Fontana schools closed due to wind damage; 3 killed when truck overturned and burned; 1 killed when stepped on downed power line. Power outages impacted 200,000 customers in Los Angeles and Orange Counties. Grass fires. Roof damage widespread in communities around Glendale and Burbank, and at John Wayne Airport. Boats torn from moorings at Newport Harbor.
May 29, 1988	Gale-force winds hit coastline; gusts to 60 mph in the mountains; 45 mph at LAX; 40 mph in San Diego. Power outages; brush fires started; hang glider crashed and killed.
November 30, 1988	Santa Ana winds with gusts to 75 mph in Laguna Peak, Ventura County.
December 8, 1988	Strong Santa Ana winds across southern California, with gusts to 92 mph at Laguna Peak. Winds fanned several major fires; buildings were unroofed; trees and power lines downed. \$20 million in estimated damages.
November 28, 1989	Strong Santa Ana winds with gusts to 70 mph at the Rialto Airport. Several tractor-trailer trucks were overturned east of Los Angeles.
December 11, 1989	Strong Santa Ana winds with gusts to 100 mph near the Grapevine. Winds reduced visibility to near zero in the desert areas and closed major interstate highways east of Ontario.
March 18-19, 1991	Storm winds with gusts to 125 mph on Laguna Peak; winds of 60 mph in the San Carlos area of San Diego caused extensive damage (possibly a tornado).
October 26-27, 1993	Strong Santa Ana winds with gusts to 62 mph at Ontario. Twenty fires in the southern California area, including the Laguna Hills Fire. 4 dead, 162 injured, \$1 billion in property losses alone; 194,000 acres destroyed.
December 24, 1993	Santa Ana winds with gusts to 75 mph at Ontario.
December 14, 1996	Santa Ana winds with gusts to 111 mph at Fremont Canyon, 92 mph in Rialto. 2 killed from flying debris.
December 21-22, 1996	Storm winds 40 - 50 mph.
January 5-6, 1997	Storm winds with gusts to 99 mph in Fremont Canyon, 58 mph elsewhere.
January 29, 1997	Santa Ana winds with gusts to 100 mph in Fremont Canyon, 87 mph in Rialto cause big rigs to be blown over.
August 20, 1997	The remnants of Tropical Storm Ignacio tracked northward and inland into central California, spawning gale-force winds over portions of the southern California coastal waters.
October 14, 1997	Santa Ana winds with gusts up to 87 mph reported in central Orange County. Large fire in Orange County.
December 10-12, 1997	Santa Ana winds with gusts to 96 mph at Pine Valley; 87 mph in Upland. Flying debris killed 2. Property damage in Sun City; crop damage; boats damaged and sunk at Coronado and Avalon.
December 18-22, 1997	Gusts to 60 mph in Rialto; 67 mph at Idyllwild and below Cajon Pass. 1 killed; fires; downed trees; and widespread wind damage.
December 29, 1997	60+ mph gusts reported in Santa Ana.
February 3-4, 1998	Strong storm winds with gusts to 60 mph at Newport Harbor, 51 mph at San Clemente.
February 23-24, 1998	Strong storm winds 40-60 mph caused widespread damage; trees and power lines knocked down.

Date	Location and Damage
March 28-29, 1998	Strong storm-related winds in Orange County with sustained 30-40 mph winds; 70-mph gusts at Newport Beach; 60-mph gust at Huntington Beach and in the mountains. Trees down, power outages, and damage reported across Orange and San Diego counties. One person died in Jamul.
September 2, 1998	Strong thunderstorm-related winds in Orange County, with 40-mph gusts. Large fires in Orange County.
December 6, 1998	Thunderstorm in Los Alamitos and Garden Grove; gusts of 50 to 60 mph; referred to as “almost a tornado.”
December 9-10, 1998	Santa Ana winds with 101-mph gusts at Modjeska Canyon, 93-mph gusts at Fremont Canyon, 52-mph gusts in Santa Ana, and 83-mph gusts at Ontario. Winds toppled trees and power lines, overturned vehicles, and caused property damage.
January 21, 1999	80-mph gust in the Salton Sea area; 70-mph gust in the Coachella Valley; 47-mph gust in Palm Springs; and 36-mph gust in Thermal.
February 10-12, 1999	Santa Ana winds with gusts to 85 mph at Rialto; gusts to 80 mph on the I-8, forcing the closure of the interstate.
May 13, 1999	Strong winds with sustained speeds of 61 mph reported at Borrego Springs, causing roof and tree damage.
November 22, 1999	80-mph gust at Highland.
December 3, 1999	Santa Ana winds with gusts to 90 mph at San Bernardino and 68 mph in Fontana.
December 10-11, 1999	Gust to 60 mph in Palm Springs.
December 21-22, 1999	Strong Santa Ana winds; 68-mph gust at Campo, 53-mph gust at Huntington Beach; 44-mph gust in Orange. Property damaged and trees downed along the coast, and in Hemet.
January 5-6, 2000	Santa Ana winds with 93-mph gust at Fremont Canyon; 60-mph gust at Ontario; 58-mph gust at Devore. Winds closed the I-15.
February 19, 2000	Santa Ana winds with gusts to 92-mph at Fremont Canyon.
February 21-23, 2000	Winter storm winds with 75-mph gust along Highway 91; winds downed trees in Lake Arrowhead.
March 5-6, 2000	Strong thunderstorm winds along the coastline; 60 mph-gusts at Huntington Beach; trees downed and property damage reported all along the coast.
April 1, 2000	Strong Santa Ana winds; 93-mph gust reported at Mission Viejo; 67-mph gust at Anaheim Hills.
April 17-18, 2000	Late winter storm brings 68-mph gusts in the mountains of San Diego County.
November 7, 2000	Santa Ana winds with 82-mph gust at Fremont Canyon.
December 25-26, 2000	Santa Ana winds; 87-mph gust at Fremont Canyon. Damage and injuries reported in Mira Loma, and in Orange and Riverside counties. 50-mph winds in northern Orange County toppled utility poles leaving about 25,000 customers in Tustin, Garden Grove, Orange, Santa Ana and Westminster without power for a few hours.
January 2-3, 2001	Winter storm with wind gust to 71 mph at Phelan.
February 7, 2001	Winter storm with gusts to 50 mph at Palm Springs and Thermal, 54 mph gusts at Fish Creek.
February 13, 2001	Thunderstorm with 89-mph gust reported in east Orange.
November 27, 2001	Strong Santa Ana winds extend offshore from the coast causing damage and causing a boating accident off of Newport Beach.
December 7-8, 2001	Santa Ana winds with gust to 87-mph at Fremont Canyon. Potrero Fire.
January 24, 2002	Santa Ana winds.
February 8-10, 2002	Santa Ana winds with 80-mph gust at Descanso, 78-mph gust at Fremont Canyon, and 76-mph gust at San Bernardino. Fire in the Fallbrook area.

Date	Location and Damage
January 6-8, 2003	Strong, widespread Santa Ana winds with 100-mph gust at Fremont Canyon, 90-mph gust at Ontario; 80-mph gust at Upland. Winds toppled power poles in Orange; blew over a mobile derrick in Placentia, crushing two vehicles; and delayed Metrolink rail service. As a result of the winds and toppled poles, thousands of people in northeastern Orange County were without power. 2 dead, 11 injured. Widespread property damage, road closures, wildfires, crop damage.
October 25-27, 2003	Strong Santa Ana winds; 45-mph at Ontario, 43-mph at Fremont Canyon. Extensive wildfires consumed hundreds of thousands of acres; killed more than 20 people, and caused more than \$1 billion in damage.
November 21, 2004	Cold storm brought 84-mph wind gusts to Fremont Canyon.
December 16, 2004	Santa Ana winds with sustained speeds of 51 mph and 78-mph gusts at Fremont Canyon; gusts to 69-mph northwest of San Bernardino and 66 mph near Pine Valley. Big rigs were blown over, temporarily closing the freeway; other property damage reported.
December 29, 2004	Storm brings 60-65 mph wind gusts to the Inland Empire and 69-mph wind gusts at Julian. Widespread wind damage reported along the coast and valleys.
January 7, 2005	Wind gusts in excess of 50 mph combined with very saturated soils knocked down hundreds of large trees in the Orange County coastal plain. The felled trees knocked out power, blocked roads, and damaged many cars and other property. A woman was injured when an eucalyptus tree fell on her car as she drove in Vista. About \$75K in property damage.
February 3, 2005	Strong storm-related winds to 70-mph impact the region. Homes in Idyllwild are damaged by felled trees; downed power lines in the Inland Empire; big rig was overturned on the I-8.
February 19, 2005	Strong thunderstorm winds blew down fences, trees, and damaged the roof of a mobile home in Laguna Hills.
February 22, 2005	Thunderstorm winds to 59 knots caused about \$15K in property damage in Newport Beach.
April 7, 2005	Strong winds in the Coachella Valley with gust to 52-mph in Thermal; stronger wind likely in the region. Winds led to reduced visibility in La Quinta, which led to a 12-car pileup.
April 28, 2005	A squall line produced strong straight-line winds as it came onshore in Orange County. The strong winds, to 60 knots, damaged 8 to 12 homes in Dana Point and knocked down several trees. In San Clemente, strong winds blew over a chimney, a large motel sign, and numerous tree limbs. Wind damage was also reported in San Juan Capistrano and Newport Beach. About \$45K in property damage.
January 2, 2006	Post-frontal 50+-mph winds widespread throughout the region. Winds downed trees, power lines, and power poles onto houses and cars. In Crestline, 20 houses were so damaged as to be uninhabitable. In San Diego Bay, boats broke loose from their moorings. \$25K in property damage.
January 5, 2006	Gusty Santa Ana winds caused minor damage to trees, utility lines and other property.
January 22-24, 2006	Santa Ana winds; peak winds of 71 mph at Fremont Canyon on the 24 th ; gusts exceeded 60 mph on 19 hourly observations. 7 big rigs overturned in Fontana; downed power lines and trees caused power outages and property damage. Dust storm closed the Ramona Expressway.
February 6-7, 2006	Santa Ana winds blew and the Sierra Fire in east Orange burned nearly 11,000 acres. 8 minor injuries.
October 26, 2006	Offshore winds blew to 40-mph in the Banning Pass. An arsonist started the Esperanza Fire; it burned 40,200 acres from Cabazon to San Jacinto, destroyed 43 homes, and killed 5 firefighters.
November 29, 2006	Offshore winds with sustained speeds of 54 mph and 73-mph gust at

Date	Location and Damage
	Fremont Canyon; 58-mph gust at Ontario, caused widespread property damage and power outages as a result of downed power lines, poles and trees.
December 3, 2006	Offshore winds gusted to 92 mph with seven gusts over 75 mph in northwest San Bernardino. Gusts to 75-mph in Fremont Canyon. Winds downed power lines that sparked a small fire in the Inland Empire; 16 power poles were downed in Valley Center.
December 27, 2006	Strong storm winds hit the coast; 54-mph gust at La Jolla; 49-mph gust at Huntington Beach. Winds downed numerous trees, damaging several vehicles.
March 27, 2007	Strong onshore flow and isolated thunderstorms produced a damaging microburst that removed a roof laminate from the Orange County Fire Authority's aviation building at the Fullerton Municipal Airport. Pieces of the roof landed on four cars. A 60-foot eucalyptus fell over three cars in Encinitas, causing two minor injuries. A funnel cloud was reported off the La Jolla coast.
January 19, 2010	A line of thunderstorms moved through Orange County, with a peak wind gust of 93 mph measured at Newport Beach pier, and several gusts in excess of 70 mph reported. Several boats in the Newport Beach harbor broke free. A building on 17 th Avenue, in Costa Mesa, sustained moderate damage – 2/3rds of the top layer of its roof blew off, with pieces of the roofing material, some over 15 feet long, littering the parking lot. In a mobile home park across the street, metal awnings were ripped off by the wind and pieces of wood were seen flying through the air. Strong winds also blew open the door to a business and shattered a window near the intersection of Harbor Blvd. And Victoria Street. \$350K in property damage. Wind damage was also reported in San Clemente, Seal Beach, Laguna Beach, and in San Diego.
April 11-13, 2012	An upper-level trough swung through southern California bringing gusty winds and moderate to heavy precipitation to the area on the 12th. A deeper upper low developed behind it. Instability ahead of the cold front set off several waterspouts and thunderstorms on the afternoon of the 13 th . Lightning strikes and wind caused roof damage and downed power lines and trees. A spotter reported downed trees, bark peeled off trees and a flipped post office box near Weir Canyon and the 91 freeway. The area was surveyed for possible tornado damage, but only evidence of straight line wind was observed. About \$4K in property damage.

Although most tornado activity in the United States occurs in the Midwest states, tornadoes can occur anywhere. The Tornado Project, a company that researches, compiles and makes tornado information available on the web at www.tornadoproject.com, indicates that 41 tornadoes have been reported in Los Angeles County between 1918 and 2000. In Orange County, The Tornado Project list includes 28 tornadoes between 1958 and 1998; whereas the National Weather Service in San Diego adds a few more to the same time period, plus at least 25 more tornadoes, waterspouts, or funnel clouds between February 1998, where The Tornado List ends, and July 2013. The tornadoes reported in Orange County are listed in Table 10-5 below. Those in Newport Beach are in bold.

Table 10-5: Tornadoes Reported in Orange County between 1958 and 2013
 (tornadoes that impacted Newport Beach are in **bold letters**)

Date, Location	Time	Fujita or Enhanced Fujita Scale (damaged caused)	Deaths	Injured
April 1, 1958, Laguna Beach	09:30	F1	0	0
February 19, 1962, Irvine	03:30	F0	0	0
April 8, 1965, Costa Mesa	11:00	F1	0	0
November 7, 1966, Newport Beach and Costa Mesa	09:09	F1 (property damage)	0	0
March 16, 1977, skipped from Fullerton to Brea	18:30	F1 (damaged 80 homes)	0	4
January 5, 1978, Costa Mesa	21:00	F1 (trees fell, roofs damaged, downed power lines)	0	0
February 9, 1978, Irvine	NA	NA	0	0
February 10, 1978, Huntington Beach	01:55	F2 (\$3 million property damage)	0	6
March 5, 1978, El Toro Marine Base		Funnel cloud		
January 31, 1979, Santa Ana and possibly elsewhere	11:30	F1 (numerous power outages)	0	0
November 9, 1982, Garden Grove	13:00	F0	0	0
November 9, 1982, Mission Viejo	13:00	F1	0	0
January 13, 1984, Huntington Beach	18:19	F0 (property damage)	0	0
March 16, 1986, Anaheim near Disneyland	05:30	F1 (property damage)	0	0
February 22-24, 1987, Huntington Beach area	NA	Tornadoes and waterspouts	0	0
January 18, 1988, Mission Viejo and San Clemente	09:30	F0 (property damage)	0	0
February 28, 1991, Tustin	12:45	F0	0	0
March 26, 1991, Huntington Beach	22:35	F1 (cut a 5-mile swath; took roofs off 6 homes; damaged several other homes and 50 mobile homes were severely damaged)	0	0
December 7, 1992, Anaheim	05:30	F1 (property damage)	0	0
December 7, 1992, Westminster	08:30	F1 (property damage)	0	0
December 29, 1992, San Clemente	11:30	F0 (property damage)	0	0
January 14, 1993	01:40	F1	0	0
January 17, 1993	19:30	F0	0	1
January 18, 1993, Orange County	14:05	F0 (property damage)	0	0
February 8, 1993, Brea	10:20	F0 (property damage)	0	0
November 11, 1993, Portola Hills near Tustin	09:30	F0 (property damage)	0	2
February 7, 1994, from	18:15	F0	0	0

Date, Location	Time	Fujita or Enhanced Fujita Scale (damaged caused)	Deaths	Injured
Newport Beach to Tustin		(roof and window damage; trees blown down)		
December 13, 1994 , waterspouts about 0.5 mile off Newport Beach	NA	NA	0	0
December 13, 1995, funnel cloud near Fullerton Airport	NA	NA	0	0
March 13, 1996, funnel cloud in Irvine	NA	NA	0	0
November 10, 1997 , waterspout came ashore at Newport Pier and quickly dissipated over western Costa Mesa	NA	F0 (winds 60-70 mph) (minor power outages; blew fisherman from one end of pier to another)		
November 11, 1997, Irvine	12:40	F1 (damage from flying debris; 10 cars thrown a few feet)	0	0
November 30, 1997 , waterspout 6 miles south of Newport Beach	NA	NA	0	0
December 21, 1997, Huntington Beach (waterspout and tornado developed from a supercell thunderstorm)	13:40	F1 (considerable damage to boats, houses and city property)	0	0
January 9, 1998, 3 miles off Laguna Beach, waterspout	NA	NA	0	0
February 24, 1998, Huntington Beach	01:30	F0 (property damage, power outage; roof travels ¼ mile)	0	0
March 13-14, 1998, numerous waterspouts between Huntington Beach and Catalina	NA	NA	0	0
March 31 – April 1, 1998, numerous funnel clouds and waterspouts near Orange County coast; one waterspout hit coast south of Huntington Beach pier	NA	NA	0	0
June 6, 1998, two funnel clouds off Dana Point	NA	NA	0	0
January 25, 1999, funnel cloud 1 mile off Costa Mesa	NA	NA	0	0
April 1, 1999 , waterspout 6 miles off Newport Beach	NA	NA	0	0
June 3-4, 1999, funnel cloud 1 mile off San Clemente; waterspout off Laguna Beach	NA	NA	0	0
December 31, 1999, funnel clouds in Santa Ana; waterspout off Costa Mesa coast	NA	NA	0	0
February 21, 2000, Anaheim	NA	NA		

Date, Location	Time	Fujita or Enhanced Fujita Scale (damaged caused)	Deaths	Injured
Hills		(property damage)		
October 28, 2000 , funnel clouds around Newport Beach and Costa Mesa	NA	NA	0	0
January 10, 2001 , funnel cloud at Orange County Airport, Newport Beach	NA	NA	0	0
February 11, 2001, waterspouts 3 miles off Laguna Beach	NA	NA	0	0
February 24, 2001, Orange	NA	NA (damage to warehouse, 6 structures, fences, and telephone wires)	0	0
March 6, 2001, funnel cloud in Yorba Linda	NA	NA	0	0
May 28, 2001, waterspouts 5 miles west of Laguna Beach	NA	NA	0	0
May 20, 2002, three funnel clouds and one waterspout off Dana Point	NA	NA	0	0
November 1, 2003, large waterspout between Laguna Beach and Catalina Island	NA	NA	0	0
October 20, 2004, several funnel clouds offshore San Clemente	NA	NA	0	0
December 28, 2004, funnel cloud in Fullerton	NA	NA	0	0
January 2, 2005, funnel clouds reported 10 miles west of Huntington Beach pier, and off Dana Point	13:28 - 14:20	NA	0	0
January 3, 2005, funnel clouds reported in Fullerton and Huntington Beach	16:00 – 16:30	NA	0	0
January 4, 2005, funnel cloud in Costa Mesa.	4:30	NA	0	0
February 19, 2005, waterspout moved ashore and became a tornado in Huntington Beach within 100 yards of the pier. Multiple waterspouts reported.	NA	(damaged and downed trees and power poles)	0	0
February 22, 2005, funnel cloud in Dana Point	14:40	NA	0	0
May 6, 2005, funnel cloud near Tustin	8:30	NA	0	0
February 18, 2006, waterspout observed 6 nautical miles off Dana Point	NA	NA	0	0
September 22, 2007, waterspouts and funnel clouds off and in Newport Beach , San Clemente and	10:00 – 10:50	NA	0	0

Date, Location	Time	Fujita or Enhanced Fujita Scale (damaged caused)	Deaths	Injured
Capistrano Beach				
January 19, 2010 in Seal Beach, tornado crossed Pacific Coast Highway and moved northeast	13:59	EF1 (flipped a parked Ford Explorer on its side, and two 35-foot catamarans in Huntington Harbor were lifted out of the water. One landed on another vessel and dock piling. Multiple reports of roof damage; the window in a residential building was blown in.)	0	0
March 6, 2010, multiple funnel clouds off the Orange County coast , south of John Wayne Airport and off Crystal Cove	9:47 – 9:50	NA	0	0
December 15, 2011, multiple funnel clouds 10-15 miles east of John Wayne Airport	13:00 – 13:30	NA	0	0
February 14, 2012, three funnel clouds 4 miles offshore Huntington Beach	7:30 – 9:00	NA	0	0

Windstorm Hazard Assessment Hazard Identification

The previous section describes the high wind events that have impacted the coastal Orange County area. By reviewing the historical record we can better understand the geographic extent of the hazard, the intensity of future events likely to impact the study area, and their probability of occurrence.

Windstorms are significant chronic events that cumulatively cause extensive damage, with property losses in the millions of dollars, in addition to potential injuries, and even loss of life. A windstorm event in the region can range from a short-term microburst or waterspout off the coast lasting only a few minutes, to Santa Ana wind conditions that can last for several days, such as the January 2003, and January and February 2006 events.

The data in Table 10-4 show that high winds can occur in the coastal Orange County area, including Newport Beach, almost any time during the year. However, Santa Ana wind conditions occur most often in the fall and winter months, between September and March. These winds generally impact a large geographic area. Similarly, high winds accompanying winter storms approaching from the north or northeast occur in the fall and winter, most often between November and February, although winter storms can occur as early as August, and as late as May. Tropical storms that make landfall in Baja California and move north into Arizona and California occur primarily in August and September. These summer winds tend to impact primarily the San Diego and desert areas. The data in Table 10-4 show that the only two months not represented in the windstorm historical record are June and July.

The historical record suggests that windstorm events can be expected almost annually across a large portion of the southern California area. The data presented in Tables 10-4 and 10-5 would suggest that windstorm events have increased in frequency over time, with more windstorm events occurring between 1997 and 2013, than between 1858 and 1996. However, the early historical record is often incomplete because 1) there were less people in the area that

could be impacted by these natural hazards, and 2) only unusually damaging storms would be recorded in newspapers, journals and other sources. Using the record from the last 15 years only, the southern California region is impacted by windstorms approximately two to eight times a year, but there is significant variability from one year to the next. For example, in 2006, the area was impacted by high winds at least eight separate times, but in 2008, 2009, and 2011, no high wind events were reported in the area.

The records show that tornados, funnel clouds and waterspouts can occur in the coastal Orange County area almost any month of the year, but preferentially between November and March. The tornado numbers also vary significantly from year to year, with substantial tornado activity some years, and none in others. For instance, during the 1997-1998 winter, as many as eight funnel clouds and tornadoes were recorded in the region, whereas in 2008 and 2009, there were none. The frequency of tornadoes seems to increase during El Niño years.

Tornadoes typically impact a relatively small geographic area. Many funnel clouds and waterspouts seem to be recorded offshore, with only a few of these actually making a landfall. The historical record suggests that tornadoes are unpredictable in their geographic occurrence in Orange County, although the cities of Huntington Beach, Newport Beach, Costa Mesa, Tustin and Irvine seem to have historically been impacted the most by these weather phenomena. Although tornado occurrence in southern California is relatively rare compared to the Midwest record, and the tornadoes that do hit this region are generally not as strong as the tornadoes in other parts of the country, the historical record shows that even F0 and F1 tornadoes are capable of causing property damage, injuries, and loss of life. Unlike flooding hazards, which are generally confined to a discrete area that can be mapped, windstorms may travel in any direction, and are only partly affected by topography (with stronger winds usually observed in canyons and passes, where the winds are funneled by the surrounding topographic highs). Given that we cannot predict when or where a windstorm will occur, nor its intensity, the conservative approach is to assume that a windstorm event can take place anywhere in the Newport Beach area anytime during the year, but preferentially in the fall or winter.

Vulnerability and Risk

Vulnerability assessment is the second step of the windstorm assessment process. It combines the geographic extent of the potential hazard (anywhere in Newport Beach for windstorms) with an inventory of City facilities within that geographic area (all City facilities are vulnerable). Santa Ana winds especially have the potential to impact the entire City of Newport Beach area. Given that these winds emanate in the Great Basin and move westward and offshore, especially strong winds often occur in and along the west-trending canyons in the San Joaquin Hills.

As past events show, windstorms in the City of Newport Beach have the potential to impact life, property, utilities, infrastructure and transportation systems, causing damage to trees, power lines, utility poles, road signs, cars, trucks, boats, and building roofs and windows (Figures 10-3, 10-4 and 10-5). Structures and facilities can be impacted directly by high winds and/or can be struck by air-borne debris. Windstorms can disrupt power to facilities and disrupt land-based communications as well. In fact, historically, trees downed during a windstorm have been the major cause of power outages in the southern California area. Uprooted trees and downed utility poles can also fall across the public right-of-way disrupting transportation. These events can be major hindrances to emergency response and disaster recovery. For example, if transportation routes are compromised by fallen debris, and loss of power occurs in the area, emergency response facilities like the hospital, fire stations, and the police station may find it difficult to function effectively. Falling or flying debris, falling trees and downed power lines can also injure or kill motorists and pedestrians. As discussed previously, windstorms, especially

Santa Ana winds, are often also associated with wildfires, which, if they occur in or near a populated area, can result in enormous losses to property, in addition to injuries and loss of life.

A windstorm also has the potential to displace residents, which may require the City to provide short-term and/or long-term shelters to accommodate these individuals, in addition to providing for other emergency response activities such as cleanup and repair. This has the potential to impact the City economically, as City funds would have to be tapped into to respond adequately to the needs of the impacted members of the community.

Community Windstorm Issues

What is Susceptible to Windstorms?

Life and Property

Based on the history of the region, windstorm events can occur in the area on an annual basis. As noted above, a windstorm event may occur anywhere in the City, and windstorm events are not readily predictable. Such an event in Newport Beach may result in the involvement of City maintenance personnel responding to cleanup and repairs during and following such an event. Similarly, maintenance crews may be required to secure certain facilities ahead of a potential windstorm, provided sufficient advanced notice is available, and that City crews are available to respond on short notice.

Depending on its age, condition, and structural design, any structure may be susceptible to damage. However, buildings with weak reinforcements are most susceptible to windstorm damage. Wind pressure can create a direct and frontal assault on a structure, pushing walls, doors, and windows inward. Conversely, passing currents can create lift suction forces that pull building components and surfaces outward and/or upward. Under extreme wind forces, the roof or entire building can fail or sustain considerable damage. Mobile homes are particularly susceptible to windstorm damage. Debris carried by the wind may also contribute to loss of life and, indirectly, to the failure of building envelopes, sidings or walls. As discussed above, when severe windstorms strike a community, downed trees, power lines and damaged property can be major hindrances to emergency response and disaster recovery.

Structures and boats next to the coastline can also be impacted by winds and swells caused by high winds. For example, during storms, the docks in a harbor can break loose and drift. This has happened infrequently in Newport Beach, especially with some of the older docks, which once they broke loose, drifted in the channels. During Santa Ana wind conditions, vessels on offshore moorings in Newport Beach have the potential to break free and drift when severe wind loads are placed upon them. This can be an extremely hazardous condition, as a freed multi-ton vessel floating aimlessly can bump into other boats and property, causing extensive damage, especially if it occurs at night. Personnel from the City's Harbor Department patrol the area for vessels that have broken free from their moorings and attempt to intervene before significant damage occurs (Chris Miller, Harbor Resources Department, personal communication, 2008). Vessel owners are required to inspect their mooring equipment by a mooring contractor every two years, but even so, mooring failures do occur, although infrequently, most likely in response to the very strong winds that hit the area periodically.

Figure 10-3: Windstorm damage to trees in a residential area of Newport Beach (Narcissus Avenue), caused by the April 28, 2005 storms. The winds felled several trees in the neighborhood, which in turn disrupted traffic, and damaged cars, fences, and sidewalks.



Photo courtesy of Mike Pisani from the General Services Department,
City of Newport Beach

Figure 10-4: Wind damage caused by the April 28, 2005 storms to trees in a residential area of Newport Beach (Narcissus Avenue). Two vehicles were damaged by this toppled tree branch.



Photo courtesy of Mike Pisani from the General Services Department,
City of Newport Beach

Lifelines and Critical Facilities

Historically, downed trees have been a major cause of power outages in the region during windstorms. Some tree limbs can break in winds of about 45 mph, and the broken limbs can be carried by the wind more than 75 feet from their source. Thus, overhead power lines can be damaged even in relatively minor windstorm events (Figure 10-5). Downed trees can also bring electric power lines down to the pavement or ground, where they become serious, life-

threatening, sources of electric shock. Lifelines and critical facilities should remain accessible, if possible, during a natural hazard event. The impact of closed transportation arteries may be increased if a blocked road or bridge is critical to access the hospital or other emergency facilities. Increased population, and new infrastructure in the region could result in a higher probability for damage to occur from windstorms as more lives and property are exposed to this hazard.

Figure 10-5: Downed power lines (and transformer) in the City of Newport Beach caused by the January 1, 2005 storm.



Photo courtesy of Mike Pisani from the General Services Department, City of Newport Beach

Infrastructure

Windstorms may damage buildings, power lines, and other property and infrastructure due to falling trees and branches. During wet winters, saturated soils cause trees to become less stable and more vulnerable to uprooting from high winds. Windstorms can also result in damaged or collapsed buildings, blocked roads and bridges, damaged traffic signals and streetlights, and damaged park facilities. Roads blocked by fallen trees during a windstorm may severely impact people attempting to access emergency services. Emergency response operations can be compromised when roads are blocked or when power supplies are interrupted. Industry and commerce can suffer losses from interruptions in electric services and from extended road closures. They can also sustain direct losses to buildings, personnel and other vital equipment, all of which have a direct impact on the local economy.

Transportation

In addition to the problems caused by downed trees and electrical wires blocking streets and highways, windstorms can also force the temporary closure of roads to vehicular traffic. This is especially true during extremely strong Santa Ana winds. These closures, however, typically do not pose a hardship to the local economy, as they do not last long.

Windstorm Mitigation Activities

Strong winds can have both short- and long-term impacts on the region's economy, and on the health and wellbeing of residents and visitors. Stronger winds, in part as a result of more severe

weather, could be the norm in the not-to-distant future due to global climate change. Although most windstorms are regional in scope, a community can implement measures that can locally help to reduce the effects of severe weather, and that can help the City to respond proactively and effectively when a strong wind event impacts the region.

Windstorm mitigation activities include current mitigation programs and activities that are being implemented by State and City agencies. As discussed extensively in the paragraphs above, one of the most common problems associated with windstorms are power outages resulting from fallen power poles, and downed trees and branches coming in contact with and disrupting nearby distribution power lines. Fallen trees can cause power lines to short-circuit and conductors to overload. Wind-induced damage to the power system can result in power outages that, at best, inconvenience, and at worst, pose a life-threatening situation to customers; incur costs to make repairs; and in some situations, can cold-start a fire. As a result, and in an effort to reduce damage to the power supply, one of the most effective mitigation strategies pertain to tree clearance. Specifically, California law requires utility companies to maintain clearances (specified distances based on the type of voltage running through the line) between electric lines and all vegetation. Enforcement of the following California Public Resources Code Sections provides guidance on tree regulations: 4293 – Power Line Clearance Required; 4292 – Power Line Hazard Reduction; 4291 – Reduction of Fire Hazards Around Buildings; and 4171 – Public Nuisances (www.cpuc.ca.gov/js.asp).

Failure to allow a utility company to comply with the law can result in liability to the homeowner for damages or injuries resulting from a vegetation hazard. Many insurance companies do not cover these types of damages if the policyholder has refused to allow the hazard to be eliminated. Undergrounding of overhead utility lines can help reduce the impact of windstorms on the power system, while improving the aesthetics of the community.

As indicated above, the City of Newport Beach requires that each mooring be inspected at least once every two years by the Harbor Resources Manager or a contractor authorized by the Harbor Resources Manager. If upon inspection, the lifted mooring is found to be defective, it has to be repaired before replaced back in the water (Municipal Code 17.25.020, Section K). Vessels using moorings in Newport Beach also need to be firmly anchored so as to prevent the vessel from swinging, turning or drifting (Municipal Code 17.25.020, Section I.1). These requirements are designed to reduce the potential for wind damage to moorings and vessels, but failure of these facilities sometimes still occurs due to the harsh water environment and often unpredictable weather conditions.

Widespread weather observation stations and networks, in addition to great advancements in computer modeling and a better, if not yet comprehensive understanding of atmospheric processes, have greatly facilitated the forecasting of meteorological events such as winter storms and windstorms. Weather forecasts, combined with an increased use of internet and media resources, permit the wide dissemination of weather warnings in real time, with the potential to greatly reduce the effect of extreme weather events on people and property. Utility companies, relief organizations, and government officials can and should use weather warnings to anticipate a need for an increase in the number of on-call maintenance and emergency response personnel to respond to power outages, downed trees and fallen electric lines, and other damages typical during and following high-wind events.

Windstorm Resource Directory

State Resources

California Division of Forestry and Fire Protection

1416 9th Street
P.O. Box 944246
Sacramento, California 94244-2460
Ph: 916-653-5123

Governor's Office of Emergency Services (Cal OES)

P.O. Box 419047
Rancho Cordova, CA 95741-9047
Ph: 916-845-8911
Fax: 916-845-8910

California Department of Transportation (Cal Trans)

120 S. Spring Street
Los Angeles, CA 90012
Ph: 213-897-3656

Federal Resources and Programs

Federal Emergency Management Agency (FEMA) – Region IX

1111 Broadway, Suite 1200
Oakland, CA 94607
Ph: 510-627-7100
Fax: 510-627-7112

National Weather Service

Los Angeles / Oxnard Weather Forecast Office

520 North Elevar Street
Oxnard, California 93030
Forecast and Weather Information: 805-988-6610
Administrative Issues: 805-988-6615

Publications

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