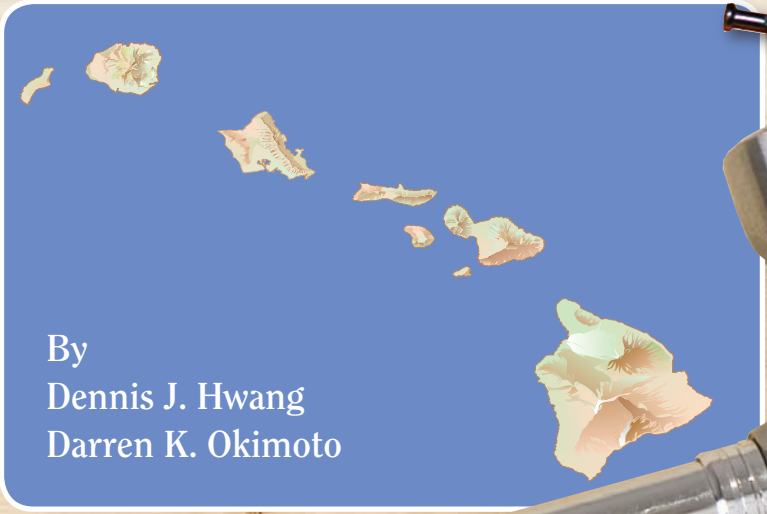
University of Hawai'i Sea Grant College Program

HOMEOWNER'S HANDBOOK TO PREPARE FOR NATURAL HAZARDS



By
Dennis J. Hwang
Darren K. Okimoto

Sea Grant University of Hawai'i

SCHOOL OF OCEAN AND EARTH SCIENCE AND TECHNOLOGY

NOAA

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It is our hope that the information contained within the handbook, which is in part a compilation from numerous publications associated with natural hazards and hazard mitigation, will be widely used and adopted by stakeholders in Hawai‘i and the region.

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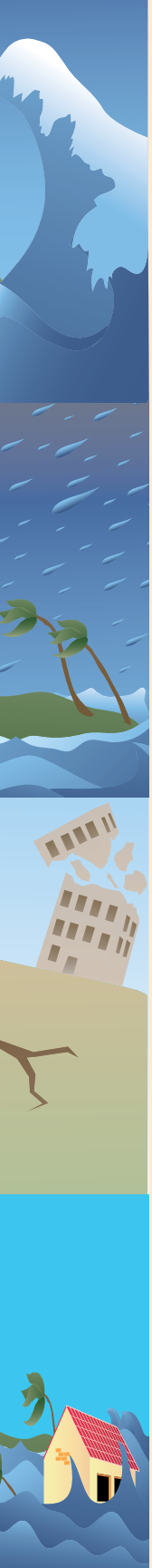

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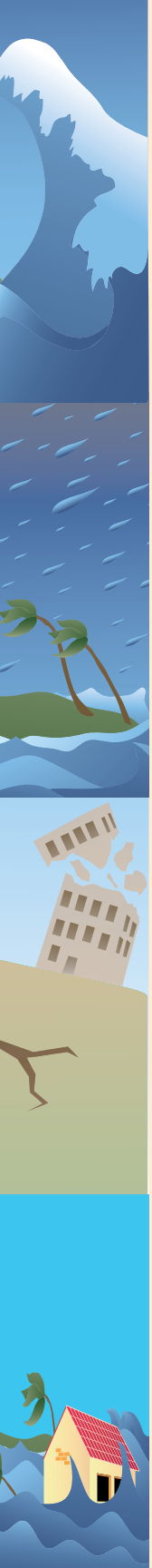

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Part 1
Introduction

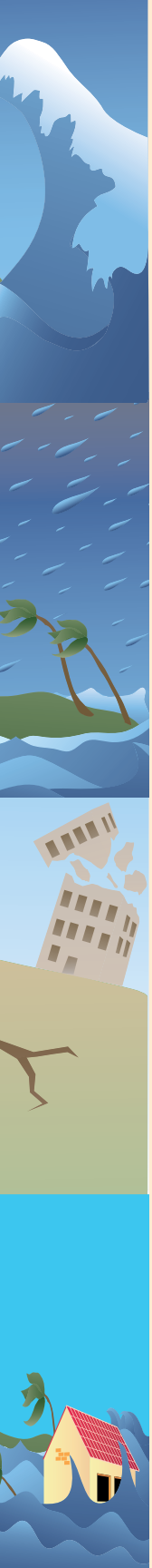
Your home is your castle. It protects you and your family, as well as your worldly possessions, from the elements. For many, the home is also your major investment. Yet natural hazards such as tsunamis, hurricanes, floods, or high wind events can threaten your home, both inhabitants and contents. When a natural hazard occurs, the results can be devastating.

This handbook was created to help you prepare for a natural hazard so that risks to family and property may be reduced. While it is never possible to eliminate all damage from a natural hazard, you as a homeowner can take action and implement many small and cost-effective steps that could significantly lower your risk. Mother Nature can be intense. Your family and home deserve protection that only you can provide.

This handbook is divided into four parts. This Introduction presents the purpose and layout of the handbook, and includes a discussion of common myths that may have prevented you from taking action in the past. There is also a summary of the content of this handbook in the form of ten action items. Part 2 provides basic information on tsunamis, hurricanes, earthquakes, and flooding that will allow you to make an educated decision about the steps to take to protect your family and property. Part 3 discusses in detail how to protect yourself and your family. Included in this section are the stock of essential emergency supplies, evacuation kit, evacuation planning, evacuation procedures, and important information that the civil defense and emergency management agencies want you to know even before a warning siren goes off. Part 4 covers how you can protect your property. Many examples are provided.

This handbook is available for free as a downloadable pdf file at the University of Hawai‘i Sea Grant College Program website.
http://www.soest.hawaii.edu/SEAGRANT/communication/communication.php.

This handbook will be updated on an as-needed basis as new information becomes available and feedback from the public is obtained. You can also contact your state or county civil defense and emergency management agencies by phone at the addresses and numbers provided. In addition, many of the sponsors and participants of this handbook may have updated information on their own websites.



1.1 Common Myths and Reasons to Prepare

You may be among the many homeowners in Hawai‘i who have not fully prepared for a natural hazard because of complacency caused by several myths. The most common myths appear as quotes below and are discussed in order to remove some of the major barriers to taking action and to encourage people to prepare.

1) **“A natural hazard can’t happen to me.”** Scientists agree that it is not a matter of IF the next tsunami or hurricane will occur, but WHEN. From 1819 to 1975, Hawai‘i experienced at least twenty-six damaging tsunamis, or about one every seven years.[1] Since 1975, we have not had a damaging tsunami. Indeed, our state has been fortunate in the last few decades, but there is still a good chance you will experience a major event in your lifetime. It is also a myth that only Hawai‘i County will be impacted by a tsunami. All islands are at risk, especially from a distant tsunami.

2) **“If a hazard occurs, it won’t be that bad.”** When a tsunami or hurricane occurs, the damage can be devastating. When Hurricane Iniki struck Kaua‘i in 1992, more than 41 percent of the island’s 15,200 homes were damaged or destroyed (1,100 were destroyed; about 1,000 suffered severe damage; 4,200 suffered moderate to minor damage).[2] More than seven thousand residents were left homeless.[3] Damage could have been much worse if Iniki had struck the islands of Maui, Hawai‘i, or O‘ahu, which have approximately two to eight times more residential properties.[4] It is also conceivable that a single hurricane can strike more than one island.

3) **“I survived Hurricane Iniki so I am sufficiently prepared.”** Many people outside of Kaua‘i have the impression that they survived Hurricane Iniki, and therefore they do not need to prepare any more than they did in 1992. As will be shown, only Kaua‘i received the full force of the winds, rain, and high surf from Hurricane Iniki.

4) **“Hurricanes only hit Kaua‘i so those on the other islands don’t need to prepare.”** It is a myth that only Kaua‘i will be hit by a hurricane. While the most recent hurricanes hit Kaua‘i—‘Iwa (1982)

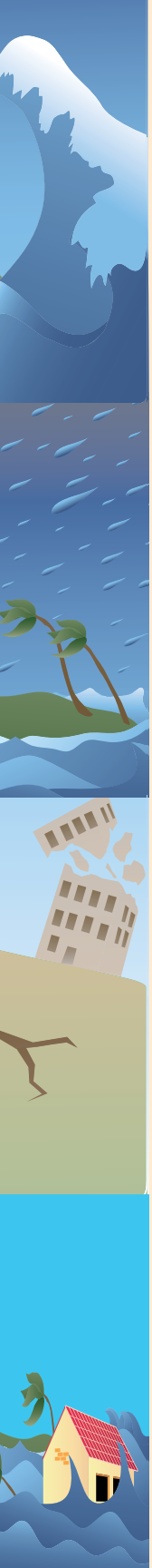
and Iniki (1992)—other hurricanes or cyclonic storms have hit the other islands at various points in history. For example, Nina damaged O‘ahu in 1957, and, according to the National Weather Service, a major hurricane hit Maui and Hawai‘i in 1871. Also, there have been many close misses, both historically and recently. Most scientists feel all the islands are at nearly equal risk from a hurricane.

5) **“I don’t live near the coast, so I am safe.”** In fact, the vast majority of damage or destruction on Kaua‘i by Iniki was caused by the powerful winds of the hurricane.[5] Therefore, all homeowners should prepare, not just those along the coast.

6) **“Installing hurricane clips doesn’t guarantee there will be no damage after a hurricane, so I won’t bother.”** Even though someone may wear a seat belt, shoulder belt, and have an airbag, there is no guarantee that a person won’t be injured in a major auto accident. Yet most people recognize the importance of these safety devices in reducing risk and use them. Likewise, the measures discussed in this handbook could significantly reduce risk, although there are no guarantees.

7) **“If a natural hazard occurs, government will come to the rescue.”** After the October 15, 2006, earthquake, many homeowners on the island of Hawai‘i found that the government will not repair their damaged houses or even provide adequate compensation for property damage. It is up to you to plan properly, strengthen your house, and have the appropriate financial protections in place, such as insurance, if it is available. After a natural hazard, government may also be overwhelmed by the number of people in need.

8) **“My house in Hawai‘i County survived the October 15, 2006, earthquake, so I do not need to retrofit for earthquakes.”** The ground shaking on all the islands during the October 15, 2006 event was significantly lower than the force exerted by an earthquake that would cause damage to homes built to the current building code specifications. If and when such an earthquake occurs, the resulting damage to homes will be much greater. Homeowners in Hawai‘i County should consider retrofits that provide a continuous load path connection, which will help protect



homes against both hurricanes and earthquakes. Additional simple measures are also possible.

9) **"Earthquakes only affect Hawai'i County, so I don't need to worry."** Although earthquakes affecting the island of Hawai'i are more frequent and likely to be larger, there is still a significant seismic hazard for Maui County and the island of O'ahu. Fortunately, many of the measures to protect a home against a hurricane on Maui County and O'ahu can also protect against an earthquake. Residents of Hawai'i County may need additional measures.

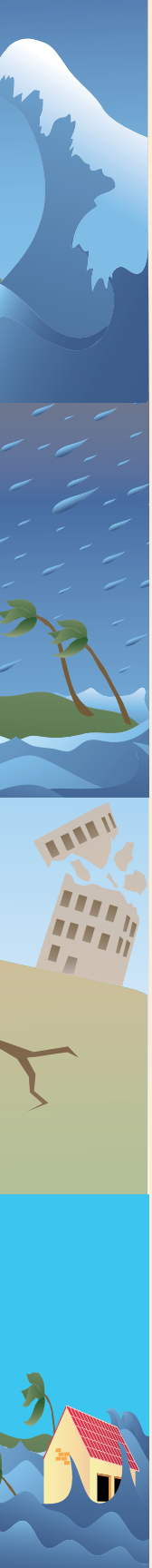
10) **"Even if a hazard occurs, there is nothing I can do."** Fortunately, there are many small steps you can take to significantly reduce the risk of damage to life and property. While it is not possible to eliminate all risk or damage, these reasonable steps to plan and prepare can make a major difference and determine whether your house survives and just receives minor or no damage. Thus, the information in this handbook covers two major parts for preparation: (i) protecting yourself and your family, and (ii) protecting your property.

11) **"Strengthening my house is too expensive and not worth the effort."** The following list discusses various ways to strengthen your house and the associated costs.

- Hurricane clips or window coverings can run on the order of a few thousand dollars. This alone offers significant protection.
- For minimal costs, the roof structure (trusses and rafters) for many houses can be strengthened with bracing.
- Strengthening your roof can be expensive if done by itself. However, if it is done when you replace your roof at the end of its normal life, the incremental cost is reasonable.
- Foundation upgrades can be expensive, but considering your house is probably your major investment, it could be worth the immediate cost.

- Strengthening your house can protect you from earthquakes and hurricanes. This is a double benefit, especially for those on Hawai‘i County. Many of these upgrades can be offset with insurance premium discounts or grants from the State Loss Mitigation Grant Program. Ultimately, strengthening your house should be considered a home improvement that adds value to your house and is worth the effort, even without external incentives. The time and money spent to prepare your house is a very small fraction of the resources that may be needed if you fail to minimize damage when a natural hazard strikes.

In addition, when a hazard such as a hurricane nears, evacuation to a shelter should be considered a last resort. There will be minimal supplies, the simplest of sanitary facilities, a bare floor, and little space (10 square feet per person—5 ft. x 2 ft.). You will have to bring your own supplies, including bedding, medication, food, and water. By preparing and strengthening your house, you can wait out the hazard in far more comfortable conditions and better take care of family members, including the elderly, those with special needs, and pets. Also, by strengthening your house you protect your neighbors as well as yourself. A house that falls apart during a hurricane will create debris which can damage adjacent properties. You also help the emergency efforts of the local, state, and federal governments by being able to assist other people instead of requiring help yourself.



1.2 Ten Things You Can Do to Prepare

As covered in later parts of this handbook, here are ten things you can do to prepare that will provide greater protection to your family and your property.

1) **Gather your emergency supplies.** You can gather emergency supplies in your house now. Check and restock each month so that the supplies are complete, not outdated or used. Avoid rushing to a store during an emergency to gather your supplies. There will be long lines and empty shelves. You will add to the crowd and confusion. The good news is many items you need are probably already in your home. (See Part 3)

2) **Create an evacuation plan for both a tsunami and a hurricane. They are different.** For a hurricane, your plan may include sheltering in your house if it is sufficiently strong (see # 5) and outside the evacuation zone (see the white pages of your phone book). If you can't use your house, use a suitable alternative structure (a friend's or relative's house) or **a shelter that is officially open (listen to local radio and television).** (See Part 3)

   For a tsunami, evacuate to high ground outside the evacuation zone (see the white pages of your phone book) only if: (i) there is an earthquake strong enough so that you cannot stand, or (ii) there is appreciable earthquake shaking **and** the siren sounds a few minutes later, or (iii) you are instructed by local radio and television to evacuate. **If there is no shaking, the siren means to turn on local radio.** Once you have evacuated, the wait may be many hours. (See Part 3)

   Discuss and practice drills of your evacuation plan with your family each year.

3) **Know your property and take appropriate action.** Look at where you are located. If the land floods, consider flood insurance. If trees overhang your house, consider trimming or cutting the branches overhead which may damage your house in a storm. If the property is near a ridge, it may be especially susceptible to wind damage during a storm or hurricane. (See Part 4)

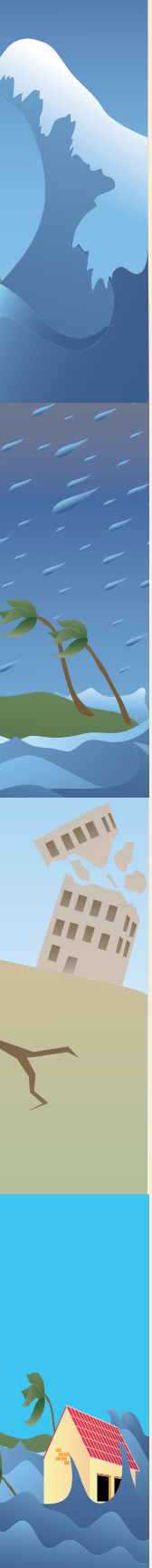
4) **Know your house and take appropriate action.** When was your house built? Does it have connectors to tie the roof to the wall or the wall to the foundation? When will you need to re-roof? Look at your blueprints. They may be available from your homebuilder, your local building department, or your architect. (See Part 4)

5) **Strengthen your house.** A house built after the early to mid-1990s should have hurricane clips to tie the roof to the wall and strong connectors from the wall to the foundation. If your house was built before then, you can still retrofit at a reasonable cost. All households should consider the many options now available to protect your windows, garage, and doors. You can also strengthen your roof when it is time to re-roof. The steps a homeowner can take will vary with each house, but for a majority of homeowners, there are a few steps that can make a significant difference. (See Part 4)

6) **Utilize the State of Hawai‘i Loss Mitigation Grant Program.** If the work is done properly, grants of up to $2,100 from the state can cover roughly a third of the cost for qualified work to strengthen your house. Grants are on a first-come, first-served basis, so check the availability of funds. Grants are available for hurricane clips, wall-to-foundation connections, and window coverings. In addition, grants may be available for strengthening your roof and building a safe room. Check the website for updates:
http://www.hurricaneretrofits.hawaii.gov (See Part 4).

7) **Insurance.** Don’t gamble with your house. Obtain adequate insurance for a hurricane, flood insurance if you are in a flood-prone area, and earthquake insurance if you are at risk and it is available. (See Part 4)

8) **Take advantage of potential discounts for your hurricane insurance premiums.** Coverage may vary among insurance companies so call your insurance agent to find out about discounts that may be available. Significant discounts may



be provided for reducing the risk to your house with window protection, roof-to-wall tie downs (hurricane clips), and wall-to-foundation tie downs. (See Part 4)

9) **Finance creatively.** Consider efforts to strengthen your house as an important home improvement project. Most projects are not that expensive. For the more costly ones, a small home improvement loan, combined with grants from the State Loss Mitigation Grant Program and potential discounts from hurricane insurance premiums, make these projects within reach. It is a great investment to strengthen your house and provide more protection to your family. (See Part 4)

10) **Seek the assistance of a qualified, licensed architect, structural engineer, or contractor.** This handbook covers work that you may be able to do yourself. If you cannot do the work, seek qualified assistance through trusted references from friends and family, the Structural Engineers Association, your county civil defense and emergency management agencies, or the contractors associations for your island. Even if you do the work yourself, it is always best to seek professional advice for initial guidance since every house is a little different. (See Part 4)

Part 2
Natural Hazards: An Overview for Homeowners

In Hawai‘i many different types of natural hazards can occur, such as flooding, fire, rock falls, landslides, earthquakes, coastal erosion, bluff erosion, sea-level rise, subsidence, volcanism, and high waves. This handbook concentrates on the most potentially devastating hazards in terms of loss of life and property damage, tsunamis and hurricanes. In addition, information is provided for earthquake and flood hazards.

Preparing for the larger hazard events (hurricanes, tsunamis, earthquakes, and flooding) will offer protection from the smaller, more frequent events. There is much more information on these hazards than can be provided in this handbook. Included here is only basic information that may play a role in how you as a homeowner may prepare for these hazards.

2.1 Tsunami Hazards in Hawai‘i

A tsunami is a series of traveling ocean waves generated primarily by earthquakes occurring below or near the ocean floor. Not all underwater earthquakes will create a tsunami. If the motion of the seafloor is more vertical than horizontal, a tsunami is more likely to be generated. Underwater volcanic eruptions and landslides can also generate tsunamis.[6]

In the open ocean, the tsunami travels at great speed (about 500 miles per hour) and has a wave height of only one foot or less. As the tsunami approaches shallow coastal waters, the waves slow down and the water piles up to form a wall that can be more than 30 feet high.

A tsunami has great destructive power. Given the proper coastal configuration, water from a tsunami can penetrate several thousand feet inland (see Figure 2-1).[7] This destructive power demands great respect. It is necessary for all residents, particularly those along the coast, to plan properly for future tsunamis.

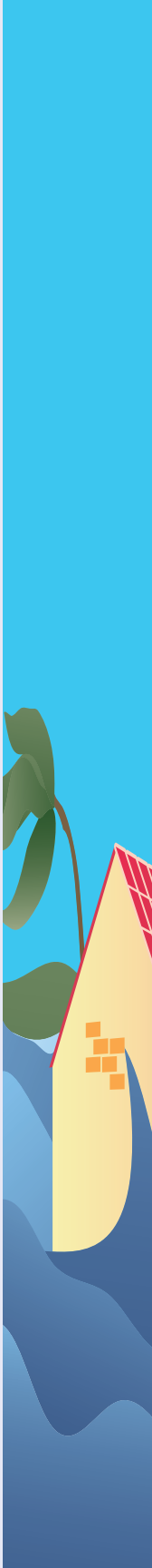


Figure 2-1. Inundation from the 1946 tsunami in Hilo reached several thousand feet inland. This photo depicts the tremendous power of a tsunami. Taken from the Hilo Tribune Herald. Photo courtesy of Pacific Tsunami Museum–Andrew Spaulding Collection.

On average, Hawai‘i is hit by a damaging tsunami about once every seven years. There were twenty-six damaging tsunamis around the islands between 1819 and 1975, but since then there have not been any.[8] This long period that Hawai‘i has enjoyed without any tsunamis is unlikely to continue so it is important to prepare.

In Hawai‘i, our major risk from a tsunami comes from earthquakes that occur both far away and locally. Since a tsunami travels at 500 miles per hour, it may take some time for the wave to reach various coastal areas. Travel times may vary from 15 hours for an earthquake off South America (Chilean earthquake of 1960) to 4.5 hours for one off Alaska (Aleutian earthquake of 1946) (Figure 2-2). For a local earthquake, travel times may vary from 40 minutes or less for an earthquake off Hawai‘i County to reach Kaua‘i, to 5 minutes or less for an earthquake off Hawai‘i County to impact that same coastline (Table 2-1).

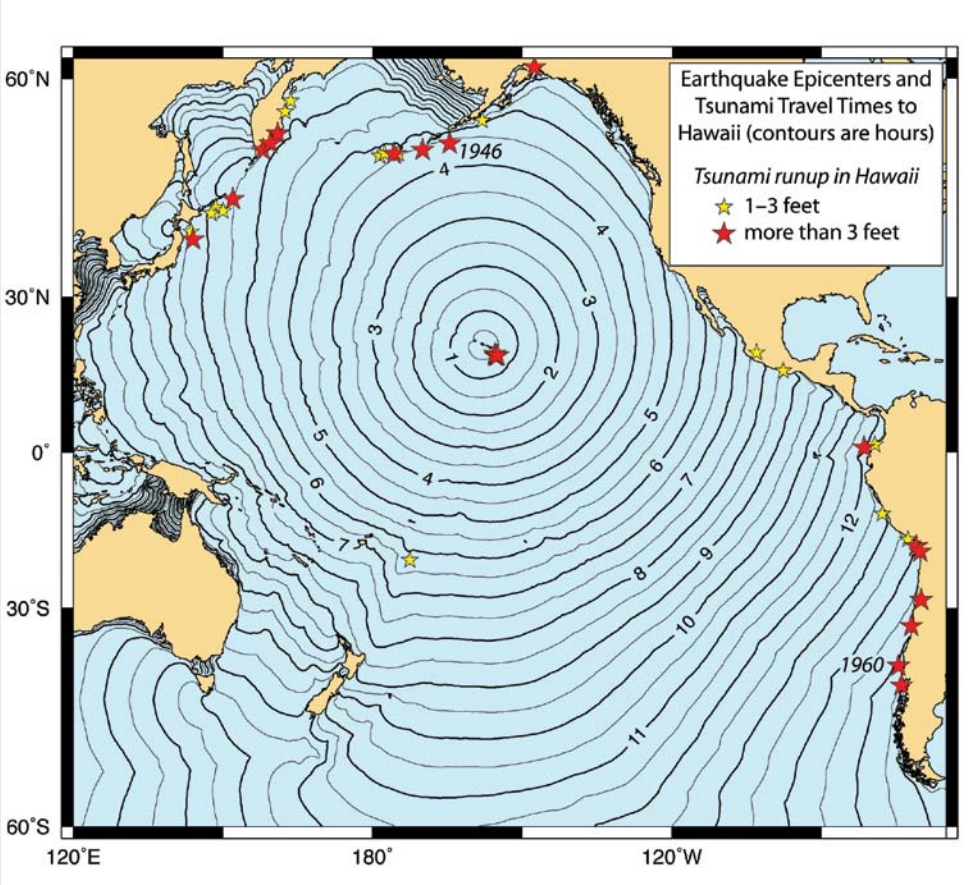


Figure 2-2. Travel times to Hawai'i in hours from various earthquake locations around the Pacific Rim. Note travel times for the 1946 earthquake near Alaska (4.5 hours) and the 1960 earthquake off Chile (15 hours). The dark lines are one hour contour intervals and the light lines are a half-hour break-down. Courtesy of the Pacific Tsunami Warning Center.

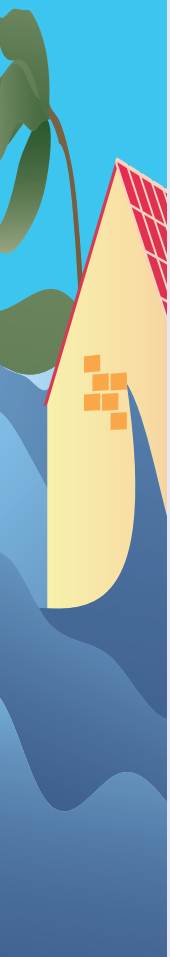


Table 2-1. Travel Times from Various Potential Sources of a Tsunami

Some Possible Sources	Destination	Tsunami Travel Time
South America (example, 1960 Chile earthquake)	State of Hawai‘i	15 hours
Japan	State of Hawai‘i	8 hours
Alaska (example, 1946 Aleutian earthquake)	State of Hawai‘i	4.5 hours
Local Earthquake Hawai‘i County	Kaua‘i	40 minutes
Local Earthquake Hawai‘i County	O‘ahu	25 minutes
Local Earthquake Hawai‘i County	Maui	15 minutes
Local Earthquake Hawai‘i County	Hawai‘i County	5 minutes or less

Our response will differ if there is a distant tsunami or a locally generated one. According to the Pacific Tsunami Warning Center, it will take about 5 minutes to analyze an earthquake, determine if a potentially damaging tsunami has been generated, and sound the siren.[9] However, from the above we learned that if there is a local earthquake near Hawai‘i County, a wave may reach the coastline there in 5 minutes or less. If you feel an earthquake strong enough that interferes with your ability to stand upright, a local tsunami may have been generated and it is necessary to evacuate inland to high ground immediately. Do not take the time to check your phone book or listen to the radio. The wave may come before the sirens can sound and before a radio message to evacuate can be issued. (See Part 3.3)

Once a tsunami reaches our coastline, it may take many hours for the series or train of waves to pass the islands.

2.2 Hurricane Hazards in Hawai‘i

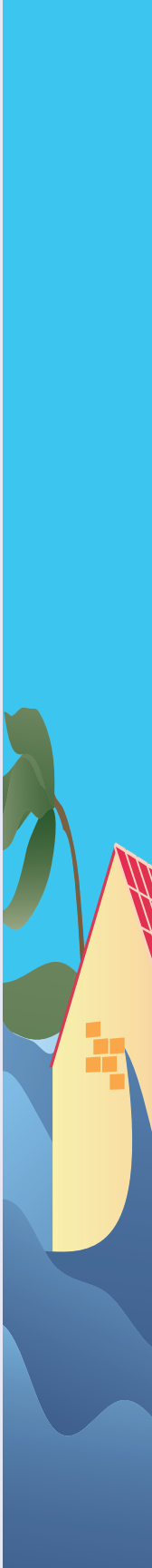
A hurricane is an intense tropical weather system with a well-defined circulation pattern and maximum sustained winds of 74 miles per hour or more. This compares to a tropical storm, which is also an organized weather system with well-defined circulation, but the maximum sustained winds are between 39 and 73 miles per hour. A tropical depression is an organized system of persistent clouds and thunderstorms with closed low-level circulation and maximum sustained winds of 38 miles per hour or less. Even a tropical storm or tropical depression can cause substantial damage.

Before a system becomes a hurricane in the tropical waters near Hawai‘i, it starts out as a tropical depression and develops into a tropical storm. After a hurricane weakens and dissipates in tropical waters, it becomes a tropical storm and then eventually a tropical depression.

Hurricane strength is often given in categories using the Saffir-Simpson Hurricane Scale, which rates hurricanes from 1 to 5 based on the intensity of the sustained winds. See Table 2-2. During a hurricane, there is a triple threat of damage from high winds, very high surf, and flooding associated with heavy rains.

One misperception around the state is that a hurricane will only strike Kaua‘i and, therefore, residents of the other islands do not need to prepare. This is based on the impacts to Kaua‘i from Hurricanes Dot (1959), ‘Iwa (1982), and Iniki (1992). However, in 1957 damage occurred on O‘ahu from Hurricane Nina. Also, the National Weather Service has records indicating a major cyclonic system (or hurricane) struck the islands of Hawai‘i and Maui in 1871.

Looking at the tracks of a few recent hurricane systems clearly illustrates the need for all islands to prepare. Figure 2-3 shows the round-about path that Hurricane Iniki took in 1992 to miss the islands of Hawai‘i, Maui, and O‘ahu, while striking Kaua‘i. If Iniki had turned north only 6 hours earlier, the more populated areas of the state could have been severely impacted. Conceivably, more than one island could have been struck. Figure 2-4 shows a satellite image of Hurricane Iniki with the



outline of the Hawaiian Islands superimposed. The major damaging winds and rain associated with the spiral bands and eye are concentrated over Kaua‘i and away from the more populated areas.

In 2000, Hurricane Daniel reached Category 3 status with winds of 125 miles per hour. It was heading toward Hawai‘i before veering away and passing to the east as a tropical storm (Figures 2-5 and 2-6). Nevertheless, Daniel did produce heavy surf along the north shores of the islands.

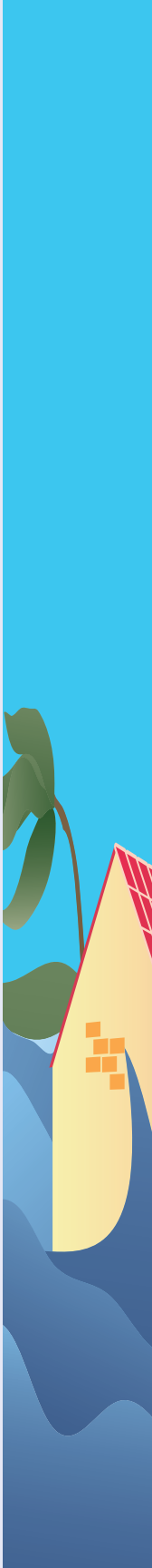
From the examples of Iniki (1992) and both Daniels (2000 and 2006), we know that major hurricanes have formed in the central Pacific. While moving northwest, these systems have either weakened or passed just to the east or west of the populous islands of Maui, Hawai‘i, and O‘ahu. It is only a matter of time before one of these systems will not weaken, and continue on its path to hit one or more of these islands directly. Thus, it is very important for all the islands to be equally prepared.

Photo courtesy of Department of Commerce and Consumer Affairs Insurance Division

Table 2-2. Expectations of Wind-Related Damage in Hawai‘i for Different Hurricane Categories (1 to 5)[10]

No.	Wind mph	Damage
1	74–95	No real damage to sturdy buildings. Damage to poorly constructed older homes or those with corrugated metal. Some tree damage such as palm fronds torn from the crowns. Examples: ‘Iwa (Kaua‘i, 1982), Dot (Kaua‘i, 1959), Nina (Kaua‘i, O‘ahu, 1957)
2	96–110	Some damage to building roofs, doors, and windows. Considerable damage to poorly constructed or termite-infested homes. Trees blown down, especially those that are shallow rooted.
3	111–130	Some structural damage to well-built small residences. Extensive damage to termite-infested buildings. Large trees blown down. Up to 50 percent of palm fronds bent or blown off. Some large trees, such as monkey pod and breadfruit, blown down, especially if the ground is wet. Example: Iniki (Kaua‘i, 1992).
4	131–155	Extensive damage to non-concrete roofs. Complete failure of many roof structures, windows, and doors, especially unprotected, non-reinforced ones; many well-built wooden and metal structures severely damaged or destroyed. Considerable glass failures due to flying debris and explosive pressure forces created by extreme wind gusts. Complete disintegration of structures of lighter material. Seventy-five percent of palm fronds blown off. Many large trees blown down. Major erosion of beach area.
5	> 156	Total failure of non-concrete-reinforced roofs. Extensive or total destruction of non-concrete residences. Some structural damage to concrete buildings from debris such as cars or appliances. Many well-constructed storm shutters ripped off from structures. Many large trees blown down. Flooding and major damage to lower floors near the shoreline. Example: No record in Hawai‘i, Andrew (Florida, 1992).

From NOAA National Weather Service–Honolulu, after Lander & Guard. These guidelines are experimental and should be used only as an approximation. Damage in some cases may result from lesser winds than indicated. Local topography (surface configuration of an area) may also strengthen or weaken the winds. Wind speed is based on the average speed of sustained winds over a one-minute period. See the cited reference for the complete guideline.



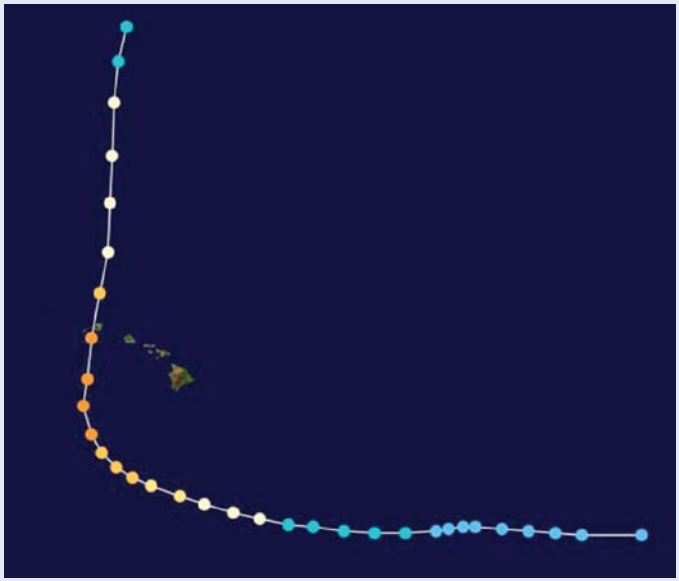


Figure 2-3. Track of Hurricane Iniki in 1992 and its evolution from a tropical depression and tropical storm (blue and aqua colors) to a major Category 4 hurricane (orange). From NOAA National Weather Service–Honolulu.

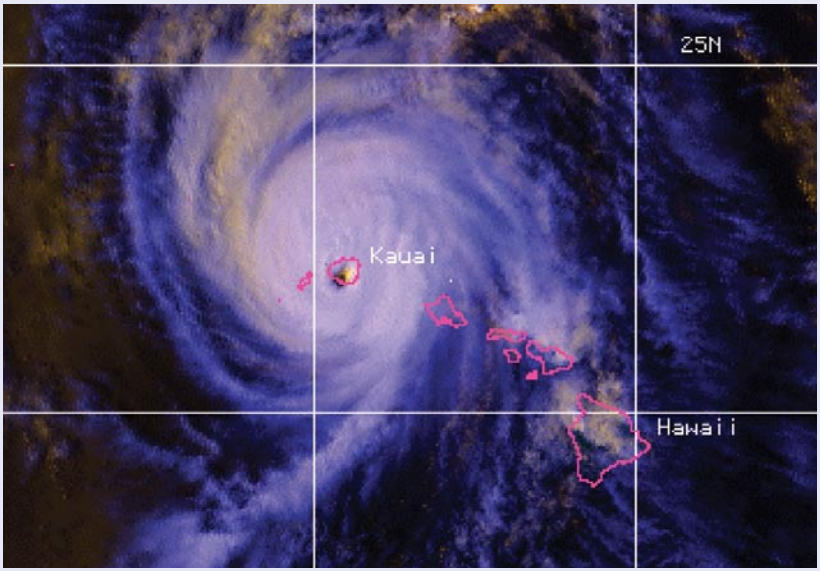


Figure 2-4. NOAA satellite image of Hurricane Iniki, September 11, 1992. The band of strong winds and rain surrounding the eye of the hurricane missed the majority of Hawai‘i’s populated areas. Iniki passed west of these areas.

Figure 2-5. In 2000, Hurricane Daniel was a Category 3 Hurricane before weakening to a tropical storm and veering to the east of the major Hawaiian Islands. From NOAA National Weather Service–Honolulu.

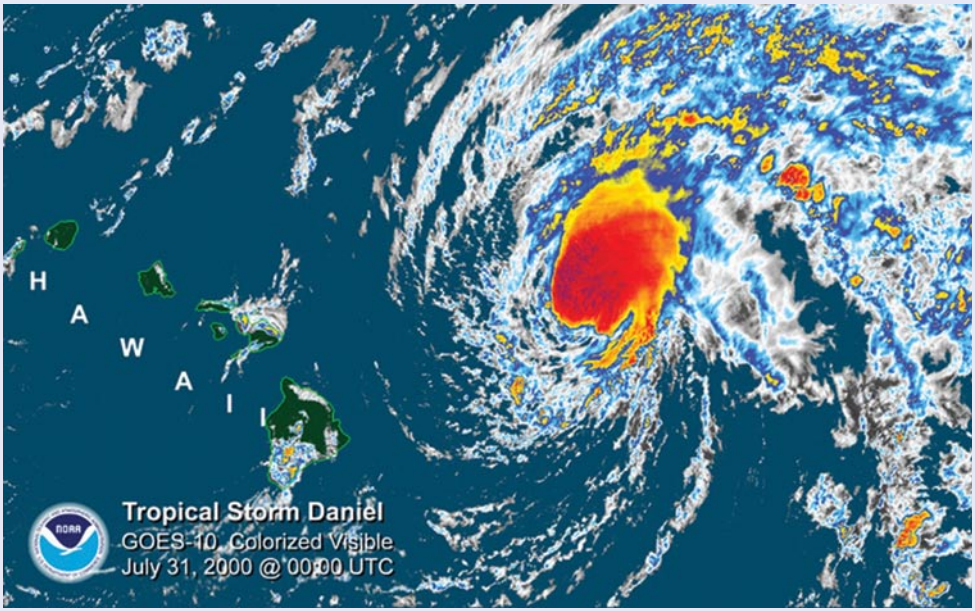


Figure 2-6. NASA satellite image of Tropical Storm Daniel, 2000. The spiral bands associated with the heavy winds and rain from former Hurricane Daniel passed to the east of the Hawaiian Islands. The major impact was high surf along the northern shorelines. Photo courtesy of NOAA.

In 2006, another Hurricane named Daniel reached Category 4 status. While this Hurricane Daniel was a very powerful system, it weakened quickly to a tropical storm and then a tropical depression as it approached the Hawaiian Islands. Thus, major damage was avoided (Figures 2-7 and 2-8).

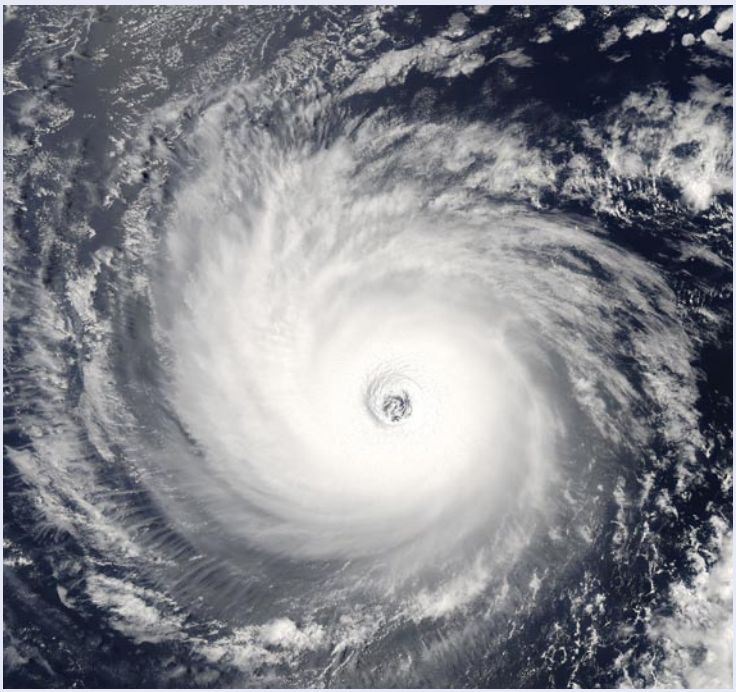


Figure 2-7. In July 2006, Hurricane Daniel reached Category 4 status in the eastern Pacific. Daniel was well organized and had a distinct eye. NASA Satellite Photo.

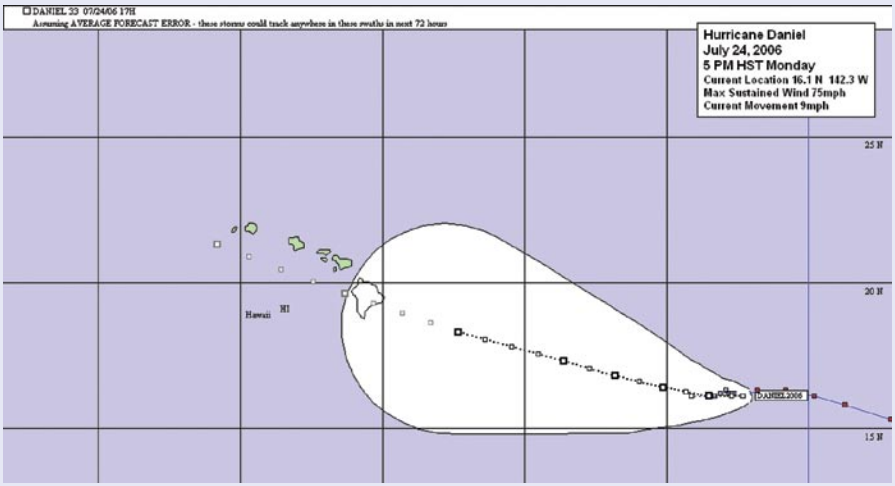


Figure 2-8. By July 24, 2006, Hurricane Daniel weakened to a minimal Category 1 hurricane and later was downgraded to a tropical storm and tropical depression before passing Hawai‘i. The white cone indicates the average forecast error in predicting the future track. From NOAA National Weather Service–Honolulu.

2.3 Earthquake Hazards in Hawai‘i

All the islands are at nearly equal risk for hurricanes and tsunamis. For earthquakes, however, the risk does differ from one island to the next. The greatest concentration of earthquake activity is found near the island of Hawai‘i, yet there have been significant earthquake events near Maui (1938) and Lāna‘i (1871) (Figure 2-9). These earthquakes, along with the recent October 15, 2006, event off Hawai‘i (Kīholo Bay and Māhukona) are deeper earthquakes caused by bending of the earth in response to the developing load of the island mass. More numerous and shallower earthquakes result from the intrusion of magma around the active volcanoes and the buildup and then release of stress along ruptures and fault surfaces.[11]

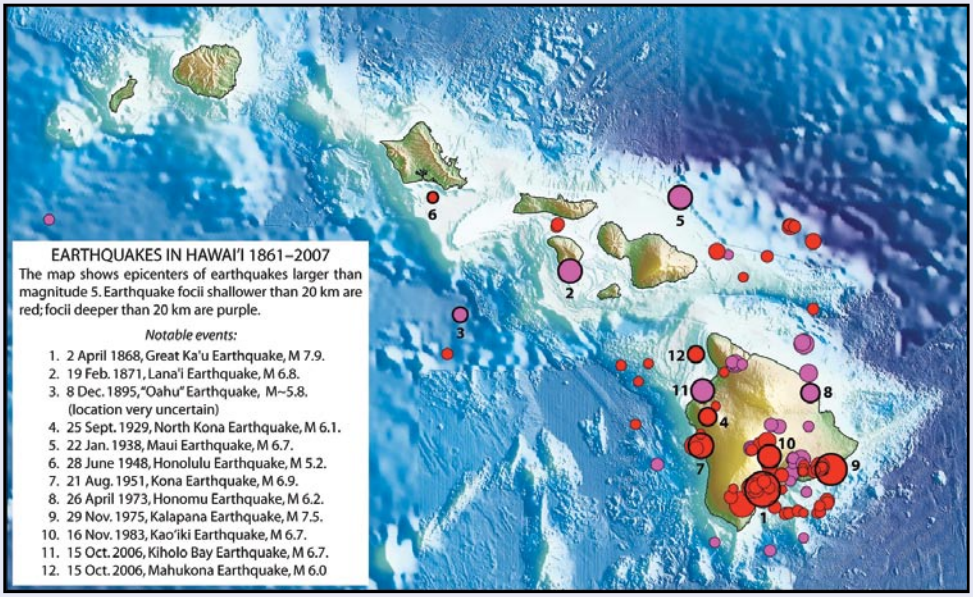


Figure 2-9. Distribution of earthquakes in the Hawaiian Islands from 1861 to 2007. The larger dots are associated with the larger earthquakes. The most frequent and larger events are associated with the southeast coast of the island of Hawai‘i. The location of the two October 15, 2006, earthquakes are marked with dots 11 and 12. Compiled by Gerard Fryer of the Pacific Tsunami Warning Center.

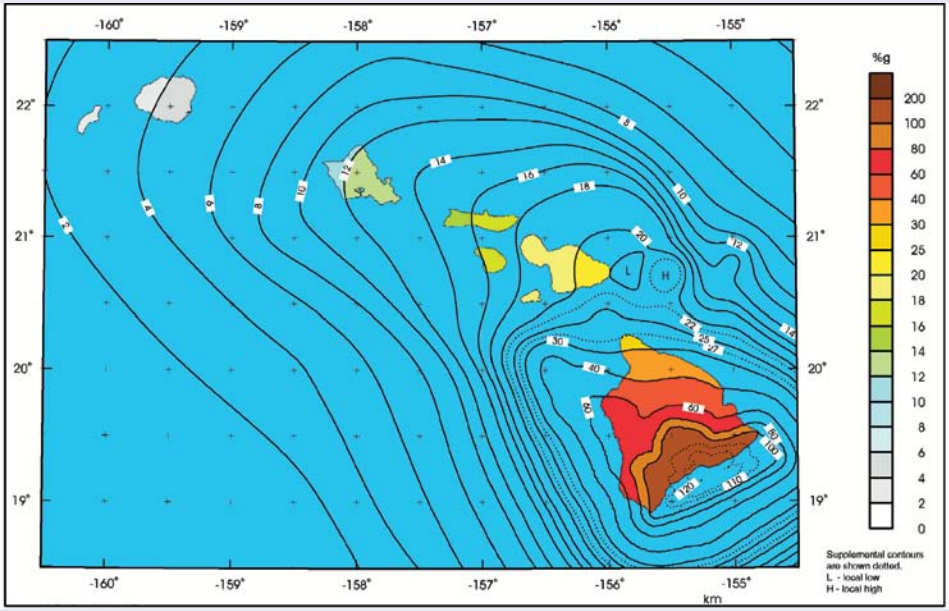


Figure 2-10. Scientists can develop maps that relate earthquake strength and probability for different areas based on the distribution of earthquakes in a given region. The map indicates that for a given period of time, the strongest earthquake shaking will occur along the southeast portion of Hawai‘i County, with the weakest near Kaua‘i. In scientific terms, the graph represents the peak horizontal acceleration expressed as a percent of gravity for events with a 10 percent probability of exceedance every 50 years. From U.S. Department of the Interior—U.S. Geological Survey.

Figures 2-9 and 2-10 indicate that homeowners in Hawai‘i County should be the most concerned about earthquakes, earthquake insurance, and strengthening their homes for ground motion, much less so for Kaua‘i homeowners who would be the least impacted by this type of hazard.

Also based on these figures, the most likely source for a local tsunami generated by a local earthquake is from Hawai‘i (remember that for a distant tsunami, all islands are at equal risk). Because residents of the island of Hawai‘i are likely to be closest to the source when there is a local earthquake, they will have the least amount of warning time, if any. Thus, it is especially important for those residents to know that if they feel shaking strong enough so that they lose their balance and cannot stand, they should move to higher ground outside of the evacuation zone as quickly as possible (see the white pages of your phone book). It will be relatively rare or unlikely that shaking will be strong enough so that you cannot maintain your stance if you are on O‘ahu and Kaua‘i.

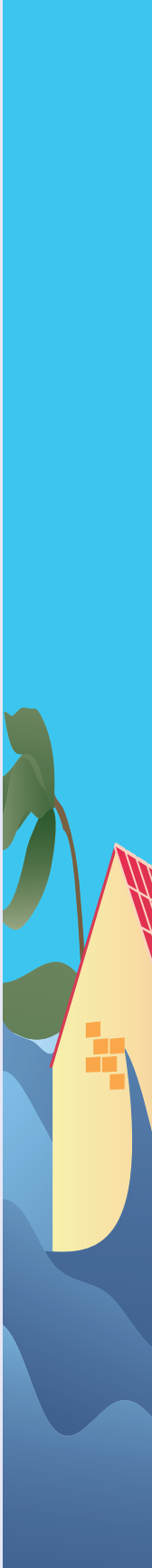
2.4 Flood Hazards in Hawai‘i

Flooding in Hawai‘i is probably the most common natural hazard in the state, if not the most intense. Flooding can be caused not only by a hurricane, but also by a tropical storm, tropical depression, or other weather system that produces heavy rain. Flooding can build up gradually over a period of days, or suddenly in a few minutes (this is commonly known as a flash flood). In addition, coastal flooding and wave inundation can be produced by a tsunami, hurricane, or high-surf event with waves generated by local storms or those that are thousands of miles from Hawai‘i.

Flooding can be associated with living near a body of water such as the ocean or a stream, river, or reservoir. You can determine if you are in a high-risk flood area by looking at the Federal Emergency Management Agency’s (FEMA) flood insurance rate maps. These maps show what areas are susceptible to flooding and high velocity wave action (for those near coastal areas). Copies of the maps can be obtained digitally at http://www.msc.fema.gov. Limited copies may be obtained from the State National Flood Insurance Program Coordinator with the Department of Land and Natural Resources. Copies may also be available for viewing at your county building departments.

Even if you are not in an official flood zone, you may be at risk from flooding. Go to the following website address and type in your street address: http://www.floodsmart.gov/floodsmart/pages/riskassesment/findpropertyform.jsp. A very general estimate of the flood risk for your property is provided.

A good way to determine the risk of flooding for your house is to observe and study your property. Even inland properties may be susceptible to flooding if there is poor localized drainage. If your property floods during small rain events, then the problem will be greater during a storm or hurricane. You can protect yourself by improving the local drainage, making your house resistant to floods, and purchasing flood insurance. You do not need to be in an official flood zone to obtain flood insurance.



Part 3
Protecting Yourself and Your Family

This part of the handbook covers the topic of protecting yourself and your family from natural hazards. In particular, it is important that your household has a stock of emergency supplies, an evacuation kit, and evacuation plans for both a tsunami and hurricane since each will differ depending on the nature of the threat. You should discuss and practice the plan with your family once a year, or whenever there is a major lifestyle change (for example, when a member of the family goes to a new school or is working in a different location).

3.1
Emergency Supplies

A stock of emergency supplies will be helpful during a major event like a hurricane or tropical storm, as well as for a minor event like a simple power outage. The importance of these supplies was demonstrated during the October 15, 2006, earthquake, which knocked out power throughout much of the state.

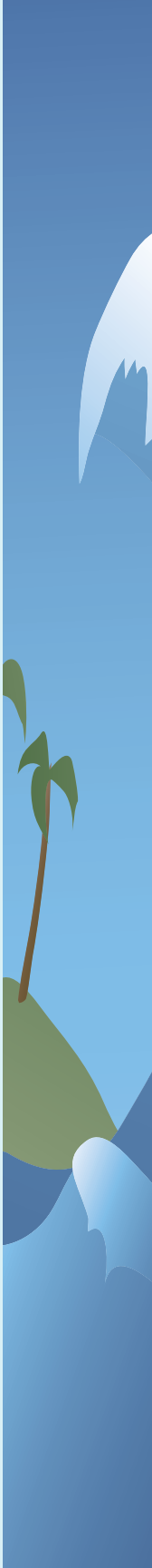
Your emergency supplies should be gathered as soon as possible and checked monthly so that they are complete, unused, and fresh (mark and check expiration dates). Old food and water should be used or discarded and replaced with fresh supplies. Do not keep expired supplies. Your supplies should include at least the following:

- ☐ **Portable radio, flashlight, and extra batteries** (or flashlight and radio with hand-crank rechargeable batteries)
- ☐ **First-aid kit**
- ☐ **List and supply of special medications** (prescriptions and others)

- [ ] **Five to seven day supply of nonperishable foods**
- [ ] **Hibachi with charcoal, camping stove with fuel, or barbeque grill with propane.** (Do not use these items indoors or in an area with no ventilation. Follow all manufacturer instructions.)
- [ ] **Manual can opener**
- [ ] **Matches or lighter**
- [ ] **Disposable plates and kitchen utensils**
- [ ] **Five to seven day supply of water.** A reasonable estimate is one gallon per person per day for drinking, cooking, and personal hygiene needs. It is important to have available good water containers for any water-interruption situations. Four- to six-gallon water containers are readily available in stores. Remember to store water for toilet use (in bathtubs, rubbish containers, washing machines, water heater, etc.).
- [ ] **Extra pet food** (if you have a pet)

Some additional items you may wish to add to your stock include:

- [ ] **Portable toilet or porta potty.** This is a suggestion from Maui County Civil Defense.
- [ ] **Spare cash**
- [ ] **Waterproof plastic sheeting or blue tarp, with string or rope**
- [ ] **Cell phone and a hardwire single line phone.** Cell phone networks maybe overloaded during times of natural hazards. Cordless phones with a base station will not work without electricity. If you need to rely on cordless phones, get an alternate source of power. Otherwise, have an old-fashioned corded phone. Use your phone during a natural hazard only in an emergency.



- ☐ **Alternate power supplies.** During an emergency or power outage, alternative sources of power may be needed (among these are generators, inverters, power stations, and battery chargers). See Part 4 for descriptions of alternative power sources that may supplement your emergency supplies.

Note that if you are taking shelter in your home (outside the evacuation zone and in a strong dwelling [Part 4]), you may wish to have more than five to seven days of supplies. There is always the possibility that a major storm or hurricane could disrupt the supply line of goods to Hawai‘i. If the space is available and your house is protected, stocking up for a two-week period is prudent. Gather the supplies over a period of time versus during an emergency, when you could face or contribute to shortages.

3.2 Evacuation Kit

The evacuation kit differs from your stock of emergency supplies since the kit is what you will take if you need to leave your house in an emergency. Your evacuation kit should be prepared as soon as possible and can be checked before the beginning of hurricane season, which runs June 1 to November 30. The components of the kit should be stored in one place, perhaps in a duffle bag or backpack, so that it is ready to go at a moment’s notice. The kit is primarily for evacuation during a hurricane, although it could be used for other situations (including tsunami evacuation, police situation, etc.).

The following evacuation kit was compiled with the input of all county civil defense and emergency management agencies:[12]

- ☐ **1 gallon potable water per day per person;**

Personal items—carry-on bag with:

- ☐ **Family needs, such as 2-week supply of daily prescription medications, a 3-day supply of nonperishable food and any special dietary foods, can opener, infant formula, and diapers;**
- ☐ **Prescription eyewear and personal hygiene items such as waterless cleaner, toothbrush/toothpaste, toilet paper roll;**
- ☐ **List of any required medications, special medical information, Medical Care Directives, health insurance card, personal identification, and other important documents;**
- ☐ **First-aid kit**;
- ☐ **Flashlights, batteries, and spare bulbs, portable radio with spare batteries**;
- ☐ **Change of clothes, towel;**
- ☐ **Pillows, blankets, and folding mattresses/air mattresses.**

The American Red Cross has been recommending that the evacuation kit should contain supplies for five to seven days. Should the supply chain be disrupted (because of, for example, a damaged airport or warehouses), you will be better off than others who do not have adequate supplies. For instance, many people after Hurricane Iniki who evacuated to a shelter were able to move back to their homes once the plastic sheets or tarps were placed over their roofs, but even this process took an average of two weeks.

There is a fine line between bringing too many supplies that overload the limited shelter space of 10 square feet per person and not bringing enough. However, if you go to a shelter, keep in mind that there will be limited space, so bring only what is recommended unless you are instructed otherwise by your civil defense or emergency management agencies.

3.3 Evacuation Planning

In Hawai‘i, it is important for families to plan for both a tsunami and a hurricane. When you put your evacuation plan together, here are some things to consider:

- Stay alert, stay calm, and be informed (tuning in to local radio and television is important). Create an evacuation plan and review it with your family every year.

- Evacuation procedures for a hurricane will differ from those of a tsunami. You must plan for both. In a hurricane, you must protect yourself from strong winds, torrential rain, and coastal inundation. In a tsunami, you must protect yourself from coastal inundation only.

- The white pages of your phone book have evacuation maps that can help you avoid coastal inundation from a tsunami or a hurricane because these maps consider historical inundation from both hazards. For example, on the south shore of Kaua‘i historical inundation from hurricanes exceeds that of tsunami inundation (due to Iniki), so these maps are based more on past hurricanes. On the north shore of O‘ahu, historical tsunami inundation exceeds historical hurricane inundation, so the evacuation maps are based on events like the 1946 tsunami.

- You should plan for a tsunami even if you live inland because members of your family may be driving through or working in the evacuation zone. **The important thing is to know where you need to evacuate if you are at home, work, school, or in your car.**

- **Always use the most recent phone book (specifically, the white pages). Evacuation maps may be updated at any time in the future, so do not depend on outdated versions.**

- **Listen to your local radio and television stations carefully as there may be additional or modified directions based on the best available information at that time. Mother Nature is unpredictable and a team of scientists will always be monitoring unusual conditions for public safety.**

- “Local” means radio and television broadcasts specific to the island you are on. Television is important but may contain information that is more applicable to one island than another, since the broadcasts are usually statewide.

- Your evacuation plan should consider yourself, the members of your family, those with special health needs for whom you may take responsibility (like the disabled or elderly), and your pets. Practice evacuation procedures with your family through yearly drills.

- In an evacuation or emergency situation, all able-bodied persons (men, women, and children) should be able to take care of themselves if they act calmly and with proper direction. This is why it is important to practice your plan regularly.

- Parents should confirm with their child’s school the evacuation plans that are in place, specifically, where the students will be held and for how long during each type of natural hazard. You should not have to drive to school to pick up your children.

- As part of your evacuation plan, consider how family members will communicate if they become separated. Each family member should have a list of telephone and cellular phone numbers of everyone in the family and phone numbers of a few contacts outside of the family.

- If needed, develop a plan to help those who cannot help themselves, such as the disabled or those with limited mobility. If people with special health needs are with a care-provider, confirm that the care-provider has an evacuation plan. Otherwise, you, your family, your friends or relatives, or someone nearby who is designated can take responsibility for that person(s).

- Develop a plan for your pets. Listen to local radio or check with State Civil Defense to determine if there are any pet-friendly shelter locations in your county. On Kaua‘i, call to see if they may be dropped off at the Humane Society. Also check if you can drop off pets with a nearby friend or relative before the storm. For a tsunami, take your pet with you. You will not be evacuating to a shelter, but rather to anywhere that is high ground outside of the evacuation zone.

- **In general, stay off the roads.** Only drive if it is absolutely essential. Your evacuation plan for tsunamis should emphasize reaching an area by walking. The police may close many roads during an emergency, so people can exit a freeway, but not necessarily get on it. On O‘ahu, buses will try to alter their normal routes and shuttle people to higher ground at no cost.

- There are a limited number of hurricane shelters and spaces that offer protection from wind, rain, and coastal waters. Since there is a shortage of shelters, there may be a possibility you cannot get in, even if you wanted to. Therefore, plan to use a shelter only as a last resort. A better alternative is to strengthen your house. If there are limitations in your house, go to a friend or relative’s house that is strongly built.

- Become familiar with the closest shelter or shelters in case you have to evacuate to one (see Appendix A). **Check for updates to the list of shelters on the State Civil Defense website.** http://www.scd.state.hi.us/documents/2006HuricaneShelters4-5-07.pdf

- If you are outside an inundation zone or flood zone and in a strong house, use your house as a shelter. You will be better off sheltering at your house than going to a public shelter. A strong house is built with connectors that tie the roof to the wall and the wall to the foundation (this is known as the continuous load path connection; see Part 4). Generally, houses built after 1994 fall into this category. In addition, the house should have coverings for the windows that protect against wind pressure and impact.

- If you use your house as a hurricane shelter, you may be better able to store food and water and take care of your loved ones, including those with special health needs, the elderly, and your pets. This is why it is important to strengthen your house.

- For tsunami evacuation, listen to your local radio. Generally, anywhere away from the coast and outside the evacuation zone on high ground is suitable for tsunami evacuation. Shelters may eventually be set up for those whose homes are uninhabitable or inaccessible.

- Plan and prepare to be at your tsunami evacuation point for several hours.

- For a tsunami, you will have less warning time to evacuate or prepare than for a hurricane. For a tsunami you may be notified up to a maximum of 15 hours for a very distant tsunami to as little as 5 minutes or less if the source is local. Because there is potential for very little warning time for a local tsunami, special procedures are in place for this scenario. For a hurricane there will be an indication of potential danger most likely days in advance. General statewide evacuation on a distant tsunami will begin three hours prior to estimated wave arrival.

- Know the difference between a tsunami watch and tsunami warning versus a hurricane watch and hurricane warning. Do not confuse the two. When each is triggered, there are different actions you and your family should take. Also note that the Pacific Tsunami Warning Center and/or the civil defense and emergency management agencies may issue what is called an **Urgent Local Tsunami Warning** in the case of a local earthquake and tsunami.

3.3.1 Key Definitions

Tsunami Watch. Issued when: (i) there is good possibility that a tsunami will arrive; or (ii) it is not certain if a damaging tsunami was generated, but it would be less than **6** hours away if it were to strike. When a Tsunami Watch is issued, stay tuned to local radio for further instructions.

Tsunami Warning. Issued when: (i) a tsunami has been confirmed elsewhere and is expected to be large enough to cause damage when it reaches the Hawaiian Islands; or (ii) it is not certain if a damaging tsunami was generated, but it would be less than **3** hours away if it were to strike. A Tsunami Warning ***will not always be preceded*** by a Tsunami Watch. When a Tsunami Warning is issued, listen to local radio for instructions on evacuation.

Urgent Local Tsunami Warning. Issued when there has been a major earthquake within the Hawaiian Islands and a damaging tsunami is probable. If the ground-shaking is so severe that you have trouble standing, immediately evacuate even before the siren sounds. If the ground-shaking is appreciable (for example, the October 15, 2006, earthquake as felt on O‘ahu) and the siren sounds a few minutes after the ground-shaking, immediately leave the evacuation zone on foot. Tune in to local radio only after you have cleared the evacuation zone.

Hurricane Watch. Issued when there is a good possibility of hurricane conditions and associated damaging winds, surf, and flooding rains occurring anytime within **36** hours. During this Watch period, prepare your home and review your plan for evacuation in case a Hurricane Warning is issued. As discussed earlier in this section, preliminary preparations should begin even before a Watch has been issued.

Hurricane Warning. Issued when there is a high probability of hurricane conditions occurring anytime within **24** hours. Complete all storm preparations and leave the threatened area if directed by local officials. Keep in mind that a Hurricane Warning ***may not always be preceded*** by a Hurricane Watch.

Flash Flood or Flood Watch. Issued when flash flooding or flooding is possible within the designated watch area. Be prepared to move to higher ground; listen to NOAA Weather Radio, local radio, or local television for information.

Flash Flood or Flood Warning. Issued when flash flooding or flooding has been reported or is imminent. Take necessary precautions at once. If advised to evacuate to higher ground, do so immediately.

3.3.2 Emergency Alert System

The Emergency Alert System (EAS) is the official source of natural hazard information and instruction in the state. This information can originate from county, state, or federal agencies. For example, the EAS Network could disseminate warnings and/or instructions from the governor's office during threats or emergencies affecting one or more counties within the state. The statewide network may also be activated by the National Weather Service Forecast Office to disseminate weather- or tsunami-related watches or warnings.

If a siren sounds, turn on your radio. Some radios with the NOAA weather radio band turn on automatically when an emergency broadcast through the EAS is announced. This could be useful for homeowners along the coast. The NOAA weather radio station broadcasts round-the-clock weather and surf conditions, and also participates in the EAS system.

All local radio stations have voluntarily agreed to participate in the EAS system. Additional information may also be available on local and cable television. There are also six primary radio stations around Hawai'i that have a wide circulation and specialized equipment including decoders and back up generators for use during emergency situations (Table 3-1).

Table 3-1. Primary Radio Stations Participating in the EAS Network.

County	Local Primary	Phone Number
O'ahu	1 KSSK-AM 590 khz	808-550-9200
	2 KRTR-FM 96.3 mhz	808-275-1000
Kaua'i	KQNG-FM 93.5 mhz	808-245-9657
Maui	KMVI-AM 550 khz	808-877-5566
Hawai'i (Hilo)	KIPA-AM 620 khz	808-935-6950
Hawai'i (Kona)	KKBG-FM 97.9 mhz	808-961-0650

3.4 Evacuation Procedures for a Tsunami

- If there is ground-shaking **strong enough so that you cannot maintain your balance and stand, you should recognize that this is nature's warning of a potential tsunami.** If you are in a tsunami inundation zone, move outside to higher ground right away, as a local tsunami may have been generated. For a local tsunami, there may not be enough time for the siren to sound and instructions for evacuation to be issued.

- If there is **appreciable shaking (for example, the October 15, 2006, earthquake as felt on O'ahu) and** the siren sounds on the island you are on a few minutes later, move to high ground outside the evacuation zone immediately. In this case, a local tsunami has likely been generated and you may not have enough time to confirm evacuation by tuning in to the radio. It is possible a siren may sound on one island and not another.

- **When a siren sounds indicating an alert, listen to the local radio first for information and follow the instructions carefully.** You may have to scan the radio band. **The siren is your notice to tune to local media such as radio, but it does not necessarily signify a need to evacuate.** Local television is also important but may contain information that is more applicable to one island than another, since broadcasts may be statewide.

- Your county civil defense or emergency management agency, through local radio and television, will give you instructions on when to evacuate. When instructions are issued, move outside of the evacuation zone (see the white pages of your phone book) and to high ground immediately.

- **To summarize Tsunami Evacuation:** evacuate only if you are in a tsunami evacuation zone (in other words, if you are near the coast; consult the white pages of your phone book for evacuation zones) and one of these three conditions apply: **(i)** there is an earthquake strong enough so that you cannot stand; **or (ii)** there is appreciable ground

shaking **and** the siren sounds; **or (iii)** the siren sounds **and** local radio or television instruct you to evacuate. If there is no shaking, the sirens will be your notice to tune to local radio or television, not to evacuate.

- **Avoid driving unless it is essential.** By driving, you may contribute to potential gridlock that places other people and emergency responders in jeopardy. Remember that many roads will be blocked off. Plan to walk to your evacuation area.

- **If your house is outside the evacuation zone, stay there and stay off the road.** You will be more comfortable and will not add to traffic.

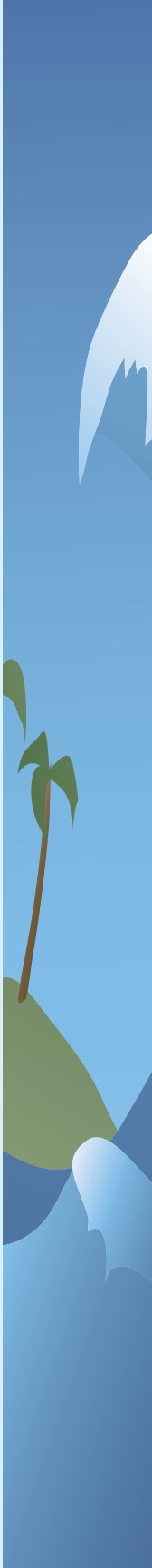
- **If your house is inside the evacuation zone, then you must leave.** You will need to evacuate even if your house is elevated on piers and columns and built according to standards for the National Flood Insurance Program.

- **Do not drive to school to pick up your children.** Most schools are outside the tsunami evacuation zone. Those very few public schools in the evacuation zone are required to have emergency plans and have carried out extensive drills to evacuate to higher ground. Trust the teachers to look after their students. The schools will hold onto your children until the all-clear signal is given. This may take several hours.

- **If you are at work and outside the evacuation zone, stay there.**

- **Respect the power of a tsunami.** A ten-foot tsunami wave will inundate much further inland than a ten-foot wind-generated wave. From a distance, the tsunami wave may not look much higher than a normal wind wave, but it will just keep coming. The tsunami may inundate an area thousands of feet inland.

- Receding water from the coastline is an indicator of an incoming tsunami, but this ***does not always happen*** and it may be too late to rely on this indicator to evacuate. Many times, the first sign of a tsunami is ***a rise in water levels***, not a drop.



- A tsunami wave can wrap around the island. Thus, all coastal sectors may be at risk from the wave and not just the side that the tsunami is approaching from. For example, even though a tsunami may be generated by an earthquake near Alaska, north of the islands, residents on the south side of the islands can still be at risk because of wrap-around.

- Tsunamis come in a series of waves, each of which may be 15 to more than 30 minutes apart. The largest wave is not always the first, but may be the third, fourth, or fifth. There may be as many as ten or more waves in the tsunami train. Do not believe that just because an area survived the first wave, it is safe from subsequent waves. Many people have drowned from making this assumption.

- **On Oʻahu and Maui only:** For concrete- and steel-reinforced buildings with six stories or more, evacuation may be by vertical evacuation (i.e. moving above the third floor of the building to the fourth floor). **For all other islands, vertical evacuation is a last resort. Moving to high ground outside the evacuation zone is safer than moving to high ground within the evacuation zone.**

- **On Kauaʻi: Vertical evacuation is not recommended.** There may be only a very few places to evacuate vertically (these places are usually hotels, like the Marriott, Hyatt Poʻipū, or Sheraton).

- **For Hawaiʻi County: Vertical evacuation is not recommended. It may be a last resort for a local tsunami in the case when there is little time, but it is better to move inland to high ground.**

- **Return to your property only when the all-clear signal has been given.** Be prepared to wait several hours. It may take a distant tsunami 4 to 15 hours to reach Hawaiʻi and 6 to 8 hours more for the train of waves to pass the state.

Table 3-2 summarizes many of the evacuation scenarios presented in Parts 2 and 3.

Table 3-2. Tsunami Evacuation Scenarios

Source & Time	If you are at home	If you are at work	If you are at school	If you are in your car
Local Tsunami Arrival in less than 5 minutes to 40 minutes	If inside the evacuation zone, walk out to evacuate if: (i) severe ground shaking, or (ii) appreciable ground shaking and siren, or (iii) siren and instructions to evacuate. If outside the evacuation zone, remain at home.	If inside the evacuation zone, walk out to evacuate if: (i) severe ground shaking, or (ii) appreciable ground shaking and siren, or (iii) siren and instructions to evacuate. If outside the evacuation zone, remain at work.	If inside the evacuation zone, walk out to evacuate if: (i) severe ground shaking, or (ii) appreciable ground shaking and siren, or (iii) siren and instructions to evacuate. If outside evacuation zone, remain at school.	If there is (i) severe ground shaking, or (ii) appreciable ground shaking and siren, or (iii) siren and instructions to evacuate, then: (a) drive out of an evacuation zone (head mauka); (b) once out, park in nearest parking lot or along the curb or a clear side street and stay there; (c) don't block traffic or abandon your car in the middle of the road. If necessary, pull to the side and walk.
Alaska – Arrival 4–5 hours away	If inside the evacuation zone, evacuate when given instructions by the radio broadcast. If outside the evacuation zone, remain at home.	If inside the evacuation zone, evacuate when given instructions by the radio broadcast. If outside the evacuation zone, remain at work.	If inside the evacuation zone, evacuate when given instructions by the radio broadcast. If outside the evacuation zone, remain at school.	Listen to local radio for instructions. In general: (a) drive out of an evacuation zone (head mauka); (b) once out, park in nearest parking lot or along the curb or a clear side street and stay there; (c) don't block traffic or abandon your car in the middle of the road. If necessary, pull to the side and walk.
Chile Arrival 15 hours away	If inside the evacuation zone, evacuate when given instructions by the radio broadcast. If outside the evacuation zone, stay at home.	If inside the evacuation zone, listen to local radio as to when you should evacuate. If outside the evacuation zone, listen to local radio to determine if you should stay or when to leave.	If inside the evacuation zone, listen to local radio as to when you should evacuate. If outside the evacuation zone, listen to local radio to determine if you should stay or when to leave.	Listen to local radio for instructions. In general: (a) drive out of an evacuation zone (head mauka); (b) once out, park in nearest parking lot or along the curb or a clear side street and stay there; (c) don't block traffic or abandon your car in the middle of the road. If necessary, pull to the side and walk.

3.5 Preparations Before a Hurricane

The following are some precautions that should be taken well before a hurricane arrives.[13]

- Wedge sliding glass doors with a brace or broom handle to prevent them from being lifted from their tracks or being ripped loose by wind vibrations.
- Unplug all unnecessary appliances. Shut off gas valves.
- Turn refrigerators and freezers to their coldest setting.
- If you are going to evacuate, shut off electricity and main switch, and gas and water at their main valves.
- Package your valuables such as jewelry, titles, deeds, insurance papers, licenses, stocks, bonds, inventory, etc. for safekeeping in waterproof containers. Take these with you if you are going to evacuate.
- Outside, turn down canvas awnings or roll them up and secure them with sturdy rope or twine.
- Check door locks to ensure doors will not blow away.
- Check outdoor items that may blow away or be torn loose; secure these items or move items such as potted plants inside.
- Store chemicals, fertilizers, or other toxic materials in a safe section or secure area of the premises.
- Secure propane tanks. They should not be stored near sources of heat (like your water heater or other appliances).
- Fill the gas tank of your car.

- Deploy window protections well in advance of the arrival of any winds. (See Part 4)

- Ensure that you have a sufficient amount of cash in hand to purchase goods and items if needed following the hurricane, as banks and ATM machines may be inaccessible because of a lack of electricity.

3.6 Evacuation Procedures for a Hurricane

- Your emergency supplies stock and evacuation kit should already be in place before there is a hurricane watch or warning.

- In your evacuation plan, you should already have decided if you will stay in your house, go to a shelter, or go elsewhere (friend's or relative's house). You should stay in a place that is away from any flood or inundation zones, and that is able to withstand strong winds and rain.

- If you evacuate, you should already have made plans for your pet and prepared your house.

- If you plan to go to a shelter, you should already know the location of two or three shelters that are closest to your residence.

- As a general guideline,[3] you should evacuate if you are:

  - Along low-lying coastal areas;

  - Along low-lying areas subject to flooding (for example, near a stream or river);

  - In any Federal Flood Insurance Zone such as a high velocity wave zone (V zone) or flood zone (A zone), even if your house is built for wave action and flooding;

- Along ridge lines exposed to strong winds;

- Living in certain wood frame structures (e.g., single wall without a continuous load path design) or lightly-constructed building.

- **Go to a hurricane shelter only if it is open. Listen to your local radio for shelters that are open to the public. Local television may also have this information, but the information may be specific to a particular island.**

- Evacuate with your evacuation kit before danger arrives.

- Not all parts of a school serve as emergency shelter. Follow the directions of personnel who are staffing the shelter. If there are no personnel, the shelter is either not open or you are at the part of the facility that is not being used as a shelter.

- When you get to an evacuation shelter, you will have a maximum space of 10 square feet. There will be a bare floor. You will have to provide your own bedding, food, water, and other essentials. Your evacuation kit should contain all of these important items.

- Make the best of the situation and cooperate with the volunteers.

3.7 Evacuation Procedures for a Flood

The general rule if you are evacuating from a flood is to stay away from flood waters and head to higher ground. Stay away from moving water. Even six inches can make you fall or cause your car to stall. Two feet of moving water can move your car. If there is a flash flood and you are caught in your house, go to the second floor or the roof, if necessary.[14]

3.8 Evacuation Procedures for an Earthquake

You will not have any warning before an earthquake occurs, since it can occur anytime without advance notice. According to the U.S. Geological Survey, if you are in your house during an earthquake, you should stay there. The U.S. Geological Survey also recommends the following: "Get under a desk or table and hang on to it, or move into a hallway or get against an inside wall. STAY CLEAR of windows, fireplaces, and heavy furniture or appliances. GET OUT of the kitchen, which is a dangerous place (things can fall on you). DO NOT run downstairs or rush outside while a building is shaking or while there is danger of falling and hurting yourself or being hit by falling glass or debris."[15]

If you are outside, get out in the open, away from anything that may fall on you. If you are in your car, stop gradually and pull your car out of the way of traffic. Do not park on or under a bridge or near power lines, trees, or signs. Stay in your car until the shaking stops. When you resume driving, watch out for obstacles that may have fallen on the road. If you are in a hilly area, watch for landslides and boulders.

3.9 Emergency Information and Contacts

For general emergency information, please contact your state or local civil defense and emergency management agencies. The best time to contact them is when there is no emergency and you are planning and preparing. The worst time is when there is an emergency and the agencies are responding to hundreds or even thousands of calls. Nevertheless, call them if you absolutely need to. However, by planning and preparing ahead, you can help yourself and the agencies. For a list of emergency contacts and contact information, please see Appendix B.

Part 4
Protecting Your Property

Protecting your property and protecting your family go hand in hand, since your house may be able to provide shelter from most weather conditions and perhaps even severe conditions. By strengthening your house, you may be able to shelter in place during a hurricane. The amount of protection your house can provide is limited by a number of factors, some of which are listed below:

(1) The Severity of the Hazard Event. Protecting against a tropical storm or Category 1 hurricane will be much easier than against a major Category 4 or 5 hurricane (Table 2-2). For stronger storms, eliminating all damage is very difficult and the major goal is to significantly lessen the amount of damage. Fortunately, stronger storms are thought to occur less frequently. Also, many small improvements can make a difference.

(2) Your Location. Even though a hurricane may be a Category 1, you could experience much stronger wind. Being on a ridge, for example, amplifies the wind speed. Wind maps have been created or are being prepared for each island that show how topography affects wind speed. Check your county building department for the status of these maps.[16]

(3) How Your House Was Built. See Table 4-1. Today, county building codes require new houses to have hurricane clips that tie the roof to the wall and other connectors that tie the wall to the foundation. This is known as a "continuous load path connection" (Figure 4-1). Because of this requirement, houses today are generally much stronger than those built before this requirement was in effect.

(4) How Your House Was Maintained. Maintenance of your house is important. Painting the exterior every five years protects the wood and prevents rot, which can weaken the structure. Termites can also weaken a wood-framed house. If the wood in the house is rotten or has severe termite damage, it will be more difficult, or even impossible, to

strengthen the house in a retrofit. So, it is important to maintain your house by periodic painting and eliminating termites. Proper maintenance will extend the life of a house in more ways than one.

(5) What You Can Do to Strengthen Your House. Even if your house was not built with double walls or hurricane clips, there are many small steps and some major ones that can be taken to address how your house was initially built and further fortify it. Part 4 concentrates on many of the steps that can be taken as well as programs in place that provide financial assistance and incentives to encourage you to act.

You may be able to perform the work for many of these measures. However, if the work is beyond your capabilities, consider hiring a licensed contractor, structural engineer, and/or architect. Even if you do this work yourself, it is best to contact one or more of these professionals first to obtain guidance and details specific to your house.

When Hurricane Iniki struck Kaua'i in 1992, over 41 percent of the island's 15,200 homes were damaged or destroyed. An approximate breakdown is shown below:

- 1,100 homes totally destroyed
- 1,000 homes were damaged severely (more than 50 percent damage to structure)
- 4,200 homes were damaged moderately (15–50 percent damage to structure) or minimally (less than 15 percent damage to structure)[17]

For many homeowners, even minor damage of 15 percent or less can be an extreme hardship. After Iniki, FEMA conducted an assessment of building performance and came up with the following statements:

"Incomplete design and construction for load transfer and improper connections, especially between roof and walls, were found to be the most important factors causing structural failure of buildings due to uplift wind forces."[18] This statement relates to Concept 1: Creating the Continuous Load Path Connection and tying your roof to the wall with hurricane clips to significantly reduce the risk of structural failure to your house.

"In many instances, loss of glazing (e.g., glass doors and windows), either from direct wind pressure or from debris impact, resulted in breach of the building envelope, subsequent internal pressures, and progressive structural failure."[19] **This statement relates to Concept 2: Creating a Wind- and Rain-Resistant Envelope by protecting the openings around your house such as windows.**

Had the impacted houses on Kaua'i been properly designed and fitted with hurricane clips, a wall-to-foundation connection, and window protection, perhaps hundreds of homes that were destroyed could have been saved, and thousands that suffered severe, moderate, or minor damage may have instead had moderate, minor, or no damage, respectively. Because the islands of Maui, Hawai'i, and O'ahu have almost two to eight times the number of houses as Kaua'i did before Iniki, taking simple steps to strengthen your house becomes even more important.

4.1
Concept 1: Continuous Load Path Connection

The concept of continuous load path connection is illustrated on the next page. This connection ties your roof to your house's foundation and helps to keep the roof from blowing off during a hurricane.

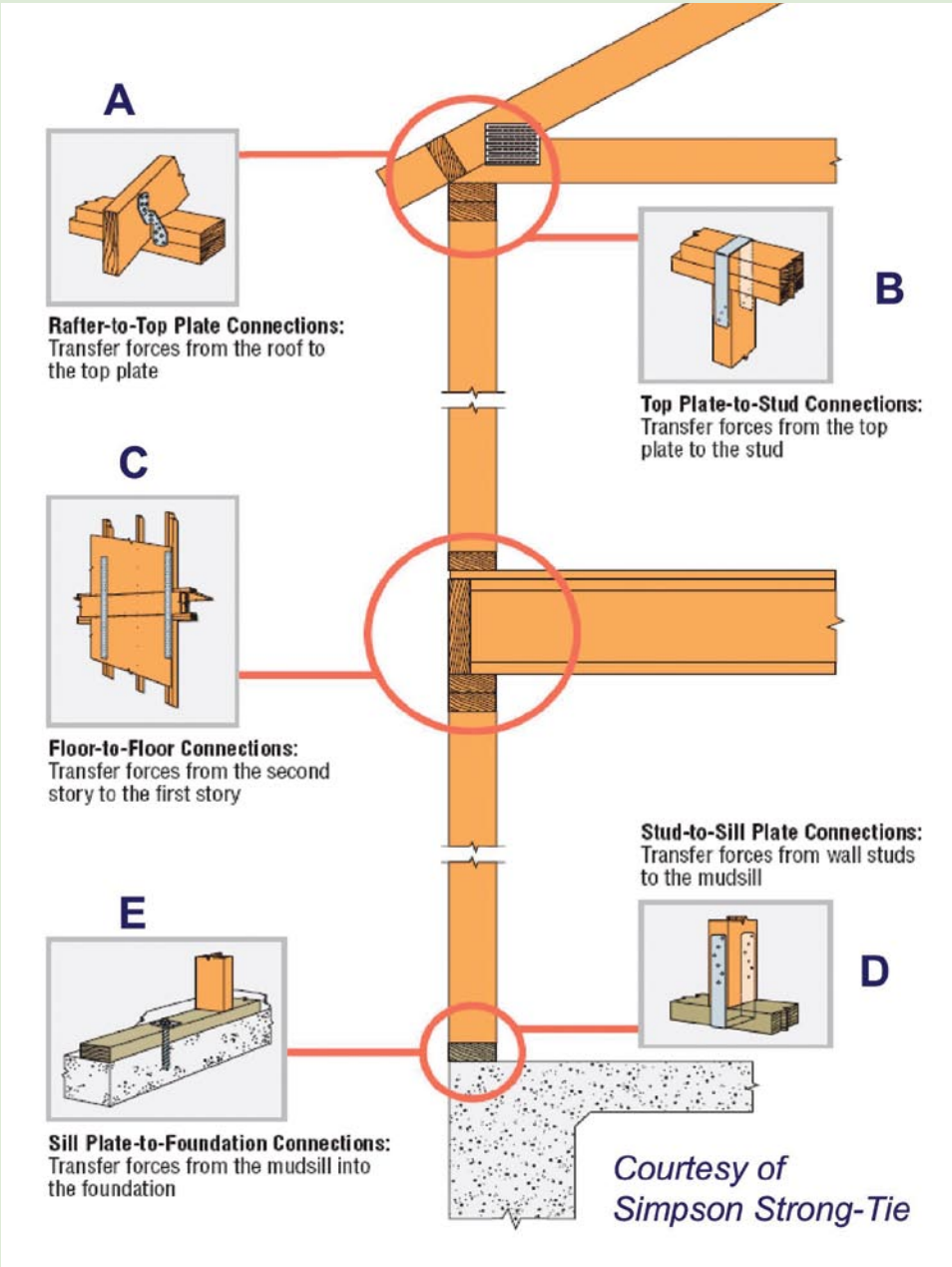


Figure 4-1. Continuous load path connection ties: (i) the roof to the wall, typically with hurricane clips (A) and plate ties (B); (ii) the wall of a higher story to the wall of a lower story with straps (C); and (iii) the wall to the foundation with plate ties (D) and anchors (E). For a single story house, the connections at C are not needed. These connections are in all new houses (Table 4-1). Older homes usually will not have these features. In many cases, retrofit can easily be done for certain portions.

The continuous load path connection is analogous to a chain: both are only as strong as their weakest link. Historically, the weakest link has often been the roof-to-wall connection. Thus, the hurricane clip was created.

Naturally, all houses have some connection from the roof to the foundation, otherwise they would fall apart. However, only recently, in response to damage from Hurricanes ʻIwa and Iniki, were much stronger connections required in the form of straps, anchors, and hurricane clips to protect against hurricane winds, as depicted in Figure 4-1.

According to the State of Hawaiʻi Loss Mitigation Grant Program, your house is likely to have the following hurricane protection based on the given benchmark dates:

Table 4-1. Key Dates for Homeowners to Know Regarding the Hurricane Protection

County	Date likely to have hurricane clips	Date likely to have complete load path, including hurricane clips
Kauaʻi	Plans dated 1989 or later; built after 1990	Plans dated 1992 or later; built 1993 or after
Oʻahu	Plans dated 1987 or later; built after 1988	Plans dated 1994 or later; built 1995 or after
Maui	Plans dated 1989 or later; built 1990 or after	Plans dated 1994 or later; built 1995 or after
Hawaiʻi	Plans dated 1993 or later; built 1994 or after	Plans dated 1993 or later; built 1994 or after

The dates in column 3 reflect when the requirements for the Uniform Building Code Appendix for Conventional Light-Frame Construction in High Wind were adopted by the various counties. If your house construction falls in the transition period, check with your architect, home builder, or developer to determine if this Appendix was adopted for your house. It is important to know if your house has: (i) no hurricane

clips; (ii) hurricane clips only (column 2); or (iii) hurricane clips along with the complete load path connection (column 3).

New houses have the complete load path connection. For older houses, it is possible to retrofit to add components of the connection (see Figures 4-2 through 4-6). Each house is different but, in general, it will be easier and less expensive to put in hurricane clips than to do the foundation connection. Check with a licensed architect, structural engineer, or contractor to determine what is feasible for your house. In some cases, if you are willing to spend the time and have proper direction from a licensed structural engineer or architect, you may be able to hammer in the hurricane clips yourself.

It is preferable to do both the roof-to-wall connection and the wall-to-foundation connection. However, if the wall-to-foundation connection is too difficult or expensive because of the way your house was built, installing only the roof-to-wall connection is better than doing nothing. Remember, the weakest link for many homes is the roof-to-wall connection and thus the hurricane clip will make that weakest link significantly stronger.

At the time of this writing, a new hurricane clip was being developed specifically for Hawai‘i. This will allow the retrofit of many older single- and double-wall houses with a hurricane clip that is tested and approved to meet the wind load guidelines for the Hawai‘i Loss Mitigation Grant Program. For example, many single-wall houses with tongue and groove redwood framing or those houses with angled or protruding blocking between the trusses or rafters may now be fitted easily with the new hurricane clip from the roof to the wall. Previously it was thought that these houses could not be strengthened, but the test data indicates otherwise. Consult the State of Hawai‘i Loss Mitigation Grant Program website for a list of approved connectors that can be used for Hawai‘i retrofit.

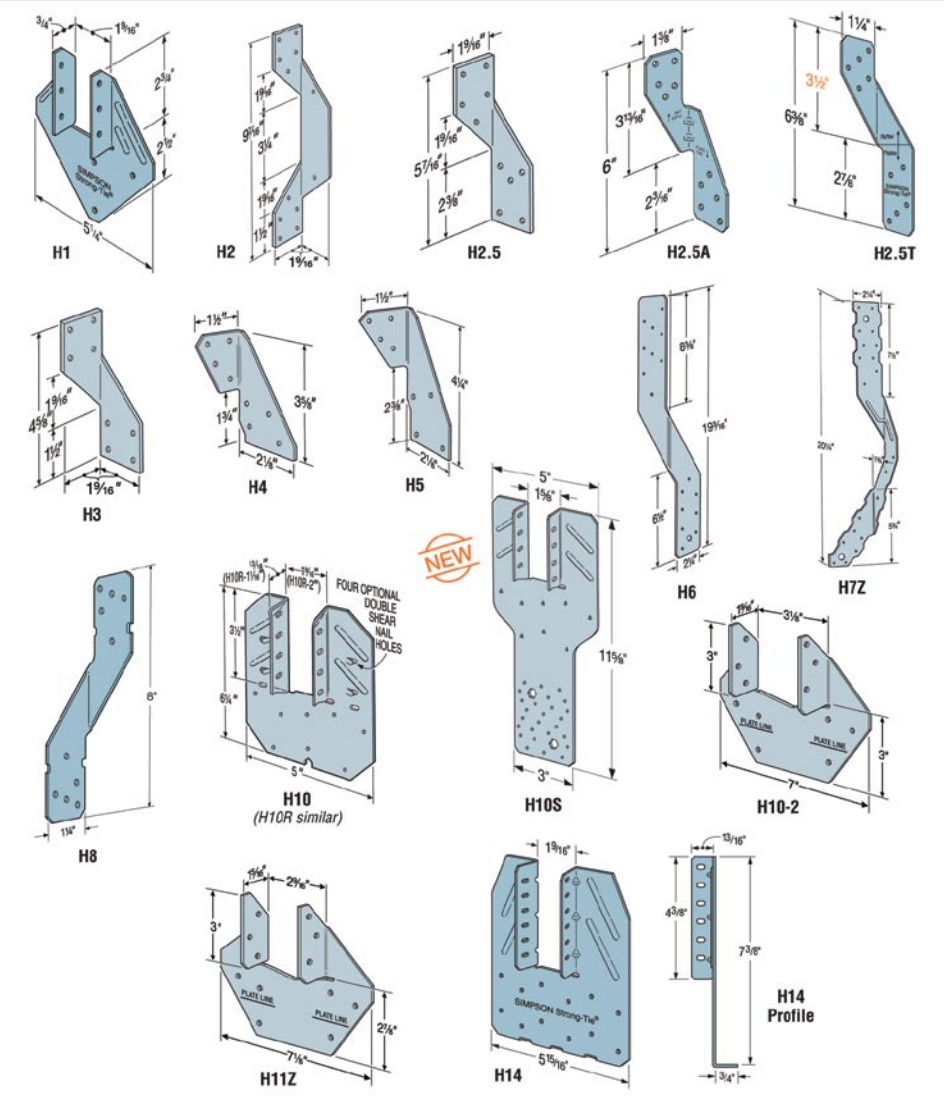


Figure 4-2. There are many different types of hurricane clips. Your licensed architect, structural engineer, or contractor can tell you what is suitable for your house and for the amount of protection you want. The H2.5 and H3 are popular models in Hawai‘i. Figure courtesy of Simpson Strong-Tie.

Figure 4-3. This is the popular H2.5 hurricane clip installed during new construction of houses. Five nails are hammered into the lower beam (or top plate) and five more need to be used for the roof (truss-rafter) connection. A hurricane clip is required for each truss-rafter. Upon completion of this structure, the hurricane clip will be hidden from view. This particular clip costs 30 cents. For less than a dollar in material cost, stronger ones can be installed for both new and retrofit applications.

Figure 4-4. This is an example of retrofitting an existing house, originally built without hurricane clips. The popular H3 clip is used here; four nails attach the clip to the roof (truss-rafter) and four more nails attach to the wall or top plate below. For a retrofit, the clips are exposed on the outside of the house; therefore, both the clip and fasteners should be corrosion resistant and painted to blend with the exterior of the house. With the correct clip and nails you could perform the work or, if you prefer, hire a licensed contractor.[20]

Figure 4-5. In this retrofit example, a hurricane clip attaches the roof structure to a horizontal ridge beam, which is in turn attached to the vertical post with a metal strap. This is an attempt to tie the load from the roof to the foundation, or create the complete load path connection. Note that these clips and straps are in the process of being painted. Photo courtesy of Hurricane Protection Services.

Figure 4-6. In some retrofit examples, it is possible to tie a portion of the house to the foundation. Here, a metal strap connects the vertical post to the foundation, which finishes the continuous load path connection from roof to the foundation. Photo courtesy of Hurricane Protection Services.

As we have seen, it is possible in many older houses to strengthen certain portions of the structure by attempting to complete the continuous load path connection. In particular, the "weakest link" in most houses, the roof-to-wall connection, can be fortified with hurricane clips. You can install the hurricane clips after consultation with a licensed structural engineer or architect, or you can hire a licensed contractor who has experience in this area of work. Other portions of this work, unrelated to the hurricane clips, will require the work of a licensed contractor. There are financial incentives, offered by the State of Hawai'i Loss Mitigation Grant Program and some insurance carriers (see Parts 4.5 and 4.7), to perform this work. However, you must follow certain guidelines to be eligible.

You should consult with a licensed structural engineer or architect if your house is being retrofitted. The structural engineer can go over the cost and benefits of installing the following:

1) Roof-to-wall and wall-to-foundation connections;

2) Hurricane clips only without additional foundation connection; or

3) Stronger connectors than those required in the current building code.

4.2 Concept 2: Creating the Wind- and Rain-Resistant Envelope

During a hurricane, it is very important to protect the envelope of your house from wind and rain. Windows can serve to protect that envelope, unless they shatter, which is almost certain to happen if they are unprotected. Taping your windows will not protect that envelope. A broken window during a hurricane can be devastating in several ways: besides the incoming hurricane-force wind and torrential rain in your living room, there is shattered glass and debris from outside flying in. It can make walking in your own house hazardous. Even more importantly, there is the problem with internal pressurization of your house (Figure 4-7).

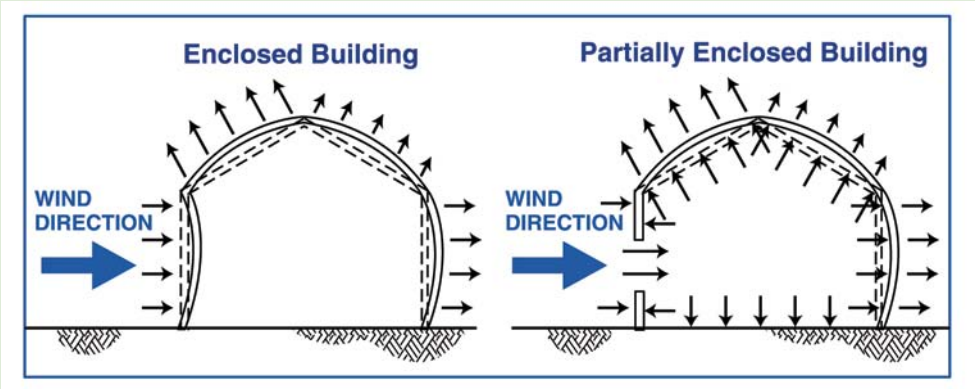


Figure 4-7. This figure illustrates the importance of protecting your windows. The diagram on the left shows a structure with the wind- and rain-resistant envelope intact. Pressure on the walls and roof comes from the outside only. In the diagram on the right, the structure's wind- and rain-resistant envelope has been breached due to a broken window. Now, pressure on the walls and roof comes from the outside and inside. The total amount of pressure increases significantly and can lead to the roof flying off and complete structural failure. Diagram from FEMA's Coastal Construction Manual (2000).

Some reports indicate that a window breach can potentially double the uplift forces on your roof and can significantly increase the chances that your roof will lift off.[21] This is why FEMA indicated in their assessment report that breach of the building envelope and subsequent internal pressurization led to progressive structural failure for many houses.

4.3 Window Coverings

Since protecting the wind- and rain-resistant envelope of your house is so important, much information is provided here on window coverings. At this point, it is necessary to go over the various options. All cost estimates provided are based on local estimates for installation, as well as estimates nationwide as of May 2007. Pricing may vary between vendors and change over time. Coverings that are installed should be tested and approved to meet industry standards for hurricane impact. Check with the manufacturer. Always use only licensed contractors and reputable dealers.

4.3.1 Roll-down Shutters

Roll-down shutters permanently attach to a building and are housed above the window.

Figure 4-8. During an emergency, roll-down shutters are quickly lowered as necessary. The shutter is held in place by guide tracks along the sides of the window and secured at the base by a latch on the guide track. For home use, the shutters can be deployed electrically or manually.

Figure 4-9. Roll-down shutters can provide significant protection against hurricane winds. The NOAA National Weather Service facility is protected with these shutters; here, the shutters are fully deployed over the two middle windows, and partially deployed at the sides. The shutters are made from heavy duty aluminum slats.

4.3.2 Bahama Shutters

Bahama shutters consist of a one-piece louvered unit that is attached above the window and propped open to provide shade. As with any permanently installed shutter system, permission may be required from your homeowner's association before you can proceed with installation. The cost of installation for Bahama shutters may range from $30 to $40 per square foot.

Figure 4-10. As a storm approaches, the Bahama shutter is pushed down against the wall and anchored with stainless steel bolts through the frame into anchor sleeves in the wall. Photo courtesy of Hurricane Secure.

4.3.3 Colonial Shutters

For many homes in Hawai'i, Colonial shutters have many of the advantages of Bahama shutters (quick deployment, aluminum panels), while being more esthetically pleasing.

Figure 4-11. Colonial shutters are typically made of aluminum or fiberglass. During a storm, the panels are closed and secured along the vertical center of the window. During good weather, the panels open along hinges on the side of the window and rest flat against the wall in a decorative manner. Photo courtesy of Hurricane Secure.

4.3.4 Accordion Shutters

Accordion shutters are similar to roll–down shutters in that the shutter unit is housed along the edge of the window. For roll-downs, however, the shutter is housed on the top of the window, while for accordions, it is stored to either side (Figure 4-12).

Figure 4-12. For deployment during a storm, the panels unfold accordion-style and extend toward the center of the window along pre-installed tracks. Photo courtesy of the Department of Emergency Management, City and County of Honolulu.

4.3.5 Storm Panels

Storm panels are made of aluminum or steel. The panels are corrugated and overlap for extra strength. Although the panels require storage when not in use, they usually stack together so the amount of space required is minimal. Storm panels are a relatively inexpensive way to protect your windows during a hurricane. Costs may range from $8 to $15 per square foot of window area.

Figure 4-13. Although installation varies, this example shows panels that slip into a track above the window. The bottoms of the panels are secured by bolts that are permanently attached to the window. Photo courtesy of Hurricane Secure.

4.3.6 Impact-Resistant Glass Systems

Many hardware and home improvement stores offer the option of purchasing windows with impact-resistant glass as a replacement for existing windows. These windows come in a variety of styles, options, and costs, and are laminated to increase the impact strength of the glass.

Figure 4-14. This attractive window can be fitted with energy-efficient glass, impact-resistant glass, or both. The impact resistant glass consists of a laminate or film sandwiched between two glass panes. The frames are reinforced and the hinges have extra fasteners to withstand high wind events. During a wind event, debris may crack the glass, but the laminate will hold the window pane together in the frame and prevent breaching of the wind- and rain-resistant envelope. After the storm, the glass will need to be replaced.

4.3.7 Laminates

Just as laminates are used to create impact-resistant glass on new windows (Part 4.3.6, Figure 4-14), they can also be placed over and used to protect existing windows (Figure 4-15). For laminates, the amount of protection is a function of the thickness of the film, the type of glass being protected (safety glass versus plate glass), the existing frame in which the window is set, and the attachment of the frame to the house structure.

Figure 4-15. Laminated film comes in various thicknesses and strengths. Here the film is applied to an existing window before it is bead-locked to the frame with silicone structural sealant.

Under the State of Hawai‘i Loss Mitigation Grant Program, laminates can qualify for the grant if details are provided on how the window attaches to the frame and walls, and data is provided showing the assembly meets hurricane impact standards. Visit the following website for complete details: http://www.hawaii.gov/dcca/areas/ins/consumer/consumer_information/Hurricane_Retrofits_Program. For some insurance companies, laminates may qualify you for a discount on your hurricane insurance premium.

4.3.8 Hurricane Mesh, Screen, or Fabric

In many cases, it may be difficult to protect your windows because they cover a large area or have unusual configuration (for example, if they extend out past the wall). In this case, one option would be to use a hurricane screen, mesh, or fabric.

Figure 4-16. Hurricane screen, mesh, or fabric consists of woven polypropylene, which is a plastic polymer. The screen can cover large areas and provide protection to windows with unusual configurations. Light can pass through the fabric so that the area inside is not totally dark. Photo courtesy of the Department of Emergency Management, City and County of Honolulu.

4.3.9 Plastic Honeycomb Panels

A relatively recent and positive development in providing the consumer with more options for window protection is the introduction of plastic honeycomb panels made of polypropylene (Figure 4-17). These panels are installed like plywood and have many of the good properties of regular plywood, with few of the disadvantages. The panels are white and translucent.

Figure 4-17. Plastic honeycomb panels have many times the strength of regular plywood and will not warp or rot. It is easy to cut and drill into, and, most importantly, it is light when compared to regular plywood. The major disadvantage is the availability of this material.

The honeycomb panels also come in a clear plastic version that lets light through. This is an attractive option to other protective systems, which can significantly darken a house when they are in use. However, these panels are more expensive than the opaque version.

4.3.10 Plywood Shutters

One of the most important options for window protection is regular plywood. Plywood is available at almost every hardware store and offers good protection if properly installed. Furthermore, the material cost is the least expensive of any of the other options discussed.

The disadvantages of plywood are that it can rot or warp if stored in a wet or warm area. In addition, plywood shutters are relatively heavy. You will need two people who can lift 30–40 pounds to help with the preparation and deployment of these shutters. Plan accordingly as it will not help if the people you are counting on to assist you may not be available during the deployment. Because of their weight, it would be difficult, or even dangerous, to install plywood shutters if a ladder is needed. Thus, plywood shutters are good for easily accessible windows on the first floor, or windows that can be reached by terrace or patio.

Table 4-2 lists the advantages and disadvantages of each type of window covering. In many cases it may be preferable to mix and match the options. For example, use plywood shutters for easily accessible windows, storm panels, or another type of system for windows with medium accessibility, and roll-down shutters or laminates for windows that are difficult to reach. This will allow all windows to be covered at reduced costs.

Table 4-2. Pros and Cons of Various Types of Window Protection

Type of Protection	Pros	Cons	Cost for 3 ft. x 4 ft. window
Roll-down Shutters	Easiest to deploy. Good protection.	Most expensive of permanent shutter systems. Needs manual backup for power outages, or an emergency power source. May need homeowner association approval.	$480 to $600
Bahama Shutters	Easily deployed. Good protection. Provides shade.	Esthetics. May need homeowner association approval. Blocks light.	$360 to $480
Colonial Shutters	Easily deployed. Good protection. Esthetically pleasing.	May need homeowner association approval. Requires room along side of window for shutter to swing out.	$300 to $420
Accordion Shutters	Easily deployed. Good protection.	Esthetics. May need homeowner association approval	$300 to $360

Type of Protection	Pros	Cons	Cost for 3 ft. x 4 ft. window
Storm Panels	Strong. Removable. Relatively inexpensive permanent shutter system.	Requires adequate space to store panels.	$96 to $120
Impact Resistant Glass	Attractive and energy efficient. Provides security protection. Storm resistant. Many options for styles and costs.	Costs vary widely and can be high. Replaces existing window. While building envelope is protected, cracked glass will likely require replacement.	Wide range in costs. $420 to $600 or more
Laminates	Storm, security and UV protection. Energy efficient. Always on. Allows light in. Ideal for hard-to-reach windows.	Other systems are stronger. Need to lock laminate to frame. Frame must be strong. Window may need replacement after storm.	$170 to $190
Plastic Honeycomb	Strong system. Lightweight. Reasonable cost. Won't warp or rot.	Storage of panels. Time to create and deploy. While cost is reasonable, still most expensive of deployable systems. Materials hard to get.	$170 to $190
Hurricane Mesh	Covers large areas and windows with unusual configurations. Allows light in. Lightweight.	Need proper supporting locations to fasten geotextile or mesh. Need accessible roofline.	$132
Plywood	Least expensive. Effective method. Materials available. Easy to install.	Storage of panels. Time to create and deploy. Weight of panels. Potential warping of plywood.	$18 to $32 for materials only

4.4 Installing Plywood Shutters

Because financial cost is a barrier to some homeowners obtaining window protection, plywood shutters are a very attractive option. Yet these shutters take time to create and deploy. Some suggestions summarized here could reduce installation time and make this option even more attractive. There is scattered information on installing plywood shutters; there is more to it than just buying plywood. Some of the tips provided in this section can also apply to the installation of plastic honeycomb panels.

4.4.1 Obtaining Assistance

Although you can install plywood shutters yourself to save on cost, you should still seek the advice of a licensed architect or structural engineer before you start. Professionals can guide you on specific details for your house's windows. The samples provided in this section may pertain to general applications, but remember that each window can be a little different. In addition, this section does not cover difficult applications such as installation for circular or triangular windows. Under the State of Hawai'i Loss Mitigation Grant Program, grants are possible for window coverings, but drawings for the windows are required by a licensed architect or engineer. Some insurance companies that offer discounts on hurricane insurance premiums for window coverings do not require the drawings.

4.4.2 Material to Use

For plywood shutters, the National Institute for Business and Home Safety and the State of Hawai'i Loss Mitigation Grant Program recommend that you use at least $^5/_8$ inch plywood.[22] Buy thinner plywood only if you cannot handle the weight and your alternative is to do nothing. Thinner plywood is not as strong as $^5/_8$-inch thick plywood and did not perform as well during destructive Hurricane Andrew in Florida in 1992. Five-eighths inch or thicker is required under the State of

Hawai‘i Loss Mitigation Grant Program. Some insurance companies may allow use of thinner ½ inch plywood to obtain a discount in hurricane insurance premiums.

You may want to consider thicker widths such as ¾ inch, since it is stronger than $^{5}/_{8}$ inch. In fact, some specifications for a safe room use ¾ inch plywood. The major concern with the thicker plywood is the added weight and difficulty in handling. For most people, $^{5}/_{8}$ inch exterior grade is a good compromise between strength and practicality during installation.

Your plywood should be treated to prevent termite damage when it is stored. In the past, harmful chemicals were used to treat plywood, but since the mid 1990s, plywood has been treated with borate, which is user friendly and requires no special handling precautions. Thus, there is no downside to handling the treated wood currently on the market.

If you buy your plywood during hurricane off-season, there will be plentiful supply and the stores may even cut the wood for no or little extra charge. If you wait until a storm is approaching, there will be long lines, limited or no supply, and possibly no cutting service.

For your installation, you will need a hammer, duplex or double-headed nails, a circular saw, jigsaw, power drill with the proper bits, straight edge, tape measure, and the correct fasteners.

4.4.3 Measuring Your Windows and Cutting the Plywood

When you measure your windows, it is important to have sufficient overlap of 4 inches on each side of the window.

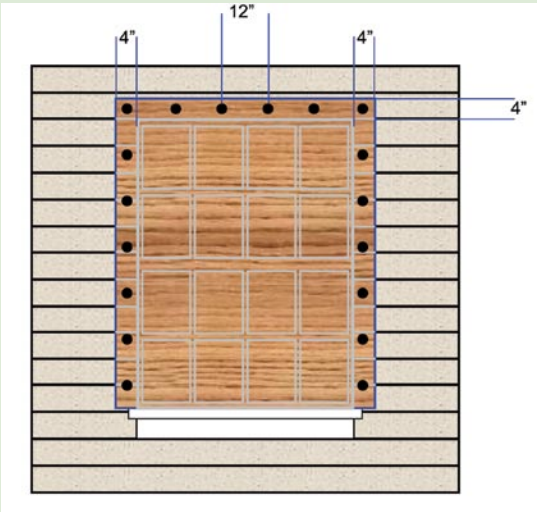


Figure 4-18. In general, a plywood shutter should have 4 inches of overlap on each side of the window. Thus, if a window is 46 inches wide, the shutter should be 54 inches wide. Figure courtesy of Department of Emergency Management, City and County of Honolulu.

The overlap of the windows is essential because you will be putting the fasteners that attach the plywood: (i) away from the edge of the window; (ii) away from the edge of the plywood; and (iii) directly into the wall studs that surround the window rather than in the siding of the house (Figure 4-19).

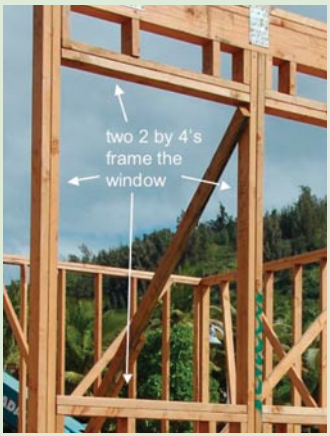


Figure 4-19. For this double-wall house under construction, two 2 by 4's frame the window. When attaching the plywood to the window, the fasteners should go into the 2 by 4's, not the siding. It is always useful to know how your house was built. Take pictures during construction (if possible), review your blueprints, drill small test holes if you have to, or ask your architect or home builder for the details on your window.

Figure 4-20. In this picture of a plastic honeycomb panel installation, the translucent panel reveals the location of the window to be protected (dark area). The panel overlaps the edges of the window by 4 inches and the fasteners are in the underlying studs around the window that are part of the structure of the building. A wood plywood installation would be similar.

Plywood comes in 4 ft. by 8 ft. sheets (48 inches by 96 inches). If you need a covering that is 54 inches by 54 inches, you will need to join together two sheets of plywood. The point where two panels meet is called a joint. These joints should be supported and can be connected by 2 by 4's (See Part 4.4.8).

It may take up to two days to measure the windows, buy the plywood, cut it to the proper dimensions, label the panels, and designate where all the fasteners are to be attached. This would be extremely difficult to do when there is an incoming storm. **These preparations need to be done in advance.**

Figure 4-21. After the plywood is cut for each window, each piece should be labeled so that the panels for one window are not mixed with those for another. It would also save time to indicate on the panels, well before any threat of a storm, where the fasteners will be attached.

4.4.4 Fasteners and Attaching the Panels

There are many different ways to attach plywood panels to the window frame. Some literature suggests using nails in an emergency. However, nails would not be as strong as screws and also are very difficult to remove after they are attached. The fasteners shown below are consistent with the State of Hawai‘i Loss Mitigation Grant Program (see Part 4.5). Based on the guidelines of this program, the following can be utilized for wood-frame houses:

A) # 8 wood screws with 2-inch embedment placed 16 inches apart for panel spans under 4 ft.; 9 inches apart for panels between 4 ft. and 6 ft.; and 6 inches apart for panels between 6 ft. and 8 ft.; **or you can use**

B) #10 wood screws with 2-inch embedment placed 16 inches apart for panel spans under 4 ft.; 12 inches apart for panels between 4 ft. to 6 ft.; and 9 inches apart for panels between 6 ft. and 8 ft.; **or you can use**

C) ¼ inch lag screw with 2-inch embedment placed 16 inches apart for all panel spans up to 8 ft.

Figure 4-22 shows what the #8 wood screws (A), #10 wood screws (B), and ¼ inch lag screws (C) look like. The duplex or two-headed nail (D) is also shown; this is used to quickly attach the panel to the frame before using one of the wood screws. Thus, D would be used with either A, B, or C. The screws discussed in A, B, or C are self driving and should require no pre-drilling. They can be attached quickly. All should be readily available at a hardware or home improvement store.

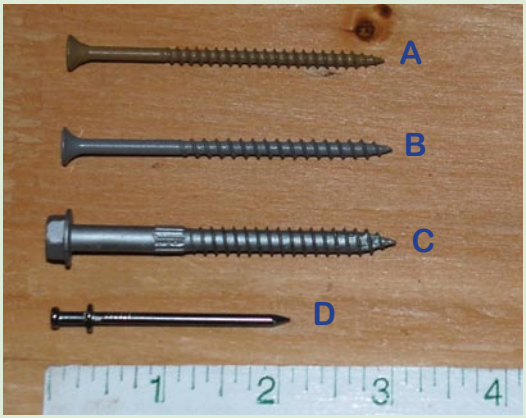


Figure 4-22. Key Materials for Fastening Plywood Panels
A. # 8—3-inch wood driving screw. Allows 2-inch embedment.
B. #10—3-inch wood driving screw. Allows 2-inch embedment.
C. ¼ Lag Screw—in this case, a 3-inch Simpson self-driving screw. Allows 2-inch embedment. Not all lag screws are self-drilling.
D. Duplex or two-headed 2-inch nail.

4.4.5 Deployment

If the plywood is (i) precut, (ii) prelabeled, and (iii) premarked with the location of all fasteners, then deploying and installing them can be relatively quick. First, align the panel, and then hammer a duplex nail into each top corner of the panel to hold it onto the frame. With the panel held by the two duplex nails, your hands are now free to drill the self-driving screws into the appropriate premarked location for the remainder of the panel. The duplex nail can easily be removed later, as they are designed for easy insertion and removal.

It is very important that you test the deployment and fasteners well before a storm. This will allow you to catch and remedy any unforeseen difficulties. For example:

1) Do the screws drive in easily without pre-drilling? If not, consider pre-drilling, which is relatively quick. It is possible for one person to pre-drill with a bit and another to drive in the screws.

2) Do the screws strip? Obtain high quality wood screws and, if necessary, pre-drill. Buying good screws will reduce the time of installation.

3) Does your hand drill have enough torque, or does it run out of power easily? Consider an 18-volt drill instead of a 12- or 14-volt one. Have extra charged batteries and an extra charger. Also consider using corded power equipment.

Many of these questions can be answered by sales assistants at your hardware or home improvement store.

4.4.6 Other Methods of Installation

It is also possible to permanently attach the fasteners to the frame of the house (Figures 4-23 and 4-24). This has the advantage that the panels can be more quickly deployed and redeployed without drilling more holes. Attaching the fasteners permanently takes more installation time and many of the materials are not readily available. This method is useful if the panels need to be taken up and down frequently (for example, those in Florida). In Hawai‘i, the frequency to deploy would not be as great and thus the method in Part 4.4.5 is acceptable as long as all the panels are fully ready to go well before a storm.

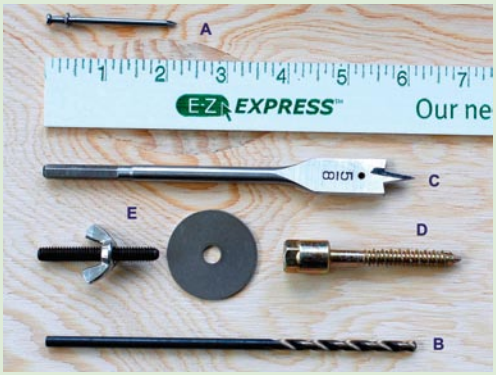


Figure 4-23. Many panels have permanent fastenings attached to the house. (i) After attaching the panel to the frame with two duplex nails (A), (ii) holes are drilled with the bit (B) into the panel and wood frame, (iii) then a spade wood boring bit (C) cuts wider holes into the panel and frame, (iv) and a lag screw anchor with female receptor (D) is screwed into the wood frame, (v) and the panel is attached with washer and wing nut (E).

Figure 4-24. Another method of attachment uses brass grommets (upper left) that are screwed into the wood frame. A wide head screw attaches the panels. Lower screw and washer wing nut are used to hold the two top corners. This is the method used in Figure 4-20.

Permanently installing the fasteners is more complicated, and either a licensed contractor or you can do this. You will, however, need some guidance from a licensed architect or engineer. One of the difficulties in permanently installing fasteners is obtaining the materials. You can look online for hurricane shutter kits with hanger bolts, or seek assistance from a licensed contractor experienced in this area.

4.4.7 Masonry Construction

Under the State of Hawai‘i Loss Mitigation Grant Program, if the screws in section 4.4.5 (#8, #10 or ¼ lag screw) are used for masonry or masonry/stucco, they must be attached using vibration-resistant anchors with a minimum withdrawal of 500 pounds. The Simpson Strong-Tie self-driving screws are not suitable for masonry; tap cons or Simpson Strong-Tie Titen screws can be used instead.

4.4.8 Larger Windows

Occasionally, more than one sheet of plywood may be needed to cover a larger window or surface, like a sliding glass door. Other times, you may have two scraps of plywood that can be used to cover one window. If two sheets are joined, the State of Hawai‘i Loss Mitigation Grant Program requires that they be supported. Certain hurricane insurance companies allow unsupported joints if they are less than 4 feet in length. Supporting all joints is stronger and can be done with a 2 by 4.

Figure 4-25. If the joint between the plywood is short, for example, 4 ft. to 5 ft. in length, a 2 by 4 (really 1 ½ inches by 3 ½ inches) can be used with the wide end on the outside against the plywood. Both ends of the 2 by 4 are then attached with screws through the plywood and into the window frame. This will require two 4 or 4 ½ inch lag screws, which may require pre-drilling or similar Simpson Strong-Tie self driving screws (SDS).

Figure 4-26. For larger windows, such as this sliding glass door, two 2 by 4’s face outside and are oriented with the narrow end against the plywood. The fastening screws attach from the plywood into the 2 by 4 (see Figure 4-27).

Figure 4-27. During assembly of the shutters in Figure 4-26, the two panels to be joined sit atop the 2 by 4's. The outline of the 2 by 4's and all screw locations are marked on the panel. Panels should be cut, labeled, and marked as to all fastening locations before hurricane season. The panels can be quickly attached with wood screws drilled from the plywood panel into the 2 by 4. The panel is then raised with the end near the window being the pivot point. The panel is then attached to the structural framing of the window as shown in Figure 4-26.

For more information on hurricane shutter design using plywood, please refer to: http://www.apawood.org

The methods discussed in this handbook are not the only ways to attach panels. The larger your window, the more plywood will flex under hurricane conditions. Thus, you should leave a 4-inch space between the plywood and the window. If there is not enough space, the window may crack, although the plywood would stay in place and continue to serve as a wind and rain resistant envelope. One way to get around this is to build 2 by 4 trim around the window frame and add stiffeners. This may take considerable time and very few window protection installers or homeowners do this. However, if you prefer to do this, refer to the above website.

If there is a hurricane strong enough to flex the plywood panel, then replacing your windows after a hurricane would be a relatively minor task if that is all the damage incurred. Note that during a hurricane, impact-resistant glass and laminated glass would be expected to

break, even though the building envelope would stay intact if the glass attachment to the frame and the frame are strong enough. Thus these systems offer protection to the building envelope, although you must accept that the glass may need replacement after a hurricane (Table 4-2).

Finally, whenever sliding glass doors or other entry areas are protected, it is necessary to make sure that there are always two storm-protected doors that will be operable for access and exiting at any time.

4.4.9 Storing Plywood Panels

Storage space may be one concern you have about using deployable plywood or plastic honeycomb panels. It is possible to store the panels in your garage if they are organized neatly and stacked together (Figure 4-28).

As this handbook was being prepared, some companies were investigating the possibility of providing storage services for window coverings. The panels would be dropped off at your house before the beginning of hurricane season and picked up at the end of the season.

Figure 4-28. Once the panels are created, they can be stored in the garage and take up minimal space if stacked neatly along the side of the garage, with the smallest pieces closest to the wall. Panels should be checked each year for any warping or rotting and replaced as needed.

4.4.10 Timing Deployment with a Hurricane Watch or Warning

You should consider getting the panels ready even before a hurricane watch. There's a fine line between installing all the panels and fasteners too early only to have the hurricane veer away, and installing them too late when the wind makes it impossible to deploy. If there is a serious threat of a hurricane but no watch or warning yet, do any minor assembly such as joining two panels (as in Figures 4-26 and 4-27) in advance. Then you can quickly mount the panels to the window if the threat increases.

If there is a hurricane watch, do the most difficult installations first. Begin deploying the panels, but not all the fasteners. For example, if you use a #8 screw on a 7 ft. panel, the fasteners should be 6 inches apart (see Part 4.4.4). Perhaps attach the four corners and the screws 18 inches apart. Leave one or two windows needed for access or light uncovered but ready to be protected. If the probability of a strike decreases and the hurricane turns away, there will be two-thirds fewer screws to remove and holes to patch with wood putty. If the probability of a strike increases, cover the remaining windows and add the remaining screws so that they are all spaced 6 inches apart. **The goal would be that if a hurricane warning is announced, you could complete full installation to your house in 1–2 hours simply by installing one or two more window panels and all the remaining screws. It is important to note that all fasteners need to be installed for the shutter to provide the full level of protection during a hurricane.**

This is a general guideline and will vary for each household depending on the situation. For example, you will need more time if you are protecting fifteen windows instead of five. Another consideration is how much help you will have and the number of other tasks you need to do to prepare your house and family. If you are deploying many windows, or have little help, consider deploying before a hurricane watch. It is better to have too much time than too little.

4.5 Hawai‘i Loss Mitigation Grant Program

Under the State of Hawai‘i Loss Mitigation Grant Program, grants that cover 35 percent of the cost of the work may be obtained for properly installed wind resistive devices (WRD) (see http://hurricaneretrofits.hawaii.gov/). The grants can be applied for in phases, with the maximum total reimbursement capped at $2,100 per dwelling. Before performing the work, make sure that funding is currently available, since the grants are provided on a first-come, first-serve basis. Also make sure that you work with a licensed contractor who can take responsibility for filling out and applying for your grant application.

Some eligible WRD include: (i) roof-to-wall connections (for example, hurricane clips), (ii) roof protection, (iii) garage door and window coverings, (iv) foundation upgrades, and, in the near future, (v) a safe room. Figure 4-29 displays the various types of protection that are covered under the program. The following sections provide further details of each option.

4.5.1 Option 1: Roof-to-Wall Connection

Concepts regarding the roof-to-wall connection were covered in Part 4.1. Under the state’s Grant Program, a properly selected hurricane clip is required for each rafter. In addition, the rafters at gable end eaves should be strapped down. Exterior beams supported by corner columns also require strap down. For houses with post and beam roof construction, fasteners should be for roof rafter to roof beams, top of post to horizontal ridge beam, and post to beam connections located at the exterior wall (see Figure 4-5).

You should seek a licensed architect, structural engineer, or contractor to select the proper connectors and nails for your house. You can then do either all or part of this work yourself, or hire a licensed contractor. To obtain the grant from the state, verification of substantial completion through an inspection and photographs is required. Your licensed contractor can assist you with the paperwork. Even if you do the work yourself, you will still need to seek an inspector who is approved by the county building department or a licensed structural engineer.

4.5.2 Option 2: Roofing

The wind from a hurricane attacks any weaknesses in the roof. Once a weakness is exposed, adjacent areas can be more easily damaged and peeled away. Thus, strengthening the roof is important and it should be considered for new construction and when a roof is replaced after its expected life. The state's Grant Program recommends the roofing option at the time that a roof is being redone. At that time, the Grant Program could pay for 35 percent of the incremental cost over a standard roofing job up to $2,100. This Option 2 is not available for the grant unless Option 1 is completed first.

The roofing option involves installing a continuous structural sheathing (for example, plywood where it is missing or damaged; see technical specification at http://hurricaneretrofits.hawaii.gov/). Additional fasteners and a secondary waterproof membrane are required. You should seek a licensed roofing contractor to do this work.

As a side note, there are small things you can do to strengthen the roof even if is relatively new. For example, if you climb in your attic and see nails that are supposed to attach the plywood sheathing to the truss have missed the truss, then you have found what could be a structural weakness. The joint can be strengthened with a wood epoxy.

4.5.3 Option 3: Exterior Opening Protection

Option 3 covers work to protect your windows, doors, and garage. This is to maintain the wind- and rain-resistant envelope of your house. Exterior window protections were covered in Parts 4.3 and 4.4. The state's Grant Program could cover work for roll-down shutters, impact-resistant glass, laminated film, and plastic or plywood shutters. To obtain the grant, three requirements need to be met: (i) the devices installed should meet impact standards that the licensed contractor should be able to prove to the state; (ii) engineered drawings and details are required; and (iii) photographic evidence and inspection are needed to verify compliance.

The grant does cover wood plywood shutters installed by the homeowner, provided at least 5/8 inch sheets are used, design drawings of each window are provided, and evidence is provided of compliance with the specifications. In addition, the plywood shutters are only allowed on the first floor to obtain the grant. When the new technical specifications are released, grants for upper floors will be allowed. Please check the program website for updates to these requirements. It should be noted that plywood shutters are heavy and, because of safety reasons, it is not recommended they be installed if you have to use a ladder. Installation on the upper floors would be acceptable if the windows are easily accessible by a terrace or patio.

Option 3 also covers work to strengthen your garage, which includes the garage door, garage windows, and the entry door. The garage door is a significant weakness during a hurricane due to its large area and the stress it is subject to. Garage door options include: (i) replacement with a stronger door, (ii) horizontal bracing, (iii) vertical bracing, or (iv) other types of a bracing kit. For many garage doors the vertical bracing is a popular and reasonably priced option. A grant application for the garage improvements (garage door, windows, and entry door) can be submitted separately from one for house window coverings.

Under Option 3, double entry doors should have slide bolts at the top header and bottom threshold of the inactive door, a deadbolt with at least 1-inch throw length between each door, and three hinges for each door. This requirement is similar to other guidelines for single entry doors, which call for at least three hinges and a bolt long enough that goes into the 2 by 4 framing of the door.[23] Whenever entry doors are fortified, at least two of them must be operable for access and exiting at any time.

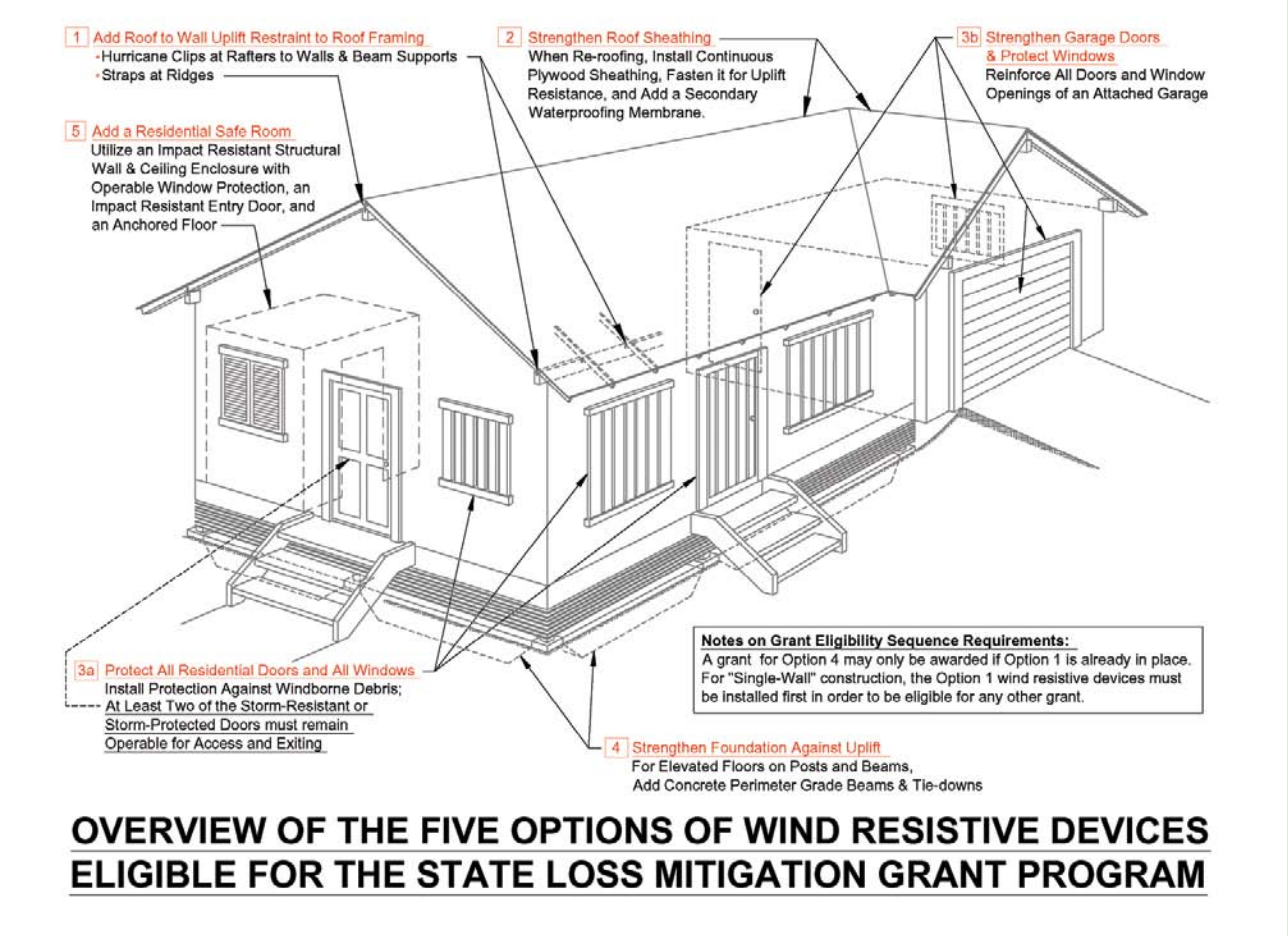


Figure 4-29. Options to Strengthen Your House under the State of Hawai‘i Loss Mitigation Grant Program.

4.5.4 Option 4: Foundation Uplift Strengthening Restraint

This grant is allowed only if the improvements for Option 1 are first in place. This is in recognition that the roof-to-wall connection is the most critical component for strengthening and completing the continuous load path connection (addressing the "weakest link").

The Option 4 grant is available only for single-story, single-wall houses that use a post and beam with an elevated first floor. In many cases the post sits on concrete blocks or "tofu" blocks. The work involves installing foundation retrofits between each tofu block around the perimeter of the house. This work needs to be performed with the assistance of a licensed structural engineer and contractor. (View technical specifications and updates at this website: http://hurricaneretrofits.hawaii.gov/)

4.5.5 Option 5: Safe Room

A safe room is a room designed to withstand winds from the strongest of hurricanes (Categories 3–5). Contact the State Department of Commerce and Consumer Affairs for the availability of funding and the status of the safe room exemption. As of the time of this writing, new rules were needed for the implementation of the safe room grant.

4.6 The Safe Room: Tax Credits and Cost

On Kaua'i, residents who build a safe room can get a credit on their property taxes. A house with a safe room gets a $40,000 safe room exemption in addition to the $40,000 primary residential tax exemption. For a $250,000 house on Kaua'i with a safe room, property taxes are based on a value of $170,000. This would save you about $200 per year in property taxes.

For Maui, a quote was received to build a 10 by 10 foot safe room within an existing structure for $300 per square foot, or $30,000. Quotes

on Kaua‘i to build a safe room for an existing house with a kit range from $6,000 to $8,000. The kit could also be used for new houses. For additional information on building a safe room, see the FEMA document “Taking Shelter From the Storm” at http://www.fema.gov/plan/prevent/saferoom/fema320.shtm.

Under the State of Hawai‘i Loss Mitigation Grant Program, details for a safe room will be in the updated technical specification for the program. See http://www.hurricaneretrofits.hawaii.gov.

It is much less expensive to build a safe room at the time a new house is built. Estimates received on Kaua‘i ranged from $3,000 to $8,000. FEMA notes that while construction costs vary nationwide, the cost to build a safe room inside a new house (which can also double as a master closet, bathroom, or utility room) ranges from $2,500 to $6,000. In the future, developers may offer the safe room as an option for new home buyers.

If you are building or buying a new home, ask your architect, developer, home builder, or licensed contractor to provide a low cost estimate to build a safe room in a master closet or other suitable room. A guideline for cost could be the lower end of the estimate provided by FEMA of $2,500 to $6,000. The additional cost can then be wrapped into the original home mortgage. According to the state, when the new rules are developed, the safe room in a new house will be eligible for the grant (Part 4.5.5). Thus, if you are on O‘ahu and a safe room costs an additional $3,500, you may be eligible for a grant of $1,166. If you are on Kaua‘i, you could possibly obtain a grant of $1,166 plus a credit on your property taxes that saves $200 per year. This is a good return for a measure that adds value to your house as well as protection and peace of mind for your family.

Safe rooms should not be built in a flood zone, where there is threat of moving water. During a hurricane or other high flood event, these areas need to be evacuated because of the water, no matter how fortified the room is against the wind.

4.7 Insurance Discounts for Installation of Hurricane Protection

Some, though not all, insurance companies offer substantial discounts in hurricane insurance premiums as an incentive for you to strengthen your house. The discounts are available for:

1) Roof-to-wall connection (hurricane clips) (typically 10 percent off)

2) Wall-to-foundation connections (typically 10–12 percent off)

3) Window coverings (15–18 percent off for single-family houses and 18 percent off for condos)

Check with your insurance agent as to the availability of the discounts and the specific requirements needed to obtain them. Each company is a little different. Conceivably, if all three strengthening measures are performed, as much as 35 percent could be saved on your hurricane insurance premiums. To obtain the insurance discounts you normally must submit a letter from the contractor verifying that the work has been completed. If you build plywood shutters, you must submit pictures to substantiate the work. If your house is already built with the continuous load path connection or has hurricane clips, your premium may already be adjusted based on the date of construction (see Table 4-1).

The discounts that may be available from the insurance companies and the grant from the State of Hawai‘i Loss Mitigation Grant Program can be combined. This can provide even more incentive to act. Note, however, that the two programs are distinctly separate with slightly different requirements. For example, the insurance companies may accept ½ inch plywood shutters and not require design drawings for window coverings. The state, on the other hand, would require at least $^{5}/_{8}$ inch plywood and the drawings. Probably the most similar overlap for you to take advantage of is for the roof-to-wall connection and addressing the “weakest link” in the continuous load path connection by installing hurricane clips.

Consider work to strengthen your home as a home improvement that adds value and longevity to your house while protecting your family and offering peace of mind. With a home improvement or home equity loan to pay for the work, you may be able to get: (i) discounts on hurricane insurance premiums, (ii) grants from the state under the Loss Mitigation Grant Program, (iii) a lower interest rate because your house is used as collateral, and (iv) a tax deduction on the interest (check with your accountant or financial institution).

4.8 Protecting Your Property with Insurance

There are two ways to protect your property from natural hazards. The proactive way is to strengthen your house to address the individual hazard. If, however, there is still damage, insurance can provide resources to aid recovery.

Hurricane insurance is important for all residents of Hawaiʻi and is a requirement for bank loans. Flood insurance is important for those in flood zones, or if you are subject to periodic flooding, even if you are outside an official flood zone. Earthquake insurance is particularly important for those on the island of Hawaiʻi and, to a lesser extent, Maui. Yet earthquake insurance may not be available or can be very expensive.

4.8.1 Hurricane Insurance

To protect your property from the winds of a hurricane, you need hurricane insurance. A regular homeowner's policy will not cover hurricanes. Coverage is typically provided in terms of replacement costs, or the cost to rebuild your house. The homeowner typically selects a deductible, for example 1–2 percent of the cost to rebuild.

In Hawaiʻi, some homeowners do not have hurricane insurance, particularly those without a mortgage. Also, older homes (built before 1959), or those in poor condition may have difficulty in qualifying for hurricane insurance. If insurance is available, it is very expensive and

provided by only a few out-of-state companies. Nevertheless the market for insurance is changing, so continue to check. For homes without hurricane insurance, it is even more important to strengthen the house or there could be a major loss during a hurricane. Ideally, you would have both a strong house and insurance.

Hurricane insurance policies vary for each company. Check with your agent and policy for the following:

- Does the policy have an inflation guard that increases each year as the cost to rebuild goes up? Construction costs have steadily increased and may increase even more so after a natural disaster.

- After a hurricane, there can be widespread damage and very few contractors or supplies available to perform repairs. After Hurricane Iniki, it took up to two years for homeowners to repair their homes because of the heavy demand. This surge can result in an increase in cost to rebuild. Some homeowners have chosen to increase their insurance coverage by 30–40 percent to account for an expected spike in future construction costs after a hurricane.

- Additions or improvements to your house made since your initial policy purchase may not be covered, so it is important to have a periodic appraisal so that your coverage is adequate.

- Check with your insurance agent. Not all companies provide discounts for hurricane protective devices. These discounts over time can pay for the cost of certain retrofit upgrades.

- Understand your policy. Many policies cover only hurricanes and not lesser events such as a tropical storm or a tropical depression.

- Make sure you have coverage for: (i) your main structure, (ii) detached structures, (iii) the contents in your house, and (iv) expenses for loss of use (like hotel stays). Only the first item is required by the banks, so you may not have sufficient coverage for the remaining items.

4.8.2 Flood Insurance

To obtain coverage from flooding, you need flood insurance. Your homeowner's insurance will not cover floods. Your hurricane insurance generally will not cover floods unless wind damage from a hurricane leads to rainfall intrusion and subsequent flooding of your house. However, check your policy to be certain.

Flood insurance will cover inundation or flooding for homes near a river, stream, or along the coastline. In addition mudflows (defined as movement of the land by viscous water saturated soil) are covered, but landslides are not (for example, movement of the land by earthquakes). Coastal flooding and flooding from high surf, hurricane, and tsunami inundation are covered.

Consider flood insurance if you are at risk of flooding (see Part 2.4). You may need flood insurance if you live near the coastline, a river, or a stream system, or any other body of water.

Contact your insurance agent to see if he or she offers flood insurance. The following website provides a listing of agents issuing flood insurance for your community: http://www.floodsmart.gov/floodsmart/pages/riskassesment/findpropertyform.jsp. For low risk areas, the cost of insurance is minimal compared to the protection it can provide.

4.8.3 Earthquake Insurance

To obtain protection from earthquakes, you will need earthquake insurance. Homeowner's policies do not cover earthquakes. Earthquake insurance is especially important for residents on the island of Hawai'i (see Figures 2-9 and 2-10). However, because of the great risk on this particular island, coverage is either very difficult to get, with only a few carriers providing it, or very expensive. Earthquake insurance is commonly offered with high deductibles.

If earthquake insurance cannot be provided, it is even more important that you take steps to strengthen your house and protect the contents

from ground shaking. Note that if your house is built to modern standards with a hurricane protection system (i.e., continuous load path connection), this may offer some protection from earthquake shaking.

Thus, strengthening your house for a hurricane offers protection from an earthquake. This provides additional incentive for homeowners to act, particularly if you live in a high-risk area and cannot obtain earthquake insurance.

4.9 Electrical Issues for Your House

An important publication for you to have is the "Information Handbook for Emergency Preparedness," distributed by Hawaiian Electric Company, Maui Electric Company, and Hawaii Electric Light Company.

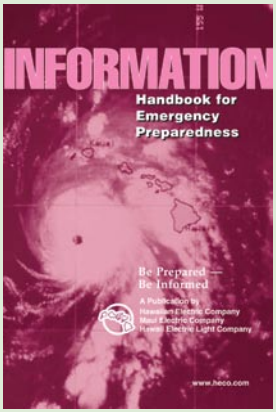


Figure 4-30. The HECO handbook covers many of the topics dealing with electrical safety and power outages. Printed copies can be obtained at the customer service departments for each company. For an electronic version, go to http://www.heco.com. Click the tab for Safety and Emergency and then the link for Emergency Preparedness.

The HECO handbook provides useful information on turning off the power to your house in case of an emergency through the main breaker switch, circuit breaker panel, or fuse box. The handbook also describes ground fault circuit interrupters (GFCI) and their role in protecting people from severe or fatal shock. GCFI's are commonly found in kitchens, bathrooms, laundry rooms, or other places where water and electricity are close together. If you don't have them, consider having them installed by a licensed electrician. The handbook also describes indoor and outdoor electrical safety tips that are applicable during both normal times and emergencies. During a hurricane there could be many

downed power lines and associated power outages. The HECO handbook provides tips for negotiating downed power lines as well as a reminder to call 911 if you spot one or if you see someone being shocked. Many tips are provided for dealing with power outages, which is especially important to know during and after a hurricane. For instance, after Hurricane Iniki only 20 percent of the power had been restored on the island of Kaua‘i after one month.

4.10 Alternate Power Sources

The following information is meant to supplement the HECO handbook’s section on power outages. Before discussing alternate power sources during an emergency, one general suggestion is to make your house as energy efficient as possible as you replace equipment and appliances in your house after they have outlived their normal life. For example, if the lights, a television, or refrigerator need replacing, consider products with the EPA’s Energy Star label. These products may cost slightly more, but over their lifetime, the energy savings will far outweigh the small initial cost increase.

Figures 4-31. Items with the Environmental Protection Agency’s Energy Star Label use much less energy than standard models. Items include washing machines, dishwashers, refrigerators, freezers, air conditioning units, and light bulbs.

Energy efficient equipment will be especially useful during an emergency, when you may be on alternative forms of power with limited supply. For example, a regular 100-watt lamp running off an emergency power station (essentially built around a car battery) may run for two hours. That same emergency station can run a fuel efficient 23-watt compact fluorescent light almost 8–9 hours with the same light output. As another example, a refrigerator with the EPA’s Energy Star label can

run on a fuel-efficient generator for 16 hours on one gallon of gas. Since most refrigerators do not need to run continuously, it may be possible to run the efficient refrigerator on one gallon of gas for one or two days.

4.10.1 Generators

Some households may require uninterrupted power because of the critical needs of some family members. For example, the elderly, disabled, or sick may require a respirator, dialysis machine, or other medical equipment. Some medicine such as insulin, which is stored over a month, may need to be refrigerated. For many families, the most important major power requirement is to run a refrigerator or freezer. If your family cannot get by without the refrigerator, or there are other critical power needs for medical or other purposes, then you may want to consider a portable generator.

This handbook will not recommend any particular generator or brand. However, if you are considering a generator, look first at your power needs and then at cost, reliability, quietness, and fuel efficiency, among other factors. You may want to read reviews of generators that are published for the consumer. Some of the factors to consider include:

1. Power needs. Size the generator so that it runs the equipment you need or want to run in an emergency. It will make a difference if you just run the refrigerator, versus the refrigerator, lights, and other equipment. Some equipment such as a refrigerator may require 500 watts to run but 1500 watts to start up. Each piece of equipment is different. You can get general guidelines from the manufacturers in the form of charts and tables for equipment power needs. A more accurate estimate, however, is to call your manufacturer or buy an amp meter that measures running and start up wattage or amperage.[24] You can also get good advice on sizing a generator from the dealer where you buy the unit.

2. Fuel efficiency. During an emergency there will be limited fuel supplies. The amount of power you need and the fuel efficiency of

the generator will determine if you need one or two gallons per day instead of five or six.

3. Quietness. Generators are usually noisy, but some are quieter than others. If you need to run a generator, your family and neighbors will appreciate if the generator is quiet.

Never run a generator indoors or in your garage because of the buildup of carbon monoxide gas, which cannot be detected by smell. Good ventilation is required. Operate your generator outside and away from open windows. Do not hook up a generator to your house power supply without a licensed electrician. Most people use extension cords to connect to the appliances and the cord should be of sufficient gauge to carry the power load.

Here is a general guideline for running your refrigerator with a generator. Keep the refrigerator and freezer at the coldest setting. Refrigerators may only need to run a few hours a day to preserve food. Using a refrigerator thermometer, you should aim to maintain 40 degrees in the refrigerator compartment and 0 degrees in the freezer.[25] Open the refrigerator door as little as possible. If in doubt on the safety of the food, do not eat it. In general, eat food in the refrigerator first, then the freezer, and, last, your nonperishable supplies in your emergency supplies stock (Part 3.1). If you have questions regarding food safety, call the Department of Health at (808) 586-4725.

4.10.2 Power Stations

Power stations are found in many hardware stores and may have a radio, flash light, air compressor, battery jump starter, AC outlet, or DC outlet built around a modified car battery. These units can come in handy during a power outage, since they can form part of your stock of emergency supplies and also provide limited emergency power. For example, many people discovered their wireless phones did not work during the power outages associated with the October 15, 2006, earthquake. If your cordless phone does not work because the base of the unit has no power, a power station could supply electricity so that calls could be made. (An alternative is to use a corded phone.) It should be noted that after an emergency, there may be many reasons the phone does not work that are beyond your control, such as heavy traffic or loss of function with the phone system.

4.10.3 Inverters

Inverters take the 12-volt DC power from your car battery and convert it to 115-volt AC power that can run household appliances. This can be very important if you need to run power tools in an emergency and the power is out. The inverter will drain your car battery, but look for inverters that have a low battery shutdown feature to prevent total battery drain. You should not run an inverter with the car running unless the manufacturer provides specific instructions with safety guidelines. In addition, the car should not be run indoors or in a garage, but rather in a well-ventilated area if the manufacturer approves of such procedures.

4.10.4 Battery Chargers

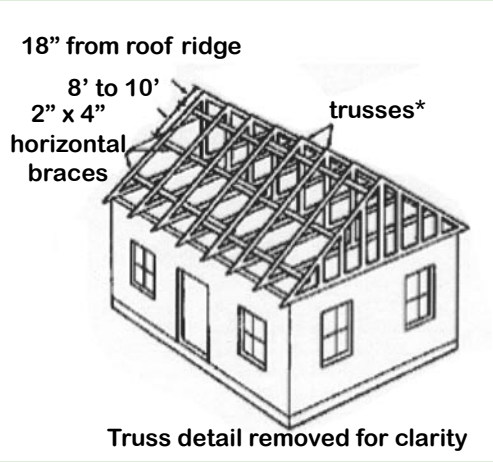
Your car battery can be an important source of DC and AC power with an inverter. To keep the car battery charged, you should consider a battery charger as part of your emergency supplies. The charger only works when there is household power, or backup power through a generator, but it can recharge your car battery if it is needed. New units are small and portable and provide a quick charge to a dead battery in only a few minutes and a total charge in a few hours.

4.11 Other Measures to Protect Your Property

Some additional measures you can take to protect your property during a hurricane include cutting or trimming trees that overhang your house and also bracing the trusses and rafters in your attic if your house has a gable end.

4.11.1 Truss Bracing

It is possible to significantly strengthen your roof by providing lateral and diagonal bracing to the trusses. This is particularly important for houses with gable-end roofs. This bracing can be done simply with 2 by 4's; it is also possible to buy prefabricated metal braces at a home improvement store.



In Figure 4-32, the trusses are built with a peak at the ridge line of the house. The trusses at the end of the house form an A-shaped pattern known as a gable end. During a hurricane, the gable end is subject to great forces from the wind and is likely to tip over, collapsing the other trusses in a domino fashion.

For lateral bracing, 2 by 4's are attached to the trusses that run the length of the roof. The 2 by 4's overlap over two trusses. Braces should be 18 inches from the ridge, in the center and at the base, about 8 ft. to 10 ft. apart. You or a professional can do this work. You should use two 3-inch, 14-gauge wood screws or two 16d (16 penny nails are used for each truss).[26]

Figure 4-33. In this application of lateral bracing, the 2 by 4's are 18 inches from the ridge and connect to horizontal members that attach the opposing trusses. Not all roofs will have the horizontal members. The 2 by 4's are connected with two #14 3-inch screws (A) and overlap over two trusses (A and B). The end is connected to the gable end with an angle or L bracket (C).

Another important type of bracing for your gable end involves making diagonal braces (Figure 4-34). Diagonal braces provide additional support against collapse of the gable end.

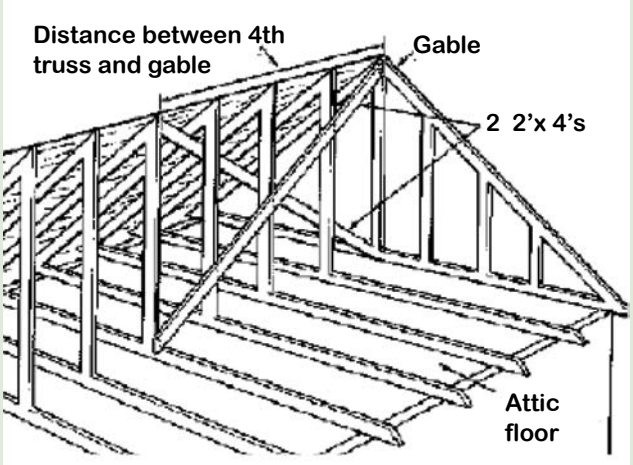


Figure 4-34. Diagonal braces form an X pattern from the top center of the gable end to the bottom center of the fourth truss and from the bottom center of the gable end to the top center of the fourth truss. The same screws as for lateral bracing are used.

Hip-style roofs do not need as much bracing, as they are aerodynamically superior and they have the bracing built into the design of the structure. While gable end roofs have a flat end that is A-shaped, hip-style roofs have all four sides of the roof sloping towards the center of the roof.

4.11.2 Tree Trimming

Considerable damage to your house can be done if tree limbs or branches fall onto or impact your house.

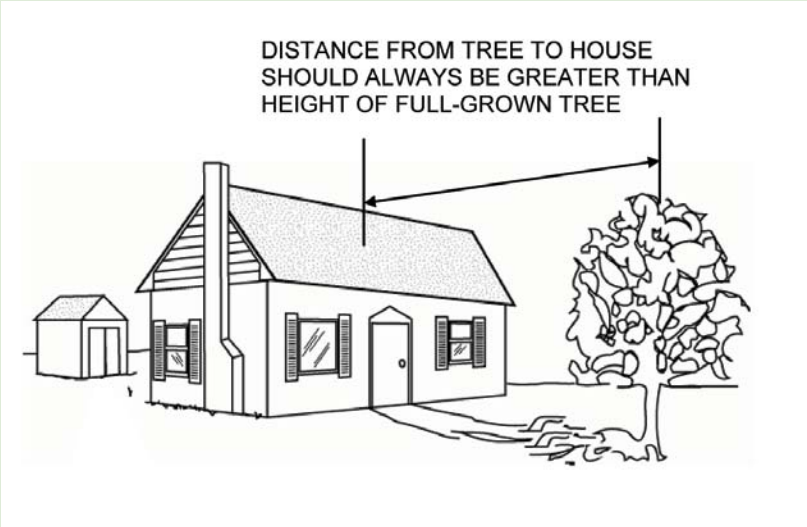


Figure 4-35. FEMA recommends that the distance between a tree and your house should always be greater than the height of the full-grown tree. This is to prevent trees from falling on the roof, either currently or in the future.[27]

If it is not possible to remove a tree, at least trim it so that air can flow through. If the branches and vines are so thick that the air cannot flow through, the tree will act like an umbrella and catch the wind before it topples over. (See http://mcifas.com/pdf/hurricane_english.pdf) Generally, you should hire a licensed tree trimmer to perform this work.

4.12 Earthquake Retrofit

The need to retrofit houses to address earthquakes is greatest for Hawai‘i County and becomes less urgent with each island to the northwest (Figures 2-9 and 2-10). At the time of this writing, the State of Hawai‘i Earthquake Advisory Committee was working on a guideline to retrofit houses on post and pier with tofu blocks. This is a very common type of construction in Hawai‘i County and elsewhere. Although the study is in progress, the results are not expected for another year. You should check with the State Civil Defense for the status of this ongoing study. Information may be found on the State of Hawai‘i Civil Defense website or from the State of Hawai‘i Earthquake Advisory Committee.

As discussed in Part 4.8.3, retrofitting your house so that it has a continuous load path connection will reduce the risk of damage from both a hurricane and earthquake. See “A Step by Step Guide to Retrofit Your Home for Earthquakes” at http://www.strongtie.com/literature/f-plans.html.

A licensed structural engineer should be consulted regarding the use of various bracing schemes, such as knee bracing and cross bracing. The concepts may be similar to those shown in Part 4.11.1.

4.13 Flood Retrofit

The best source of information for protecting your property from flooding is found in the FEMA’s Coastal Construction Manual: http://www.fema.gov/rebuild/mat/fema55.shtm.

You should also familiarize yourself with the FEMA report “Protecting Your Property from Flooding,” found at:
http://www.fema.gov/plan/prevent/howto/index.shtm#4.
This report covers:

(1) Adding waterproof veneer to exterior walls;
(2) Raising electrical system components;
(3) Anchoring fuel tanks;

(4) Raising or flood-proofing ventilation or air conditioning equipment;
(5) Installing sewer black flow valves;
(6) Dry flood proofing a building;
(7) Building with flood resistant materials; and
(8) Protecting wells from contamination by flooding.

In many cases flooding on a property can be caused by poor drainage. If this is the case, it may be of great benefit to address the drainage issue with the professional advice of a licensed civil engineer.

4.14 Licensed Contractors

Selecting a contractor to do your work is very important. This handbook does not recommend or endorse any particular company. It is up to you to select the companies and verify their record. Make sure the contractor is licensed, insured, and has not received complaints. You should always ask for a list of referrals. You can check the contractor's record at the State of Hawai'i Department of Commerce and Consumer Affairs, Regulated Industries Complaints Office.

The City and County of Honolulu Department of Emergency Management has a list of contractors performing work in the area of hurricane protection. This compilation is not a recommendation or endorsement of any particular company, but a listing of what company is performing work in this area so that you can follow up with further investigation. The number at the department is (808) 523-4121.

You can also look in your yellow pages using the key word "hurricane" for locating contractors who perform work in this area. When selecting a company, it is still necessary to do the proper due diligence and check their qualifications (see above).

Hiring a licensed contractor is very important. After Hurricane Iniki, many families lost savings and insurance funds as a wave of unlicensed contractors flooded the impacted area in search of work. A good resource

to find a licensed contactor is the particular organization on each island that deals with contractors. These organizations can provide direction and are listed below:

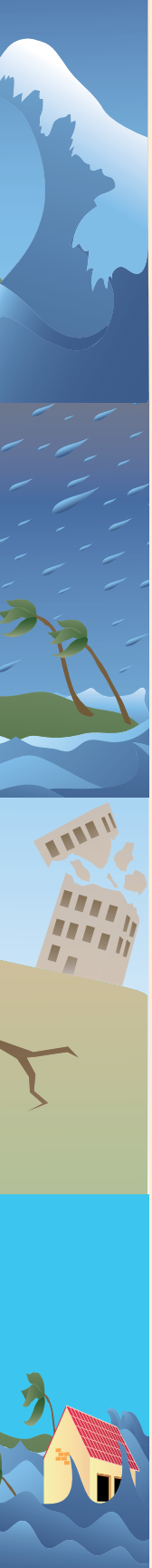
Contractors Association of Kaua‘i: (808) 246-2662

Maui Contractors Association: (808) 871-5733

Hawai‘i Island Contractors Association: (808) 935-1316

General Contractors Association of Hawai‘i: (808) 833-1681

Before you have extensive work performed, you should see a licensed architect or structural engineer, depending on the particular work that needs to be done. Even if you perform the work yourself, a licensed professional should be consulted for initial guidance, since every house is slightly different.



Useful Links

This page contains links to websites where you can get more information on planning for a natural hazard.

American Red Cross—Hawai‘i State Chapter
http://www.hawaiiredcross.org/

Department of Emergency Management, City and County of Honolulu
http://www.oahuDEM.org

Electrical Safety Foundation
http://www.esfi.org

Federal Alliance for Safe Homes
http://www.flash.org

Federal Emergency Management Agency (FEMA) Coastal Construction Manual
http://www.fema.gov/rebuild/mat/fema55.shtm

Hawai‘i County Civil Defense
http://www.hawaii-county.com/directory/dir_defense.htm

Hawai‘i State Civil Defense
http://www.scd.state.hi.us/

Hawai‘i Statewide Hazard Mitigation Forum
http://www.mothernature-hawaii.com/

Hawaiian Electric Company, Inc.
http://www.heco.com

Institute for Business and Home Safety
http://www.ibhs.org

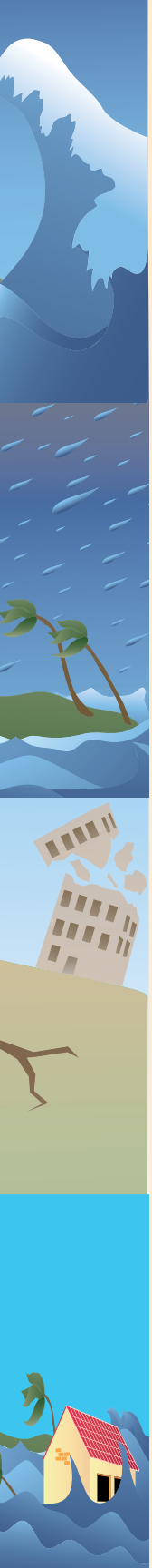
Kaua‘i County Civil Defense
http://www.kauai.gov/Government/Departments/CivilDefenseAgency/tabid/90/Default.aspx

Maui County Civil Defense
http://www.mauicounty.gov/departments/CivilDefense/

National Weather Service Honolulu
http://www.prh.noaa.gov/hnl/

Pacific Tsunami Warning Center
http://www.prh.noaa.gov/ptwc/

University of Hawai‘i Sea Grant College Program
http://www.soest.hawaii.edu/SEAGRANT



Appendix A
State of Hawai'i Hurricane Shelters

When a hurricane warning is issued, civil defense information will be released through local radio and television stations and all other available means, **concerning which shelters will be opened and when.** Shelter personnel will be on site to direct you to the specific shelter buildings.

If you are advised to evacuate, try to keep family members together and don't forget your survival kit, including important papers. It is essential that you take your survival kit with you because food, cots, blankets, and other comfort items will probably not be available.

Prepare a plan for your pets in case you must evacuate. Public pet shelters are not yet available. Contact your veterinarian or the Hawaiian Humane Society for more information on pet arrangements. Only service animals are presently allowed in public shelters.

This list is current but subject to change. Shelters may be opened selectively depending on the severity of the storm. Should an evacuation become necessary, please listen to your radio or television for up to the minute information on shelters open in your area. When you arrive at your shelter, please follow Red Cross directions for the appropriate room or building.

O'ahu

North Shore (Ka'ena Point–Kahuku)

Kahuku High and Intermediate
Waialua High and Intermediate

Leeward Coast (Mākua–Waipahu and Vicinity)

August Ahrens Elementary
Campbell High
'Ewa Elementary
Honowai Elementary
'Ilima Intermediate
Kamaile Elementary
Kanoelani Elementary
Kapolei Elementary
Kapolei High
Leihoku Elementary
Mā'ili Elementary
Mākaha Elementary
Makakilo Elementary
Mauka Lani Elementary
Nānākuli Elementary
Nānākuli High & Intermediate
Pōhākea Elementary
Wai'anae Elementary

Wai‘anae Intermediate
Ka‘imiloa Elementary
Kaleiopu‘u Elementary
Waipahu Elementary
Waipahu High
Waipahu Intermediate

Central O‘ahu (Wahiawā–Mililani and Vicinity)

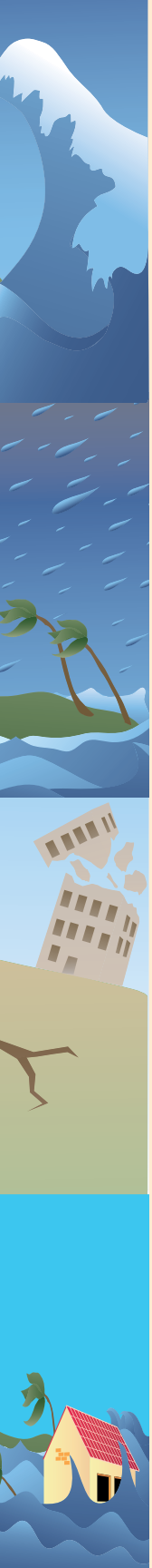
Hanalani Elementary
Helemano Elementary
‘Iliahi Elementary
Ka‘ala Elementary
Kīpapa Elementary
Leilehua High
Mililani High
Mililani ‘Ike Elementary
Mililani Mauka Elementary
Mililani Middle
Mililani-Uka Elementary
Solomon Elementary
Wahiawā Elementary
Wahiawa Middle

Pearl City–Salt Lake and Vicinity

‘Aiea Elementary
‘Aiea Middle
‘Aiea High
Āliamanu Elementary
Āliamanu Middle
Hālawa District Park
Highlands Elementary
Lehua Elementary
Makalapa Elementary
Moanalua Elementary & Middle
Moanalua High
Momilani Elementary
Palisades Elementary
Pearl City District Park
Pearl City High
Pearl City Highlands Elementary
Pearlridge Elementary
Radford High
Red Hill Elementary
Salt Lake Elementary
Waiau Elementary
Waimalu Elementary
Webling Elementary

Salt Lake–Punchbowl and Vicinity

Central Middle
Dole Middle
Farrington High
Ka‘ahumanu Elementary
Ka‘ewai Elementary
Ka‘iulani Elementary
Kalākaua Middle
Kalihi Elementary
Kalihi-Kai Elementary
Kalihi-Uka Elementary
Kalihi Valley District Park
Kalihi-Waena Elementary
Kapālama Elementary
Kauluwela Elementary
Kawānanakoa Middle
Lanakila District Park
Lanakila Elementary
Likelike Elementary
Linapuni Elementary
Ma‘ema‘e Elementary
Makiki District Park
Nu‘uanu Elementary
Pauoa Elementary
Pu‘uhale Elementary
Roosevelt High
Royal Elementary
Stevenson Middle



Punchbowl–Waiʻalae and Vicinity

Aliʻiōlani Elementary
ʻĀnuenue Elementary
Hawaiʻi Convention Center
Hōkūlani Elementary
Jarrett Middle
Jefferson Elementary
Kaʻahumanu Elementary
Kaimukī High
Kaimukī Middle
Kūhiō Elementary
Liholiho Elementary
Liliʻuokalani Elementary
Lunalilo Elementary
Mānoa Elementary
McKinley High
Neal Blaisdell Center
Noelani Elementary
Pālolo Elementary
Roosevelt High
Stevenson Middle
Waiʻalae Elementary
Waikīkī Elementary
Washington Middle
Wilson Elementary

ʻĀina Haina–Hawaiʻi Kai and Vicinity

ʻĀina Haina Elementary
Hahaʻione Elementary
Kaiser High
Kalani High
Kamiloiki Elementary
Koko Head Elementary
Niu Valley Middle

Windward Coast (Kahuku–Makapuʻu Point)

ʻĀhuimanu Elementary
Benjamin Parker Elementary
Brigham Young University of Hawaiʻi
Castle High
Enchanted Lake Elementary
Heʻeia Elementary
Kahaluʻu Elementary
Kahuku Community Center
Kahuku High and Intermediate
Kailua Elementary
Kailua High
Kailua Intermediate
Kainalu Elementary
Kalāheo High
Kāneʻohe Elementary
Kapunahala Elementary
Keolu Elementary
King Intermediate
Lanikai Elementary
Maunawili Elementary
Mōkapu Elementary
Pope Elementary
Pūʻōhala Elementary
Waiāhole Elementary
Waimānalo Elementary and Intermediate

Maui

Hāna
Hāna High & Elementary

Kahului/Wailuku/Waiheʻe
Baldwin High
ʻĪao Elementary
Lihikai Elementary
Maui Community College
Maui High
Maui Waena Intermediate
Waiheʻe Elementary
Wailuku Elementary

Kīhei/Mākena
Kamaliʻi Elementary
Kīhei Elementary
Lokelani Intermediate

Lahaina (West Maui)
Lahaina Intermediate
Lahainaluna High
Princess Nahiʻenaʻena Elementary

Upcountry
Kalama Intermediate
King Kekaulike High
Makawao Elementary
Pukalani Elementary

Hawaiʻi

North Kohala District
Kohala Elementary
Kohala Intermediate

South Kohala District
Waikoloa Elementary
Waimea Elementary
Waimea Intermediate
Waimea State Office Building

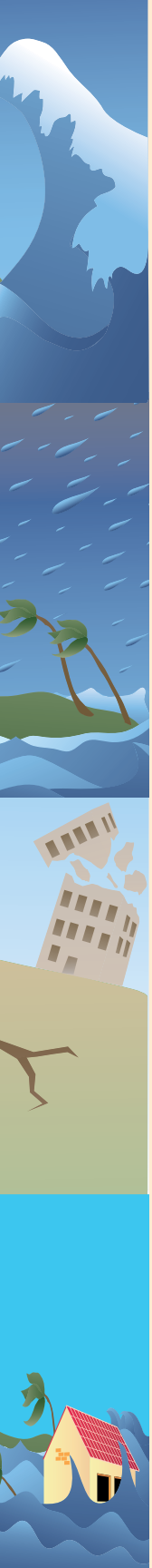
North Kona District
Hōlualoa Elementary
Kahakai Elementary
Kealakehe Elementary
Kealakehe High
Kealakehe Intermediate

South Kona District
Hōnaunau Elementary
Hoʻokena Elementary
Konawaena High

Kaʻū District
Kaʻū High

Hāmākua District
Honokaʻa High and Intermediate
Kalanianaʻole Elementary

South Hilo District
E B de Silva Elementary
Hilo High
Hilo Intermediate
Kaūmanu Elementary
Waiākea Elementary
Waiākea High
Waiakeawaena Elementary



Puna District
Kea‘au High
Kea‘au Intermediate
Keonepoko Elementary
Mountain View Elementary
Pāhoa Elementary
Pāhoa High
Pāhoa Intermediate

Kaua’i

Central
Kamakahelei Middle
Kaua‘i Community College
Kaua‘i High and Intermediate
Kaua‘i War Memorial Convention Hall
King Kaumuali‘i Elementary
Wilcox Elementary
Eastside
Kapa‘a Elementary School
Kapa‘a High School
Kapa‘a Middle School

North
Kīlauea Elementary School
Kīlauea Neighborhood Center

South
‘Ele‘Ele Elementary School
Kalāheo Elementary School
Kāloa Elementary School

West
Kekaha Elementary School
Waimea Canyon Elementary
Waimea High

Moloka‘i
Kaunakakai Elementary
Kualapu‘u Elementary
Moloka‘i High and Intermediate

Lāna‘i
Lāna‘i High and Elementary

When evacuating to a shelter don’t forget your family’s emergency kit and be sure to make arrangements for your family pets.

Appendix B
Emergency Contacts

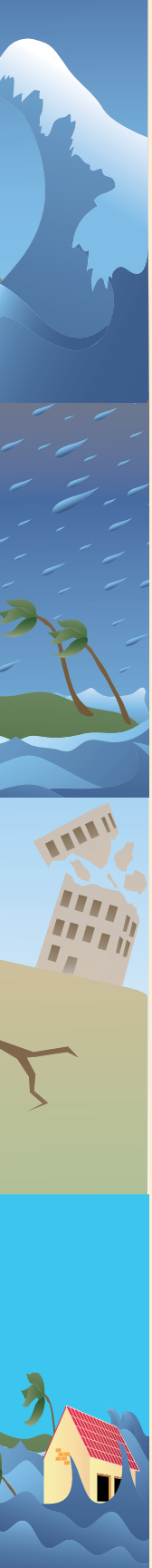
Department of Emergency Management—City and County of Honolulu
650 South King Street,
Honolulu, HI 96813
Ph: (808) 523-4121;
Fax: (808) 524-3439
http://www.oahuDEM.org

Hawai‘i Civil Defense Agency
920 Ululani Street,
Hilo, HI 96720
Ph: (808) 935-0031;
Fax: (808) 935-6460
http://www.hawaii-county.com/directory/dir_defense.htm

Kaua‘i Civil Defense Agency
3990 Kā‘ana Street, Suite 100,
Līhu‘e, HI 96766
Ph: (808) 241-1800;
Fax: (808) 241-1860
http://www.kauai.gov/Government/Departments/CivilDefenseAgency/tabid/90/Default.aspx

Maui Civil Defense Agency
200 South High Street,
Wailuku, HI 96793
Ph: (808) 270-7285;
Fax: (808) 270-7275
http://www.mauicounty.gov/departments/CivilDefense/

State of Hawai‘i—Civil Defense Division
3949 Diamond Head Road,
Honolulu, HI 96816-4495
Ph: (808) 733-4300;
Fax: (808) 733-4287
http://www.scd.state.hi.us/



Endnotes

[1] C.H. Fletcher, E.E. Grossman, B.M. Richmond, and A.E. Gibbs, *Atlas of Natural Hazards in the Hawaiian Coastal Zone*. (U.S. Department of the Interior, U.S. Geological Survey, University of Hawai‘i, State of Hawai‘i Office of Planning, National Oceanic and Atmospheric Administration, 2002) 182.

[2] Based on data from the former Office of Emergency Permitting, Kaua‘i County. This is based on the reconstruction and building permit database.

[3] Figures from the Federal Emergency Management Agency (FEMA). *Honolulu Star Bulletin* 8 September 2002.

[4] Based on the number of single family homes on each island. From the *Hazard Mitigation Study for the Hawaii Hurricane Relief Fund* 7 December 2001. See also Center for Development Studies, Social Science Research Institute, University of Hawai‘i. 1993. Hawai‘i Coastal Hazard Mitigation Planning Project.

[5] Report by U.S. Army Corps of Engineers, Pacific Ocean Division, “Hurricane Iniki—Coastal Inundation, September 11, 1992.”

[6] UNESCO-IOC, *Tsunami, The Great Waves.* IOC Brochure 2006-2. (Paris, UNESCO, 2006.)

[7] During the 1946 tsunami, the water also inundated several thousand feet inland at Kahuku on the north shore of O‘ahu. On December 26, 2004, a tsunami generated from a magnitude 9.3 earthquake in the Indian Ocean resulted in the deaths of over 200,000 citizens in over eleven countries. In Indonesia, the tsunami inundated an area several miles inland. The December 26, 2004, tsunami in the Indian Ocean is thought by many scientists to be a very rare event (time interval between a return event is greater than once every two hundred years) and outside the realm of local historical experience.

[8] See note 1.

[9] It used to take about 30 minutes, but advances in science and increased monitoring have cut the time needed to analyze potentially damaging earthquakes.

[10] To see the entire guideline, go to http://www.typhoon2000.ph/tropical_SS.htm.

[11] Interview with Gary Chock of Martin and Chock.

[12] This kit was developed pursuant to Hawai‘i Special Session 2005—Act 5. It appears in “Report of Recommended Statewide Public Hurricane Shelter Criteria, Hurricane Shelter Criteria Committee, State Civil Defense.”

[13] Adapted from the Hawai‘i County Civil Defense Guide on Hurricane Preparedness. Also from “Information—Handbook for Emergency Preparedness,” by Hawaiian Electric Company, Maui Electric Company, and Hawaii Electric Light Company.

[14] From “Information Handbook for Emergency Preparedness,” published by Hawaiian Electric Company, Maui Electric Company, and Hawaii Electric Light Company.

[15] http://earthquake.usgs.gov/learning/faq.php?categoryID=14&faqID=80.

[16] These maps were created at the offices of Martin & Chock. First-generation wind maps exist for the islands of O‘ahu, Kaua‘i, Lāna‘i, and Moloka‘i. High-resolution wind maps have been created for O‘ahu.

[17] See note 2.

[18] From “Building Performance: Hurricane Iniki in Hawaii—Observations, Recommendations, and Technical Guidance” from the FEMA Federal Insurance Administration, in cooperation with the State of Hawai‘i Civil Defense and Kaua‘i County. January 1993.

[19] See above.

[20] The State of Hawai'i Loss Mitigation Grant Program recognizes that installing hurricane clips is something that a homeowner could do as a "do it yourself project." However, a licensed structural engineer or architect should be consulted to provide initial guidance on the correct clip and fasteners for your home. Each house is a little different.

[21] Institute for Business & Home Safety. 1998. *Is Your Home Protected from Hurricane Disaster?—A Homeowner's Guide to Retrofit*; see also http://www.mothernature.com.

[22] State of Hawai'i Department of Commerce and Consumer Affairs, Loss Mitigation Grant Program, Wind Resistive Devices Technical Specifications, and Institute for Business & Home Safety. "Keep Water and Wind Out." http://www.ibhs.org/publications/view.asp?cat=78&id=555.

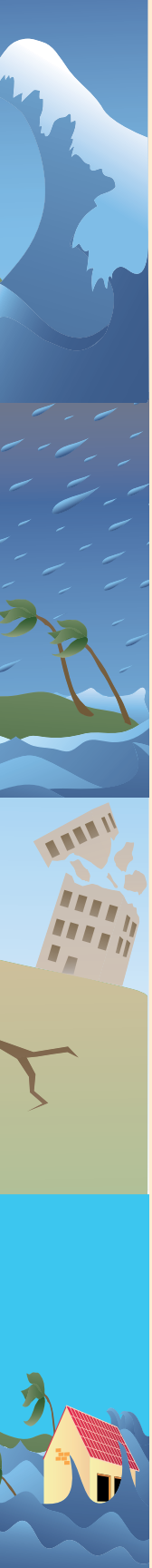
[23] See Escambia County, Florida—Hurricane Preparation Manual, http://www.escambia-emergency.com/Hurricane_Preparedness/hurricaneprepmanual/windbrochure.pdf.

[24] Watts are equal to the voltage (usually 110 to 120) times the amps. Amp meters can measure in watts or amps and provide information on the running and startup power needs in digital readout.

[25] Tip from Florida Power and Light on running your refrigerator with a generator. http://www.fpl.com/storm/generator_safety.shtml.

[26] From "Against the Wind—Protecting Your Home From Hurricane Wind Damage," by American Red Cross, FEMA, Home Depot, National Institute of Home Builders, and Georgia Emergency Management Agency.

[27] From "Protecting Your Property From Wind," by FEMA.



Notes

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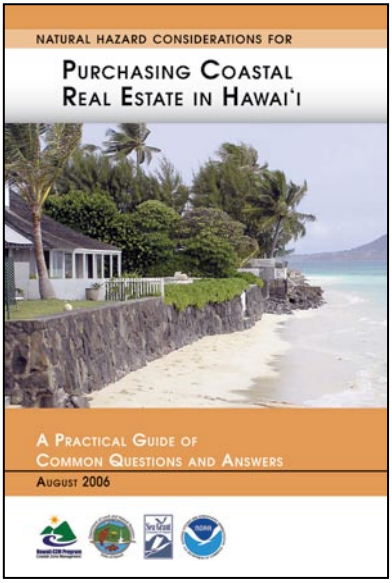
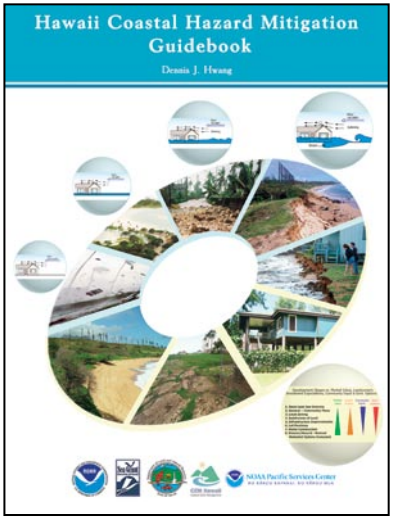


Natural Hazard Considerations for Purchasing Coastal Real Estate in Hawai'i:
A Practical Guide of Common Questions and Answers

This guidebook is the perfect resource for anyone thinking about purchasing coastal property in Hawai'i. It teaches the landowner how to identify potential coastal hazards and also identifies what factors to consider in response to these hazards. In addition, a basic summary of common questions and answers to Hawai'i coastal land use and related regulations is included.

Hawai'i Coastal Hazard Mitigation Guidebook

Written for a wide and varied audience including planners, architects, homeowners and government agencies, the guidebook covers how to mitigate the risks associated with coastal hazards during the development process. Emphasis is placed on early planning to address where to build as well as how to build, specifically addressing coastal & bluff erosion, sea-level rise, flooding, tsunamis and hurricanes.



To order copies of these or other publications, contact:
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Honolulu, HI 96822
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email: uhsgcomm@hawaii.edu

TSUNAMIS

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