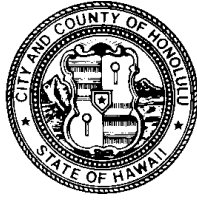


OAHU CIVIL DEFENSE AGENCY
CITY AND COUNTY OF HONOLULU
650 SOUTH KING STREET HONOLULU, HAWAII 96813



Atmospheric Hazards

4. Strong Winds

WIND HAZARDS

Wind is one of the most costly insured property perils, causing more damage than earthquakes, freezing, or other natural perils. (IIPLR, 1994) In most wind storms, but especially in hurricanes, windborne debris can be a major factor in causing damage. Flying objects such as tree limbs, outdoor furniture, signs, roofs, gravel, and loose building components from progressively failing adjacent buildings can impact the building envelope, creating openings that allow internal pressure to build within.

Strong Winds

Winds on Oahu originate from three main sources: trade winds, Kona winds, and hurricanes or tropical storms. Northeast trade winds are dominant throughout most (70%) of the year and generally range in velocity between 10 and 20 mph. However, trade winds of 40–60 mph occasionally occur for several days at a time when the sub-tropical high-pressure cell located in the central North Pacific Ocean intensifies. During the 1993–1994 and 1994–1995 winter seasons, for example, strong and gusty trade winds of 40 to 50 mph lasted several days and inflicted damage to roof tops, tree limbs, and telephone equipment. The east-facing coastlines, as a result, are the windward coasts and most impacted by trade wind energy. Kona winds are southerly winds and occur as light and variable winds during summer months when trade wind circulation breaks down, but in winter they can be very strong when storm systems moving across the central North Pacific draw air from the south toward their low pressure troughs. Damaging Kona winds from storms generally occur during the winter and spring seasons and have reached velocities of 50 mph for several days on end.

Wind Patterns

Trade winds are by far the most common winds over Hawaiian waters and play a major role in defining the climatology of the region. (Kodama 1998). These persistent winds, which blow from a NE to ENE direction, became known as trade winds long ago when clipper ships carrying cargo depended on the broad belt of Easterly winds encircling the globe in the subtropics for fast passage. Trade winds account for 70% of the total winds experienced in Hawaiian waters. (Kodama 1998)

Though pleasantly brisk and refreshingly cool on land, strong, gusty trade winds can cause problems for mariners. These strong trades blowing from the NE through East funnel through the major channels between the islands--Kauai, Kaiwi, Pailolo, Kalohi, and Alenuihaha Channels--at speeds 5-20 knots faster than the speeds over the open ocean. North Pacific High pressure systems are responsible for the majority of the gusty trade wind episodes over Hawaiian waters, which commonly persist for several days before tapering off. Mariners and beachgoers must exercise good judgment prior to entering the waters exposed to strong trades, especially in the major channels.

High winds from trade winds, which blow 70% of the time, Kona winds (30% of the time, and winds from hurricanes and tropical storms passing through Hawaiian waters all affect the island of Oahu. (Fletcher 2000) Tradewinds predominate from the northeast and generally range from 10 – 25 miles per hour, although occasional extreme events reach 40 - 50 miles per hour when the sub-tropical high pressure cell north of the islands intensifies. (Fletcher 2000)

Kona Storms

"Kona" is a Hawaiian term for the stormy, rain-bearing winds that blow over the islands from the SW or SSW, from the opposite direction of trade winds. The western or leeward sides of the islands, then, become windward in this case, as the predominant wind pattern is reversed. Kona winds are most likely to occur when a low pressure center is located within 500 miles NW of the islands and has an unusually low central pressure, below 1000 millibars for the subtropics.

Kona winds occur as light and variable winds, most often during winter months when trade wind circulation diminishes, and as strong generally southerly winds when storm systems move across Hawaiian waters. Damaging Kona winds have reached velocities of 50 miles per hour for several days on end. Kona storms generally form in the region bounded by 15° - 35° N and 175° E – 140° W and move erratically, though with a slow tendency toward the west. (Kodama 1998. These storms are persistent and can last up to two weeks. During this time, considerable damage can be inflicted to boats caught in the open ocean or boats anchored in SW exposed anchorages. Coastal erosion can also result from the extended periods of heavy rain, strong surf and high winds.

On land, effects of strong Kona winds can be very dramatic. It is not uncommon for trees to be uprooted, branches downed, and roofs blown off houses. When reinforced by mountainous topography, downslope winds can increase and can be very destructive to land in low lying areas. The Kaneohe-Kahaluu area below the Koolau Mountains have had extensive wind damage due to strong Kona winds.

Damaging winds on Oahu associated with passing tropical cyclones:

- **Hurricane:** An intense tropical weather system with a well defined circulation and maximum sustained winds of 74 mph (64 knots) or higher.
- **Tropical Storm:** An organized system of strong thunderstorms with a defined circulation and maximum sustained winds of 39 to 73 mph (34-63 knots).
- **Tropical Depression:** An organized system of clouds and thunderstorms with defined circulation and maximum sustained winds of 38 mph (33 knots) or less.

Historically, most tropical cyclones have passed the Hawaiian Islands to the south and west. Because they spin counter-clockwise in the Northern Hemisphere, east-facing coastlines in Hawaii receive the brunt of strong onshore winds as storms approach the islands, while the

south and west coastlines feel onshore winds as the storms pass to the west. The highest wind speeds, however, may occur on the side opposite the storm approach, as localized microbursts and downdrafts accelerate downslope as they descend over the pali (cliffs). As Hurricane Iwa passed west of Oahu the highest winds were observed at the base of the Pali in Kaneohe. Even so, coastlines facing the passing storms usually are adversely impacted by both wind and storm surge damage, like the Waianae Coast was as Hurricane Iniki passed to the west, before slamming into Kauai. History has shown that the islands do not have to take a direct hit from a storm to sustain a high level of damage. Wind strength, storm radius of maximum winds, timing, and proximity, are important factors that control storm impact to the coastal zone.

Wind Pressure

Internal pressures develop within a building when the building envelope is breached. The breach in the envelope is commonly caused by the breakage of window glass or the failure of an overhead door. The internal pressures add to the external pressures producing more severe pressures on the building components of the structure. (IPLR, 1994) The roof then feels tremendous internal pressure building from inside, together with the negative wind pressures lifting the roof from outside. The resulting combined forces may be too large, even for good roofs if the roof has not been designed for them. After the roof is gone, high winds and rain destroy the inside of the structure.

TABLE 4-1 TROPICAL STORMS THAT AFFECTED OAHU IN HISTORICAL TIMES

Year	Date	Name	Track	Closest island	Wind Average (mph)	Gust (mph)	Low BP (mbar)	Rate of Travel (kts)	Eye (nmi)	Rain (in)	Stream	Marine Surf (ft)	Tidal Surge (ft)	Max. Run-up (ft)	High Water (ft)	Type of damage	Damage (1998 \$)	Comments
1993	7/23	Eugene	Waimea at Hawaii	Hawaii	35		*1008	25		~ 3						Hawaii: Up to 3 in rain in Hilo, Kau, Kona, some flooding. All islands: showers with isolated thundershowers.		Hurricane downgraded to tropical depression on 21st, disintegrated E of Hawaii.
1993	7/22	Dora	W. hit Hawaii	Hawaii						Heavy						Oahu: Heavy rain caused floods and power outages, especially on windward side, Polynesian Cultural Center closed, lightning over west/central Oahu, 3 in rain in 8 hrs in Nuuanu. Maui: Flooding closes Honoapiilani Hwy, clogged drainage channel, silt in water supply, 1 family evacuated. Hawaii: Snow on Mauna Kea/Mauna Loa, some roads flooded, some damage.		Tropical storm.
1988	9/20-9/25	Wila	W. recurved NE	Hawaii	40		*1007			6-12	Wide-spread					All islands: Some heavy showers.	\$50,000	Tropical storm, widespread minor floods
1988	7/30-8/3	Gilma	NW, passed along Maui, over Oahu, just S of Kauai	Oahu	35		*1008			2-4						Oahu, Kauai: Showers, thundershowers, local stream flooding.	\$500-5,000	Tropical depression.
1985	7/1-7/5	Enrique	SW, passed 350 mi S of Hawaii	Hawaii	29		*1010	17				10 ft				Hawaii: Local heavy showers on windward/Kona slopes. All islands: 10 ft surf on S shores, minor damage to roadways, minor injuries to surfers.	\$50,000	Tropical depression.
1983	9/27-9/30	Narda	W. passed 150 mi S of South Point	Hawaii	52		*1003						Higher than normal			All islands: High surf on E and SE shores, high wind, rain.		
1983	8/3	Gil	NW, passed 10 mi N of Kilauea Point	Kauai	63		1011	20		Heavy		High surf				Kauai: Heavy rains, surf, N and E shores. Oahu: High winds and surf, vessel lost.	\$500-5,000	Tropical storm.
1978	8/6-8/9	#10	W. passed 300 mi SSW of Oahu		35		*1008			5-6.5						All islands: Heavy rains, local thunderstorms.		Tropical depression.
1978	7/3-7/11	Daniel	W							5-7						Hawaii, Maui: 5-7 in rain on windward/mountain sides. Other Islands: Spotty rainfall up to 2 in.		Ex-hurricane/vortex
1978	6/26-7/3	Carlotta	W. passed over Aenuihaha Chnl	All						6						Brought 6 in of rain, especially to Oahu.		Ex-hurricane, major weather producer of the season.
1971	1/8-1/18	Sarah	NW		69		987	69		3-6						Oahu: Powerlines and trees downed, 28 houses damaged, 2 injured as tree fell on car. Molokai: Five houses damaged, Lanai airport closed. Kauai: 61-66 mph winds at Kokee.	\$100,000	Tropical storm, moved on to acific NW.
1967	8/10-8/14	D	NW, passed 250 mi W of all islands					14-15		2-3						All islands: Spotty rainfall of 2-3 in.		Tropical vortex.

[BP, barometric pressure; mph, miles per hour; mbar, millibars; kts, knots; nmi, nautical miles; in, inches; ft, feet; \$, dollars; M, million; B, billion]
 * Values are calculated from $P_o = 1013 - V^2 / 14^2$ where P_o = minimum pressure (mbar), and V = maximum sustained winds (kts). This empirical relationship relating minimum pressure to maximum wind speed was determined by the National Hurricane Center.

TABLE 4-1 TROPICAL STORMS THAT AFFECTED OAHU IN HISTORICAL TIMES

Year	Date	Name	Track	Closest island	Wind Average (mph)	Gust (mph)	Low BP (mbar)	Rate of Travel (kts)	Eye (nmi)	Rain (in)	Stream	Marine Surf (ft)	Tidal Surge (ft)	Max. Run-up (ft)	High Water (ft)	Type of damage	Damage (1998 \$)	Comments
1967	8/2-8/11	B	W, passed over South Point, moved NW.	Hawaii						~12	Floods in Hilo.					Hilo, Hawaii: 12 in rain in 36 hrs, flash flooding, landslides. Oahu: 3-4 in rain, rockslides (Pali), mudslide in Aina Haina nearly destroyed house.	\$50,000	Tropical cyclone.
1967	7/11-7/21	Eleanor	WNW, passed 250 mi S of Oahu		63		*998			~9						Hawaii: Up to 9 in rain, heavy hail on Mauna Kea. Maui: 2 in rain, small hail on Haleakala, flooding between Napili and Honolua. Other Islands: 2 in rain.		Tropical storm.
1967	7/5-7/18	Denise	WNW, passed 180 mi S of South Point	Hawaii	63		*998			~6						Hawaii: Up to 6 in rain Other Islands: Moderate to heavy.		Tropical storm.
1967	7/4-7/8	Unnamed	W, passed S							8-10						Hawaii: 8-10 in rain in Kipa, Papaikou, Mauka, Kaumana. Other Islands: 2-3 in rain.		Tropical depression.
1966	9/10-9/12	#22	W, passed 240 mi S of South Point	Hawaii						Moderate, heavy						All islands: Moderate to heavy rainfall.		Tropical depression.
1963	9/12-9/19	Irah	Center moved into Molokai channel		52		*1003									All islands: Moderate rainfall, wind 36 mph at Honolulu airport. Tropical Storm.		
1958	8/7-8/9	Unnamed	Appeared off Hilo, moved across islands	Hawaii	58	86	*1000									Hawaii: Torrential rain, houses, 3 bridges destroyed, 100's trees, powerlines down; crop damage 1 dead in plane crash. Other Islands: Heavy rains scattered damage.	\$552,000 \$50,000	
1938	8/18-8/19	Mokapu Cyclone				61	1008			4						Oahu: Thunder and lightning, winds up to 61 mph. Some damage to Waimanalo plantation. Oahu, Maui: 4 in rain.		
1925	7/31-8/4	Ramage Cyclone									High					Hawaii: Honuapo and Punaluu flooded, strong winds. Oahu: Very high surf on S shore (Honolulu, Diamond Head), Fort Kam flooded		
1911	9/29	Ship Cyclone														Oahu: Rough seas capsized boat off Waikiki		
1874	11/17-11/20	Die Seewarte III	Deutsche					1002.4			20					Oahu: 20 in in Honolulu in 2 days. Molokai: 23 houses destroyed, 50 destroyed at Kalaupapa.		

[BP, barometric pressure; mph, miles per hour; mbar, millibars; kts, knots; nmi, nautical miles; in, inches; ft, feet; \$, dollars; M, million; B, billion]
 * Values are calculated from $P_0 = 1013 - v^2 / 14^2$ where P_0 = minimum pressure (mbar), and v = maximum sustained winds (kts). This empirical relationship relating minimum pressure to maximum wind speed was determined by the National Hurricane Center.

Oahu

Strong winds

Islandwide strong winds

- 1871 Aug 9 Kohala Cyclone
- 1918 Dec 3-4 High winds
- 1925 Jul 31 Ramage Cyclone, gale easterlies
- 1938 Aug 18-19 Mokapu Cyclone, 84 mph
- 1949 Jan 15-17 High winds
- 1954 Nov 27-28 High winds
- 1957 Nov 30-31 H Nina, high winds
- 1958 Aug 7-9 Tropical storm
- 1959 Jan 17-18
- 1959 Aug 4-7 H Dot
- 1981 Oct 24 Strong winds
- 1983 Jan 15-17 Strong winds, gusts to 70 mph
- 1983 Jan 30-31 Gusts to 84 mph
- 1983 Sep 12-19 TS Irah
- 1985 Nov 10-15 High winds
- 1987 Feb 16-17 Gusty winds
- 1987 Nov 2-11 High trade winds
- 1987 Dec 12 Winter storm
- 1988 Jan 18-17 Winter storm, gusts >50 mph
- 1970 Dec 25-29 Winter storm, 50-80 mph
- 1971 Jan 5 Strong winds
- 1971 Jan 8-18 TS Sarah, strong winds
- 1976 Feb 5-7 Strong winds
- 1976 Nov 6-7 Strong winds
- 1980 Jan 8 Storm
- 1981 Feb 11 Strong winds
- 1982 Feb 11 Winter storm, strong winds
- 1982 Nov 23 H Iwa
- 1982 Dec 18-19 Gusty trades, to 80 mph
- 1982 Dec 23-24 Gusty trade winds
- 1983 Sept 28 High winds
- 1983 Dec 24-25 Winter storm, gusts >50 mph
- 1984 Mar 1-9 Gusts 30-40 mph
- 1984 Dec 24-25 Kona storm
- 1985 Jan 29-30 High winds, esp. at Nanakuli & Waianae
- 1985 Mar 1-11 Gale force winds
- 1985 Nov 30 Strong northerly winds
- 1987 Jan 19 High winds, 35 mph
- 1988 Nov 4-5 Storm, gusts 40-50 mph
- 1988 Dec 5-8 Southerly 50 mph
- 1988 Dec 30-31 Winds 40-50 mph
- 1989 Mar 1-4 Storm, strong winds
- 1989 Jul 19-20 TS Daillia, strong winds
- 1989 Dec 9-11 Gusty winds
- 1990 Feb 6-9 Gusts to 80 mph
- 1992 Sep 11 H Iniki
- 1993 Dec 4-8 Strong trade winds 80-80 mph
- 1994 Mar 12-18 40-50 mph trades
- 1995 Apr 14-19
- 1996 Dec 7-8 Strong North winds, gusts to 80 mph
- 1996 Dec 28-31 South winds, gusts to 75 mph
- 1997 Jan 2-3 South winds, gusts to 80 mph

- Lakes and reservoirs
- 0-1000 feet
- 1000-2000 feet
- 2000-3000 feet
- 3000-4000 feet
- 4000-5000 feet
- over 5000 feet
- Urban areas

- Highways
- Streams
- Canals
- H Hurricane
- TS Tropical storm
- 50 mph Max. winds (miles per hour)

Central Oahu
 1915 Dec 26 High winds
 1971 Jan 8-18 TS Sarah, gusts to 82 mph
 1971 Jan 27 Tornado at Whitmore Village
 1973 Aug 15 Dust devil
 1982 Feb 13 Tornado
 1982 Nov 23 H Iwa, 80-85 mph

Waterspouts frequent
 1982 Nov 23 H Iwa, 50-55 mph

Kaena Point
 Waterspouts, funnel clouds occasional
 1971 Jan 8-18 TS Sarah, gusts to 89 mph

West Shore
 1986 Dec 18 Whirlwind
 1988 Nov 28 Strong winds up to 69 mph
 1989 Feb 20-21 Strong winds
 1982 Nov 23 H Iwa, strong winds
 1992 Sep 11 H Iniki, 60-65 mph

Waterspouts, funnel clouds occasional
 1959 Aug 4-7 H Dot, 40 mph
 1968 Apr 9-10 30-50 mph
 1969 Feb 20-21 Strong winds
 1982 Nov 23 H Iwa, strong winds
 1986 Apr 8 Strong winds at Nanakuli
 1992 Sep 11 H Iniki, strong winds

Barbera Point
 Waterspouts, funnel clouds frequent
 1859 Aug 4-7 H Dot, 60 mph
 1983 Feb 28 Tornado
 1982 Nov 23 H Iwa, strong winds
 1988 Mar 26 Tornado
 1992 Sep 11 H Iniki, strong winds

Waterspouts, funnel clouds frequent
 1982 Nov 2 H Iwa, 55-60 mph
 1983 Sep 23 Tornado at Pearl City
 1988 May 13 Sm. tornado at Waipahu
 1992 Sep 11 H Iniki, strong winds

Waterspouts, funnel clouds frequent
 1874 Nov 17 Tropical cyclone, 55-63 mph
 1906 Mar 6-7 High winds
 1914 Jan 12-13 High NE wind
 1916 Jan 10 High winds
 1925 Aug 25 Ramage Cyclone, strong winds
 1926 Jun 8 Possible tornado
 1950 Aug 15 H Iki, 39 mph
 1957 Nov 30-31 H Nina, 65 mph
 1963 Sep 12-19 TS Irah, 38 mph
 1980 Jan 8 Storm
 1982 Nov 23 H Iwa, 49 mph, gusts to 84 mph
 1982 Dec 23-24 High winds
 1992 Sep 11 H Iniki, strong winds
 1993 Mar 9 Honolulu area, strong winds of passing cold front, minor damage

Windward Side

- 1925 Jul 31 Ramage Cyclone, strong winds
- 1950 Aug 12-18 H Iki, 50-60 mph
- 1985 Mar 30-31 High winds
- 1988 Feb 15-18 SW winds, gusts to 62 mph
- 1989 Jan 30 Strong winds
- 1970 Dec 25-29 Winter storm, 50-80 mph
- 1971 Jan 8-18 TS Sarah
- 1972 Feb 4 Gusts to 88 mph
- 1981 Feb 11 Strong winds
- 1982 Nov 23 H Iwa, 55-85 mph
- 1983 Aug 3 TS Gill
- 1986 Dec 5 Gusts to 60 mph
- 1988 Dec 5-8 Southerly 50 mph
- 1994 Mar 12-18 Strong, gusty trades, 40-50 mph
- 1995 Apr 14-19 Strong trades, 40-50 mph

Waterspouts, funnel clouds frequent
 1938 Aug 18-19 Mokapu Cyclone, 81 mph
 1970 Jan 13-15 96 mph, gusts to 117 mph
 1971 Jan 8-18 TS Sarah, gusts to 89 mph
 1982 Nov 23 H Iwa, 65-70 mph, gusts to 112 mph

Kaliua
 1983 Mar 31 Strong winds
 1978 Oct 22 70 mph
 1997 Jan 27-28 Southwest winds 80 mph

Waterspouts frequent
 1938 Aug 18-19 Mokapu cyclone, near 80 mph
 1971 Jan 8-18 TS Sarah, strong winds
 1982 Nov 23 H Iwa, 50-55 mph, gusts to 82 mph
 1988 Dec 30-31 Southwest winds gusts to 80 mph

Waterspouts, funnel clouds frequent
 1892 Sep 11 H Iniki, strong winds

