DELAWARE

HOMEOWNERS HANDBOOK TO PREPARE FOR NATURAL HAZARDS

DEMA

DELAWARE DEPARTMENT OF NATURAL RESOURCES AND ENVIRONMENTAL CONTROL

Sea Grant Delaware

SECOND EDITION • AUGUST 2019

HOMEOWNERS HANDBOOK TO PREPARE FOR NATURAL HAZARDS SECOND EDITION Delaware Sea Grant

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This handbook was developed as a cooperative project among the Delaware Emergency Management Agency (DEMA), the Delaware Department of Natural Resources and Environmental Control (DNREC) and the Delaware Sea Grant College Program (DESG). A key priority of this project partnership is to increase the resiliency of coastal communities to natural hazards. One major component of strong communities is enhancing individual resilience and recognizing that adjustments to day-to-day living are necessary. This book is designed to promote individual resilience, thereby creating a fortified community.

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

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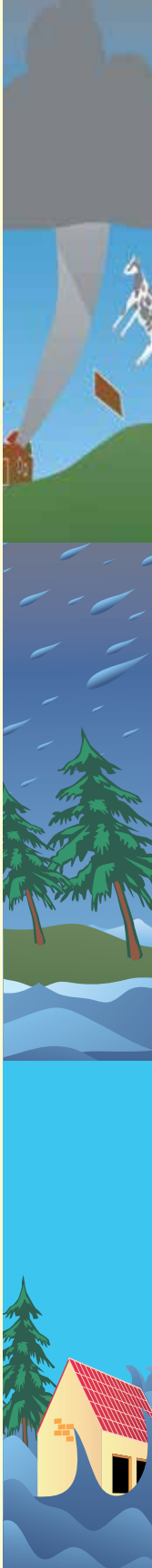

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Resilience

Delaware enjoys the reputation of being the first state to ratify the U.S. Constitution. It is also a first among states for having the lowest mean land elevation. This low elevation, combined with extremely flat terrain, 381 miles of coastline, and natural land subsidence, makes Delaware especially vulnerable to flooding. Flooding can occur during storms or even on sunny days at high tide. It is the number one hazard in the state according to the State of Delaware's All-Hazard Mitigation Plan[2.2], and our exposure and vulnerability are increasing because of land development practices, population increases, and changing climate conditions such as sea level rise. In addition to flooding, the state experiences other effects from storms, such as wind damage and erosion, and natural hazards including drought, tornadoes and extreme heat.

Protecting our property and way of life will require a strategy to manage these changes and cope with hazardous events. That strategy is resilience. **Resilience is the ability to withstand—or rapidly recover from—disruptions due to weather emergencies or other hazards.** In other words, it means having the capacity to bounce back from an event. This concept applies not only to individuals and our communities, but also to our natural resources and "built" environment such as highways, wastewater treatment plants and water supply networks.

In order to improve resilience, proactive planning is needed. It begins by gathering information and data about the hazard, then assessing the degree of exposure and vulnerability to that hazard to get a more complete characterization of risk. Once the risks are identified, it is necessary to investigate options that minimize risks or support adapting to the risks. Prioritizing these options and then taking action to implement strategies will ultimately improve resilience. Resilience planning should be carried out well in advance and with future conditions in mind, such as climate change and shifts in family needs or community demographics. This Homeowners Handbook identifies several strategies for improving the resilience of your family and home that can also be applied to your community or business.

Steps to Resilience:

1. Explore Hazards
2. Assess Vulnerability & Risks
3. Investigate Options
4. Prioritize & Plan
5. Take Action

Source: U.S. Climate Resilience Toolkit

Source: NOAA Office for Coastal Management

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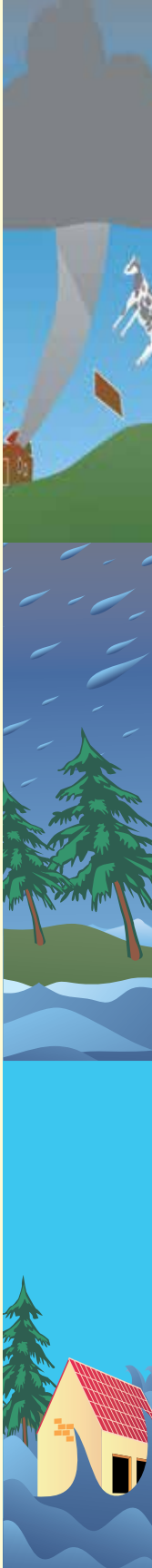


Part 1
Introduction

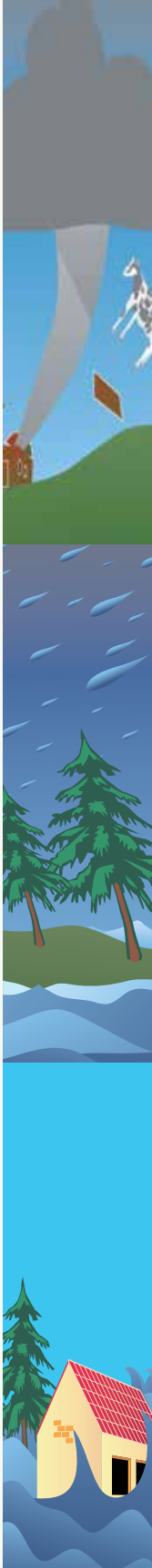
Your home is your castle. It protects you and your family, as well as your possessions, from the elements. For many, the home is a major financial investment. Yet natural hazards such as coastal storms, floods, high winds and tornadoes can threaten the inhabitants and contents of your home. When a natural disaster occurs, the results can be devastating.

This handbook was created to help you prepare for natural hazards so that risks to family and property may be reduced. While it is never possible to eliminate all damage from a natural disaster, 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 the protection that only you can provide.

This handbook is divided into six 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 several things you can do to prepare. Part 2 provides basic information on coastal storms, flooding and other hazards that will allow you to make an educated decision about the steps to take to protect your family and property. Part 3 provides an overview of climate change in the Mid-Atlantic region and how climate change may exacerbate impacts of natural hazards in the future. Part 4 discusses in detail how to protect yourself and your family. It includes recommendations for essential emergency supplies, evacuation kits and evacuation planning and evacuation procedures and important information that emergency management agencies want you to know even before a warning is issued. Part 5 covers how you can protect your property from wind and water hazards. Part 6 presents general insurance information and resources to aid in recovery if storm damage occurs.

To access a free download of the handbook visit:

- Delaware Sea Grant College Program (www.deseagrant.org/coastal-hazards)



1.1 COMMON MYTHS AND REASONS TO PREPARE

Many homeowners in Delaware become complacent about natural hazards because we are fortunate to experience them infrequently or we believe in one or more common myths. The risk is that we fall into a false sense of security and may not be prepared when the inevitable happens. Some of these myths are examined below.

Myth 1: "Delaware is not at significant risk of hurricanes or other natural hazards."

Scientists agree that it is not a matter of if, but when the next major coastal storm will occur in Delaware. Over the past 30 years, Delaware has experienced more than 85 meteorologically significant coastal storm events, including the nor'easter in January 2016 and Hurricane Sandy in 2012.[1.1] Delaware also occasionally experiences tornadoes such as the EF2 tornado that tore through a six-mile path from Laurel to Seaford in April, 2019, seriously damaging a dozen buildings and injuring one person. Its winds peaked at 120 mph. While Delaware has been fortunate to avoid many direct hits during the last few decades, there is a very good chance our state will experience impacts from a major natural hazard in your lifetime.

Myth 2: "I survived a hurricane before, so I am sufficiently prepared."

Many people have the impression that if they survived past hurricanes, they do not need to prepare any more than they did previously. Although previous storms like Hurricane Sandy resulted in widespread damage along the East Coast, their impacts to Delaware could have been much more severe had those storms tracked slightly differently. Delaware is experiencing a rate of sea level rise that is twice the global average, and combined with current land use patterns and population growth, that means our exposure and vulnerability to storms are increasing. Yesterday's storms are no indicator of tomorrow's hazard.

Myth 3: "I don't live near the coast, so I am safe."

Powerful thunderstorms and wind can cause widespread damage in all parts of Delaware. In addition, flooding can occur almost anywhere. About 20 % of flood claim payments in the United States go to people who live outside

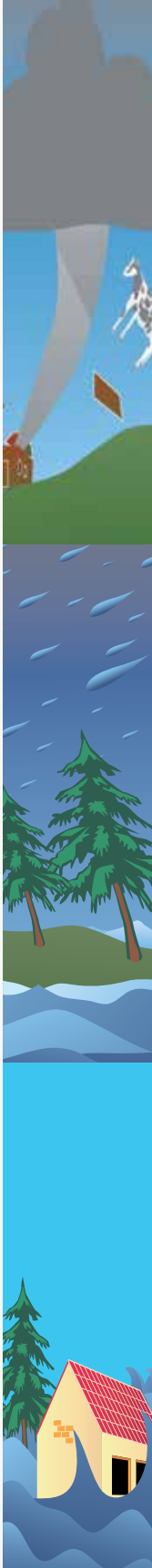
of federally mapped high-risk zones, such as low-lying coastal areas[1,2]. With changing climate conditions like sea level rise and more intense rainfall projected, impacts from extreme weather events are more likely in Delaware in the future. Therefore, all homeowners should prepare—not just those who live along the coast. Develop a family communication plan to stay in touch with family members if separated during an emergency. Prepare an emergency supply kit for sheltering in place and a waterproof go-bag with essential documents, flashlights, cash, batteries, first aid and medications. Know your evacuation routes. Make a plan for the safety of household pets as well as mobility or health needs.

Myth 4: "My homeowner's insurance plan covers flood damage."

Most homeowners insurance policies do NOT cover flood damage. For this reason, the federal government established the National Flood Insurance Program (NFIP). Flood insurance is sold as a separate policy and is available to homeowners within—and outside of—the high-risk zones of the FEMA-mapped flood plain. Flood insurance policies typically take 30 days to go into effect, so avoid waiting until severe weather is forecasted. Further details and assistance to find an agent is available through the NFIP call center at 800-427-4661 or by visiting floodsmart.gov.

Myth 5: "If my home or property is damaged by a natural hazard event, FEMA or other disaster programs will provide assistance."

After major disasters, many homeowners expect government assistance, only to find that government funds are often unavailable or take the form of small grants or loans that are insufficient to compensate for property damage. For example, following Hurricane Harvey in 2017 in Harris County, Texas, the average individual assistance grant awarded to property owners was only $4,200. Most other federal assistance came in the form of loans. By comparison, those property owners that had flood insurance through the National Flood Insurance Program received an average claim payment of $113,000.[1,2] Government compensation evaluations are conducted after a disaster strikes and are based on the amount of damage that occurs on a county-wide basis. Sometimes, the event does not qualify. It is up to you to plan properly, strengthen your house, and have the appropriate financial



protections like insurance in place. After a natural disaster occurs, the government may be overwhelmed by the number of people in need and help may not arrive quickly.

Myth 6: "Mother nature is in charge. There is nothing I can do to lower my risks from a natural hazard."

Just one inch of water in an average home can cause more than $25,000 in damage.[1,2] Fortunately, there are many small steps you can take to significantly reduce the risks of damage to life and property. While it may not be possible to eliminate all risks, taking proactive steps to plan and improve your household's resilience to major weather events can be the difference to whether your house escapes major damage and family members are able to bounce back from the disruption.

Myth 7: "Even if I install hurricane clips, my home could be damaged."

Even though someone wears a seat belt and drives a car with airbags, there is no guarantee that person won't be injured in a major auto accident. Yet most people recognize the importance of these safety devices and use them. Similarly, building and retrofitting a home to higher standards can avoid damage and losses that are difficult to recover from.

Myth 8: "Strengthening my house is too expensive and not worth the effort."

There are several relatively inexpensive ways to strengthen your house:

- Hurricane clips or window coverings can range from a couple hundred dollars to 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.
- Elevating a home can be expensive, but it can considerably reduce federal flood insurance premiums over time, thus recouping that investment. Plus, you avoid the cost of future losses from damage.

Strengthening your house protects your neighbors as well as yourself. A house that falls apart during a hurricane will create debris that can damage adjacent properties. It spares emergency responders from rescuing you instead of helping others. Ultimately, strengthening your house can add value to your house and help you avoid future losses. Keep in mind that even if you strengthen your home, you should still evacuate if your neighborhood is at risk of becoming inaccessible due to floodwaters. Always follow evacuation instructions issued by your local/state emergency management officials.

1.2 THINGS YOU CAN DO TO PREPARE

There are some things you can do to prepare that will provide greater protection to your family and your property. They are summarized below with more detail provided later in this handbook.

Gather emergency supplies

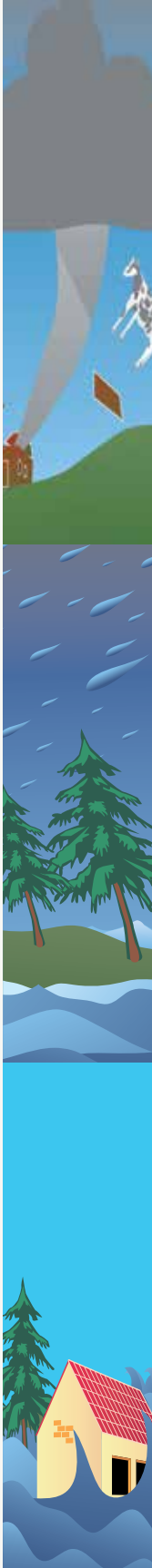
You can gather emergency supplies in your house now. Check and restock each month so that the supplies are complete, not outdated or used. Avoid rushing to a store during an emergency to gather your supplies. There will likely be long lines and empty shelves—you will add to the crowd and confusion and may not be able to procure the supplies you need.

Compile an evacuation kit

If your evacuation plans include using a public shelter for a coastal storm or flood, you will need an evacuation kit that contains clothing, medications, personal hygiene products and other items such as bedding for five to seven days. Water and food are provided at shelters, but if a special diet is required, you should bring these foods with you. The kit should already be assembled and checked before hurricane season (see Part 4). If the kit will be used during evacuation for other hazards, three days of supplies may suffice. Don't forget to plan for the special needs of family members and older adults, as well as the needs of pets (see Part 4).

Create an evacuation plan for both a flood and a coastal storm

For a tropical storm or strong nor'easter, your plan may include sheltering in a structurally fortified house if it is outside the high-risk flood zone or any evacuation zone. 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 or go to redcross.org and click on "find a shelter;" see Part 4). For a flood, evacuate to high ground outside the evacuation zone if you are instructed by emergency management officials to do so. In any event, do not drive through high water—"turn around, don't drown." Discuss and practice drills of your evacuation plan with your family each year.

Know your property and take appropriate action

Look at where you are located. If the land has flooded in the past or is shown to be in a special flood hazard area on Federal Emergency Management Agency (FEMA) flood maps, you should consider flood insurance. If trees overhang your house, you should consider trimming or cutting branches that may damage your house in a storm. If your property is near a ridge, open land, or water, it may be especially susceptible to wind damage during a storm or hurricane (see Part 5).

Know your house and take appropriate action

When was your house built? Does it have connectors that tie the roof to the walls or the walls to the foundation? When will you need to replace the roof? Look at your blueprints. They may be available from your homebuilder, your local building department, or your architect (see Part 5).

Strengthen your house

A recently built house should have hurricane clips to tie the roof to walls and should also have strong connectors from the walls to the foundation. If you have an old home, you can 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 replace it. The steps a homeowner can take will vary with each house, but for the majority of homeowners, there are a few steps that can make a significant difference (see Part 5).

Finance creatively

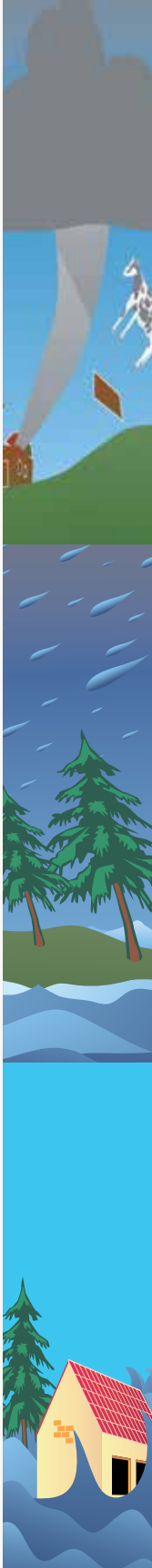
Consider efforts to strengthen your house as an important home-improvement project. Most projects are not that expensive. It is a great investment to strengthen your house and provide more protection to your family (see Part 5).

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 Delaware Professional Engineering Society, or contractors' associations. 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 5). If you are located in Sussex County's high-wind region, you should seek professional advice for how to secure your home from high wind damage. Remember to obtain all required local, county and state permits and approvals before any work is initiated.

Don't gamble with your house

Obtain adequate insurance if you are in a flood-prone area (see Part 6). Remember that regular homeowner's insurance does not cover flooding, which requires a separate policy. Flood insurance coverage does not take effect until 30 days after purchase. Contact your insurance company or agent and verify that coverage is in place before a disaster strikes. Coverage may vary among insurance companies, so communicate with your insurance agent specifically about your policy and what is covered. Renters should remember that they should purchase their own renter's insurance. The Delaware Department of Insurance suggests that you prepare for severe weather disasters by creating a home inventory. A proper home inventory will create a record of what you own and what it is worth.



Part 2
Natural Hazards: An Overview for Homeowners

In Delaware, many different types of natural hazards can occur, including coastal storms, flooding, tornadoes, severe thunderstorms, drought/extreme heat, wildfire, earthquakes and even tsunamis. This handbook concentrates on the most likely and potentially devastating hazards in Delaware with regard to loss of life and property damage: coastal storms, floods and tornadoes.

Preparing for these larger hazard events 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, can prepare for these hazards.

2.1 COASTAL STORM HAZARDS

There are two types of common coastal storms that bring significant hazards to Delaware: hurricanes and nor'easters.

2.1.1 HURRICANES—TROPICAL SYSTEMS

Hurricanes and tropical systems have tracked over or have passed close to Mid-Atlantic states many times in the past. Hurricane Irene in 2011 tracked within 27 miles of the Delaware coast as a Category 1 storm, bringing tropical storm-force winds, record flooding and tornadoes (Figure 2-1). Hurricane Sandy was technically an extratropical storm when it tracked over northern Delaware in 2012. It caused significant storm surge, flooding and precipitation as well as the mandatory evacuation of more than 35 communities.

A hurricane is an intense tropical weather system with a well-defined circulation pattern and maximum sustained winds of 74 miles per hour (mph) or more. A tropical storm is also an organized weather system with well-defined circulation, but its maximum sustained winds are lower—between 39 and 73 mph. A tropical depression is a low-level circulation

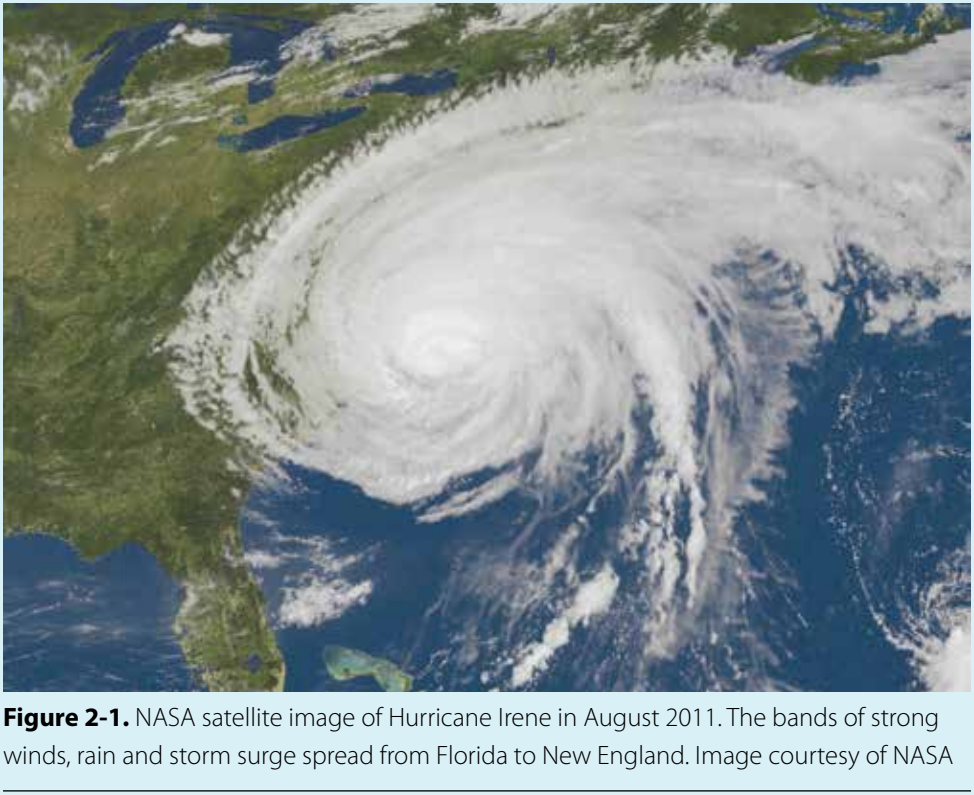


Figure 2-1. NASA satellite image of Hurricane Irene in August 2011. The bands of strong winds, rain and storm surge spread from Florida to New England. Image courtesy of NASA

system of persistent clouds and thunderstorms with maximum sustained winds of 38 mph or less. While far less powerful than hurricanes, tropical storms and tropical depressions can cause substantial damage and sometimes develop into hurricanes. As a hurricane weakens and dissipates, it may revert to a tropical storm, a tropical depression, or an extratropical cyclone.

Hurricane strength is often given in categories using the Saffir-Simpson Hurricane Wind Scale,[2.1] which rates hurricanes from 1 to 5 based on the intensity of the sustained winds. Table 2-1 shows expected wind-related damage from the different hurricane categories. It is important to note that the Saffir-Simpson Scale only illustrates the "sustained winds" of a hurricane. Wind gusts can reach up to 135 mph for a Category 2 storm and 160 mph for a Category 3 storm.

Hurricanes may also produce tornadoes that add to their destructive power. During a hurricane, there is a triple threat of damage from high winds, storm surge and flooding associated with heavy rains.

Table 2-1. 2012 Saffir-Simpson Hurricane Wind Scale[2.1]

Category	Sustained Wind Speed	Types of Damage Expected Due to Hurricane Winds
1	74-95 mph	**Very dangerous winds will produce some damage:** Well-constructed frame homes could have damage to roof, shingles, vinyl siding, and gutters. Large branches of trees will snap and shallowly rooted trees may topple. Extensive damage to power lines and poles likely will result in power outages that could last a few to several days.
2	96-110 mph	**Extremely dangerous winds will cause extensive damage:** Well-constructed frame homes could sustain major roof and siding damage. Many shallowly rooted trees will be snapped or uprooted and block numerous roads. Near-total power loss is expected with outages that could last from several days to weeks.
3	111-129 mph	**Devastating damage will occur:** Well-built framed homes may incur major damage or removal of roof decking and gable ends. Many trees will be snapped or uprooted, blocking numerous roads. Electricity and water will be unavailable for several days to weeks after the storm passes.
4	130-156 mph	**Catastrophic damage will occur:** Well-built framed homes can sustain severe damage with loss of most of the roof structure and/or some exterior walls. Most trees will be snapped or uprooted and power poles downed. Fallen trees and power poles will isolate residential areas. Power outages will last weeks to possibly months. Most of the area will be uninhabitable for weeks or months.
5	≥157 mph	**Catastrophic damage will occur:** A high percentage of framed homes will be destroyed, with total roof failure and wall collapse. Fallen trees and power poles will isolate residential areas. Power outages will last for weeks to possibly months. Most of the area will be uninhabitable for weeks or months.

Source: NOAA's National Weather Service website

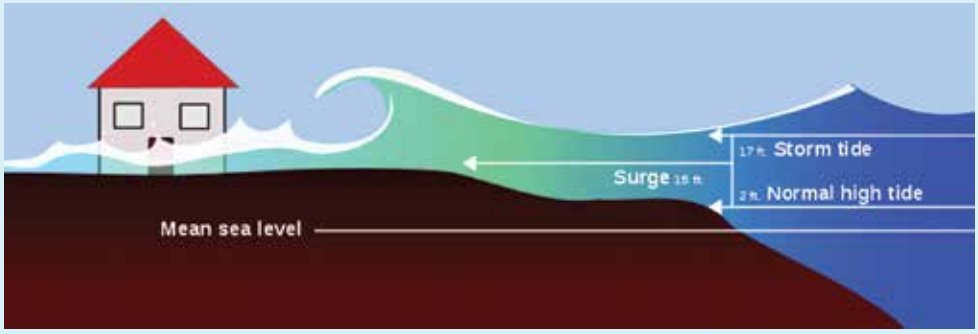


Figure 2-2. Storm surge depiction. Image courtesy of NOAA

Storm surge (Figure 2-2) is a large dome of water produced by the central low pressure of a storm system and its winds. It sweeps ashore along with the height of the tide, waves and precipitation runoff, producing a total water level that can cause major erosion of dunes, infrastructure and property damage and evacuations. Storm surge typically accounts for 90% of storm-related deaths in oceanfront and bayside communities. Storm surge can also cause severe flooding inland when the surge piles up within tributaries and marshes surrounding communities, particularly over consecutive tide cycles, preventing the marshes from draining out.

Rainfall totals of 10 inches or more are common when a tropical storm or hurricane moves across a coastal location. Rainfall totals of this magnitude can result in destructive flash flooding near streams and rivers. Flooding also causes extensive property damage and agricultural losses. Torrential rains produce runoff that can overwhelm stormwater drains and drainage ditches, particularly if they are not maintained properly, and can plague upland areas in western and northern parts of the state long after the high winds of a hurricane diminish along the coast. For these reasons, tropical systems can impact all of Delaware, not just the immediate coast.

A review of Delaware's tropical system history clearly illustrates the need for all of Delaware to prepare. In September 1999, Tropical Storm Floyd's eye tracked over southeastern Delaware, resulting in torrential rainfall throughout western portions of the state, exceeding 10 inches in some places. Associated flooding caused record-breaking river levels across the state—hundreds of roads, railroad lines and bridges were closed or destroyed. Winds uprooted hundreds of trees, leaving 25,000 homes and businesses

Figure 2-3. Torrential rainfall associated with Tropical Storm Henri resulted in extensive flooding in New Castle County in 2003. Image courtesy of Delaware DNREC

without power for three days. Most of the damage and destruction occurred in New Castle County, with only minor beach erosion and minimal damage near the ocean.

Two tropical systems exerted major impacts to Delaware in September 2003, resulting in presidential disaster declarations. Tropical Storm Henri produced heavy rainfall (exceeding 9 inches in a 24-hour period), and associated flooding damaged hundreds of houses, trapped motorists in submerged vehicles, flooded roadways and destroyed bridges in New Castle County (Figure 2-3). Hurricane Isabel caused beach erosion and overwash along the Delaware coast. Wind gusts of up to 70 mph knocked down many trees and power lines, causing significant power outages throughout the state.

In September 2004, remnants of Hurricane Jeanne produced heavy rainfall, raising river water levels and flooding roadways throughout the northern portion of the state. The storm also spawned a tornado in northern New Castle County. The tornado's 5-mile path of destruction included the New Castle Airport, where five people were injured and numerous planes and buildings damaged.

Figure 2-4. Following Superstorm Sandy in October 2012, more than 40,000 tons of sand that the storm had deposited from storm surge and flooding had to be removed from Route 1 to reopen the vital road through coastal Sussex County. Photo by Ron MacArthur

Strong winds associated with Tropical Storm Ernesto (September 2006) caused tree and power line damage, leaving approximately 151,000 homes without power. Storm surge and wave impacts also resulted in beach erosion and overwash along the coast.

Hurricane Irene (August 2011) brought tropical-force winds and heavy rain throughout the state as a Category 1 storm. Extreme precipitation produced record flooding of the Christina River and Brandywine River in New Castle County. More than 50,000 residents in Delaware lost power during the storm and mandatory evacuations were issued for 80,000 to 100,000 residents and tourists. More than 200 roads were reported underwater, hampering evacuations. In Lewes, a tornado destroyed one home and caused damage to 36 others. Two fatalities were attributed to the storm.[2.2]

Hurricane Sandy, which was technically an extratropical storm system when it passed by Delaware, had been forecasted to make landfall close to Lewes. It tracked north, sparing Delaware the worst, but evacuations were mandated for more than 35 communities. Delaware sustained a storm tide of 9.1 feet,

or 5.06 feet of surge above predicted tide levels. Winds kicked up debris throughout the state (Figure 2-4). Widespread storm surge and flooding led to significant damage to homes, buildings and roadways, particularly near Bethany Beach and South Bethany. Over 40,000 tons of sand had to be removed from Route 1 in coastal Sussex County before it could be opened. Road closures and power outages were widespread throughout the state, and Claymont recorded a new record low pressure of 954 mb.[2.2]

Although Delaware has been spared direct hits by many tropical systems, it is notable that the state is not immune to major impacts and these impacts are not isolated to Sussex County or the coast. No two storm systems are alike, and storm characteristics are changing due to warming temperatures and sea level rise. Thus, it is very important for all Delaware residents to be fully prepared when the next storm hits and heed emergency warnings and evacuations.

2.1.2 NOR'EASTERS—EXTRATROPICAL STORMS

While not as powerful in terms of wind speeds as hurricanes, nor'easters (short for northeasters) occur more frequently in Delaware. Because they cover a larger area and are typically slow-moving storms, nor'easters usually affect a large portion of the coast and exert significant impacts on beaches, dunes, buildings and roads over several successive tides. Nor'easters are most damaging when they stall off the coast.

Nor'easters are a year-round threat to Delaware but occur more frequently during winter and spring months. These intense storms move along the coast with winds blowing directly from the northeast, right off the Atlantic Ocean onto the shoreline. They develop around regions of low pressure and derive their energy from the strong temperature gradients that commonly occur when cold and warm fronts collide.

Nor'easters typically produce winds ranging from 30 to 40 mph, with gusts that can exceed 74 mph. These strong winds can create waves ranging from 5 to 15 feet high, depending on the storm's duration and location relative to the shoreline. The size and strength of these waves can erode beaches and dunes and demolish buildings, boardwalks and roads. Tidal flooding is also a serious hazard associated with nor'easters. Storm tides of 3 up to 10 feet are especially damaging when they occur over several consecutive

Figure 2-5. The March 1962 nor'easter caused significant damage to property in Delaware, especially along the coastlines of the Inland Bays, Delaware Bay and Atlantic Ocean. Image courtesy of Delaware Public Archives

tidal cycles. The torrential rainfall from nor'easters can cause extensive flooding in both coastal and inland areas.

The most damaging coastal storm to impact Delaware was a nor'easter that occurred in March 1962 (Figure 2-5). The March (Ash Wednesday) 1962 storm was extremely severe because it stalled off the Delaware coast for more than three days and coincided with the highest monthly astronomical tides through five successive high-tide cycles. The extreme storm surge combined with strong northeast winds and wind-driven waves to produce a record high tide of 9.22 feet above mean lower low water (mllw) registered at the Lewes Breakwater Harbor tide gauge.

Approximately 80% of the top 50 flood events recorded by the NOAA tide gauge at Lewes Breakwater Harbor were caused by non-tropical systems. From 1950–2018, nearly 50% of all major and moderate flooding events as defined by the National Weather Service occurred since the year 2000.[2.3]

On January 4, 1992, the Delaware coast was hit by a nor'easter that produced a tide of 8.75 feet (mllw), the third-highest tide recorded at Breakwater Harbor (Lewes). Significant beach erosion occurred along Delaware's Atlantic Ocean coast. Dunes were breached and there was severe flooding and property damage from Rehoboth Beach to Fenwick Island.

Back-to-back nor'easters occurred in January and February 1998, producing heavy rains, high winds, waves and extreme tides. The high tide during the January storm was 8.68 feet (mllw) at the Breakwater Harbor tide gauge (4.3 feet above normal). Wind gusts exceeded hurricane strength (>80 mph) in the vicinity of Indian River Inlet and gusts reached 70 mph at the Lewes Pilot Tower. One week later, in February 1998, another severe nor'easter pounded Delaware's coast with tides of 8.49 feet (mllw). The cumulative effect of two severe coastal storms hitting the coast within a week was devastating to all coastal areas, causing eroded beaches and dunes, flooding, overwash and property damage. About 10,000 homes and businesses in the state lost power, primarily in Sussex County, although no serious injuries were reported. Damage estimates were approximately $1.3 million for the January storm and $1.7 million for the February storm.

In May 2008, a severe nor'easter impacted the entire Delaware coastline. Extreme tides along Delaware Bay beaches caused water to overtop dunes and flood adjacent roadways and communities. Many Delaware Bay residents woke to find their homes surrounded by water. Most of the flooding was caused by rising waters flooding from the marsh side of communities along the bay coast. The Murderkill River reached a flood level of 8.5 feet above mllw, setting a new tidal record. Winds peaked at 68 mph as recorded in Lewes, and the Breakwater Harbor tide gauge recorded a maximum tide height of 7.89 feet. The storm lasted two days through four tide cycles, and many Delaware Bay beach residents compare this storm to the March 1962 storm. Along the Atlantic Ocean coast, beaches and dunes were eroded, but little or no flooding occurred on the landward side of the beaches.

In mid-November 2009, the remnants of Tropical Storm Ida developed into a nor'easter that impacted Delaware over a period of three days and six tide cycles. Not only did the entire coast experience significant beach erosion, but ocean and bay waters broke through the dunes in several

Figure 2-6. A nor'easter in January 2016 brought widespread flooding, evacuations and power outages to coastal Delaware. Photo by Laura Ritter/Cape Gazette

areas. Portions of Route 1 north of Indian River Inlet were covered by water and sand, requiring the Delaware Department of Transportation (DelDOT) and Delaware Department of Natural Resources and Environmental Control (DNREC) to clear the road and rebuild dunes on the east side of the highway.

A historic nor'easter affected Mid-Atlantic states, including Delaware, in January 2016. In Sussex County, gusts in the 55–75 mph range produced blizzard conditions and contributed to widespread flooding in coastal Delaware (Figure 2-6). During the storm, the tide in Lewes was the highest ever recorded, even surpassing the storm of 1962. Numerous roads were closed and motorists had to be rescued. Storm conditions brought extreme inundation along the coast and up through tributaries and marshes, flooding many inland neighborhoods.

In March 2018, another nor'easter blanketed the Delaware region with more than 9 inches of rain in Middletown, 8.1 inches at New Castle

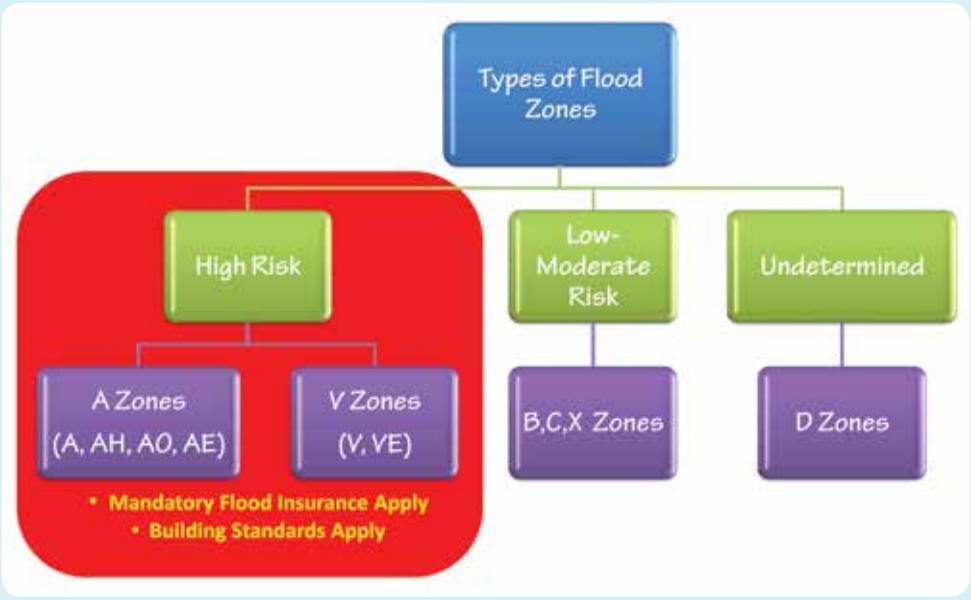


Figure 2-7. High-Risk Flood Zones are in the Special Flood Hazard Area (subject to inundation by the 1% annual chance flood or 100-year flood). They consist of flooding (A zones) and high-velocity wave action (V zones) near the coast. In addition, there are areas of low-moderate risk (B, C, X zones) and areas where the risk is undetermined (D zones). Even in these zones, the homeowner should consider flood insurance if there are localized flooding or drainage conditions on their property as indicated by past weather or storm events. Image courtesy of Hawai'i Department of Land and Natural Resources

Airport and 7.0 inches in Milford. Storm surge caused localized flooding and moderate erosion in Sussex County.

2.2 FLOOD HAZARDS

Flooding is the most common natural hazard in Delaware. Flooding can be caused not only by a hurricane, but also by a tropical storm, tropical depression, nor'easter, or any other weather system that produces heavy rain. Flooding can build up gradually over a period of days or suddenly in a few minutes (commonly known as a flash flood). Coastal flooding can also result from high tides (usually on either side of a new or full moon), storm surge, and waves generated by storms located hundreds or thousands

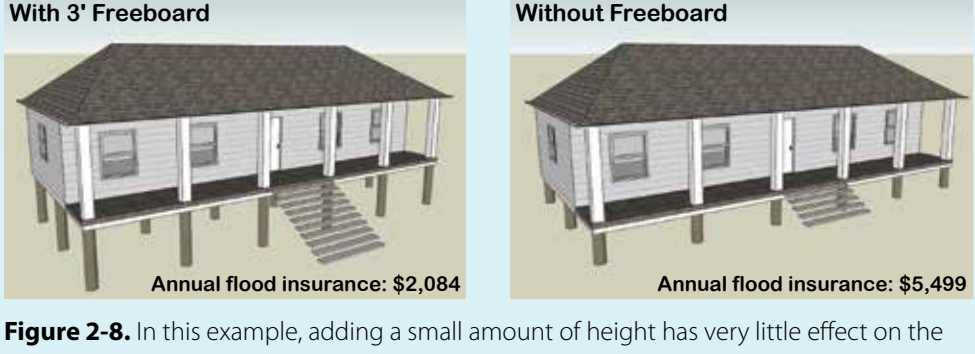


Figure 2-8. In this example, adding a small amount of height has very little effect on the look of a home, but results in a substantial flood insurance savings.[2.4] Image courtesy of Dan Gihring for StormSmart.org

of miles from Delaware. Flooding is not isolated to coastal areas, however. 98% of all counties in the United States have experienced a flood.

To determine whether you are in a high-risk flood area, consult the Federal Emergency Management Agency's (FEMA) Flood Insurance Rate Maps (FIRMs). These maps show areas that are susceptible to flooding and high-velocity wave action (for those near coastal areas) from a 1% annual chance event (a.k.a. 100-year flood). Note these maps do not take sea level rise or other changes into consideration, such as rates of erosion, filling of the flood plain or development, which increases impervious surfaces.

Electronic copies of the maps can be downloaded from FEMA's Map Service Center (msc.fema.gov). DNREC also maintains an interactive web-based application called the Delaware Flood Planning Tool to help residents assess flood risks to their property (maps.dnrec.delaware.gov/FloodPlanning/default.html). Visit either of these sites and type in your street address to gain a better understanding of historic flood risk and inform your decisions about insuring, protecting, or purchasing property. Copies of the maps may also be available for viewing at your city or county building departments.

Flood Zones are geographic areas that FEMA has defined according to varying levels and types of flood risk and are depicted on a community's FIRM. Generally, these zones can be identified as one of three risk classifications (see Figure 2-7). In high-risk zones, there is at least a one-in-four chance of flooding over the course of a 30-year mortgage, and flood

insurance is required in these areas for homes with a federally-backed mortgage. Even if you are not in one of FEMA's high-risk flood zones, risks do not automatically drop to zero. According to FEMA, nearly 20% of flood insurance claims come from low- to moderate-risk zones. For example, flooding can occur in areas where drainage is insufficient or blocked by debris. A good way to determine the risk of flooding for your house is to observe and study your property, looking for potential nearby water sources or blockages of surface water flow. If your property is immediately adjacent to a road or drainage ditch, try to evaluate the potential for water to accumulate in the ditch due to blocked culverts. If the crown of the nearby road is higher than your driveway or crawlspace, this may be an indication that heavy rainfall runoff could accumulate on your property, regardless of whether you are in a mapped flood plain. Inland properties may be susceptible to flooding if there is poor localized drainage or if recent development involving fill and impervious surfaces has altered the ability of water to soak in or drain out of your area. If your property floods during small rain events, then the problem will be greater during a severe thunderstorm or hurricane. You can protect yourself by improving the local drainage, elevating your utilities, wet- or dryproofing the home and purchasing flood insurance.

For those homes located within a high-risk flood zone, elevating a building's lowest inhabited floor above predicted flood elevations by a small additional height (known as "freeboard") has very little effect on the look of a home, yet it can lead to substantial reductions in damages caused by flooding as well as reductions in flood insurance cost (Figure 2-8).[2.4] Elevating mechanical systems can also reduce flood damage. Consult with your local flood plain manager to determine how much freeboard (if any) is needed for your property for flood insurance savings. Consider using flood-resistant materials for portions of the structure that are below expected flood elevations. Examples of flood-resistant materials include clay, concrete or ceramic tile, indoor-outdoor carpet with synthetic backing, metal doors and window frames, and marine-grade plywood.

Standard homeowners insurance does not cover flood damage, but flood insurance is available through the National Flood Insurance Program. Visit floodsmart.gov for information or talk to your insurance agent. You do not need to be in a high-risk flood zone to obtain flood insurance. Even if you

Table 2-2. The EF Scale[2.5]

EF-Scale Number	Class	Wind Speed	Description
EF0	**Weak**	**65–85 mph**	Gale: Some damage to chimneys; breaks branches off trees; damages sign boards.
EF1	**Weak**	**86–110 mph**	Moderate: Peels surface off roofs; mobile homes pushed off foundations or overturned; moving autos pushed off the roads; attached garages may be destroyed.
EF2	**Strong**	**111–135 mph**	Significant: Considerable damage. Roofs torn off frame houses; mobile homes demolished; boxcars pushed over; large trees snapped or uprooted; light object missiles generated.
EF3	**Strong**	**136–165 mph**	Severe: Roof and some walls torn off well-constructed houses; trains overturned; most trees in forest uprooted.
EF4	**Violent**	**166–200 mph**	Devastating: Well-constructed houses leveled; structures with weak foundations blown off some distance; cars thrown and large missiles generated.
EF5	**Violent**	**>200 mph**	Incredible: Strong frame houses lifted off foundations and carried considerable distances to disintegrate; automobile-sized missiles fly through the air in excess of 100 meters; trees debarked; steel reinforced concrete structures badly damaged.

are not in a high-risk flood zone, you should consider purchasing flood insurance, especially since flooding risks may still be present, as described above. The rates for properties outside of flood zones are very affordable and provide financial protection if a flood event should occur.

2.3 TORNADO HAZARDS

One of nature's most violent storms, a tornado is characterized by a twisting, funnel-shaped cloud extending to and in contact with the ground.

Figures 2-9. In September 2012, an EF-0 tornado with estimated maximum wind speeds of 85 mph caused structural damage in Kent County, Del. Image courtesy of Kent County Office of Emergency Management

Tornadoes most often result from the intersection and interaction of cool dry air as it overrides warm moist air, causing the warm air to rise rapidly. These conditions are also associated with severe thunderstorm activity, so it follows that tornadoes are most often generated by thunderstorms (including those associated with tropical systems such as hurricanes).

With wind speeds ranging from 40 to more than 300 mph, tornadoes can cause fatalities and devastate a neighborhood in seconds. The result is catastrophic failure of structures and facilities, as well as the potential for injury and death. Damage paths can be in excess of 1 mile wide and 50 miles long.[2.6]

The size of a tornado is not necessarily an indication of its intensity; large tornadoes can be weak and small tornadoes can be violent. The Fujita (F) Scale is used to estimate tornado wind speeds based on damage left behind by a tornado. An Enhanced Fujita (EF) Scale (Table 2-2), developed by a forum of nationally renowned meteorologists and wind engineers, makes improvements to and replaces the original F scale.[2.5]

While tornadoes are most frequently reported east of the Rocky Mountains during spring and summer months, peak tornado season in Delaware is

Figure 2-10. In April 2019, an EF2 tornado touched down in Laurel and Seaford, damaging a dozen homes, knocking out power and injuring one person. Image courtesy of LFD Files

March through May. They are most likely to occur between the hours of 3 and 9 p.m., but can occur at any time.

Tornadoes generally occur near the trailing edge of a thunderstorm or accompany a tropical storm or hurricane as it moves onshore. The average forward speed of a tornado is 30 mph but may vary from stationary to 70 mph.[2.6] Before a tornado hits, the wind may die down and the air may become very still. A cloud of debris can mark the location of a tornado even if a funnel is not visible. It is not uncommon to see clear, sunlit skies behind a tornado.[2.6]

Waterspouts are tornadoes that form over water. In June 2012, a waterspout observed in Rehoboth Bay—associated with a severe thunderstorm with 65-mph winds—damaged property in Dewey Beach and Angola.

The entire state of Delaware is at nearly equal risk for tornadoes. In

September 2012, an EF-0 tornado touched down in a Kent County neighborhood, causing widespread damage that left six homes uninhabitable and 24 properties damaged overall (Figure 2-9).[2.7] In the early morning hours of April 2019, an EF-2 tornado traveled from Laurel to Seaford, with peak winds of 120 mph, resulting in one injury when a tree fell on a house.[2.8] Serious damage was reported to over a dozen structures, as well as power outages and numerous road closures (Figure 2-10).

Evaluate whether your home is at high risk of damage from tornadoes by considering the following:

- Improperly maintained or potentially damaging trees;
- Nearby high-risk structures, which might produce wind-borne debris such as abandoned out-buildings or buildings with improperly connected flat roofs;
- Improper grounding leading to lightning damage; and
- Failure to monitor and heed tornado warnings.

2.4 ADDITIONAL HAZARDS

SEVERE THUNDERSTORMS

Although thunderstorms typically impact a small area, they can be extremely dangerous due to their capability of generating tornadoes, hail, strong winds, flash floods and damaging lightning. These storms can move through an area very quickly or linger for several hours, with longer duration resulting in the possibility of excessive precipitation and increased likelihood of flash floods. The National Weather Service considers a thunderstorm to be severe if it produces hail at least one inch in diameter, winds of 58 mph or stronger, or a tornado. Straight-line winds associated with severe thunderstorms can exceed 125 mph and are responsible for most thunderstorm damage.

Straight-line winds, or downbursts, are much more common than tornadoes and tend to cause more damage than the typical tornado in Delaware. In August 2012, severe thunderstorms accompanied by straight-line winds estimated at 60 mph ripped through homes and property in Sussex County. Roofs were lifted from homes, and many properties were damaged or

Figure 2-11. In August 2012, winds associated with severe thunderstorms damaged property and scattered debris in the Long Neck area of Sussex County. Image courtesy of Ron MacArthur/Cape Gazette

destroyed (Figure 2-11). Heavy rains associated with the storms caused flooding in low-lying areas.

DROUGHT/EXTREME HEAT

Drought conditions are the result of extended periods of limited precipitation. Human activities, high temperatures, high winds and low humidity can exacerbate drought conditions and may also make areas more susceptible to wildfire. Periods of drought can have significant negative impacts on agriculture, water reservoir levels, surface and groundwater supplies, or any water-dependent resource or product. An extreme heat condition is commonly identified when prolonged temperatures are greater than or equal to 10 degrees above the average high temperature for a region. Periods of extreme heat in Delaware are also often accompanied by high humidity. Extreme heat can cause medical problems and pose significant risks to humans, especially the elderly, young children and people with respiratory difficulties.

WILDFIRE

Wildfires, or any naturally occurring fire in a grassland, brush, or forested area, are especially dangerous hazards during periods of drought. The most common cause of wildfires is negligent human behavior (causing 80% of forest fires). Lightning strikes are the second most common cause and typically occur during summer months. Areas with large amounts of dry fuel, such as vegetation, debris, or trees, are particularly susceptible to wildfires caused by lightning strikes. Fire probability depends on local weather conditions, human activity and implementation of community fire prevention measures.

EARTHQUAKES

Every year approximately 3 million earthquakes occur worldwide. Between 2000 and 2009, the United States experienced approximately 32,000 earthquakes; six were considered major and occurred in either Alaska or California. Earthquakes do not occur exclusively in the western United States. Seven events with magnitudes greater than 6.0 have occurred in the central and eastern sections of the United States since 1811. In August 2011, a magnitude 5.8 quake, centered in Virginia, was felt from northernmost New Castle County to coastal and inland Sussex County (see Figure 2-12). Many Delaware residents reported moderate building shaking and movement or shaking of furniture. According to the Delaware Geological Survey, 59 earthquakes have been recorded in the state of Delaware since 1871. The largest measured earthquake in Delaware occurred in November 2017 near Dover. It measured 4.1 on the Richter scale. In 1997, Delaware was reclassified from being a low seismic risk state to being a medium seismic risk state by FEMA and the U.S. Geological Survey.

TSUNAMIS

While tsunamis are not considered to be a high-risk hazard in Delaware, it is possible that a tsunami could impact the Delaware coast. Tsunamis in the Atlantic Basin are most commonly generated by earthquakes and landslides. Primary sources of tsunami-producing earthquakes in the Atlantic are located near Puerto Rico, Portugal and the Canary Islands. Tsunamis in the Atlantic Ocean may also be caused by underwater landslides, usually

occurring near the continental shelf and slope. Since 1600, 40 tsunamis and tsunami-type waves have been documented in the eastern United States. East Coast tide gauges can detect even small tsunami waves caused by distant earthquakes. For example, Atlantic basin gauges recorded 5- to 10-inch waves generated by the December 2004 Indian Ocean tsunami.

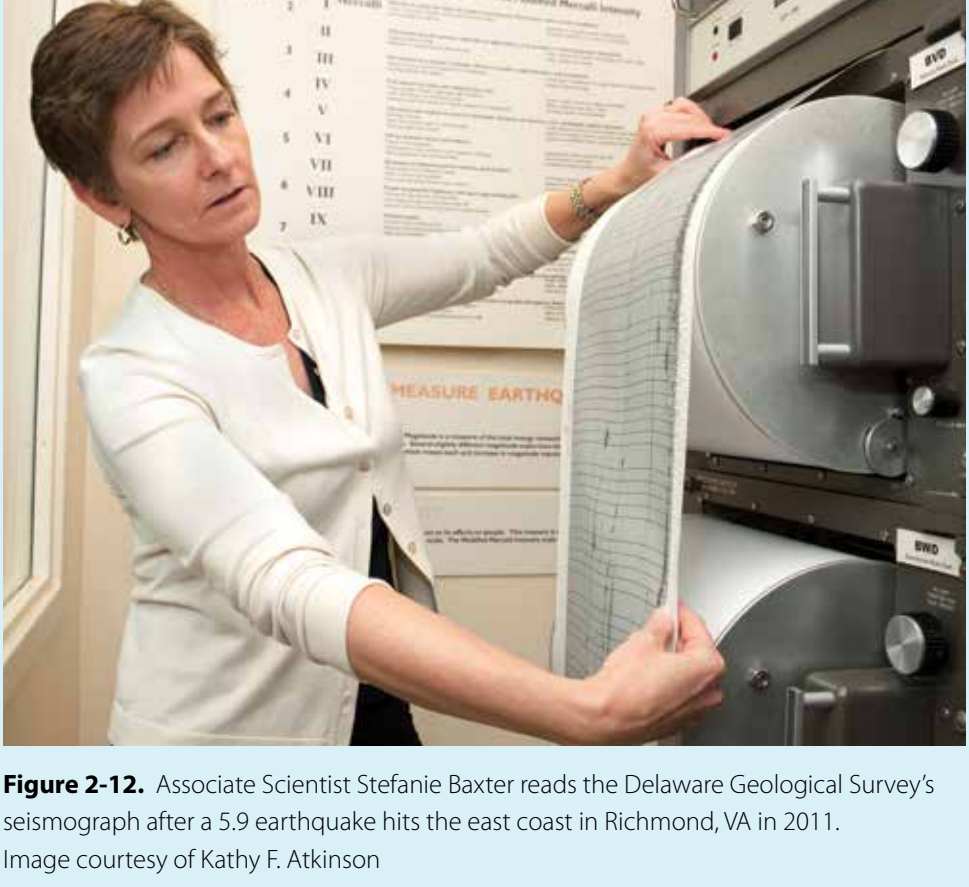


Figure 2-12. Associate Scientist Stefanie Baxter reads the Delaware Geological Survey's seismograph after a 5.9 earthquake hits the east coast in Richmond, VA in 2011. Image courtesy of Kathy F. Atkinson

Part 3
Future Conditions: Factoring in Climate Change's Impacts on Natural Hazards

Climate change effects in Delaware will likely include more extreme weather events (e.g., more droughts, more intense rainfall and more intense storms and flooding), sea level rise and warmer temperatures. These changes are likely to amplify many of the coastal hazards we already face, and for this reason, future conditions should always be factored into emergency preparedness and resilience planning.

3.1 CLIMATE CHANGE

The word "climate" describes the overall, long-term pattern of weather in an area. Weather is typically measured over a period of days or weeks, while climate can be defined as the average weather for a particular region over months, seasons, years or decades.[3.1] When scientists talk about climate, they're looking at averages of precipitation, temperature, and extremes. Another way to think about it is, if weather is your mood, climate is your personality.

Climate change refers to alterations in the long-term record of climate components (such as air temperature) sustained over a time period of several decades or longer.[3.2] Climate change is caused by a combination of natural influences and human activities.

While Earth's climate has experienced periods of natural changes over time frames of hundreds and thousands of years, the large and rapid changes underway today are unprecedented and have never been recorded over Earth's paleoclimatological record. Climate change is affecting sea level, ocean chemistry, temperatures, length and timing of seasons, and the amount of annual rain and snowfall. Many of these changes have negative consequences for people and the environment. Climate change influences quality of life, the economy, and human and ecological health. The degree to which climate

change poses risks to different sectors of our society depends on geographic exposure, our sensitivity to changes and our capacity to adapt. One thing is clear: the risks are highest for populations that are already vulnerable, including older adults, children, low-income families and some communities of color. Climate change exacerbates the impacts we experience from natural hazards, and vulnerable communities will be disproportionately impacted.[3.3]

There have been numerous documented changes in global climate conditions over the past century. To date, the world has seen increases in annual average temperatures, rates of sea level rise, and altered precipitation patterns, as well as other trends such as increases in weather extremes, changes in the onset of seasons and more frequent flooding. Current global climate change trends are expected to continue into the future, and the rate of change for many of these variables is expected to increase.[3.3]

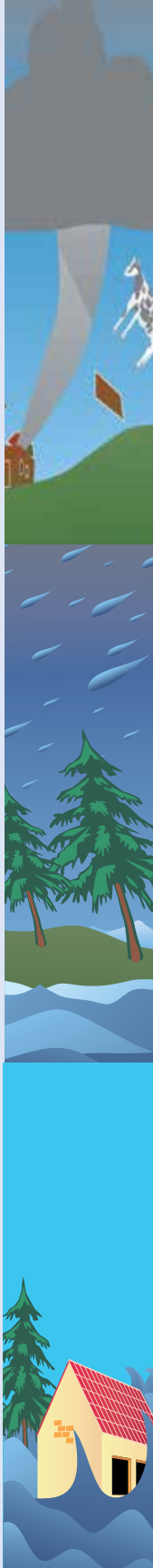
3.2 REGIONAL CLIMATE TRENDS

Global patterns of climate change represent an average, with individual regions experiencing varying degrees of change.

The Fourth National Climate Assessment synthesized climate change trends for the Northeast region including Mid-Atlantic states such as Delaware. Among their findings are increases in annual average temperature and rainfall intensity. Heat waves and riverine and coastal flooding will increasingly impact residents as they try to carry out their daily activities and stress infrastructure, such as stormwater management systems and transportation networks. Agriculture and natural resources such as wetlands and fisheries will experience crop failures and species migration among other impacts.[3.3] While many of these takeaways have relevance to Delaware, there are unique characteristics in the state's physical geography, oceanography and hydrology that warrant closer attention at a finer scale.

3.3 POTENTIAL CLIMATE CHANGE IMPACTS ON NATURAL HAZARDS IN DELAWARE

In 2014, a community of scientists and practitioners from Delaware state agencies and universities collaborated on a climate assessment specific to the State of Delaware. The Delaware Climate Change Impact Assessment summarized the best available climate science and ways in which climate



change may impact Delaware's natural resources, communities and sectors. The assessment is a practical, decision support tool to aid efforts by homeowners and communities to become more resilient to change. Resilience means the capability to prepare for hazardous conditions and adapt to or rebound more quickly from them. Resilience planning is anticipatory in nature: it emphasizes future conditions such as climate change or shifting population demographics because they increase exposure and vulnerability to hazards.

Changes in precipitation, temperature and sea level are already being observed in Delaware. Temperature increases, more intense rainfall and sea level rise are projected to exacerbate the impacts of natural hazards in Delaware (see Table 3-1). A general overview is included below.

Temperature

Since 1900, annual and seasonal temperatures have increased in Delaware by 2 degrees Fahrenheit. We are already experiencing warmer summers and longer growing seasons. By the time a new 30-year mortgage is paid off, the average temperature is expected to be 2.5 to 4.5 degrees warmer. By 2100, it could be as much as 8 degrees warmer.[3,4] These increases will trigger longer, more frequent heat waves which have the potential to contribute to drought conditions. Drought can be caused by both a reduction of precipitation as well as by heat that causes increases in evaporation. The number of very hot days (over 95 degrees Fahrenheit) will increase as well, which will increase the risk of heat stroke and other illnesses, particularly among children, older adults, those without access to air conditioning, or those who work outside for a living such as in the agricultural and construction sectors. Demand for air conditioning will lead to increasing electricity costs and burdens on our energy infrastructure, especially during peak usage hours. Air quality may suffer from elevated ground-level ozone conditions, also contributing to human health impacts.

Pets, poultry and other livestock will be impacted by rising temperatures too. In the agricultural sector, Delaware may witness greater heat stress on animals and crops, reduced crop yields and changes to the growing season (both good and bad). Rising temperatures also speed the deterioration of roadways and add demand for irrigation. Increasing water temperatures are likely to promote the risk of harmful algal blooms and impact species' health.

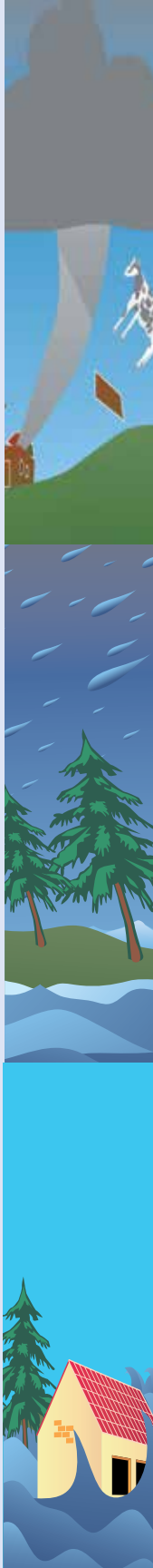
Finally, warmer temperatures on land and in water increases evaporation, which feeds moisture to the atmosphere, producing more rain and intensifying storms. There is growing evidence that warming sea surfaces have resulted in the increased destructive potential of Atlantic tropical storms since 1970.[3.5] Certainly population growth and development along the coast have also played a part in increasing impacts from these storms. Major storm tracks have been moving northward, and this has been attributed to a changing climate.[3.6] It is important to note, however, that determining whether climate change is increasing the frequency of tropical storms is an area of current active research. Separating the effects of human-influenced climate change from natural variability on hurricane activity is very difficult. At present, it remains uncertain whether past changes in hurricane activity have exceeded the trends found in natural climate variability.[3.7]

Precipitation

Historically, Delaware's annual precipitation rates vary considerably year to year.[3.8] Only the autumn season has indicated a slight upward trend in precipitation. Into the future, annual precipitation is projected to increase by approximately 10% by the year 2100.[3.4] More importantly, rainfall extremes will also increase. Heavy rainstorms are projected to grow more frequent and intense. Delawareans will witness an increasing number of very wet days exceeding 2 inches of rainfall or more.[3.4] Extreme rates of rainfall can overwhelm stormwater drains and culverts, wastewater treatment facilities, and transportation systems that are not designed with climate change in mind. These events can cause major erosion and flooding on public and private property. Intense rain storms can also delay planting and harvesting; stress crops and natural habitat; deteriorate water quality in rivers, ponds, and streams; and impact recreation and tourism.

Sea Level Rise

Sea level rise is an increase in mean sea level over time, which raises the average height of tides. Delaware is especially vulnerable to sea level rise due to its flat terrain, low land elevation and geologic land subsidence, a by-product of the last Ice Age. These and other factors contribute to relative sea level rise that is twice the global average, making Delaware a "hotspot" for sea level rise.[3.9]



Increases in the average height of tides will not only increase flood heights, but inhibit draining of tidal waterways, wetlands and marshes. These natural systems are a vital resource for the protection of life and property because they absorb inundation and reduce wave velocities during storms. But as drainage capacity decreases from sea level rise, the frequency and severity of flooding may increase. These patterns are further exacerbated by development that paves over land with properties and impervious surfaces.

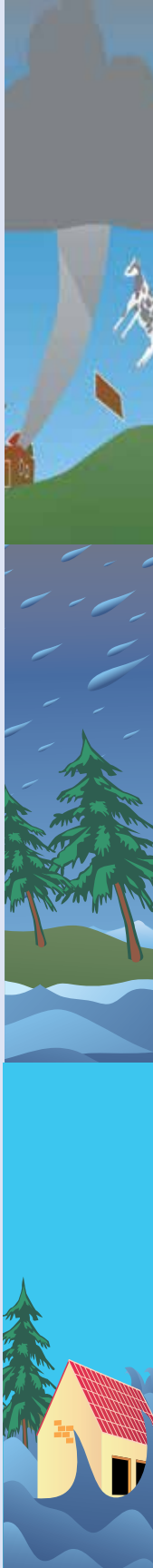
Sea level rise has major implications for Delaware because it amplifies the risks of flooding and damage to property, natural habitats and infrastructure—whether from thunderstorms that bring heavy rain, coastal tropical systems that bring storm surge, or simply high tides that bring "sunny day" nuisance flooding on low-lying roads and yards. Impacts may include saltwater intrusion and degradation of low-lying agricultural fields, coastal erosion, loss of habitat as tidal wetlands convert to open water, infrastructure damage to water supply, wastewater and transportation systems. Over time, sea level rise will also expand the federally regulated flood plain that is part of FEMA's National Flood Insurance Program (NFIP).[3.10, 3.11] The federal flood risk maps used in the NFIP determines which properties are in high-risk zones, thus needing federal flood insurance to receive federally-backed mortgages. Some houses located just outside the high-risk zones may eventually find themselves inside one, or some parcels may no longer be buildable or habitable due to chronic inundation.

Simply put, it is critical that homeowners and communities have access to future sea level rise information from which to make informed choices about where they live and how they live. In late 2017, a team of university scientists and state agency practitioners updated the state's sea level rise projections based on the latest scientific, peer-reviewed literature, international/national assessments and technical reports (see Figure 3-1). The resulting scenarios project sea level rise based on the latest scientifically-supported climate model projections and observations. These scenarios are not forecasts or predictions because estimating future sea level rise depends greatly on the pace of global greenhouse emissions and future mitigation activities. Thus, the scenarios adopt a "business as usual" rate of emissions representing today's current trends, and incorporate modeling and scientific observations that reflect conditions in Delaware.[3.10] The sea level rise scenarios offer a

Table 3-1. Delaware Climate Trends and Projections

Climate Change Variable	Current Trend in Delaware	Future Climate Projections	What This Means
Air Temperature	Annual and seasonal temperatures increased approximately 2 degrees Fahrenheit over the past century. The number of cooling degree-days showed significant upward trends annually and during the summer.	Average temperatures expected to increase 2.5 to 4.5 degrees Fahrenheit by 2050 and by as much as 8 degrees by 2100. The number of very hot days (over 95 degrees) Is projected to increase.	Longer, hotter summers increase drought potential and human health effects, particularly for vulnerable populations. Heat stress on animals and crops. Higher demand for electricity. Increasing evaporation feeds moisture into the atmosphere, potentially intensifying storms.
Precipitation	Precipitation trends are highly variable in the state. Only the autumn season recorded a modest upward trend.	Average precipitation expected to increase by 10% by 2100. Rainfall will increase in frequency and intensity, with more days with rainfall at/over 2 inches.	More intense storms means increased risk of flooding and property damage. Rainfall intensity may overwhelm the capacity of stormwater and septic systems and damage infrastructure such as roads and bridges. Less snow in winter and greater risk of crop disease.
Sea Level Rise	More than one foot of sea level rise observed in Delaware in the past 100 years. Exponential increases in tidal flooding observed.	95% chance that Delaware will experience sea level rise of up to 1.9 feet in 2050 or 5.02 feet by 2100.	Increased tidal flooding leads to damage to property, road closures, disruptions to way of life. Greater risk of erosion, storm surge and inundation from tropical storms. Loss of habitat, wetlands, agricultural productivity, saltwater intrusion of crops, water supply and septic systems. Expanding flood plain.

framework to plan within so that homeowners and communities have more information about future conditions when improving their resilience to hazardous events (see Figure 3-2).



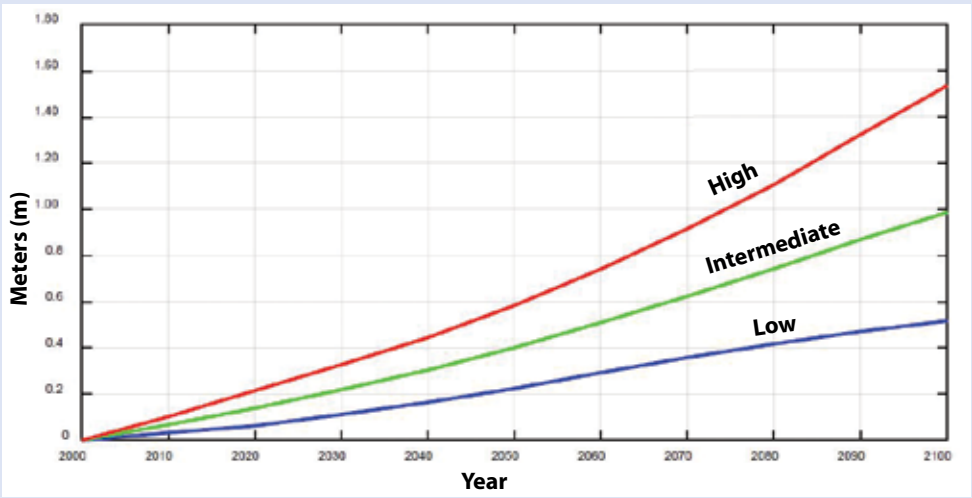


Figure 3-1. The 2017 Low, Intermediate and High Sea Level Rise Planning Scenarios for Delaware correspond with the 5%, 50% and 95% probability levels.[3.9]

		Possible Future Sea Level Rise		
		Low	Intermediate	High
Year	2030	0.11 m / 0.36 ft	0.22 m / 0.72 ft	0.33 m / 1.08 ft
	2050	0.22 m / 0.72 ft	0.40 m / 1.31 ft	0.58 m / 1.90 ft
	2080	0.42 m / 1.38 ft	0.74 m / 2.43 ft	1.11 m / 3.64 ft
	2100	0.52 m / 1.71 ft	0.99 m / 3.25 ft	1.53 m / 5.02 ft

Figure 3-2. The 2017 Delaware Planning Scenarios for selected years 2030, 2050, 2080 and 2100. Data are in meters (m) and feet (ft) relative to mean sea level in 2000.[3.9]

3.4 HAZARD MITIGATION AND CLIMATE CHANGE ADAPTATION

Climate change amplifies the risks and impacts we face from our natural hazards. While some uncertainties exist about the timing and magnitude of change, one thing is certain: Delaware is already experiencing unprecedented change. For example, sea level rise in Delaware has increased 13.2 inches in the past 100 years at the Lewes tide gauge and that rate is accelerating.[3.9] Delaware is experiencing about twice the rate of global mean sea level rise,

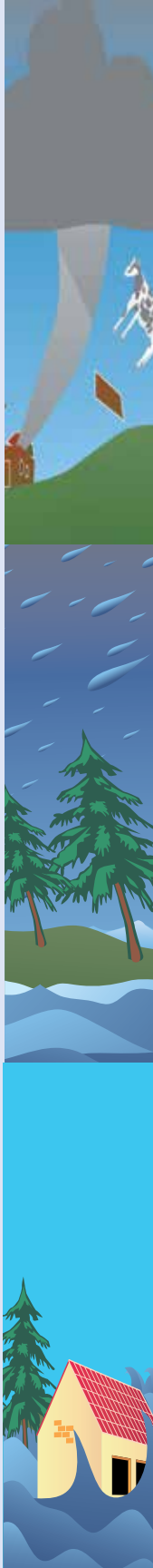
making it a hotspot for impacts. Sea level rise increases the average height of tides, causing more frequent tidal flooding in low-lying areas that is commonly referred to as nuisance flooding. Data from NOAA's tide gauge in Lewes shows an exponential increase in the total number of days where observed water levels exceed the National Weather Service's Coastal Flood Advisory Level.[2,3] Natural hazards like flooding are already taking a toll on individuals and communities, and it requires a proactive strategy to manage risks.

Resilience is the ability to prepare for hazardous events so that one can rebound more quickly from disruptions. The key to successful resilience planning is taking future conditions like climate change into account and not just present-day conditions. Given Delaware's known natural hazard risks and the ever-increasing certainty of climate change impacts, there are a number of reasons for individuals and communities to take action now to mitigate risks. It improves the safety of household members and community residents. It protects one of your most important investments—your home and property. According to FEMA, for every $1 spent on mitigation of flood risks, we save $6 in avoided losses such as property damage.[1,2] It also generates benefits that might not be related to safety of life and property. For example, some building and design strategies have the added benefit of reducing federal flood insurance premiums or improving energy efficiency.

Figure 3-3. Future conditions and resilience should be integrated into all facets of planning at the state and local level.

Because significant time may be required to implement changes, acting now will allow for the time needed to achieve these long-term goals.

Proactive planning can provide immediate benefits and is often more effective and less costly than reacting to hazards as they arise. First, begin by identifying the hazard(s) you wish to assess and then gather information related to your exposure to

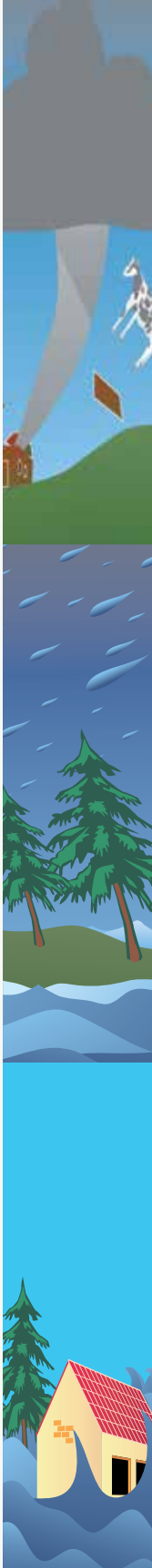


that hazard. For example, find out the elevation of the lowest living space of your residence by securing an elevation certificate, and consult FEMA flood plain risk maps to see if your property is located within a high-risk zone of the federal flood plain. Next, plan for what conditions might look like 20 to 30 years from now (the term of a mortgage). Your household members will age and perhaps retire or enter the workforce. The condition of your house will age. Consult climate projections to see how hazardous events might evolve during that time frame. Identify key vulnerabilities that exist now or may develop over time and start mapping out strategies to address them. For instance, you might lack a generator if the power goes out and you have a diabetic family member who depends on refrigerated insulin. Or you have a roof that is old and may not withstand heavy rains and wind in a couple more years. Once these needs are identified, you can consult with community members, insurance agents, town building officials and contractors to investigate effective mitigation options. Prioritize the actions you need to take and get to work implementing them now.

Finally, resilience planning is most effective when it is carried out at different scales: household, community, county and region. It should be integrated into comprehensive land use, emergency operations, hazard mitigation, and sustainability plans (see Figure 3-3). Resilience, and particularly future conditions, should be the lens through which many decisions are evaluated. Examples include transportation planning: are roadways and evacuation routes being maintained to such a standard that they will retain functionality even with sea level rise? Are new subdivisions being sited in low-risk zones of the flood plain or away from wetlands that need room to migrate with sea level rise? Integration of hazard mitigation and land use planning (with its focus on past events) with climate change adaptation and resilience planning (and its attention to future conditions) results in a win-win, no-regrets strategy that will support thriving households and communities well into the future.

Part 4
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, evacuation plans for several types of hazards, including floods, coastal storms (hurricanes and/or nor'easters) and severe wind events such as tornadoes. Your response may differ depending on the nature of the threat. You should discuss and practice the evacuation 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).



4.1 EMERGENCY SUPPLIES

A general rule of thumb when preparing for a hazard is to be self-sustaining for the first 72 hours (three days) after a hazardous event. Due to a lack of access or availability, basic supplies may be unobtainable, so it is wise to have supplies for three to five days depending on the type and extent of the disaster event. Therefore, a stock of emergency supplies will be helpful during a major event like a hurricane, tropical storm, or nor'easter, as well as for a minor event like a simple power outage.

Your emergency supplies should be gathered as soon as possible and checked monthly to ensure that they are complete, unused and not expired (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)
- NOAA weather radio
- First-aid kit
- Supply of special medications (prescriptions and others)
- Three-day supply of nonperishable foods

- Hibachi with charcoal, camping stove with fuel, or barbecue grill with propane. Do not use these items indoors or in an area without ventilation. Follow all manufacturer instructions.
- Manual can opener
- Matches or lighter
- Disposable plates and kitchen utensils
- 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. Larger containers that sit in a bathtub and can be used to store up to 100 gallons of potable water are also available. Remember to store water for toilet use (in bathtubs, rubbish containers, washing machines, water heater, etc.).
- Pet supplies (food, water, bedding, leash, medications)

Additional items you may want to add to your stock include:

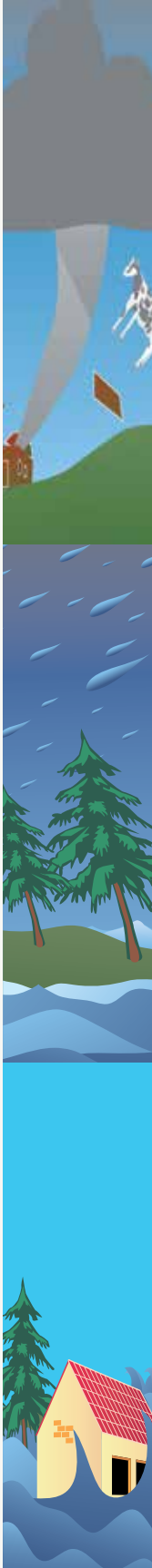
- Sanitary supplies and/or a portable toilet
- Spare cash—Automated teller machines require electricity to operate and may not be available or accessible for weeks.
- Waterproof plastic sheeting or tarp, string or rope and duct tape
- Cell phone with a car charger and a hardwired single line phone—Cell phone networks may be 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.
- Bedding and clothing for each person
- Blankets and towels
- Rain jackets and pants
- Sunscreen and bug repellent
- Baby supplies (diapers, food, formula, medication)

- Toothbrush, toothpaste, soap, shampoo, cleanser, bleach, trash bags, towelettes, water-free hand sanitizer
- Copies of important documents, ideally stored in a waterproof box or folder—Driver's license, social security card, proof of residence, insurance policies, wills, deeds, birth and marriage certificates, tax records, medical records, family pictures, etc.
- 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 5 of this book for descriptions of alternative power sources that may supplement your emergency supplies.

Always heed local evacuation warnings. If it is safe enough to shelter in your home (outside the flood evacuation zone, well inland of the strongest winds of a hurricane, and in an exceptionally strong dwelling), you may wish to have more than five to seven days of supplies. There is always the possibility that a major storm or hurricane can disrupt the supply line of goods. If space is available and your house is protected, stocking up for a two-week period is prudent. Gather supplies over a period of time rather than rushing out during an emergency when shortages are likely.

4.2 EVACUATION KIT

The evacuation kit differs from your stock of emergency supplies because the kit needs to be lightweight and transportable in case you need to leave your house in an emergency. Consider packing items in a roll-on suitcase if you are concerned about the weight of the items. 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 suitcase, duffle bag or backpack, so that it is ready to go at a moment's notice. It may include:

- One gallon potable water per day per person
- Personal items and family needs, such as a two-week supply of daily prescription medications, a three-day supply of nonperishable food and any special dietary foods, manual can opener, infant formula and diapers, prescription eyewear and personal hygiene items such as waterless cleaner, toothbrush, toothpaste and toilet paper
- 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 and towels
- Pillows, blankets and folding mattresses/air mattresses

A general recommendation is that the evacuation kit should contain supplies for five to seven days. Should the supply chain be disrupted (because of damage to airports or warehouses, for example), you will be better off than others who do not have adequate supplies.

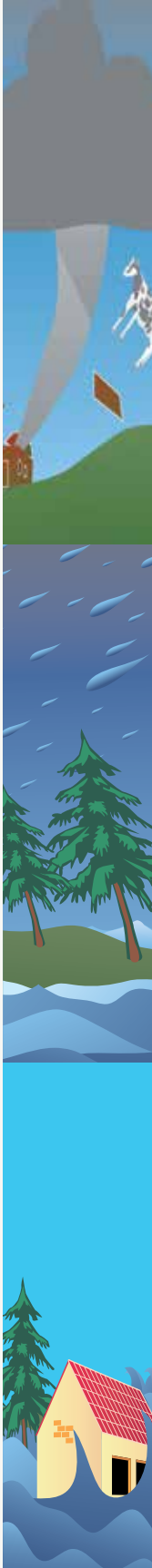
There is a fine line between bringing too many supplies that overload limited shelter space and not bringing enough. However, if you go to a shelter, keep in mind that they will provide food and there will be limited space, so bring only the essentials unless you are instructed otherwise by your local emergency management agencies.

4.3 EVACUATION PLANNING

In Delaware, it is important for families to plan for various natural hazard events, including floods and coastal storms. 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 or coastal storm may differ from those for an inland flooding event. You must plan for both. In a hurricane or strong coastal storm, you must protect yourself from strong winds, torrential rain and coastal inundation. In a flood, you must protect yourself from rising water.
- Delaware Department of Transportation (DelDOT) maintains a web resource (www.deldot.gov/information/projects/tmt/evac_map.shtml) to help citizens determine possible routes of evacuation during disaster. Evacuation maps may be updated at any time, so do not depend on outdated versions. In addition, the type of disaster may impact which evacuation route should be considered. It is important for citizens to be familiar with multiple evacuation routes and test them to see which best meets their needs. Individuals should also be mindful that bridge closures may be enforced during inclement weather, such as snow or high-wind conditions. DelDOT's Transportation Management Center provides real-time traveler information that includes updates on travel advisories, road closures, and restrictions (www.deldot.gov/Traffic/travel_advisory/#advisories). DelDOT's Traveler Advisory radio station (WTMC 1380 AM) is also available through the website.
- Listen to your local radio and television stations carefully as there may be additional or modified directions based on the type of disaster and best available information at that time. Mother Nature is unpredictable, and a team of scientists and emergency responders will always be monitoring unusual conditions for public safety. "Local" means radio and television broadcasts specific to the area in which you live. Television is important but because a station may broadcast over a larger area—including multiple states—the information provided may be more applicable to one area than another.
- Plan for the needs of yourself and your family, including those with health or mobility needs (see Figure 4-1). Consider helping elderly or disabled friends and neighbors if they are not otherwise under the care of another family member or healthcare provider. These individuals pride themselves on their independence but may have some difficulty managing the unique circumstances of a disaster such as extended power outages and flooding. Practice evacuation procedures through yearly drills.



- Parents should confirm the evacuation procedures in place at their child's school; 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.
- Develop a communications plan for family members should they become separated. Each family member should have a list of phone numbers and email addresses of all immediate family members. This list should include landline numbers, as well as the phone number and Facebook web address of an out-of-state relative or friend who can act as an intermediary if there is network congestion or downed phone networks in the state. Communication lists should be readily accessible if power goes out (e.g., not stored on a cell phone or computer).
- Develop a plan for your pets that includes possible locations for them to stay (see Figure 4-2). Your options may include pet-friendly shelters (if available), friends or relatives who live outside of the evacuation zone, or an animal clinic or kennel. Pets entering shelters must be vaccinated and you may be asked for proof. Owners must provide a cage, food, bowls, bedding, waste disposal bags, leash and medication for their pets. Ideally, take your pet with you to high ground outside of the evacuation zone. Detailed disaster preparedness information for pets (and livestock) is available from DEMA at: http://dema.delaware.gov/disprep/pet_tips.shtml.
- In general, stay off the roads. Only drive if it is absolutely essential. The police may close many roads during an emergency, so people can exit a highway, but not necessarily get on it.
- Consider shelters as a last resort if you cannot evacuate out of the area and stay with friends and relatives or safely shelter in place. Immediately following a large disaster, suitable shelter sites will be selected from a pre-designated list based on the type of hazard, areas of need and estimated numbers of displaced people. Therefore, it is not possible to say in advance which sites will actually operate as shelters. As soon as specific emergency shelter sites have been formally designated, this list will be announced through local media and included on the American Red Cross website: redcross.org.

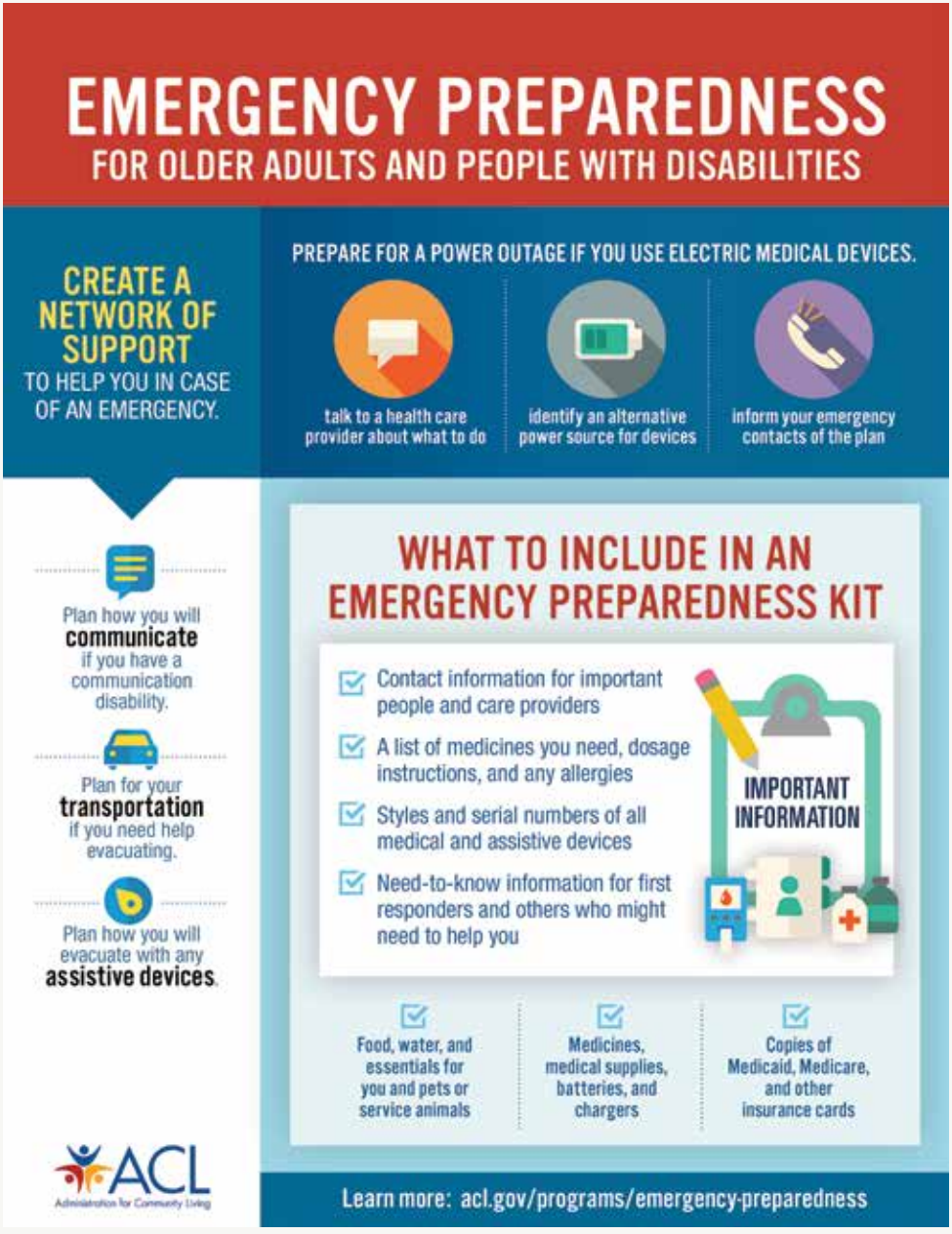


Figure 4-1. Consider special needs for older adults and people with disabilities when making your evacuation plan. Image courtesy of U.S. Department of Health and Human Services Administration for Community Living

Figure 4-2. Having a plan for household pets is an important part of emergency preparedness. Image courtesy of FEMA

- Prepare to be at your evacuation point for a minimum of 72 hours or longer.
- Know the difference between a watch and a warning. Do not confuse the two (see Part 4.4 below). When each is triggered, there are different actions you and your family should take. Also note that state and local emergency management agencies may issue a mandatory evacuation.

4.4 KEY DEFINITIONS

Hurricane Watch. Sustained winds of 74 mph or higher are possible in the specified area of the watch, usually within 48 hours. During a watch, prepare your home and review your plan for evacuation in case a hurricane warning is issued. As discussed earlier, preliminary preparations should begin even before a watch has been issued.

Hurricane Warning. Sustained winds of 74 mph or higher are expected in the specified area of the warning, usually within 36 hours. Complete hurricane preparations and leave the threatened area if directed by officials.

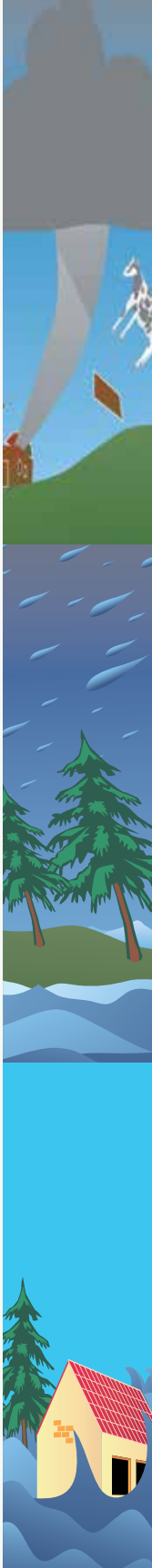
Tropical Storm Watch. Winds of 39 to 73 mph or higher pose a possible threat, generally within 48 hours. These winds may be accompanied by storm surge, coastal flooding and/or river flooding. During a watch, prepare your home and review your plan for evacuation in case a tropical storm warning is issued.

Tropical Storm Warning. Winds of 39 to 73 mph or higher associated with a tropical cyclone are expected in 36 hours or less. These winds may be accompanied by storm surge, coastal flooding and/or river flooding.

Coastal Flood Advisory. Minor coastal flooding is occurring or imminent. Listen to the NOAA weather radio station or local radio stations or check your local television station for information.

Coastal Flood Watch. Moderate to major coastal flooding is possible. Such flooding would potentially pose a serious risk to life and property. Be prepared to move to higher ground—listen to the NOAA weather radio station or local radio stations or check your local television station for information.

Coastal Flood Warning. Moderate to major coastal flooding is occurring or imminent. This flooding will pose a serious risk to life and property. Take



necessary precautions at once. If advised to evacuate to higher ground, do so immediately.

Flash Flood or Flood Watch. Flash flooding or flooding is possible within the designated watch area. Be prepared to move to higher ground—listen to the NOAA weather radio station or local radio stations or check your local television station for information.

Flash Flood or Flood Warning. 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.

Severe Thunderstorm Watch. A Severe Thunderstorm Watch is issued when severe thunderstorms are possible in and near the watch area. It does not mean that they will occur; it only means they are possible.

Severe Thunderstorm Warning. A Severe Thunderstorm Warning is issued when severe thunderstorms are occurring or imminent in the warning area. Severe thunderstorms are defined as having winds of 58 mph or higher and/or hail 1 inch in diameter or larger.

Tornado Watch. A Tornado Watch is issued when severe thunderstorms and tornadoes are possible in and near the watch area. It does not mean that they will occur; it only means they are possible.

Tornado Warning. A Tornado Warning is issued when a tornado is imminent. When a Tornado Warning is issued, seek safe shelter immediately.

4.5 EMERGENCY NOTIFICATION SYSTEMS

If a situation or event becomes a potential threat to Delaware residents and visitors, the public will be alerted by one (or several) of the following methods, as appropriate:

Delaware Emergency Notification System. The Delaware Emergency Notification System (DENS) is the primary system for public warnings and emergency notifications in the State of Delaware. Municipalities, counties and state agencies utilize the system to inform and warn the public when the health, safety and welfare of Delaware citizens is at risk. The system allows local 911 centers or emergency managers to send alerts to the street, neighborhood, or larger grids affected by the event. In the event a line is

busy, the DENS system will retry two additional times to deliver the message. If an answering machine or voicemail is reached, the system will deliver the emergency message there.

DENS allows emergency voice messages to be delivered to a home or business within the traditional landline telephone network. If you have this type of phone, your address and phone number is already in the DENS database.

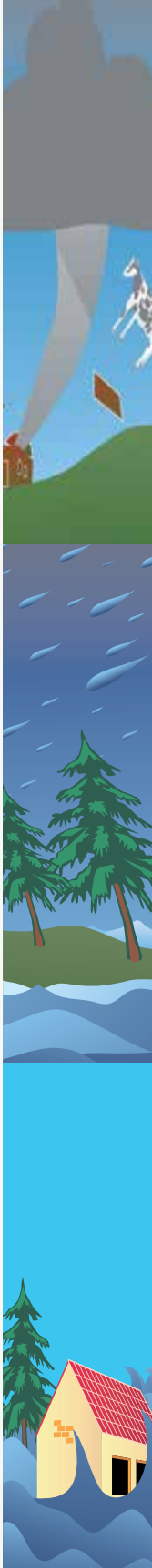
Many home and business owners today do not have traditional landline telephones. You may have a cell phone or Voice Over IP phone (VOIP). Therefore your phone is not automatically part of the DENS database of contacts in your area in case of emergency. If you do not have a landline phone, you must register your phone in the DENS system in order for you to receive your emergency messages from DENS.

Registering your phone enables DENS to geocode your phone number to your home (or work) address to send messages to your cell phones and VOIP home phones. Post office boxes may not be used as addresses during registration because they do not have your physical location affiliated with them. If an emergency message has a text or email included, registering your phone information will allow you to receive the text or email messages.

Table 4-1. Participating Radio Stations Broadcasting Emergency Alerts

County	Radio Station
New Castle County	WDEL - AM 1150 KHz WDEL - FM 101.7 MHz WSTW - FM 93.7 MHz WJBR - AM 1290 KHz WJBR - FM 99.5 MHz
Kent County	WDOV - AM 1410 KHz WRDX - FM 94.7 MHz WAFL - FM 97.7 MHz
Sussex County	WZBH - FM 93.5 MHz WOSC - FM 95.9 MHz
Statewide Traffic Information	WTMC - AM 1380 KHz

In addition to the State Emergency Operations Center and the Delaware State Police Communications Center in Smyrna, activating points for the DENS include the primary emergency 911 centers in each county and Wilmington. DENS can provide emergency notifications to the entire state or to an area as specifically defined as 10 houses on one street. Calls from DENS will include the name of the agency that activates the system, the type



of emergency, recommended protective actions (if any) and resources for obtaining additional information. Appropriate Emergency Alert System radio stations and television stations will also be provided in the message.

Multiple phone numbers may be registered. You can learn more about DENS and register for the service by visiting dema.delaware.gov/services/DENS.shtml.

Smart911. Smart911 is a free, national safety service that every county in Delaware participates in. Smart911 allows residents to create a safety profile for their household that populates the 911 database with vital details for emergency responders. For example, the profiles can record the number of family members living in the household and any mobility needs and health conditions, such as epilepsy or autism. Households can identify pets and the location of household exits to further aid fire and rescue. Over 80% of calls made to 911 come from cell phones. When you dial 911 from a cell phone, emergency responders have little information to help locate your address–only a general location. Smart911 allows you to register that cell phone number to your address, which can mean the difference between life and death when every second counts.

To register your profile on Smart911, visit www.smart911.com. Remember to periodically update your profile to keep the information on your household current. Smart911 is a secure system and your information is only available to the 911 call taker if you place a call from the phone number associated with your Smart911 account.

Emergency Alert System. The Emergency Alert System (EAS) is the official source of all hazard information and instruction in the state. EAS information can originate from county, state, or federal agencies. For example, the EAS network disseminates warnings and/or instructions from the governor's office during 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 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 radio stations around Delaware that have a wide circulation and specialized equipment including decoders and backup generators for use during emergency situations (see Table 4-1).

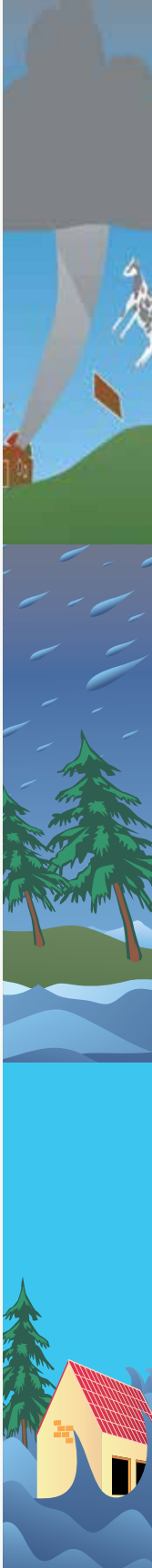
Additional Emergency Alert Resources. Other means of alerting individuals to emergency situations include:

- NOAA All-Hazards Radio provides an excellent source of up-to-date, real-time emergency information.
- Police and fire department personnel may use loudspeakers and make door-to-door contacts.
- Local news media may provide up-to-date, real-time emergency information.

4.6 PREPARATIONS BEFORE A HURRICANE OR COASTAL STORM

The following precautions should be taken well before a hurricane or severe coastal storm arrives:

- 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 at its 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. However, valuables such as jewelry should not be taken to a shelter.



- 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 and fill fuel cans for generators.
- Deploy window protections well in advance of the arrival of any winds. For those who have already prepared plywood shutters, partial deployment could begin before there is any official hurricane or coastal storm warning. Closely monitor advisories and warnings to guide your deployment (see Part 5).
- 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.

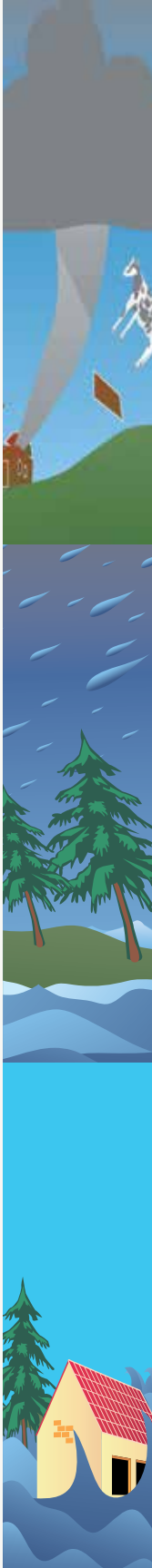
4.7 EVACUATION PROCEDURES FOR A HURRICANE OR COASTAL STORM

Your emergency supplies 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 (e.g., a 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 prepared your house and made plans for your pet. Shelter locations are not designated in advance, but are determined based on the type and location of hazard event. If you plan to go to a shelter, listen to your local radio or television station for information about the closest open shelter location.

- As a general guideline, you should evacuate if emergency responders tell you to and/or you are located along:
  - low-lying coastal areas;
  - low-lying areas subject to flooding (for example, near a stream or river);
  - 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;
  - ridge lines exposed to strong winds;
  - certain wood-frame structures (e.g., single wall without a continuous load path design) or lightly constructed buildings.
- Develop contingencies for pets, neighbors and family members with health or mobility needs.
- Go to a shelter if you are unable to evacuate out of the area to stay with friends and family. Listen to your local radio station or connect to redcross.org for a list of shelters that are open to the public. Local television stations may also provide this information.
- When you get to an evacuation shelter, you will have limited space and there may be a bare floor. You should plan to provide your own bedding and other essentials such as personal hygiene items and medications. Your evacuation kit should contain all of these important items.
- Local emergency management officials and/or shelter staff will provide notification when it is safe to return home.

4.8 PREPAREDNESS, SAFETY AND EVACUATION PROCEDURES FOR A FLOOD

Most flash floods are caused by slow-moving thunderstorms, thunderstorms that move repeatedly over the same area, or heavy rains from tropical storms and hurricanes. Each year, more deaths occur due to flooding than from any other hazard. People underestimate the force and power of water. Many of the deaths occur in automobiles, as they are swept downstream. Whether you are driving or walking, if you come to a flooded road, “turn around, don’t drown.” You will not know the depth of the water nor will you know the condition of the road under the water.[4.1]



If you are in a flood warning area or if flooding occurs, get to higher ground immediately. Never attempt to cross swiftly flowing water or waters of unknown depth by foot. There could be open manhole covers and stormwater drains as well as debris underwater. Do not attempt to cross flowing streams, even a small one, on foot. Roadbeds may be washed out under flood waters. Never drive through flooded roadways and do not attempt to cross water-covered bridges, dips, or low water crossings. Be especially cautious at night when it is harder to recognize flood dangers. Even 6 inches of water can make you fall or cause your car to stall.[4.1] Two feet of moving water can float 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.

4.9 PREPAREDNESS AND SAFETY PROCEDURES FOR A TORNADO

Tornadoes can occur at any time of day, any day of the year. Keep in mind that even though the weather may be calm at the time a Tornado Watch or Warning is issued for your area, conditions can rapidly deteriorate and become life threatening. Remain alert for signs of an approaching tornado such as a dark, often greenish sky, large hail, or a loud roar similar to a freight train.[4.2]

The safest place to be is an underground shelter, basement, or safe room. If no underground shelter or safe room is available, a small, windowless interior room or hallway on the lowest level of a sturdy building is the safest alternative. Mobile homes are not safe during tornadoes. Abandon mobile homes and go to the nearest sturdy building or shelter immediately.

If you are caught outdoors and cannot get indoors to seek shelter, immediately get into a vehicle, buckle your seat belt, and try to drive to the closest sturdy shelter. If flying debris occurs while you are driving, pull over and park. Stay in your vehicle with the seat belt on. Put your head down below the windows, covering with your hands and a blanket if possible. If you can safely get noticeably lower than the level of the roadway, exit your car and lie in that area, covering your head with your hands.[4.2]

4.10 EMERGENCY INFORMATION AND CONTACTS

The best time to prepare is long before an emergency or disaster. During these “blue skies” you can use your local and state emergency management

agencies as resources to plan and prepare for “grey skies” events. During an event, if you absolutely need help, contact your local first responders and emergency management agencies. But understand that they may be responding to hundreds or even thousands of calls, and it may take considerable time for them to be able to reach you. By planning and preparing now, you can make sure that you are ready to help yourself and your neighbors in the event of an emergency. Make a plan, make a kit and stay informed!

For general emergency information, contact your local emergency management agency (municipality or county), visit Prepare Delaware online (www.PrepareDE.org) or on Facebook (www.Facebook.com/PrepareDE), or use the Delaware Emergency Management Agency (DEMA) General Contact Form (www.dema.delaware.gov/dema-contact.shtml). DEMA and its partner Delaware Citizen Corps works with many volunteer, non-profit, private and state organizations to promote emergency preparedness through community engagement, training and education, and volunteerism. The Prepare Delaware website (www.PrepareDE.org) is a partnership with the Division of Public Health Office of Preparedness and provides emergency information and important resources.

See Appendix A for a list of emergency contact information.

Part 5
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. It's never too early to prepare, and you can take several basic steps right now to protect your family and your home from disaster. By strengthening your house, you can reduce the risk of damage to your home and possibly reduce insurance premiums.

The amount of protection your house can provide from a natural hazard is limited by a number of factors that you should very carefully consider:

The Severity of the Hazard Event

Protecting your home against a nor'easter or a tropical storm is much easier than against a major event such as a Category 2 hurricane. For stronger storms, eliminating all damage is very difficult, so the main goal is to significantly lessen the amount of damage that could occur. Each and every small improvement you invest in your home can make a difference. The more small improvements you make to your home, the less likely there will be severe damage during minor events.

Your Location

Buildings in proximity to water are much more likely to flood, even during minor storm events. These flooding events can threaten you and your family, and evacuation should be considered even during minor events. In addition, if your home is close to an open beach, a large bay, or a large marshland area, the force of the wind can be much greater than if the house were surrounded in all directions by buildings, other homes and/or trees. Erosion is also at play in our dynamic coastal environment. Homes that appear to be located on a stable shoreline with adequate dune structure may become more at risk as sea level rise advances and the dunes erode.

How and When Your House Was Built

Building codes adopted by some counties and communities require new houses to have connectors that create a continuous load path from the

roof to the wall to the foundation. Because of this requirement, many newer homes in coastal areas are generally much stronger than those built before this requirement was in effect. It is important to note, however, that building codes provide minimum requirements, not best practices. Most of the buildings in the state are older than 10 years and thus built without the benefit of many of today's building standards.

How Your House is Maintained

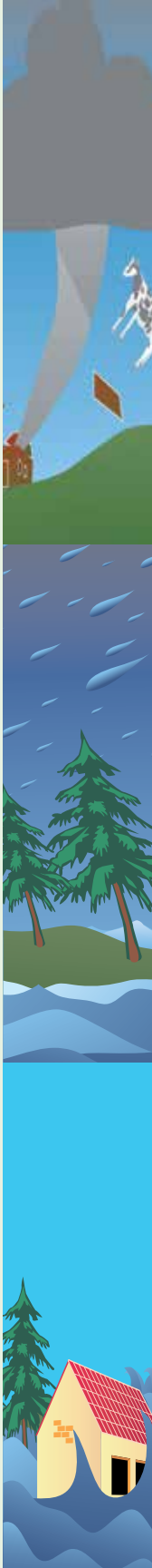
Maintenance of your house is important. Painting the exterior every five years protects the wood and prevents rot, which can weaken the structure. Termites can also weaken a wood-framed house. If the wood in the house is rotten or has severe termite damage, it will be more difficult and more costly, or even impossible, to strengthen the home. In the coastal areas of Delaware, there are many places where houses are on crawl spaces and where standing water or high water tables are prevalent. It is important to keep moisture from intruding into the wood of the home and causing decay. Proper maintenance will extend the life of a house in more ways than one.

How Well You Strengthen Your House

Even if your house was not built with hurricane clips or does not follow continuous load path concepts, there are many small steps and some major ones that can be taken to retrofit or address how to strengthen your existing home.

The remainder of Part 5 concentrates on many of the options to consider when strengthening your home, whether you're designing a new home or planning a retrofit of an existing home, including:

- Roof-to-wall connections (e.g., hurricane clips), improving the connection of the roof-sheathing to roof-framing members (rafters or trusses), and reinforcing gable ends with bracing;
- Wall-to-foundation connections;
- Stronger connectors than those required in the current building code;
- Flood retrofit measures (strengthening existing foundations and piers for flood forces, elevating mechanical equipment and elevating structures);
- Protection for windows, doors and garage doors; and
- Alternate sources of back-up electricity.



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 structural engineer and/or architect to plan the strengthening and retrofitting program for your home and a licensed contractor to do the installation or construction. 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.

The complete topic of retrofitting existing homes has been tackled by numerous nonprofit organizations and governmental agencies and the result of their hard work fills many reports and several excellent videos.

The following sources can give you more information:

- The Insurance Institute for Business and Home Safety (IBHS) website (disastersafety.org) includes numerous articles, reports and videos that are extremely informative and explain preventative measures that reduce losses from all natural hazards, including hurricanes.[5.1] IBHS has a retrofit guide that is used in their FORTIFIED for Existing Homes Program.
- The Mitigation Directorate of FEMA is continuously researching hurricane-resistant designs and building methods for the construction of residences and the performance of residences that have been subjected to hurricanes. All of the government publications are available for free and most can be downloaded from the FEMA website (fema.gov) and the agency's *Safer, Stronger, Protected Homes and Communities* page (fema.gov/safer-stronger-protected-homes-communities).[5.2] FEMA released a publication on retrofitting existing homes called *Wind Retrofit Guide for Residential Buildings* (FEMA P-804), which is available at fema.gov/library.

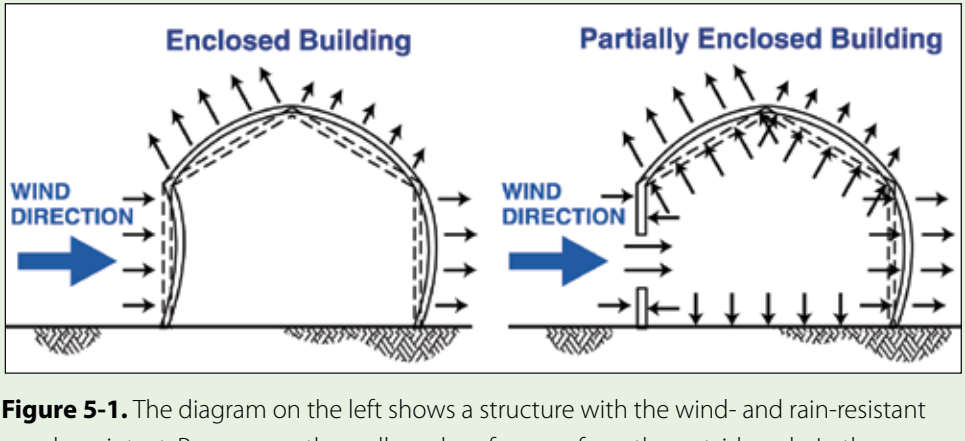
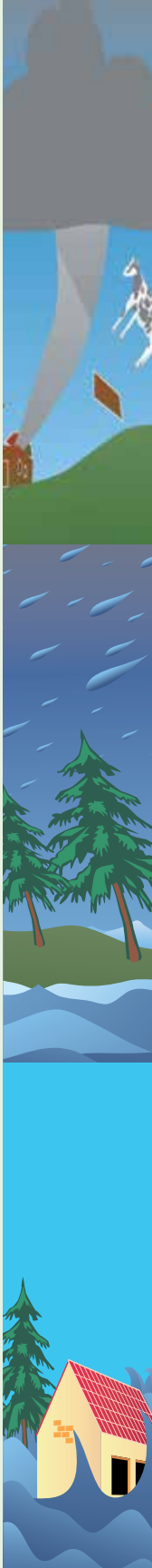


Figure 5-1. The diagram on the left shows a structure with the wind- and rain-resistant envelope intact. Pressure on the walls and roof comes from the outside only. In the diagram on the right, the structure's wind- and rain-resistant envelope has been breached due to a broken window. Now, pressure on the walls and roof comes from the outside and inside. The total amount of pressure on the roof and leeward wall increases significantly and can lead to the roof flying off and complete structural failure. Source: FEMA's *Residential Coastal Construction Manual* (2011)[5.3]

5.1 CREATING THE WIND- AND RAIN-RESISTANT ENVELOPE

It is very important to protect the envelope of your house from wind and rain. The wind from a coastal storm, especially a hurricane, attacks any weaknesses in the roof. Once a weakness is exposed, adjacent areas can be more easily damaged and peeled away. 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 (see Figure 5-1).

A door or window breach can potentially double the uplift forces on your roof and can significantly increase the chances that your roof will lift off.[5.4] Several FEMA hurricane mitigation assessment reports indicate that breaching of the building envelope and subsequent internal pressurization leads to progressive structural failure for many houses.



5.1.1 KEEP YOUR ROOF ON

The wind from a hurricane attacks any weakness 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.

Roof Framing/Truss Bracing

There are generally three ways that roofs and roof systems fail in high winds:

- Roof sheathing can be pulled off the roof framing by high-suction wind pressure.
- Roof framing can fail at the roof-to-wall connection.
- Gable end walls can collapse into the attic space or be pulled out from the exterior wall.

Failure of the roof sheathing can be prevented by ensuring the sheathing is adequately attached to the roof rafters or trusses. This can be done from the outside of the roof at the time the roof covering is replaced. Add nails (8d ring-shank nails are recommended) at a minimum spacing of 6 inches on center around the edge of the roof sheathing before re-applying the roof covering. The sheathing may also be secured to the framing from inside the attic by using closed-cell expansive foam to form a bond between the edge of the roof rafter or truss chords and the underside of the roof sheathing.

Roof-to-wall connections can be accomplished on existing homes in several ways:

- Roof sheathing can be removed while replacing the roof covering, and a connector can be attached from the exterior wall to each rafter or truss. The roof sheathing is then re-installed, and the roof covering is replaced.
- The soffit on the outside overhang can be removed, a new 2"x4" board installed on the exterior siding parallel to the roof, a new connector attached to the rafter or truss, and then installed on the new board and the soffit re-installed.
- A section of drywall or interior wall and roof covering can be removed on the inside of the home, new connectors installed on the inside between the rafters or trusses, and then crown molding or other

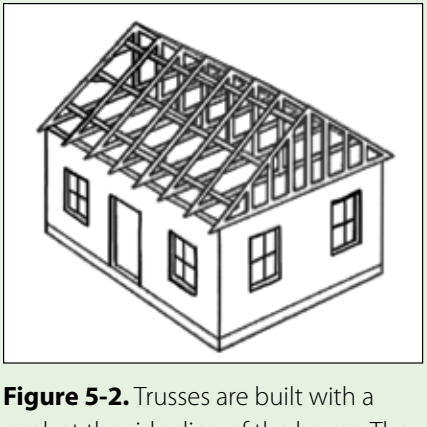


Figure 5-2. Trusses are built with a peak at the ridgeline of the house. The trusses at the end of the house form an A-shaped pattern know as a gable end. During a hurricane, the gable end is subject to great forces from the wind and could tip over, collapsing the other trusses in a domino fashion. Source: FEMA's *Against the Wind* brochure 247

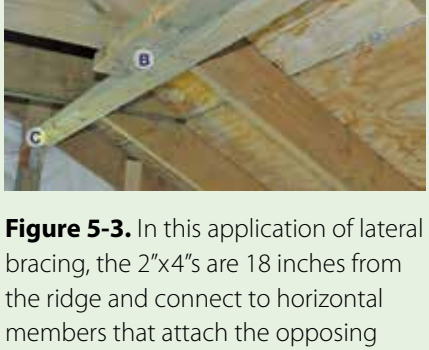


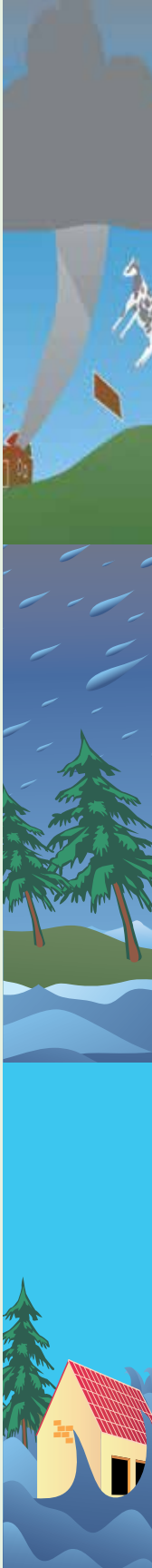
Figure 5-3. In this application of lateral bracing, the 2"x4"s are 18 inches from the ridge and connect to horizontal members that attach the opposing trusses. Not all roofs will have the horizontal members. The 2"x4"s are connected with two #14 3-inch screws (A) and overlap over two trusses (A and B). The end is connected to the gable end with an angle or L bracket (C). Image courtesy of Dennis Hwang

architectural treatment installed to cover the new connectors.

It is possible to significantly strengthen your roof by providing lateral and diagonal bracing to the rafter or trusses. This is particularly important for houses with gable-end roofs. This bracing can be done simply with 2"x4" boards purchased at a hardware store. Figure 5-2 is from the FEMA brochure *Against the Wind* (FEMA 247), which can be downloaded at fema.gov/library. Also consult *Wind Best Practices* at the same website: fema.gov/library

For lateral bracing, 2"x4" boards are attached to the trusses that run the length of the roof (Figure 5-3). The 2"x4" boards overlap over two trusses. Braces should be 18 inches from the ridge, in the center and at the base, about 8 to 10 feet apart. You or a professional can do this work, although this can be difficult with long pieces of lumber in small attics. This bracing should have been installed when the trusses were installed in newer homes.

Another important type of bracing for your gable end involves making diagonal braces (Figure 5-4). Diagonal braces provide additional support against collapse of the gable end caused by high winds pushing (or pulling) on the gable end. Gable ends are more susceptible to high-wind damage because they are usually installed between the exterior



wall of the house and the roof rafter or truss. There is a joint in the wood framing at that point, making the connection of the gable ends a weak link in the load path.

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.

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 or spray polyurethane foam (Figure 5-5).

FEMA provides guidance on these subjects in its *Home Builder's Guide to Coastal Construction* (FEMA 499) and *Wind Retrofit Guide for Residential Buildings* (FEMA P-804). An additional source of information regarding roofs and how to reduce risks from high winds can be found at the IBHS website, disastersafety.org.[5.5] The site includes information

Figure 5-4. 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. Source: FEMA's *Against the Wind* brochure 247

Figure 5-5. Spray polyurethane foam is used to add strength between the rafters and the plywood sheathing. This method can be used to strengthen existing roofs and may negate the need to replace older roofs. It can also be used where fasteners are missing or at the corners of hip style roofs or the ends of gable end roofs, which are especially susceptible to wind forces. See FEMA publication numbers P-499 and P-804. Image courtesy of FEMA

on re-nailing roof decks, maintaining steep-sloped roofs, guidance for re-roofing, and choosing a roofing material.

Continuous Load Path Connections

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. The concept of continuous load path connection is illustrated in Figure 5-6. This connection ties your roof to your home's foundation and helps to keep the roof from blowing off during a severe wind event.

Naturally, all houses have some connection from the roof to the foundation; otherwise, they would fall apart. However, in some coastal areas, much stronger connections

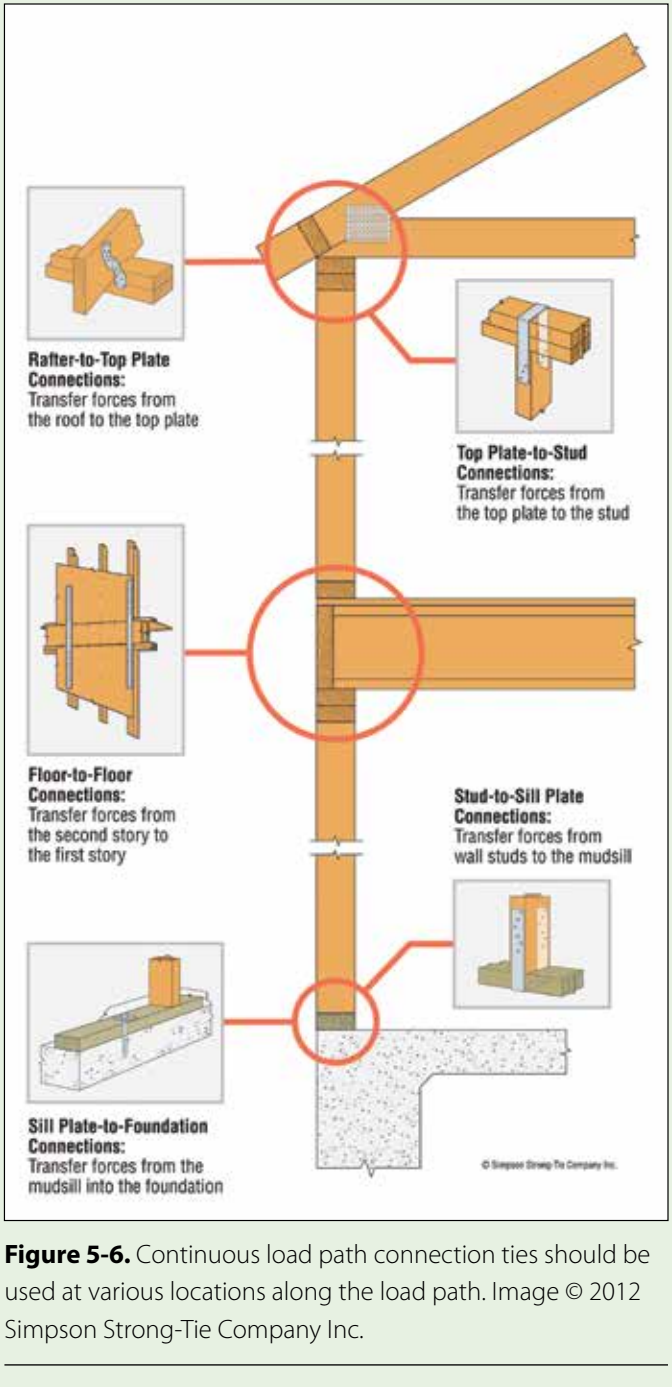
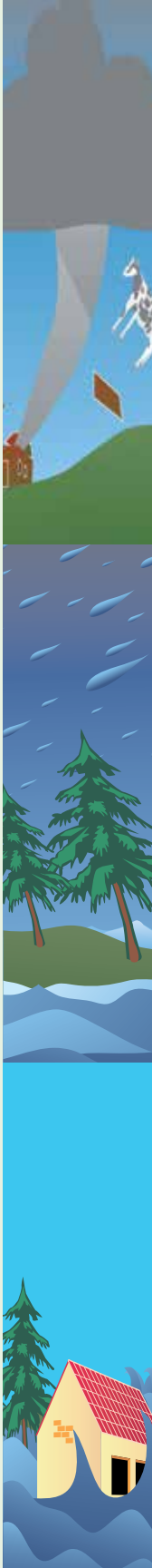


Figure 5-6. Continuous load path connection ties should be used at various locations along the load path. Image © 2012 Simpson Strong-Tie Company Inc.



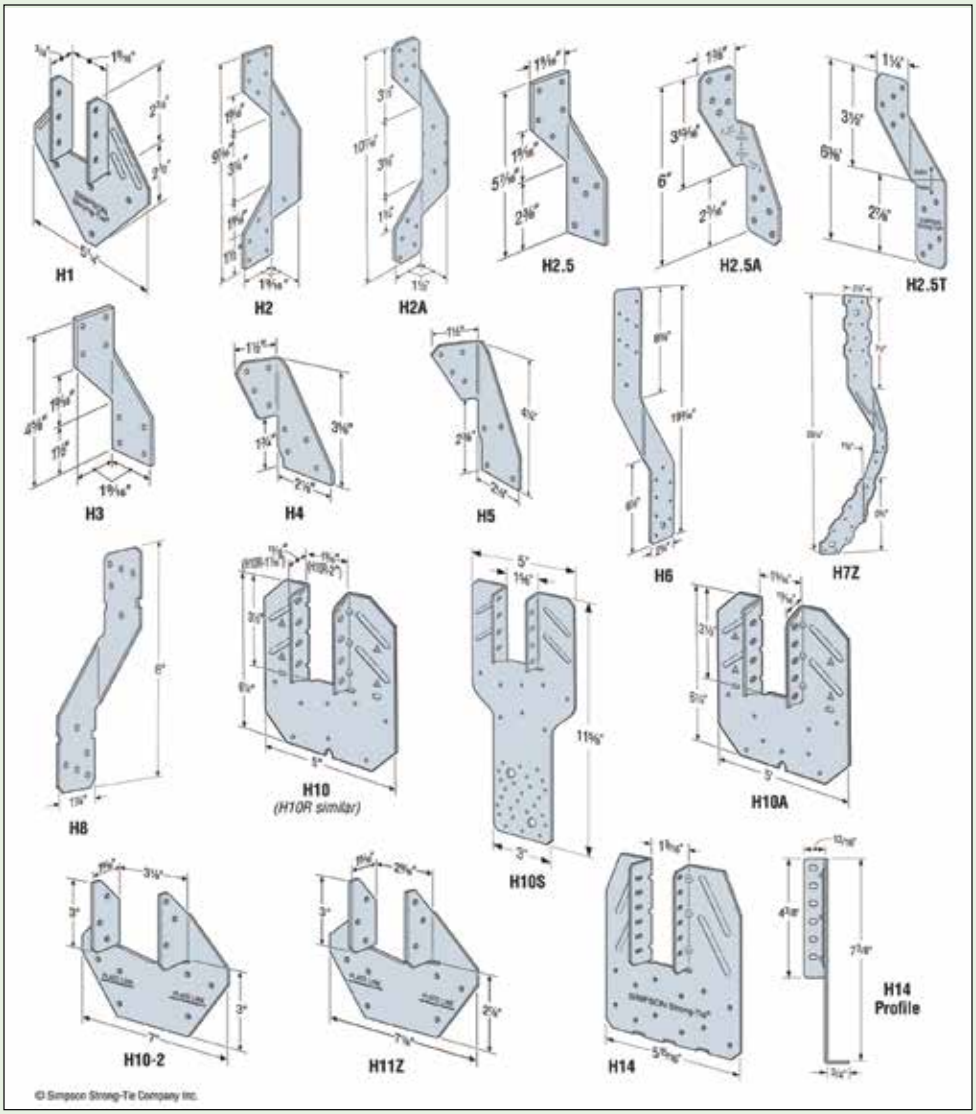


Figure 5-7. There are many different types of hurricane clips. Your licensed architect, structural engineer, or contractor can tell you what is suitable for your house for the amount of protection you want. Image © 2012 Simpson Strong-Tie Company Inc.

are now required in the form of straps, anchors and hurricane clips to protect against extreme winds from coastal storms, as depicted in Figures 5-7 and 5-8. A properly selected hurricane clip is required for each rafter. In addition, the rafters at gable end eaves should be strapped down. Exterior

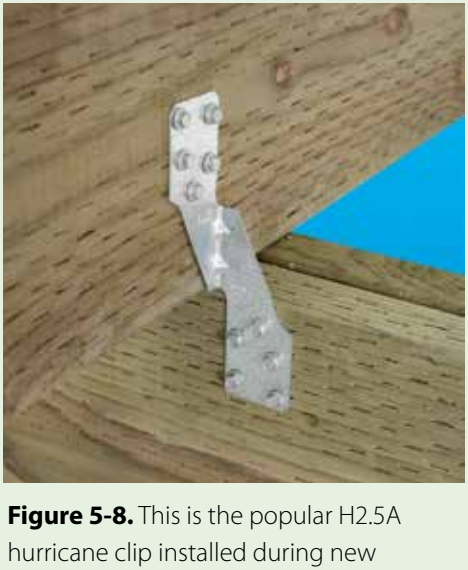


Figure 5-8. This is the popular H2.5A hurricane clip installed during new construction of houses. Five screws are driven into the lower beam (or top plate) and five more are used for the roof (truss-rafter) connection. A hurricane clip is required for each truss-rafter. Upon completion of this structure, the hurricane clip will be hidden from view. For a dollar or less in material cost, clips can be installed for both new and retrofit applications. Image © 2012 Simpson Strong-Tie Company Inc.

Figure 5-9. 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. Image courtesy of Dennis Hwang

beams supported by corner columns also require strap down. For houses with post and beam roof construction, fasteners should be installed 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 5-9).

You should seek a licensed structural engineer or architect 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.

Building Beyond Code Requirements

Building beyond code requirements can minimize damage and result in a home that is more wind and flood resistant. For many homeowners, even minor damage of 15% or less can be an extreme hardship. After Hurricane Ike (2008) in Texas, FEMA conducted an assessment of both wind and flood building performance and determined the following:

> As is frequently observed during Mitigation Assessment Team (MAT) investigations, damages to buildings and other structures are routinely produced by less than design wind speeds due to the following: lack of understanding of basic wind-resistant design and construction practices; insufficient codes and standards at the time of construction; insufficient or lack of design guides and/or test methods at the time of construction; and improper or non-compliant building modifications or lack of maintenance by the property owners.
>
> Overall, the damages observed by the MAT were consistent with typical wave damage patterns, where damage to properly designed and constructed elevated homes is generally minor until such time as the waves reach above the elevated floor system, at which point the damage increases dramatically with increasing water level and wave height. Performance of residential building foundations with regard to coastal and near-coastal hazards depended primarily on the residence having adequate elevation, proper construction and proper foundation selection. If any of these criteria were not satisfied, performance suffered.[5.6]

In Sussex County's designated coastal wind zone, recently built houses are required to have the complete load path connection. For older houses, it is possible to retrofit to add components of the connection (see Figures 5-6 and 5-7). 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.

Strengthening the foundation to resist uplift will generally require the removal of interior finishes. The installation of uplift connections should be planned by a licensed structural engineer and only after they have inspected the home to understand materials and methods used to construct the home and have calculated the wind uplift requirements.

Figure 5-10. Synthetic underlayments are typically made from polypropylene, polyester, or fiberglass fabric, which weighs less than felt building paper, can be manufactured with anti-slip surfaces, and can withstand exposure to the elements for six months. Image courtesy of Carlisle Coatings & Waterproofing

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 and improve the performance of the home during weaker wind events. Should Delaware experience a design wind event of nearly 120 mph however, houses without a strong floor-to-foundation connection are still expected to fail.

Synthetic Roof Underlayment

Until the 21st century, most residential sloped roofs received a layer of asphalt-saturated felt building paper underneath the roofing material. Mimicking the attributes of house wraps, synthetic roof underlayments (Figure 5-10) are now available that serve the same function as a secondary weather barrier with better resistance to tearing, moisture and ultraviolet rays than traditional roofing felt.

Recent natural disasters and subsequent rebuilding efforts have highlighted the versatility of synthetics as roof underlayments by providing a real-life test environment. After several hurricanes ravaged southern coastal areas of the United States, many people were forced out of their damaged homes. At the same time, large numbers of homes required quick roof repair and "drying in" to minimize further damage due to water intrusion. With limited resources, contractors triaged homes, repairing the critical components and installing synthetic underlayments as temporary roofing. The underlayments performed better than FEMA's blue tarps and did not require removal and discarding when the new shingles were installed.[5.7]

5.1.2 KEEP WATER OUT

Flood Prevention

Protecting your property from flooding can involve a variety of actions, from elevation to inspecting and maintaining the building to installing protective devices. Most of these actions, especially those that affect the structure of your building or their utility systems, should be carried out by qualified maintenance staff or professional contractors licensed to work in your state, county, or city. The most important information to know about your home when considering flood prevention techniques is the relationship between the base flood elevation (BFE) shown on the Flood Insurance Rate Map (FIRM) for your community and the elevation of your lowest floor (the one that would get wet if flooded).

FEMA's National Flood Insurance Program (NFIP) website (floodsmart.gov) provides detailed information on flooding and flood risks, including a tool that calculates the cost of flooding on different types of homes: floodsmart.gov/why/why-buy-flood-insurance.

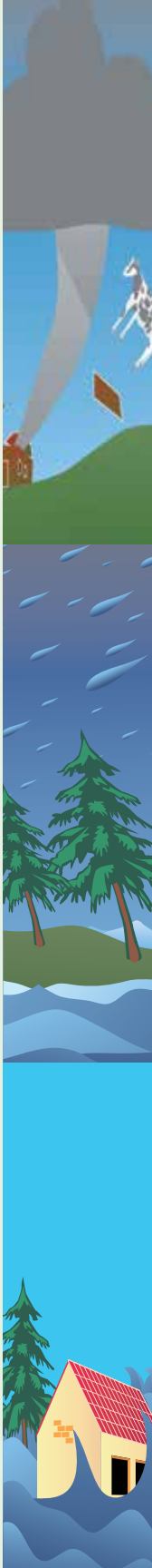
The best way to reduce damage from floods for residential structures in a flood-prone area is elevation. An excellent source of information about floods and protecting your property from flooding is found on FEMA's *Ready–Prepare, Plan, Stay Informed* website (ready.gov/floodawareness). Additional information is available in FEMA's *Coastal Construction Manual* (FEMA P-55), *Protecting Your Property from Flooding* (fema.gov/media-library/assets/documents/13261), *Home Builder's Guide to Coastal Construction* (FEMA P-499) and *Homeowner's Guide to Retrofitting* (FEMA P-312).

Wet Floodproofing

For those homes not located in a special flood hazard area and if local regulations allow, you could consider the option of wet floodproofing your home. Wet floodproofing means modifying the uninhabited portions of the house, such as a crawlspace, so that floodwaters can get in but won't cause significant damage. It may be a practical solution for parts of the house that are not living space. Remember that wet floodproofing does nothing to alleviate the threat from fast-moving floodwaters, which are often a major cause of damage.

Wet floodproofing encompasses a variety of measures:[5.8]

- Use Flood-resistant Materials—Materials have differing abilities to resist flood damage. Flood resistance classifications have been developed for flooring, wall and ceiling materials, and the adhesives used to install them. These classifications are published by FEMA and are listed in *FEMA Technical Bulletin 2: Flood Damage-Resistant Materials Requirements* (fema.gov/library). Examples that can be very attractive and flood resistant include clay tile, stone, or brick with waterproof mortar; solid vinyl flooring with chemical-set adhesives; stained concrete; terrazzo; decay-resistant or pressure-treated woods; and rigid, closed-cell foam insulation.
- Create Flushable, Drainable Walls—In wet floodproofing, floodwater should be able to flow into and drain out of walls and other cavities to prevent damage from water pressure and keep the wall cavity from trapping contaminants. After flooding, there should be a way to drain, clean and dry these spaces easily to remove silt and contaminants and prevent the growth of harmful fungi and bacteria. Consider removable wide baseboards or wainscoting.
- Flood Openings—Openings or vents in the house's foundation or enclosure walls that allow for floodwaters to enter and exit the structure, relieving some of the pressure of standing or slow-moving water against them (called hydrostatic loads). If the lowest floor of a house below base flood elevation does not have openings, the walls can fail during a flood. Consult FEMA Technical Bulletin 1 *Openings in Foundation Walls and Walls of Enclosures* for more information: fema.gov/library
- Elevate Appliances and Utilities—Items to elevate include your outside air conditioner compressor, inside furnace or air-conditioning unit, washer and dryer (choose front-loaders if on platform), water heater, freezer, and electrical outlets and switches. Also substitute cooktop and wall ovens for freestanding range or drop in units. An appliance can be elevated by placing it on a sturdy, flood-resistant platform or a strong shelf, which is securely attached to a structural support that can withstand flooding. If wood is used, it should be solid, pressure-treated lumber.



- Install Barriers around Appliances—Build a mini flood wall around appliances where shallow-depth flooding occurs often or set the washer and dryer on sturdy plastic sheeting or bags that can be raised during a flood threat.
- Add a Storage Building above Flood Levels—Relocate some appliances to a new building built high enough to be safe from flood damage. Keep enough space available in it to store valuable furnishings during a flood threat. Construction of the building may be subject to regulation.

Keep these points in mind when you wet floodproof:[5.9]

- Activities that involve work on the electrical system, gas, or air-conditioning compressor usually require the services of a licensed contractor. Check with your local permit official to find out about requirements in your area.
- Raising the electrical system above flood levels will protect it from water damage, but it won't make it safe to have service turned on while water is in the building.
- Even when a home is allowed to flood, sewage backflow prevention is important to prevent the serious health hazards and more expensive cleanup procedures associated with that type of contamination. A backflow valve should be installed.
- Since wet floodproofing does not keep the structure dry, cleanup is very important. Even if you successfully stop sewage backup through your plumbing, there is a good chance water coming in from outside has some chemical and biological contaminants. Disinfection, cleansing and thorough drying are essential to remove contamination and to prevent growth of hazardous molds and decay.
- Wet floodproofing activities will not reduce your flood premiums, so the motivation for this activity should center on reducing the damage caused by flooding. During a flood event, you may still be required to evacuate by local emergency management officials.

Dry Floodproofing

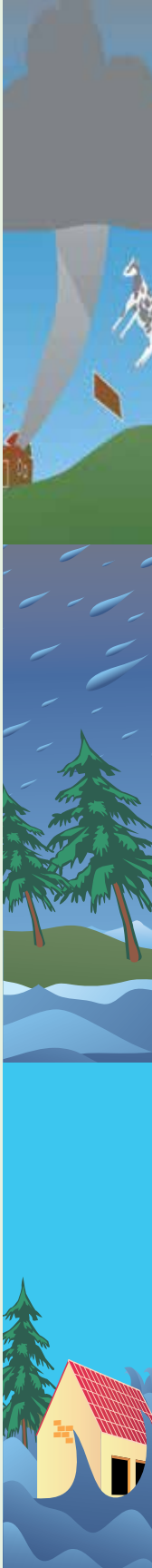
When elevation is not an option, another way to protect a structure and its contents from flood damage is to seal the building so that flood waters

cannot enter. Dry floodproofing is primarily for slab on grade buildings with concrete or solid masonry walls. It cannot be used to put residential structures in compliance with the National Flood Insurance Program. It may have application in sturdy, structurally sound buildings in areas of shallow, low-velocity flooding. Check with your state flood plain coordinator and local NFIP regulator for applicability. In addition, this flood protection method is not for buildings located in coastal high hazard areas like V zones or coastal A zones (as designated on FEMA Flood Insurance Rate Maps). These special flood hazard areas are not only subject to inundation by the 1-%-annual-chance flood event, but are also subject to additional hazards due to storm-induced velocity wave action.

You should consult a design professional before undertaking a dry floodproofing project. Dry floodproofing is not effective when water velocities are high, when waves are present, or for rapidly rising water. Dry floodproofing is appropriate primarily for slab-on-grade buildings with concrete or solid masonry walls. Concrete and masonry are easier to seal, more resistant to flood damage and stronger than other materials.[5.8]

Dry floodproofing encompasses a variety of measures:[5.8]

- applying a waterproof coating or membrane to the exterior walls of the building;
- installing watertight shields over doors, windows and other openings;
- anchoring the building as necessary so that it can resist flotation;
- installing backflow valves in sanitary and storm sewer lines;
- raising HVAC and electrical system components above the flood level;
- anchoring fuel tanks and other storage tanks to prevent flotation;
- installing a sump pump and foundation drain system;
- strengthening walls so that they can withstand the pressures of flood waters and the impacts of flood-borne debris;
- building with materials that are flood-resistant, i.e. can withstand flood waters for at least 72 hours (examples: concrete, ceramic tile, pressure-treated lumber, steel, metal, brick, epoxy paint, foam and closed-cell insulation); and



- ensuring wells are properly constructed to avoid contamination from floodwaters.

Keep these points in mind when you dry floodproof:[5.8]

- There are several disadvantages to dry floodproofing. Flood insurance premiums are not reduced for dry floodproofed residential structures. Ongoing maintenance is required, adequate warning time is required to close any openings and the home must not be occupied during a flood.
- The height of your dry floodproofing should not exceed 3 feet. The pressures exerted by deeper water can cause walls to buckle or collapse. Before you use dry floodproofing to protect against greater flood depths, have a structural engineer evaluate the strength of your walls.
- If your dry floodproofing measures require human intervention before flood waters arrive, such as placing shields over doors and windows, you should have an operations and maintenance plan that describes all the actions that must be taken and lists the people who are responsible. It should also include a schedule of periodic maintenance that states how often the dry floodproofing measures will be inspected and who will perform the inspections.
- The cost of individual dry floodproofing measures will vary with the size, condition and use of your building; the dry floodproofing height; and the extent to which you use contractors and engineers.
- 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.

5.1.3 WINDOW AND DOOR COVERINGS

Protection of your home's envelope from breaches during a windstorm is critically important, particularly to its vulnerable windows and doors.

If your home is located in a high-wind zone, it is important that window coverings not only withstand hurricane-force winds, but also withstand wind-borne debris impacts. The usual standard for impact resistance is known as the "Large Missile Impact Test." Essentially, it determines whether a given covering can withstand the impact of a 9-pound 2"x4" board fired at 30+ mph.

Coverings should be tested and approved to meet industry standards for hurricane impact and should carry a label indicating such approval. Check with the manufacturer. Use only licensed contractors and reputable dealers selling products tested by reputable testing vendors.

Several types of window and door opening protection systems are generically described below. Within each category, numerous reputable manufacturers provide different products, each with individual features, benefits and costs. You should consult with a competent contractor specializing in supplying and installing these systems and visit the IBHS website (ibhs.org) for information on the FORTIFIED for Existing Homes Program.

Roll-down Shutters

Roll-down shutters represent the window covering type that is easiest to deploy and offers the best overall protection features (Figure 5-11). These are permanently attached to the building. The shutter consists of a movable "curtain" of slats that is held in place by vertical tracks. When not deployed, the shutter stores in a hood that is housed above the window or door being protected. Most of the components of roll-down shutters are made from extruded aluminum.

Because the roll-down shutter makes solid contact with the window sill, patio deck, or other structure at the bottom of the shutter and its farthest extent of travel, this shutter type demonstrates the highest level of protection against wind-driven rain in addition to wind and debris. Roll-down shutters can be deployed using a variety of operators—both manual and electric motor types. These can be installed directly over windows and doors, or in some cases, at a balcony's edge to form an enclosure.

Figure 5-11. Coastal home protected with roll-down shutters on all windows and doors. The shutter is held in place by vertical guide tracks and can be deployed manually or with an integrated electric motor. Image courtesy of QMI Inc.

Since roll-down shutters are easily deployed, they often are used on a regular (non-storm) basis for light control, insulation against heat and noise, or privacy and security. The variety of features and methods of operation leads to a wide range of costs for this shutter type. These shutters can be made for custom sizes and uses.

Accordion Shutters

One of the most commonly used shutter types in hurricane-prone regions is the accordion shutter (Figure 5-12). This is a permanently installed system with interconnected "blades" that operate between horizontal tracks. When not in use, the blades fold and are stored on either side of the door or window being protected. Accordion shutters are manually deployed and can be deployed from the inside of the home, if the opening is a single- or double-hung window or an in-swinging window or door.

Figure 5-12. Accordion shutter (shown in the open position) installed over a large window of a coastal home. Shutter has been installed to allow deployment from inside the home. Image courtesy of Roll-a-way

Decorative/Protective Shutters

For homeowners who wish to add a decorative flair to the home's exterior while protecting windows against storm forces, Bahama (or Bermuda) shutters are available (Figure 5-13). These are most commonly made using extruded aluminum frames and louvers, although some composite materials have also been used in these types of shutters. Typically, these are finished using a durable, exterior-grade powder coating or automotive-grade polyurethane paint system.

While these shutter types imitate the design of traditional wood shutters, it should be noted that no wood shutter of either type has been tested and approved as opening protection since wood will not pass the "Large Missile Test."

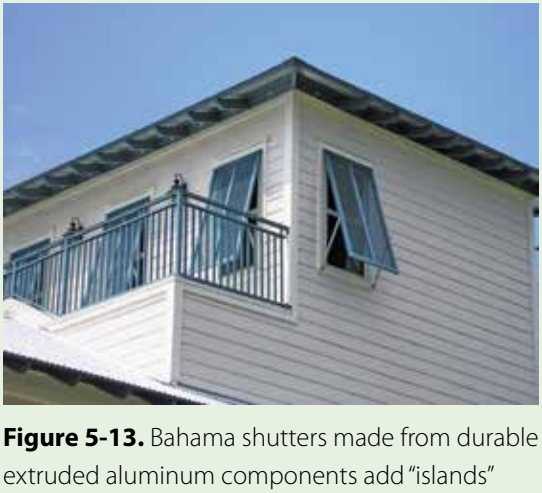


Figure 5-13. Bahama shutters made from durable extruded aluminum components add "islands" flair to a home and provide effective opening protection. Image courtesy of Roll-a-way

Figure 5-14. These 0.050 gauge aluminum storm panels offer cost-effective storm protection. In this example, panels slip into a track above the window and secure onto a bottom track using wing nuts. Image courtesy of Roll-a-way

Storm Panels

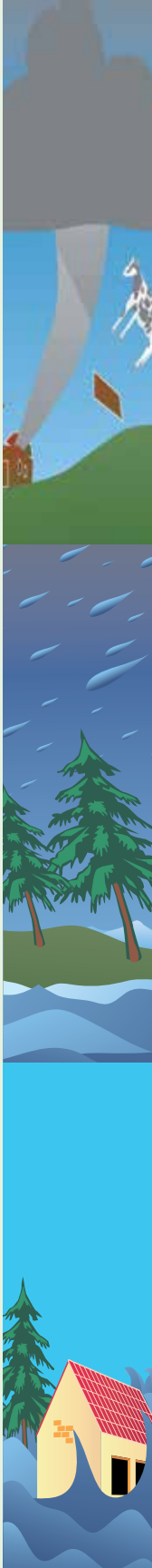
Removable storm panel systems (Figure 5-14) are one of the most widely used and cost-effective systems available for opening protection. These consist of a series of panels, made from steel, aluminum, or impact-resistant polycarbonate.

When not in use, panels are stackable for convenient storage. A wide variety of track options are possible. While these systems are relatively inexpensive, they require much more effort for the homeowner to deploy than the other types mentioned above.

In-Place Systems

Requiring no advance deployment, impact-resistant systems that are permanently installed on a structure can be an attractive option for opening protection. Two types currently on the market are impact-resistant stainless steel screen units and installed flat impact polycarbonate. Both have little, if any, negative aesthetic impact on the home.

Impact-resistant stainless steel screen systems (Figure 5-15) consist of a heavy-gauge,



stainless steel screen mesh that is secured in an extruded aluminum frame. The unit is installed over the window to be protected. These are available as operable units, which facilitates cleaning and emergency escape. Screen units also provide excellent solar shading characteristics.

Flat impact polycarbonate units (Figure 5-16) are available to protect most single and double window sizes and types found in residential homes. They are made from UV-stable, optical-quality grades of polycarbonate and provide excellent protection against all storm forces. Because these systems are not operable from the inside of the home, emergency escape from the home must be considered before installing this system.

Figure 5-15. In-place stainless steel impact screen protects several windows of a coastal residence. This system requires no deployment and provides shade. Image courtesy of Roll-a-way

Figure 5-16. Flat impact polycarbonate panels are installed directly over windows of a coastal home. This window covering provides excellent storm protection with minimal aesthetic impact. Image courtesy of Roll-a-way

Fabric Windscreen

Impact-resistant fabric panels (Figure 5-17) made from high-tensile-strength, geosynthetic fibers such as polyethylene or reinforced PVC have become increasingly popular for use as window and door protection. These systems are attached on opposite sides of the window or door, usually to permanently installed panel mates or tracks with mounting studs. The panels include integrated grommets, which facilitate the deployment of the windscreens.

The polyethylene fabric types, which are basket weave systems, allow some light and visibility through the deployed screens. Some models incorporate emergency escape zippers. The PVC types are somewhat translucent, allowing light in the dwelling, but do not allow visibility through the screen.

Geosynthetic screens have also been extensively employed to enclose large, even irregularly shaped openings (Figure 5-18). Because of the installation requirements of such systems, site-specific engineering is often required. Consultation with a contractor is recommended.

Figure 5-17. Polyethylene basket weave fabric windscreen deploys directly over ground floor windows of a coastal home. Image courtesy of Roll-a-way

Figure 5-18. Polyethylene basket weave fabric windscreen is deployed at edge of patio, enclosing the entire area. Image courtesy of Roll-a-way

Impact-resistant Windows and Glazed Doors

In order to withstand both wind pressures and impact from wind-borne debris, window and door manufacturers have developed products with both sturdier frames and laminated (impact-resistant) glazing (Figure 5-19). Such systems are available in a variety of styles, options and costs.

While impact-resistant openings offer deployment-free protection, the glass can still be broken (but remains in the frame). Also, while these products are often available to the consumer through home improvement stores, professional installation is highly recommended in order to ensure that proper attachment of the windows to the structure is achieved.

Figure 5-19. 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. Wind-generated debris may crack the glass, but the laminate will hold the windowpane together in the frame and prevent breaching of the wind- and rain-resistant envelope. After the storm, the glass will need to be replaced. Image courtesy of Dennis Hwang

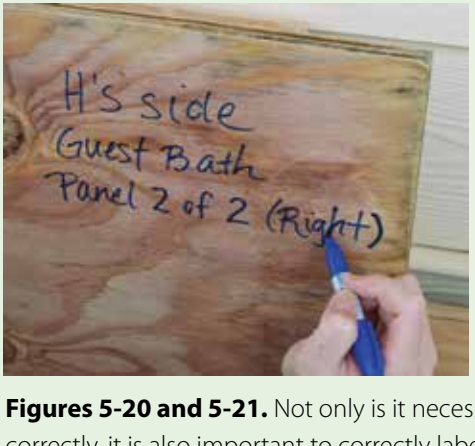
Plywood

Historically, plywood has been the most commonly used option for protecting window openings. This is undoubtedly due to its relatively low cost and ready availability. Plywood coverings offer protection for moderate level storms if properly installed (Figures 5-20 and 5-21).

Plywood can rot or warp if stored in a wet or warm area. Also, plywood is relatively heavy. You will need two people to help prepare and install plywood window coverings. Because of its weight, it would be difficult or even dangerous to install plywood if a ladder is needed. Thus, plywood shutters may be appropriate for easily accessible windows on the first floor, or windows that can easily be reached by a terrace or patio on upper floors.

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 windows.

A general recommendation is that you use at least 5/8-inch exterior-grade plywood for shutters. Thinner plywood is not as strong and did not perform as well during destructive Hurricane Andrew in Florida in 1992. While the International Residential Code (and other similar codes) allows some use of plywood as protection under very specific conditions, those allowances are restricted to areas where the design wind speed is 130 mph or less.



Figures 5-20 and 5-21. Not only is it necessary to install plywood opening covers correctly, it is also important to correctly label them and store them away from heat and humidity. Images courtesy of Dennis Hwang

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

Window Film

An after-market product used to enhance glass breakage prevention is commonly known as security window film. Such products are often touted as "hurricane film" or similar claims that cannot be substantiated by testing. Application of any of these window films to existing windows does NOT constitute adequate opening protection and should not be considered for use as opening protection. For more information, visit the website of the International Window Film Association (www.iwfa.com).[5.10]

Table 5-1 lists the advantages and limitations of each type of covering discussed above. For most homes, a combination of different covering types is employed, based on the needs and budget of the homeowner.

Impact-resistant Garage and Entry Doors

Among the most important yet overlooked openings in a home that require protection are its garage and entry doors. Most major suppliers of both types of doors offer products (with or without glazing options) that meet both wind- and impact-resistance requirements. Often, the replacement of a non-rated door with one of these newer types is cost-effective when compared to the cost of providing a covering for the older door.

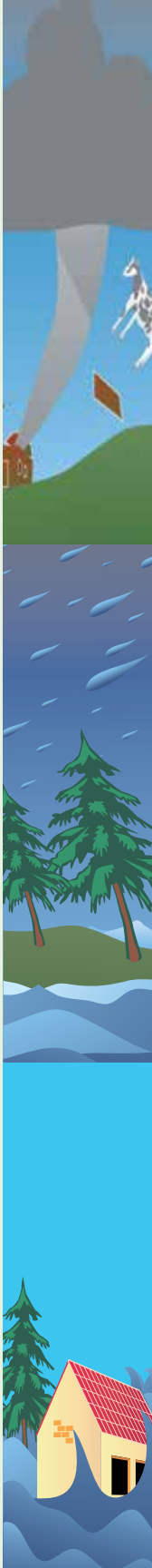


Table 5-1. Pros and Cons of Various Types of Window Protection

Type of Protection	Pros	Cons	Approx. Cost for 3'x4' Window Protection
Roll-down Shutters	Easiest to deploy; Good overall protection, especially from wind-driven rain	Most expensive of permanent shutter systems; Motorized versions need manual backup for power outages or an emergency power source	$360 to $600
Accordion Shutters	Easily deployed; Simple manual operation; Good overall protection; Modest cost	Possible aesthetic issues	$300 to $360
Bahama Shutters	Easily deployed; Good protection; Provides shade	Blocks some light and view	$360 to $480
Storm Panels	Strong; Removable; Relatively inexpensive permanent shutter system; Good protection for the costs	Manual deployment required; Requires adequate space for storage when not in use	$144 to $168
Stainless Steel Impact Screens	Always in place; Provides shade	Some aesthetic impact; Emergency escape issues must be considered; Less effective for wind-driven rain	$375 to $750
Flat Impact Polycarbonate Units	Always in place; Minimal aesthetic impact	Emergency escape issues must be considered; Care must be taken in cleaning	$375 to $525
Fabric Windscreen (Direct Mount)	Inexpensive; Easy to handle and store	Manual deployment required; Greater shutter deflection than metal systems	$105 to $180
Impact Resistant Windows and Doors	Attractive and energy efficient; Provides security protection and storm resistance; Always in place; Many styles and options	Costs vary widely and can be high; Replaces existing windows or doors; Glass can still break requiring expensive replacement	Wide range in costs: $360 to $600 and higher
Plywood	Materials readily available; Easy to install on lower levels; Inexpensive	Not as strong as some other shutter systems; Manual deployment is difficult on upper levels; Must be properly stored; Doesn't provide impact-resistance for winds >130 mph	$25 to $35 for materials only

Note: Be certain that purchased products (other than plywood) have been tested and approved to meet industry standards for hurricane impact and that they carry a label indicating such approval.

As with impact-resistant glazed windows and doors, a qualified professional installer should be used to install an impact-resistant garage or entry door. Doors that swing out are more storm resistant than in-swing doors because the door is closing against the door jamb, which provides resistance to the door being pushed in by high winds.

The garage door is a significant weakness in the building envelope due to its large area and the stress it is subject to from wind pressure (Figure 5-22).

Garage door options include:

- replacement with a stronger door;
- horizontal bracing;
- vertical bracing; or
- other type of a garage door bracing kit.

For many garage doors, vertical bracing is a popular and reasonably priced option (Figure 5-23).

Double entry doors should have slide bolts at the top header and bottom threshold of the inactive door, a dead bolt 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

Figure 5-22. Because of their width, double-wide garage doors are more susceptible to wind damage than single doors. The wind can force it out of the roller track, especially if the track is lightweight or some of the anchor bolts are not in place. This occurs because the door fails under excessive wind pressure. You should reinforce your garage door by installing horizontal and/or vertical bracing onto each panel, using wood or light gauge metal girds bolted to the door mullions. You may also need heavier hinges and stronger end and vertical supports for your door.[4.12] Image courtesy of Florida Hurricane Depot

Figure 5-23. Vertical braces such as these can be deployed during high-wind events to strengthen the garage door. The braces are secured from the header over the garage door to the fasteners installed in the concrete floor. Deployment and breakdown are about 10 minutes each. The windows have been covered with a laminate film. Image courtesy of Dennis Hwang

three hinges and a bolt long enough that goes into the 2"x4" framing of the door. Whenever entry doors are fortified, at least two of them must be operable for access and exiting at any time.

5.1.4 TREES

Cutting or trimming trees that overhang your house are additional measures that you can take to protect your property during a hurricane. Although trees provide a buffer to the full strength of the wind, there is a serious danger if there are large trees or limbs that are close enough to fall on the house. Few roofs are strong enough to withstand a falling 20-inch diameter, 40-foot tall pine tree.

Tree limbs or branches falling onto your house will cause considerable damage. Figure 5-24 illustrates the distance from the tree to the house to ensure that falling limbs do not affect the roof. If it is not possible to remove a tree, you can at least cut off all branches that hang over the roof of the house. Generally, you should hire a licensed tree trimmer to perform this work.

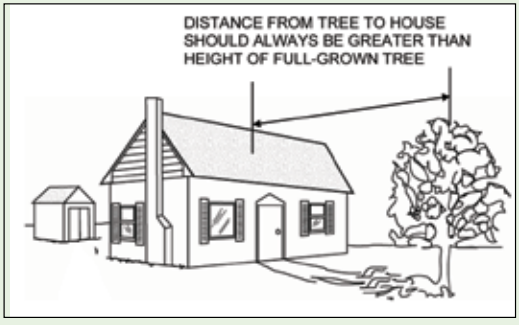


Figure 5-24. FEMA recommends that the distance between a tree and your house should always be greater than the height of the full-grown tree. This is to prevent trees from falling on the roof, either currently or in the future. Image courtesy of FEMA

Trees with shallow roots may also be susceptible to falling over when the soil is saturated. Shallow roots cannot prevent a tree with leaves from falling over when the tree canopy is filled with blowing wind. This is a probable occurrence when the area is affected by severe rainfall along with heavy winds, which is usually the case with nor'easters and hurricanes.

5.1.5 SAFE ROOMS

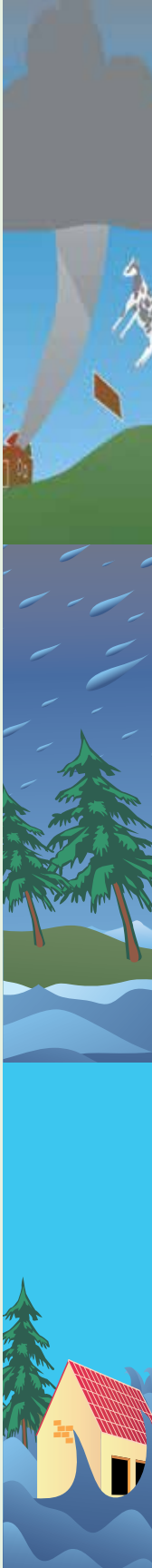
A safe room is designed to withstand winds from the strongest hurricanes (Categories 3 to 5) and strong tornadoes. This option should only be considered if the house is outside of all known flood and storm surge zones and is strengthened to the highest level. Safe rooms should not be built in a flood zone, where there is threat of moving water. During a hurricane or other high-flood event, these areas need to be evacuated no matter how fortified the room is against the wind.

It is much less expensive to build a safe room during original construction of the house. The additional cost can be wrapped into the original home mortgage. This is a good investment that yields a sizable return by adding value to your house as well as protection and peace of mind for your family.

For more information regarding the design and construction of safe rooms in homes, see FEMA's *Taking Shelter from the Storm* (Publication 320) available at fema.gov. Additional information is available at the Federal Alliance for Safe Homes, Inc. website (flash.org) and the safe room website (highwindsaferooms.org).

5.2 ELECTRICAL AND POWER ISSUES

In case of an emergency, the power to your house should be turned off through the main breaker switch, circuit breaker panel, or fuse box. In addition, all homes should be equipped with ground fault circuit interrupters (GFCIs). GFCIs are inexpensive electrical devices that, if installed in household branch circuits, are designed to protect people from severe or fatal electric shocks. GFCIs could prevent over two-thirds of all electrocutions.[5.11] Because a GFCI detects ground faults, it can also prevent some electrical fires and reduce the severity of others by interrupting the flow of electric current. GCFIs 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.[5.11]

By following key safety precautions when dealing with electricity during and after storms and other disasters, you can help prevent death, injuries and property damage. Take care when stepping into a flooded area and be aware that submerged outlets or electrical cords may energize the water, posing a potentially lethal trap.[5.11]

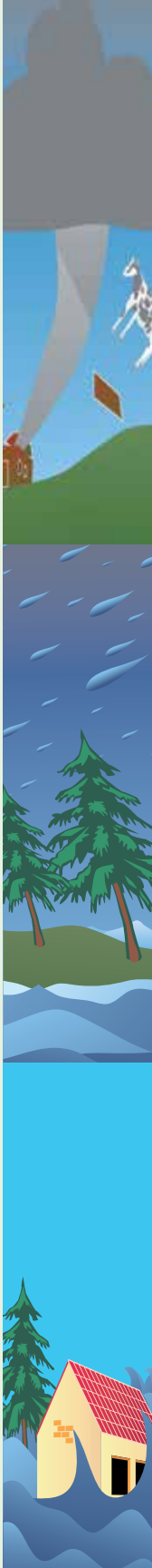
Flooded Areas: Do not use electrical appliances that have been wet. Water can damage the motors in electrical appliances such as furnaces, freezers, refrigerators, washing machines and dryers.[5.11]

Wet Electrical Equipment: A qualified service repair dealer should recondition electrical equipment that has been wet. For more information, the National Electrical Manufacturers Association (NEMA) has produced a brochure, *Guidelines for Handling Water-Damaged Electrical Equipment,* for use by suppliers, installers, inspectors and users of electrical products to provide advice on the safe handling of electrical equipment that has been exposed to water. It outlines whether items will require complete replacement or can be reconditioned by a trained professional. Items covered include electrical distribution equipment, motor circuits, power equipment, transformers, wire, cable and flexible cords, wiring devices, GFCIs and surge protectors, lighting fixtures and ballasts, motors and electronic products.[5.11] The NEMA brochure can be downloaded free of charge at nema.org/Products/Documents/guidelines-handling-water-damaged-elect-equip.pdf.

Figure 5-25. Downed or damaged power lines in a residential area can pose a serious danger to public safety. Image courtesy of U.S. EPA

Downed Power Lines: These can carry an electric current strong enough to cause serious injury or death (Figure 5-25). The following tips can keep you safe around downed lines:[5.11]

- If you see a downed power line or wire of any kind, move away from the line and anything touching it. You may not be able to differentiate between a cable, telecommunications, or electric wire, so stay clear of all downed wires of any kind. Avoid contact with objects that could come in contact with downed wires such as metal fences, sheds, vehicles, and tree limbs and branches. The human body is a ready conductor of electricity.
- The proper way to move away from the line is to shuffle away with small steps, keeping your feet together and on the ground at all times. This will minimize the potential for a strong electric shock. Electricity wants to move from a high voltage zone to a low voltage zone—and it could do that through your body.
- If you see someone who is in direct or indirect contact with the downed line, do not touch the person. You could become the next victim. Call 911 instead.
- Do not attempt to use another object such as a broom or stick to move a downed power line or anything in contact with the line. Even nonconductive materials like wood or cloth, if lightly wet, can conduct electricity and then electrocute you.
- Be careful not to put your feet near water where a downed power line is located.
- If you are in your car and it is in contact with a downed line, stay in your car. Tell others to stay away from your vehicle.
- If you must leave your car because it's on fire, jump out of the vehicle with both feet together and avoid contact with the car and the ground at the same time. This way you avoid being the path of electricity from the car to the earth. Shuffle away from the car.
- Do not drive over downed lines.



5.2.1 ALTERNATE POWER SOURCES

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 your lights, television, or refrigerator need replacing, consider products with the EPA's Energy Star label (Figure 5-26). These products may cost slightly more, but over their lifetime, the energy savings will far outweigh the small initial cost increase.

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 to 9 hours with the same light output. As another example, a refrigerator with the 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.

5.2.2 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.

Take special care with portable electric generators, which can provide a good source of power but can become deadly if improperly installed or operated.[5.11] Power from generators can backfeed along power lines and electrocute anyone coming in contact with them, including electric utility line workers who are making repairs. A qualified, licensed electrician

Figure 5-26. 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.

should install your generator to ensure that it meets local electrical codes. [5.11]

Other generator-related tips:

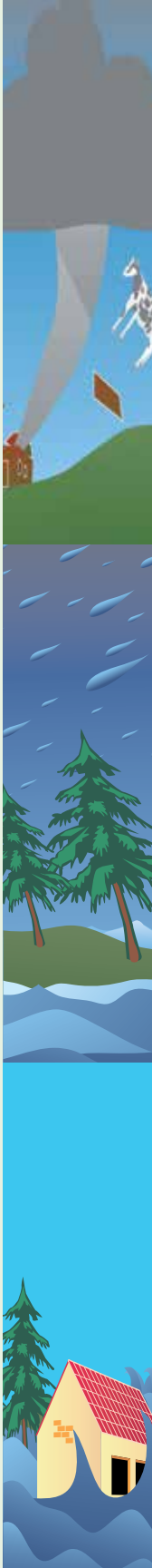
- Make sure your generator is properly grounded.
- Keep the generator dry.
- Plug appliances directly into the generator.
- Make sure extension cords used with generators are rated for the load, free of cuts and worn insulation, and have three-pronged plugs.
- Do not overload the generator.
- Use a ground fault circuit interrupter (GFCI) to help prevent electrocutions and electrical shock injuries. Portable GFCIs require no tools to install and are available at prices ranging from $12 to $30.

Most importantly, never run a generator indoors or in your garage because of the possibility of carbon monoxide gas accumulation, 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.[5.12]

In general, when 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°F in the refrigerator compartment and 0°F in the freezer. Open the refrigerator door as little as possible.

This handbook does 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 consumer reviews of generators and consider some of the following factors:

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 1,500 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. To get a more accurate estimate, however, call your manufacturer or buy an amp meter that measures running and startup wattage or amperage. You can also get good advice on sizing a generator from the dealer where you buy the unit.

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.

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

5.2.3 POWER STATIONS

Power stations are found in many hardware stores and may have a radio, flashlight, air compressor, battery jump starter, AC outlet, and/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. 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.

5.2.4 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, so 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 in a garage, but rather in a well-ventilated area if the manufacturer approves of such procedures.

5.2.5 BATTERY CHARGERS

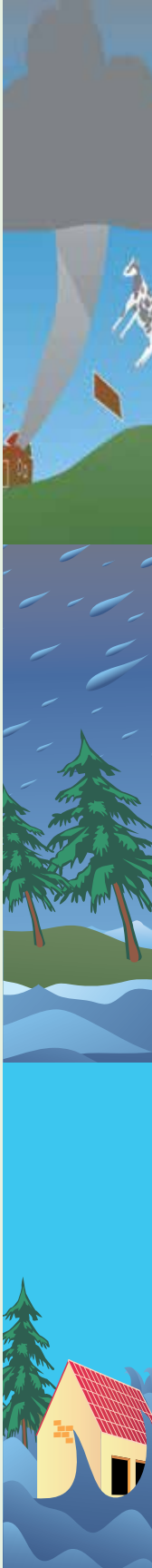
Your car battery can be an important source of DC and AC power with an inverter. To keep the car battery charged, you should consider a battery charger as part of your emergency supplies. The charger only works when there is household power or backup power through a generator, but it can recharge your car battery if 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.

5.3 LICENSED CONTRACTORS

Selecting a contractor to do your work is very important. This handbook does not recommend or endorse any particular company. When selecting a contractor, it is necessary to perform proper due diligence and check qualifications. It is up to you to select the companies and verify their records. The Delaware Department of Justice suggests that you get an estimate from at least three reputable contractors. Make sure the contractor is licensed, insured, and has not received complaints. You should always ask for a list of referrals. Get the agreement in writing with the final payment due on completion. The Home Builders Association of Delaware (www.hbade.org) can provide guidance on selecting a remodeler. You can also check the Better Business Bureau's Accredited Business Directory online at www.bbb.org/us/de.

Hiring a licensed contractor is very important. In many areas across the country that have been impacted by disasters, there are numerous examples of families who have lost savings and insurance funds as a wave of unlicensed contractors flooded the impacted area in search of work.

Before you have extensive work performed, you should also consider a consultation with 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.



5.4 HAZARD MITIGATION ASSISTANCE PROGRAM

FEMA's Hazard Mitigation Assistance (HMA) program is intended to encourage investment in long-term mitigation measures to reduce vulnerability to natural hazards. DEMA administers the HMA program in this state. HMA consists of three grant programs: the Hazard Mitigation Grant Program (HMGP) which is available following a Presidential Major Disaster Declaration, the Flood Mitigation Assistance (FMA) program and the Pre-Disaster Mitigation Program (PDM). FMA and PDM grants are dependent on annual allocations from Congress. The state of Delaware hopes to reduce the risk to individuals and property from natural hazards while simultaneously reducing reliance on federal disaster funds. As such, DEMA encourages state and local governments to take advantage of the funding provided both before and after disasters.

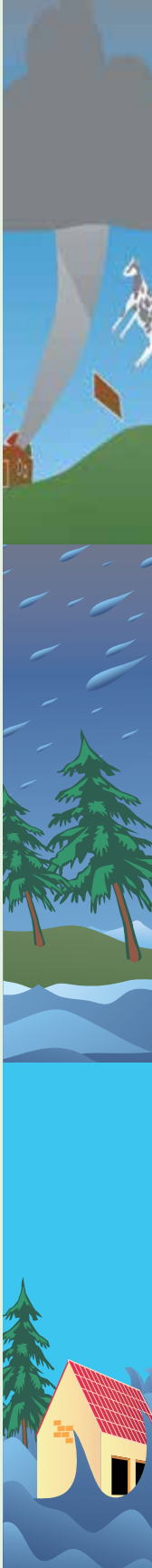
Among other things, the program can provide funds to states to assist homeowners in implementing mitigation measures to existing structures. Some of the project types that have been approved by FEMA for use in assisting homeowners are:

- **Property Acquisition and Structure Demolition**—the acquisition of an existing at-risk structure and/or property and conversion to open space through the demolition of the structure. The property must be deed-restricted in perpetuity to open space uses to restore and/or conserve natural flood plain functions.
- **Property Acquisition and Structure Relocation**—the physical relocation of an existing structure to an area outside of a hazard-prone area or a regulatory erosion zone and, typically, the acquisition of the underlying land. Relocation must conform to all applicable state and local regulations. The property must be deed-restricted in perpetuity to open space uses to restore and/or conserve the natural flood plain functions.
- **Structure Elevation**—physically raising an existing structure to an elevation at or above the Base Flood Elevation or higher if required by FEMA or local ordinance. Structure elevation may be achieved through a variety of methods, including elevating on continuous foundation walls; elevating on open foundations such as piles, piers, posts, or columns; and elevating on fill. Foundations must be designed to

properly manage all loads and be appropriately connected to the floor structure above. Utilities must be properly elevated as well. FEMA encourages applicants and sub-applicants to design all elevation projects in accordance with the American Society of Civil Engineers (ASCE) 24-05 Flood Resistant Design and Construction (fema.gov/media-library/assets/documents/14983).

- **Mitigation Reconstruction**—the construction of an improved, elevated building on the same site where an existing building and/or foundation has been partially or completely demolished or destroyed.

Funding under HMA programs is subject to the availability of appropriations and, for Hazard Mitigation Grant Program funds, to the amount of FEMA disaster recovery assistance specified under a presidential major disaster declaration. To assist in establishing funding priorities, local and state mitigation plans are utilized to identify the highest risks.



Part 6
Protecting Your Property with Insurance

Unfortunately, many homeowners do not find out until it is too late that their insurance policies do not cover flooding. The National Flood Insurance Program (NFIP) offers a separate flood policy that protects what for most people is their single most important financial asset: their home. NFIP coverage is available to all owners of insurable property (a building and/or its contents) in a community participating in the NFIP. Renters may also obtain contents coverage through an NFIP policy.

An overview of the NFIP is on FEMA's *FloodSmart* website (floodsmart.gov). A list of participating Delaware communities can be found on the NFIP's *Community Status Book* site (fema.gov/cis/DE.html).

Not sure about the high costs associated with flooding? All it takes is one inch of water to cause $25,000 in damages to your home and its contents.[1,2] FEMA's NFIP website (floodsmart.gov) includes an interactive tool that demonstrates the cost of flooding and shows you what a flood in your home could cost, inch by inch. What are your chances of experiencing a flood? The site also includes animated flood risk scenarios that demonstrate how various factors impact different neighborhoods, providing excellent illustrations of where flooding can occur and the damage flooding does to a home.

Even homes located away from the coast or a river are susceptible to flooding to varying degrees, and flood insurance is an important consideration for all Delaware residents. Homes and businesses in high-risk flood areas with mortgages from federally regulated or insured lenders are required to have flood insurance. While flood insurance is not federally required if you live in a low- to moderate-risk flood area, it is still available and strongly recommended: The NFIP reports that more than 20% of flood insurance claims come from low- to moderate-risk areas.[1,2]

No matter where you live, the Delaware Department of Insurance suggests that you prepare for severe weather disasters by creating a home inventory,

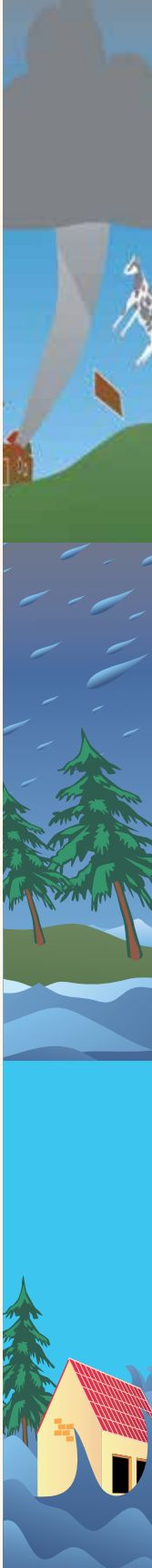
which will create a record of what you own and what it is worth. A home inventory will help you estimate the value and replacement cost of your possessions in order to ensure that you have sufficient coverage under your homeowner's or renter's insurance policy. The inventory will create a detailed record of what you have in case disaster strikes and you have to provide your insurance company with a comprehensive list of what needs to be replaced. Note the condition of your possessions by taking video or photos of every angle of each room and store these in a safe, watertight space. Additional information and a home inventory checklist are included on the Department of Insurance website (insurance.delaware.gov/wp-content/uploads/sites/15/2018/09/Home-Inventory-Form-2018.pdf).

6.1 GENERAL INSURANCE INFORMATION

Natural disaster planning is one of the most important duties a homeowner can perform. Protection of life is first and foremost before, during, and immediately following a disaster. It is very important that consumers take time out before a disaster strikes to be certain that insurance coverage is in place (typically plans require at least 30 days to go into effect) and concerns have been addressed. Delaware's Department of Insurance (delawareinsurance.gov) provides the following suggestions that consumers should consider before they are faced with a disaster.

Pre-Disaster Activities

- Contact your insurance company or agent and verify that coverage is in place before a disaster strikes. Make sure you have wind coverage protection and flood insurance if your home or business is located in a flood plain area.
- Make sure that you understand the deductible provision of your policy.
- Keep all of your insurance policies in an easily accessible location.
- If forced to evacuate, take copies of important paperwork, including your insurance policy and contact information for your insurance company or insurance agent.
- Be certain you understand the claim procedures of your insurance company.



- Make sure you have insurance up to at least 80% of the value on your home to avoid penalties under any co-insurance provision of your policy.
- Keep all necessary information regarding your health coverage, including prescription information, with your insurance records in the event of an evacuation.
- Be prepared to board up your windows and doorways to protect your home or business.
- Have a suitcase packed to last each member of your family for at least two to three days in case you need to evacuate from your home.
- In the event of a hurricane or flood watch, be sure that your vehicle has sufficient fuel in it in order to relocate to a safe area.
- Keep available a tarp and other supplies to protect your home in case it is damaged. An insurance policy usually requires the policyholder to protect the property from further damage.

Personal Property

Before a disaster occurs, take photographs or make a video of each room of your home and compile a set of records, old receipts, and bills to help establish the price and age of your property. Write down brand names and model numbers of appliances and electronic equipment and date purchased. Do not forget to list items such as clothing, sports equipment, tools, china, linens, holiday decorations, business equipment, hobby materials and all other materials associated with your home or business.

Protect Your Home from Damage

Consumers can do a number of things to reduce the cost of their property insurance. Protecting property from possible damage before a disaster can have a major impact on insurers' willingness to continue insuring the property and can also impact future prices the consumer will have to pay in the event their home is met by a disaster. By performing some of the following duties, consumers can make major contributions toward reducing the amount of losses occurring to their home:

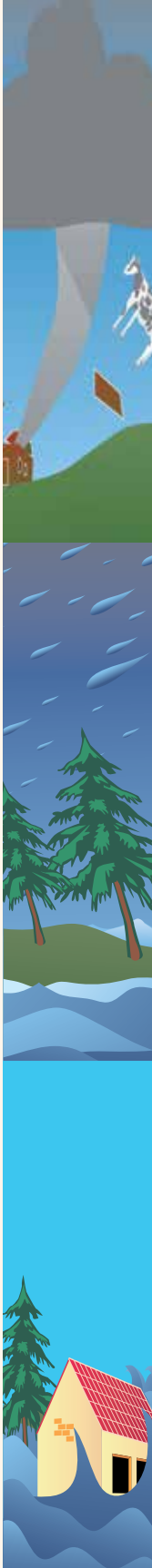
- Consider adding storm shutters to the windows and doors of your home.

- Glue or nail down any loose shingles.
- Make certain yard items are tied down or secured. Bicycles, grills, toys, unsecured benches and any other items not tied down should be placed inside an enclosed building. These items become missiles during a tornado or hurricane.
- If you own a vehicle, do not park it under a tree if a storm is anticipated.
- Take precaution to prune or remove any tree that has the potential of damaging your home during a storm.

Communicate with Your Insurance Agent

Check with your agent and policy declarations pages for information about what is covered:

- Coverage is typically provided in terms of replacement cost or the cost to rebuild your house.
- 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.
- 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 about possible discounts and incentives. 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 (1) your main structure, (2) detached structures, (3) the contents in your house and (4) expenses for loss of use (like hotel stays). Only the first item is required by mortgage lenders, so you may not have sufficient coverage for the remaining items.



6.2 FLOOD INSURANCE

Floods are the most common—and most costly—natural disaster. In the past several years, about 60% of all declared disasters involved flooding.

To obtain coverage from flood events, you need flood insurance. Standard homeowners insurance policies do not provide protection against floods. It is a hard lesson that has been learned by some in Delaware in the past, and it is an unfortunate reality that many people don't find out until it's too late.

Just one inch of water from a flood can cause $25,000 in damage.[1.2] According to FEMA, over the past five years the average paid flood insurance claim was nearly $34,000. Flood insurance is the best way to protect yourself from devastating financial loss. Many homeowners mistakenly assume that government assistance will be available following a flood, only to find that government funds are often unavailable or take the form of small grants or loans. For example, following Hurricane Harvey in 2017 in Harris County, Texas, the average individual assistance grant awarded to property owners was only $4,200. Most other federal assistance came in the form of loans. By comparison, those property owners that had flood insurance through the National Flood Insurance Program received an average claim payment of $113,000.[1.2]

In areas with the greatest risk of flooding, Special Flood Hazard Areas (SFHAs), a building has a 26% chance of being flooded during a 30-year mortgage. On average, more then 20% of all flood insurance claims paid by the NFIP are for property outside of SFHAs. Homeowners, business owners, and renters can all buy flood insurance as long as their community participates in the NFIP.

While some private companies offer flood insurance, most flood insurance in the U.S. is backed by the federal government under the NFIP. Flood insurance is available to homeowners, renters, condo owners/renters and commercial owners/renters in participating communities through local insurance agents. Costs vary depending on how much insurance is purchased, what it covers and the property's flood risk.

NFIP rates are set and do not differ from company to company or agent to agent. These rates depend on several factors, including the date and type of construction of your home and your area's level of risk. Residential property

owners located in low- to moderate-risk areas should ask their insurance agents if they are eligible for the Preferred Risk Policy, which provides very inexpensive flood insurance protection.

If your community participates in the FEMA Community Rating System (CRS), you may qualify for an insurance premium discount—in some communities of up to 45%—if you live in a high-risk area and up to 10% in low- to moderate-risk areas (see Figure 6-1).

You should discuss insuring personal property with your agent, since contents coverage is optional. Typically, there's a 30-day waiting period from date of purchase before your policy goes into effect. That means now is the best time to buy flood insurance—don't wait until a storm is approaching.

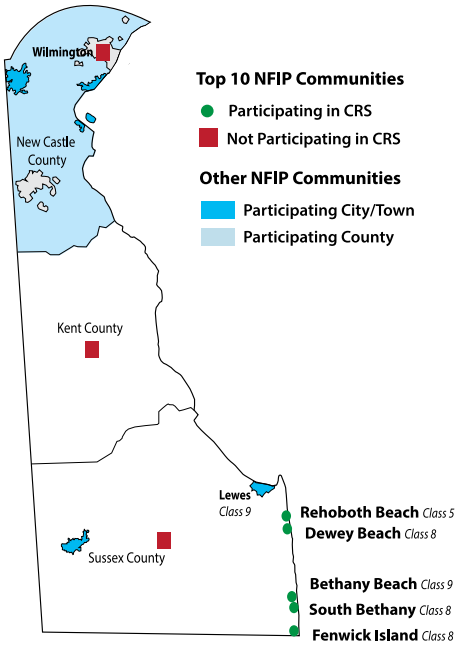
The website floodsmart.gov provides information about flood insurance, including detailed information about what typically is and isn't covered. FEMA's website also assesses the flood risk for any address and provides a list of insurance agents in the area that offer NFIP-backed insurance.

Figure 6-1. FEMA Community Rating System (CRS)

FEMA's Community Rating System (CRS) is a voluntary program that encourages flood risk reduction strategies in exchange for discounts in flood insurance premiums for participating communities. Communities receive credit points for efforts that exceed minimum standards. A CRS class (1 to 10 with 1 being the gold standard) is assigned to each community based on the number of points they have earned. Property owners receive insurance discounts from 5% to 45% depending on their community's CRS class. Qualifying activities fall into categories including public information, mapping and regulations, flood damage reduction, and flood preparedness.

As of the date of this publication, 11 communities including New Castle County participate in CRS with classifications ranging from 6 to 9.

Source: Amanda Gowans, Insurance Services Office



Appendix A
Emergency Contact Information

County and City of Wilmington Emergency Management

City of Wilmington Emergency Management Office 302-576-3914
New Castle County Office of Emergency Management.....302-395-2700
Kent County Department of Public Safety.....302-735-3465
Sussex County Emergency Operations Center 302-855-7801

Delaware Emergency Management Agency (DEMA)

302-659-DEMA (3362) or 877-SAY-DEMA
877-729-3362 (Delaware only)
dema.delaware.gov

Delaware Department of Transportation (DelDOT)

302-659-4600 or #77 (Transportation Management Center)
deldot.gov
deldot.gov/Traffic/travel_advisory/index.shtml#advisories
deldot.gov/information/projects/tmt/evac_map.shtml
twitter.com/DelawareDOT (Twitter feed)
deldot.gov/Publications/syndication (RSS feeds)

Delaware Department of Safety and Homeland Security

dshs.delaware.gov

Delaware Health and Social Services

dhss.delaware.gov/dhss

American Red Cross: Wilmington, Del.

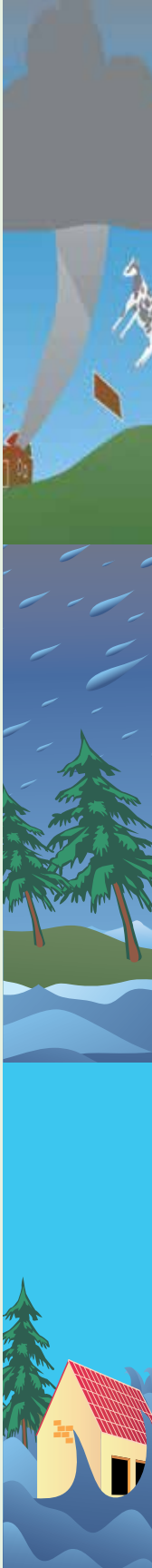
302-656-6620

redcross.org

Federal Emergency Management Agency (FEMA)

800-621-FEMA (3362)

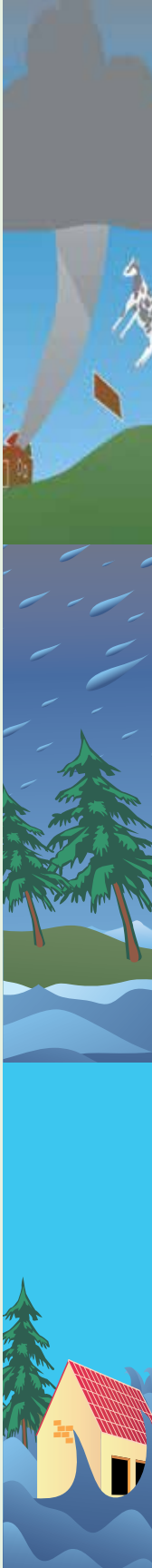
fema.gov



Appendix B
Managing Flood Risks On Your Property

Know Your Risk	• Obtain an elevation certificate for your property • Consult floodplain maps for historic flood elevations and risk zones • Identify local drainage issues • Consider future climate and land use changes when calculating risk
Avoid Building or Living in High Risk Areas	• Select a lower risk area to build or buy property in • Choose neighborhoods with multiple egress routes, well-maintained stormwater systems, and vegetated riparian buffers or dunes
Build To Higher Standards	• Elevate your first floor living space • Elevate mechanical/utility systems • Use water resistant materials
Purchase Flood Insurance	• Consult floodsmart.gov • Talk to your insurance agent

Appendix C
Construction at the Coast, Beach Management, and Coastal Property Checklist



CONSTRUCTION AT THE COAST

If you are a coastal property owner, it is important to understand the dynamic processes that shape Delaware's shorelines as well as the potential risks and consequences of living at the coast. Most properties along the ocean, Delaware Bay, inland bays, marshes and tidal rivers are vulnerable to coastal hazards such as storms, erosion, sea level rise and flooding. Property owners should be mindful of potential impacts and risks associated with living at the coast. Some basic considerations are included in this section.

Investigations conducted by the Federal Emergency Management Agency (FEMA) and other organizations after major coastal disasters have consistently shown that properly sited, well-designed, and well-constructed coastal residential buildings generally perform well. An excellent source of information for protecting your property at the coast is found in FEMA's Coastal Construction Manual (FEMA P-55) available on FEMA's website at fema.gov/library. Prepared by FEMA with assistance from other agencies, organizations and professionals involved in coastal construction and regulation, this manual is intended to help designers and contractors identify and evaluate practices that will improve the quality of construction in coastal areas and reduce the economic losses associated with coastal disasters. Note, properties that are well-sited today may not be well-sited 10 to 15 years from now due to sea level rise, so always factor future conditions into your planning.

Additional coastal construction resources and publications are available via FEMA's website (fema.gov/residential-coastal-construction), including various National Flood Insurance Program Technical Bulletins, *Home Builder's Guide to Coastal Construction* (FEMA P-499), *Recommended Residential Construction for Coastal Areas: Building on Strong and Safe Foundations* (FEMA P-550), Local Officials Guide for Coastal Construction (FEMA P-762), *Wind Retrofit Guide*

for Residential Buildings (FEMA P-804) and *Protecting Manufactured Homes from Floods and Other Hazards* (FEMA P-85).

As part of an ongoing effort to reduce impacts from coastal hazards, restricted building areas for oceanfront and bayfront construction are established with a setback line, which is delineated by DNREC's building line. Established as part of the *Regulations Governing Beach Protection and the Use of Beaches*, the building line controls construction activities on beaches and dunes so that these coastal features are able to perform their protective and recreational functions. The building line, which parallels the coastline, is designated on DNREC maps for ocean and Delaware Bay beaches. No construction may take place seaward of the line without a coastal construction permit. Construction proposed to be located within the defined beach area and landward of the building line requires a coastal construction letter of approval from DNREC.

Permitting guidelines are designed to ensure that structures are located behind the primary dune or as far landward as possible on the lot to reduce impact on the primary sand dune or active beach area. It is advisable to build as far away from the shoreline as possible and to develop on the highest elevation of the property, but not on the coastal dunes. It is important for property owners to realize that the required building setback established by the state of Delaware does not guarantee a safe location. Every lot is different, so be sure to contact DNREC prior to conducting any construction activities.

Building codes in flood-prone areas, including coastal high-hazard areas, require structures to be built to a minimum height above Base Flood Elevation (BFE). For example, some municipalities require the lowest living space in a structure to be one foot, 18 inches or more above the BFE. This margin of safety is known as freeboard and can reduce flood damages as well as lower federal flood insurance premiums. To determine the BFE elevation in high-risk zones, consult local Flood Insurance Rate Maps (FIRMs). A FIRM is an official map of an area's special hazard areas and flood risk premium zones. They are used to determine flood insurance rates and should be available at your local town hall, county planning office, state flood mitigation office, or the Federal Emergency Management Agency. Contact your local building official for additional information on BFEs and flood zone information for your property.

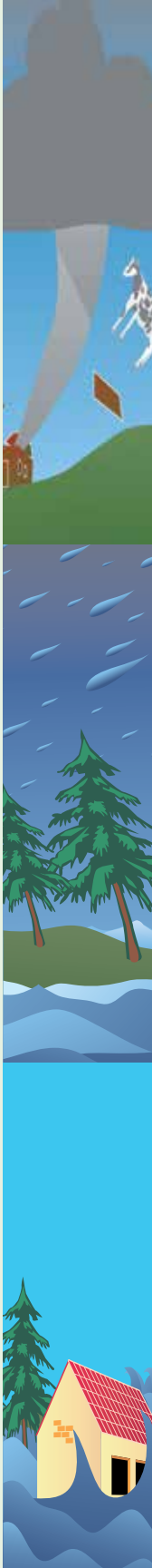
DO'S AND DON'TS

Do:

- Gain an understanding of local coastal processes, wave conditions and how the beach changes seasonally. The beach can look very different in February and March than it does in August and September.
- Determine whether the land has experienced flooding in the past, including any details such as how high the water was and if waves washed over the property.
- Determine whether all buildings are properly elevated to at least the BFE that is calculated based on historic flood heights. Consider elevating structures higher than BFE to account for future conditions.
- Locate all structures and improvements well away from the shoreline to allow the beach space to migrate as well as minimize risks from coastal hazards.
- Investigate the history and status of any shoreline structures on the property to confirm their legality. New homeowners assume responsibility for existing structures whether they are legal or not.
- Investigate alternative erosion management measures if necessary.
- Maintain the natural dune features and native plants around the shoreline area.

Don't:

- Build structures within a coastal high-hazard area that are likely to be threatened by waves or erosion.
- Assume the shoreline is stable just because it looks wide and has weathered previous storms well. Every storm is different, and storms are intensifying.
- Assume you will be granted authorization for a shoreline structure just because the shoreline is eroding. There are specific criteria that must be met in order to obtain permission for shoreline structures.
- Alter, grade, trample on, or reduce the height of the coastal dune.



BEACH MANAGEMENT IN DELAWARE

Coordination of federal, state and local agency activities is necessary to support regional approaches to addressing coastal erosion and storm damage to beaches. Federal government agencies that assist the state in managing Delaware's beaches include the U.S. Army Corps of Engineers, NOAA, FEMA and the Department of the Interior. The need for a comprehensive, coordinated, and proactive approach to shoreline management is emphasized by numerous factors: The coast is actively changing and moving; storm activity can, and very often does, dramatically alter the coast; and coastal population and development continue to increase. Delaware's comprehensive coastal planning and regulatory programs continue to evolve with coastal science and general understanding of processes that impact all aspects of the coast. The science and management tools of shore protection have generally progressed from building structures designed to protect buildings (seawalls and bulkheads) to practices that protect and enhance the natural beach (construction setbacks, dune protection and beach nourishment).

Along the immediate coast, beach nourishment is one of the strategies used to minimize storm damage to personal property and public infrastructure. Beach nourishment is the process of adding sand to an eroding beach to restore its width and elevation to specified, engineered dimensions. Used almost exclusively in developed beach areas, nourishment is commonly accomplished by pumping sand onto the beach from an offshore source using a dredge, although it may also be conducted by trucking sand onto the beach.

Beach nourishment does not prevent erosion or stop the movement of sand along a beach. It is actually a strategy that resets the erosion clock by adding sediment to the system and reestablishes the buffer of sand between the ocean and structures. To be effective over the long term, beach nourishment projects must be periodically maintained by adding more sand.

Faced with an increasing demand for beach services that includes storm protection, DNREC has developed a management approach that incorporates several different tools to mitigate impacts of shore erosion. Beach preservation efforts in Delaware took a significant turn in response to the Beaches 2000 Report to the Governor. The committee behind the report saw the merits in beach nourishment as long as the benefits resulting from the nourishment exceeded the cost of conducting the work. This

remains the policy of the state, and economic analyses of beach nourishment work along the Atlantic Ocean coast were conducted in 1998 and again in 2004 to ensure that nourishment costs return economic values that are higher than project implementation costs. However, the cost of beach nourishment is rising and given current fiscal realities, the time between beach replenishment projects may lengthen.

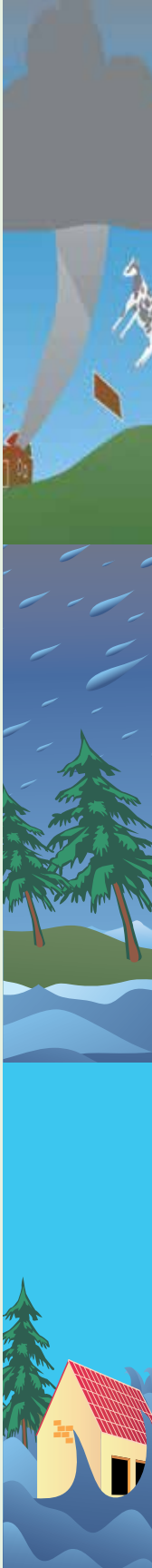
DUNES AND DUNE MANAGEMENT

Sand dunes—ridges or mounds of windblown sand—are an integral part of Delaware's beach system. Dunes are vital to shoreline stability because they are protective features that also serve as reservoirs for sand. They are resilient natural barriers to the destructive forces of coastal storms and offer the least expensive and most efficient defense against flooding tides and waves.

Coastal storms can destroy even well established dunes. During storms, high-energy waves may wash against the base of the dunes, eroding sand and undermining the seaward dune face. In extreme storms, the dune face may recede significantly and the dune itself may be destroyed. During storm events, dune sand is removed and redistributed along the beach—essentially the dunes act as a sand storage system and a buffer between waves and coastal property. Depending on the size of the dune and intensity of the storm, high continuous dunes can provide a barrier to storm surge and overwash, thereby reducing flooding on the landward side.

Natural dune recovery after a storm depends on the severity of the storm and the initial condition of the dune. The front dunes can be severely eroded or completely flattened or overtopped during a storm. In the days and weeks after a storm, waves begin to push sand from nearshore bars back to shore to rebuild the beach. Eventually sufficient sand returns to the beach, and the dune begins to recover from storm damage as the wind blows sand up into the dune area. Natural dune rebuilding processes operate relatively slowly. Left solely to natural processes, dunes may take years or even decades to recover after a severe storm.

Because dunes play such a direct role in providing storm and flood protection, it's important to remember that removal of dune material will increase flood risk. The NFIP prohibits all man-made alteration of sand dunes within VE and V zones unless an engineering analysis demonstrates that the activity will not result in an increased flood risk.



There are many ways for individuals and communities to help protect Delaware dunes:

- Place signs on the dune to explain the importance of keeping off of the beach grass and dunes.
- Restore damaged dunes, plant vegetation and put up dune fencing to restrict traffic. Do not remove any material from the dune—all sand should remain on the dune and beach system.
- Use designated dune walkovers and access points to control pedestrian and vehicular traffic flow across dunes. All planted areas should be protected from vehicles, pedestrians and pets.
- Allow beach grass and dune vegetation to grow naturally. Mowing destroys the grasses' ability to trap sand and may kill the plants.
- Maintain a clear, clean and natural dune environment. Items such as Christmas trees, cut shrubs and yard clippings will smother natural dune vegetation and may also become a fire hazard. This type of debris should not be placed on the dune or beach. Similarly, items such as cars, trucks, bikes and boats should be kept off of the dune.
- Avoid hard landscaping such as railroad ties, flower boxes, retaining walls, piling tops, large stone, brick, cement blocks and concrete. These items should not be placed in dune environments. They are easily lifted by storm waves, becoming debris that can batter your home and adjacent buildings and may cause severe damage or loss of property.

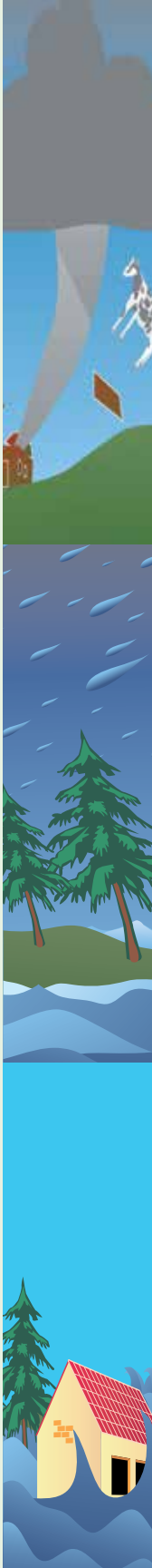
COASTAL PROPERTY CHECKLIST

If you live along the immediate coast, you are more vulnerable to the effects of coastal storms. High winds and waves may damage and destroy improperly constructed homes. Floating debris can crack foundation piles, causing collapse of the home or severe damage to windows and doors. Pressure from floodwaters on solid foundations can lead to collapse.

You can prevent or minimize damage by taking precautions during initial construction or by making modifications to an existing home. The following checklist is not all-inclusive and is not intended to replace local building code requirements or to serve as the only options for protecting your home from storm damage. For more information, contact your local building official or a building professional such as a coastal engineer, architect, or experienced contractor.

FLOODING

- ❏ Do you know the projected flood elevation for your area? Ask your building department to see a flood map of your community. You can also visit DNREC's online Flood Planning tool and search the address of your property: maps.dnrec.delaware.gov/FloodPlanning/default.html
- ❏ Do you know the estimated long-term erosion rates for your area? Are any actions such as beach nourishment or other erosion control projects being implemented to mitigate long-term erosion?
- ❏ Is the first floor of the dwelling located above the projected flood elevation for your area? If your house is in a flood plain, you can also find your BFE on DNREC's online Flood Planning tool by searching your address: maps.dnrec.delaware.gov/FloodPlanning/default.html
- ❏ Is your home located in a V zone? Inclusion in a V zone indicates the potential for waves of three feet or greater in a storm event having a 1% chance of being equaled or exceeded in any given year. Retaining walls, bulkheads, or other soil management structures located underneath, connected to, or in close proximity to existing or proposed buildings are generally prohibited within V zones.



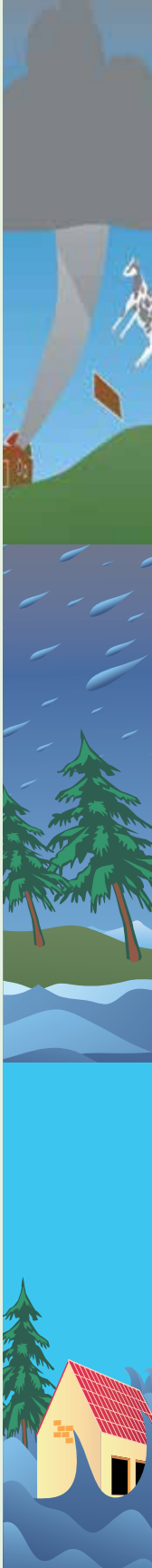
- ❏ If your house is elevated on piles, do you have an open foundation, free of obstruction, that allows fast-moving waves and water to flow beneath the building?
- ❏ If storage areas or other enclosures are needed below projected flood elevations, they must be constructed with breakaway walls to allow water to flow through unobstructed. Is your enclosure breakaway?
- ❏ Are steps used for accessing the beach from the structure or the pedestrian dune crossover elevated or removed out of the reach of waves and floodwaters?
- ❏ Are the main electric panel, outlets and switches located at least 12 inches above potential floodwaters?
- ❏ Are the washer, dryer, furnace and water heater elevated above potential floodwaters?
- ❏ Are outside air-conditioning compressors and heat pumps elevated above expected flood levels?
- ❏ Is the fuel tank securely anchored? It can tip over or float in a flood, causing fuel to spill or catch fire. Cleaning a house inundated with oil-contaminated water can be difficult and expensive.
- ❏ What is the orientation of crossbracing on the pilings? Diagonal bracing will obstruct velocity floodwaters and waves and will often trap debris, therefore bracing is often placed parallel to the primary direction of flow. Check with your architect or engineer.
- ❏ Does the sewer have a backflow valve? Contact a licensed plumber to install the valve.
- ❏ Are there potential projectiles such as landscaping ties, cinder blocks, cement patio blocks, pile butts, or split-rail fences located in the pathway of waves and flood waters? These objects can crack and damage piles and lower level enclosures, causing possible collapse of the structure.

WIND

- ❏ Are windows and exposed glass surfaces protected by coverings? This is one of the best ways to protect your home against wind and flying debris.
- ❏ Is the roof fastened to the walls with galvanized metal hurricane clips? This will reduce the risk of losing your roof to high winds.
- ❏ Are the galvanized clips, straps, hangers and joist-to-beam ties corrosion free? Corroded metal components can fail during extreme wind events. These should be replaced when corroded.
- ❏ Are the foundation piles notched less than 50% of the pile cross section? Overnotching can lead to failure of the piles.
- ❏ Are deck and lawn furniture, which are likely to become airborne debris, securely fastened or taken indoors?

EROSION

- ❏ Is your property protected by a maintained beach and dune system? Is that project currently being maintained to its intended design? Is the dune in front of your home well vegetated to prevent wind erosion? Is the dune of sufficient height and width to prevent overtopping by waves during a storm?
- ❏ Are there bare, low areas in the dune created by walking over the dune to access the beach? These areas are weak spots that will allow waves to flow over the dune and cause loss of the dune and subsequently allow waves and water into the house.
- ❏ Do not undertake any dune alteration activity unless a proper engineering analysis demonstrates that there will be no increase in flood risk. The NFIP prohibits man-made alteration of sand dunes within VE and V zones, which would increase potential flood damage. DNREC can also provide technical and permitting guidance before undertaking any dune alteration activity.
- ❏ Is your home built on a concrete slab and located on the ocean or bay front? Concrete slabs can be undermined and destroyed during



storms, causing the collapse of the structure. Crawl-space homes are also vulnerable to undermining. If possible, elevate the structure on pilings.

- ❏ Does your home have a septic system located in a coastal high-hazard area (V zone)? Both buried and mound septic systems are frequently exposed, destroyed, or displaced during coastal storm events. Special design criteria must be used to protect septic systems in areas vulnerable to high-velocity flooding, wave action, erosion and storm damage. See dnrec.delaware.gov/swc/Shoreline/Documents/designing_septic_systems_coastal_areas.pdf for more information and contact appropriate local and state officials before beginning work.

STRUCTURAL

- ❏ Inspect strapping and connectors for corrosion and replace if necessary.
- ❏ Check roof for loose or missing shingles. Be certain gutters are clear of debris.
- ❏ Inspect condition of storm shutters or plywood used to protect windows and doors. Cover all large windows and doors (especially patio doors) with securely fastened, impact-resistant shutters with proper mounting fixtures.
- ❏ Make sure all doors and windows are caulked and/or weather stripped.
- ❏ Inspect sewer backflow valves.
- ❏ Inspect condition of elevated utilities and supporting platforms. Be sure utilities are securely anchored to the supporting frame.

LOT AND LAND AREA

- ❏ Remove, secure, or store any objects that may be carried by waves or winds (e.g., deck furniture, landscaping, construction materials, etc.).
- ❏ Raise or remove steps accessing the beach.
- ❏ Check condition of dune (width and elevation). Inspect condition of beach grass. Replant bare areas in the spring and fertilize as needed.
- ❏ Trim back dead or weak branches from trees.

Endnotes

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3.3 *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II* U.S. Global Climate Change Research Program, 2018. Accessed May 2019 at nca2014.globalchange.gov.

3.4 *Delaware Climate Change Impact Assessment*. Department of Natural Resources and Environmental Control, Division of Energy and Climate. 2014. dnrec.delaware.gov/energy/Pages/The-Delaware-Climate-Impact-Assessment.aspx

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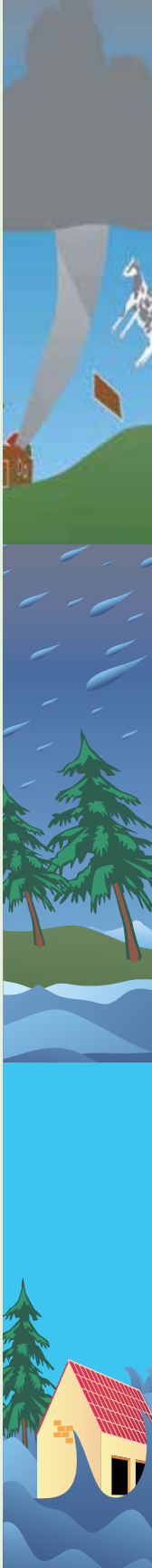

Hawkey, (eds.), 2008. Available online at mde.maryland.gov/programs/air/climatechange/documents/final-chapt%202%20impacts_web.pdf.

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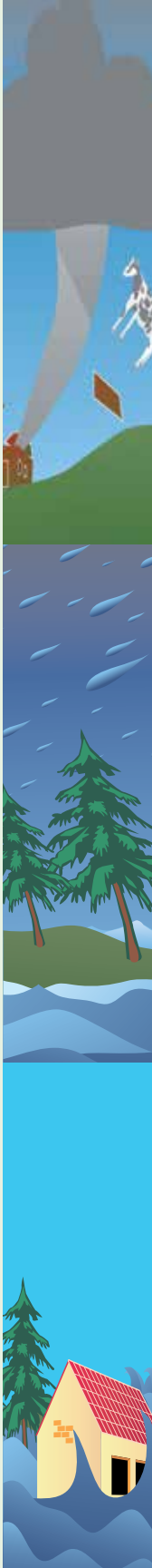


Acronyms and Abbreviations

ASCE: American Society of Civil Engineers
BFE: Base Flood Elevation
CRS: Community Rating System
CEMA: Center for Environmental Monitoring and Analysis
DEMA: Delaware Emergency Management Agency
DelDOT: Delaware Department of Transportation
DENS: Delaware Emergency Notification System
DFIRM: Digital Flood Insurance Rate Map
DNREC: Delaware Department of Natural Resources and Environmental Control
EAS: Emergency Alert System
EPA: Environmental Protection Agency
°F: Degree(s) Fahrenheit
FEMA: Federal Emergency Management Agency
FIRM: Flood Insurance Rate Map
FMA: Flood Mitigation Assistance
GFCI: Ground Fault Circuit Interrupter
HMA: Hazard Mitigation Assistance
HMGP: Hazard Mitigation Grant Program
IBC: International Building Code
IBHS: Insurance Institute for Business and Home Safety
MAT: Mitigation Assessment Team
MLLW: Mean Lower Low Water
MPH: Miles Per Hour
NAHB: National Association of Homebuilders
NEMA: National Electrical Manufacturers Association
NFIP: National Flood Insurance Program
NOAA: National Oceanic and Atmospheric Administration
NWS: National Weather Service
PDM: Pre-Disaster Mitigation
SFHA: Special Flood Hazard Area
TMC: Transportation Management Center

Useful Links and Resources

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

American Red Cross: redcross.org

- Disaster Preparedness for Pets: redcross.org/get-help/how-to-prepare-for-emergencies/pet-disaster-preparedness

Center for Environmental Monitoring and Analysis (CEMA): cema.udel.edu

- Delaware Environmental Observing System: www.deos.udel.edu
- Delaware Coastal Flood Monitoring System: coastal-flood.udel.edu

Delaware Department of Insurance: delawareinsurance.gov

Delaware Department of Natural Resources and Environmental Control (DNREC): dnrec.delaware.gov

Delaware Department of Transportation (DelDOT): deldot.gov

- Evacuation Route Maps: deldot.gov/information/projects/tmt/evac_map.shtml
- Interactive Traffic Maps: deldot.gov/map/index.shtml

Delaware Emergency Management Agency (DEMA): dema.delaware.gov

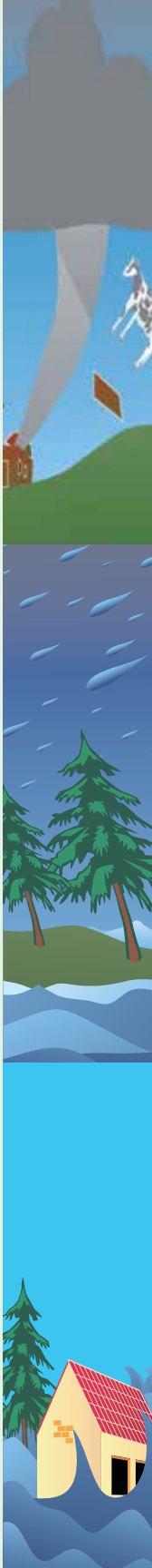
Delaware Emergency Preparedness Voluntary Registry: de911assist.delaware.gov

Delaware Electric Cooperative: www.delaware.coop

Delaware Geological Survey: www.dgs.udel.edu

- Delaware sea level rise scenarios and inundation maps: www.dgs.udel.edu/slr

Delaware Sea Grant College Program: www.deseagrant.org



Delmarva Power: delmarva.com

Electrical Safety Foundation: esfi.org

Federal Alliance for Safe Homes: flash.org

Federal Emergency Management Agency (FEMA): fema.gov

- *Against the Wind: Protecting your Home from Hurricane and Wind Damage* (FEMA 247). Available at fema.gov/library.
- *Coastal Construction Manual: Principles and Practices of Planning, Siting, Designing, Constructing, and Maintaining Residential Buildings in Coastal Areas* (FEMA P-55). Available at fema.gov/library.
- *Home Builder's Guide to Coastal Construction.* Technical Fact Sheet Series, (FEMA P-499). Available at fema.gov/library.
- *Homeowner's Guide to Retrofitting: Six Ways to Protect Your Home From Flooding* (FEMA P-312). Available at fema.gov/library.
- *Local Officials Guide for Coastal Construction* (FEMA P-762). Available at fema.gov/library.
- Flood Map Service Center Search By Address: msc.fema.gov/portal/search
- National Flood Insurance Program (NFIP): floodsmart.gov
- NFIP Technical Bulletins: fema.gov/nfip-technical-bulletins
- Ready—Prepare, Plan, Stay Informed: ready.gov
- *Recommended Residential Construction for Coastal Areas: Building on Strong and Safe Foundations* (FEMA P-550). Available at fema.gov/library.
- Safer, Stronger, Protected Homes and Communities: fema.gov/safer-stronger-protected-homes-communities
- *Wind Retrofit Guide for Residential Buildings* (FEMA P-804). Available at fema.gov/library.

Insurance Institute for Business and Home Safety: ibhs.org

National Flood Insurance Program: floodsmart.gov

National Oceanic and Atmospheric Administration (NOAA): **noaa.gov**

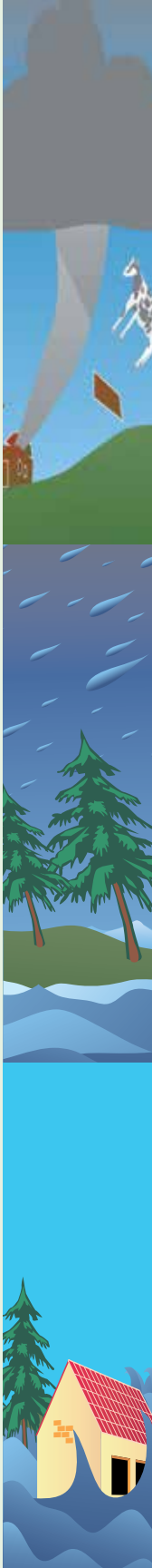
- Office for Coastal Management: coast.noaa.gov

NOAA National Weather Service: **weather.gov**

- Flood Safety: weather.gov/safety/flood
- Mt. Holly, N.J. Forecast Office: weather.gov/phi
- National Hurricane Center: www.nhc.noaa.gov and www.nhc.noaa.gov/prepare
- Weather Safety Tips: weather.gov/safety
- Weather Radio: weather.gov/nwr

Prepare Delaware: **preparede.org**

Resilient and Sustainable Communities League (RASCL): **derascl.org**



Notes